BC Rivers Consulting

1499 Hillside Place
Kamloops, BC
V2E 2E1

Ph: (250) 851-3158
Fax: (250) 851-3157
E-mail: bcosterton@shaw.ca

Ministry of Water, Land and Air Protection
1259 Dalhousie Drive
Kamloops, BC
V2C 5Z5

24 June 2005
File: 04-11

Attention: Alan Caverly, R.P.Bio., Aquatic Ecosystems Biologist

Dear Alan:

Re: Sinmax Creek Flow Recovery Plan

BC Rivers Consulting is pleased to provide one copy of the final report for the above project. An electronic copy of the report, in pdf format, is included on the attached CD for your use.

Yours truly,

BC Rivers Consulting

Bob Costerton, P.Eng.
Hydrotechnical Engineer

Attachment: Final Report - Dated June 2005.

BRITISH COLUMBIA

Ministry of Water, Land and Air Protection

Environmental Stewardship Division

Ecosystems Section

Thompson Region

Final Report

Sinmax Creek Flow Recovery Plan

June 2005

BC Rivers Consulting
1499 Hillside Place
Kamloops, BC, V2E 2E1

Funded By:

HCTF

Habitat Conservation Trust Fund

Summary

A severe drought in the summer of 2003 made it clear that water shortages could compromise the aquatic habitat in Sinmax Creek. A section of Sinmax Creek went dry for portions of August and October and all of September, resulting in a fish kill in the dewatered section. Spawning habitat for Kokanee and Sockeye was limited to the three kilometers downstream of the dewatered section. Problems with operation of the weir on Johnson Lake during that time negated any ability it may have had to improve the low flow situation during the most critical time.

The intent of this project was to develop strategies to reduce the impact of inadequate flow on fish habitat and to improve water management in Sinmax and Johnson Creeks.

The previous operating plan for the Johnson Lake weir was developed in 1996 and prescribed only average discharges from the lake, presumably during an average runoff year. In wet or average runoff years the flows are adequate to meet existing water needs. In extremely dry years the flows cannot meet all needs. One of the primary goals of this study is to provide greater direction regarding operating the weir during drier than average years. Since 1996 an additional 8 years of streamflow data has been gathered, including a wider variation of low flows. The lessons learned during these years are incorporated into this updated operating plan.

Data collected and identified during this study improves understanding of the watershed and weir operations. Lessons learned can provide improved dam operation, but the reliability of the conclusions is limited by the poor quality of data collected in past years. A lack of recent flow measurements to confirm the validity of the rating curve at the outlet of Johnson Lake, which converts the gathered water level information to flow rates, is a significant constraint to the reliable interpretation of the this key streamflow data. Changes occurred in the channel, which affected the relationship between water level and flow, but the timing and sequence of the changes cannot be know with any certainty.

Draft revisions to operating plan are appropriate, subject to continued monitoring. These revisions could improve the ability to maintain streamflow connectivity during severe droughts (such as 2003) without severe restrictions on water use.

Previous studies have overestimated the water availability in the watershed. Updated estimates can provide a more realistic basis for weir operation and more realistic expectations for the goals that can be achieved.

The primary objective in the short-term should be refining the operation of the Johnson Lake weir to best meet the existing needs. Initial discussions with irrigators and Inmet Mining show promise for cooperatively improving water management, to retain more water instream through the driest sections, and should be pursued while operating under the proposed draft operating plan. The draft operating plan should be reviewed following a 5 year trial period. If necessary, other water conservation initiatives should be pursued at that time.

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1. Introduction

The Ministry of Water, Land and Air Protection (WLAP) has contracted BC Rivers Consulting to examine water supply and demand in the Sinmax watershed to enhance the ability to reliably maintain reasonable instream flows while respecting existing licensed off stream water use. A broad list of options is to be examined, including optimizing system performance for Johnson Lake reservoir.

Sinmax Creek is a high value fish stream with significant stocks of resident and migratory fish (i.e. Adams Lake Kokanee) and anadromous salmon. The consideration of listing Sinmax Creek as a sensitive stream (flow, temperature) under the Fish Protection Act and recent dewatering of a section of streambed in Sinmax Creek in the Smith property during the drought of 2003 was the impetus for this study. This event underlined the possible shortage of water in the watershed, with many users, and limited supply in very dry years. The fact that the reservoir has not completely filled in three of the past four years is a clear sign of the need to re-examine the current weir operating plan and look for ways to optimize water storage and use.

Figure 1 shows key locations / features in the watershed. A large-scale watershed map is included in a map pocket in Appendix A; this is similar to Figure1, but lacks some of the annotations regarding key features.

Fisheries values in the watershed are understood to include the following:

- Outlet spawning Rainbow Trout in Johnson Lake. These adults spawn, in part, in constructed spawning beds immediately downstream of Johnson Lake and downstream of the small “outlet lake” below the main lake and must then return upstream to the lake. Fry emerge in the late spring / summer and move upstream to Johnson Lake or spend the first winter in Johnson Creek below the lake,
- Resident Rainbow Trout (and other species) throughout Sinmax Creek,
- Adult Rainbow Trout moving upstream from Adams Lake to spawn in the lower reaches of Sinmax Creek, up to 7 km from the mouth. A log jam appears to impede access to another 1 to 2 km of potential spawning habitat,
- Sockeye Salmon migrating upstream through Adams Lake to the lower reaches of Sinmax Creek in October. Most of the spawning is thought to occur in the ~3 km of Sinmax Creek below the very large tributary spring on the Keller property as flows are much higher and relatively constant in this reach. Water temperatures are also more moderate. It is uncertain whether this species would spawn more successfully if they were able to move upstream above the “dry section” on the Smith property, which was dry for most of August to October in 2003,
- As above for Kokanee, which spawn in much greater numbers over a longer time period in the fall. During a large run the fish end up digging up each other’s redds. The unusually long spawning period is not typical of area

streams and supports the hypothesis that limited accessible stream length is a limiting factor during large return years. Spawning occurs in the lower 5 km of Sinmax Creek, with most of the spawners found in the lower 3 km,

- As above for Coho Salmon, in November, but in much smaller numbers. Spawning has been seen up to 7 km from the mouth, but with the majority in the lower 3 km.

A fish periodicity chart, included in Appendix B, shows the timing of important biological processes for fishes in the watershed.

Water storage structures exist on Forest and Johnson Lakes, with the vast majority of the stored water on Johnson Lake. The Johnson Lake weir was constructed in 1988. The Forest Lake dam was constructed in 2004.

Consumptive water use is largely for irrigation of fields in the Sinmax Creek valley bottom. Numerous water intakes exist. The largest single diversion is a ditch running off of Sinmax Creek below Johnson Creek. This is referred to later in the report as the "main diversion ditch", and is shown on Figure 1. This ditch is approximately 4 km long and is unlined. Any water that reaches the end of this ditch re-enters Sinmax Creek near the mouth.

Figure 1 also shows other major features in the watershed, including the watershed boundary, tributary streams and lakes, points of water diversion, locations of flow measurements, agricultural lands and the Inmet Mining Corporation (Inmet) Samatosum Mine (hereafter referred to as "the mine").

2. Johnson Lake Weir

Inmet built the water storage weir (dam) on Johnson Lake to supply water for the operation of the Samatosum Mine downstream of Johnson Lake. The mine was in operation between 1988 and 1992. As part of the original agreement regarding the weir construction the Sinmax Creek Water Users Community (WUC) took over the water license held by the mine in 1993. WLAP hold the remaining storage license on Johnson Lake. This license provides conservation flows for fish downstream of the weir in Johnson Creek and Sinmax Creek

The WUC and the mine have overseen the operation of the weir. WLAP took on a greater advisory role in suggesting acceptable minimum flows during problems with the operation in 2003. The official ownership of the weir is unknown. The weir has now been operated for 17 years. The WUC had an operating plan developed in 1996, which is included in Appendix C. This plan gives average flows to be released from the lake, but it not specific about minimum flows during drought years.

The design of the weir is such that additional water is stored on Johnson Lake above the historic natural level (i.e. positive storage). There is no ability to draw the lake down lower that the natural outlet (i.e. negative storage).

Noteworthy lake levels and licensing quantities are as follows. The weir crest is at 0.89 m on the lake level gauge. The minimum level to which the lake can be lowered is 0.29 m, which is controlled by the streambed level in the creek downstream. Therefore, the total depth of water stored on the lake is 0.6 m. The total licensed volume is 851 acre-ft, or a depth of 0.40 m on the roughly 2,624,000 sq. m lake. This leaves 0.20 m for evaporation and to allow for restrictions in operating the weir at low lake levels (some practical restrictions apply to releasing water at lake levels below 0.43 m). The allowance of 0.20 m appears to cover evaporation reasonably well, but may still result in restrictions in releasing the desired flow rates while lake levels are low in September.

3. Available Streamflow Data

The following sources of streamflow data are available in the Sinmax Creek watershed:

- Water Survey of Canada (WSC) operated a seasonal (typically Apr to Sept) gauge on Sinmax Creek below Johnson Creek (08LD004) from 1926 to 1928, and then again from 1965 to 1976,
- WSC operated a seasonal (Apr to Sept) gauge on Homestake Creek above the Agate Bay Road (08LD005) from 1926 to 1928,
- WLAP / WUC / Samatosum Mine gathered water level data on Johnson Lake and Creek adjacent to the weir. This was originally obtained from 1996 to 2004. Information was gathered by the mine previously, but is not initially available. Following completion of the draft report, the mine staff retrieved the 1990 to 1995 data from archives in Ontario. This data has not been included in the water supply analysis done to date. The data is included in Appendix D as it may be very useful for future water supply analysis, provided the quality of the data can be verified,
- Samatosum Mine recorded water levels (with an old curve to convert to streamflow) in Johnson Creek several kilometers downstream of Johnson Lake (Site 7, also known as Staff Gauge 4) from 1990 to present. The data initially available, from 1996 to 2004, was of poor quality due to the outdated rating curve used to determine flows from gathered water level data. The recently retrieved 1990 to 1995 data may be more reliable, but has not been assessed,
- The Water Allocation Section of Land and Water BC Inc (LWBC) have collected some miscellaneous streamflow measurements in the watershed. These relate to instream flows and diversion quantities,
- In 2003 a regional low flow study was performed by Paul Doyle to assess the severity of the 2003 summer drought. Streamflow data was gathered at four locations on Sinmax Creek (including the dry section at Smith's) and two

locations on Johnson Creek. Data was gathered during the most severe portion of the drought, from August to October,

- As part of this study, streamflow measurements were made at 14 sites in the watershed between May 2004 and March 2005. The full data set in included in Table 1. This data was intended to provide representative snapshots of flows throughout the watershed at points / times of interest. Special consideration was given to linking data to previously gathered data (i.e. old WSC site, Johnson Creek at the weir and at the mine's site 7, and the 2003 flow measurement sites). An electronic copy of this data set is included on CD,
- Anecdotal data is available from Doyle's 2003 low flow study as well as other sources. While not precise, such accounts can give an indication of flows and the influence of diversions at various times,
- Water temperature data was collected by WLAP in lower Sinmax Creek over the past two years.

4. Streamflow Data Limitations

This section refers to problems with the reliability of the gathered data, not the normal limits on the extent of available data in time and space.

The key data for planning reservoir operation is net inflow to the lake. This is calculated using the actual outflow and the change in the amount of water stored in the lake. The critical weakness in the outflow data collected for years at Johnson Lake was that the rating curve, for converting collected water levels to flows, was not updated by doing periodic flow measurements to see if the relationship remained constant. Changes in the channel bed can naturally occur (typically at peak annual streamflow) and will change the rating curve. A shift in the rating curve did occur for the outlet of Johnson Lake between flow measurements done in 1996 and 2003. It is not possible to reliably determine when the change(s) took place. The effect is that the outflow is now higher for a given water level. This was first suspected in 2003 when more water than intended was released from the lake, based on the outdated rating curve. Flow measurements conducted in 2003 and 2004 have now reestablished a reasonable rating curve, which is shown as Figure 2. The previous rating curves are also shown for comparison. Data from 2003 and 2004 is not subject to the same uncertainty as it is supported by numerous flow measurements.

This lack of flow measurements over a period of 6 years leaves the interpretation of the flow data from 1997 to 2002 uncertain. A closer examination of the rating curves in Figure 2 leads to the follows observations: changes in the rating curve can double the flow for a given creek level (gauge height); the error of applying the wrong rating curve is greatest for low flows; for a given flow, the water level is now typically 3 cm lower then it was in 1996; the streambed may have eroded down a few cm to create this change. The changes in the streambed most likely occurred during the highest flows in the intervening period, such as 1997, 1999 and 2002. The highest flow would appear to be in 2002, but this is not supported by regional flow data. Several scenarios were used in an attempt to reconstruct the historic data. The use of the "old" rating curve from 1996 to 2002 and the "new" rating curve from 2002 to 2004 produces results that are not consistent with regional flows (i.e. the most severe drought would be in 1998 when this is know to be untrue). Most credible scenario, which provides reasonable data, but is by no means known to correctly reflect actual outflows from the lake, is: use the old curve from 1996 to 1997 and the new from 1997 to 2004. There may have been more than one change in the streambed so this may still not be correct, but it is the best that can be done short of disregarding all the data.

The following results are based on this uncertain Johnson Lake / Creek data and should be regarded as rough estimates:

- Inflows to the lake. Prior to 2003, outflows and inflows may be overestimated by the use of the 2003 / 2004 rating curve,
- Relationships between drought indicators (such as snowpack, groundwater levels and local streamflow) and actual inflows to the lake, used to better forecast water availability,
- Conclusions regarding the adequacy of water supply under certain scenarios.

In the future flow measurements must be done regularly (at least annually, preferably two or more times a year) to ensure the data collected will be useful. Water Survey of Canada does roughly 10 flow measurements per year at each station to ensure that the period of time is very short between a shift in a rating curve and its detection during a flow measurement. If the period of time is limited, one can make very good assumptions about when the change would have occurred, and reliably correct the data for the entire period of record. If only a few months pass between measurements, and a change occurs it can typically be traced back to the peak flow between the measurements. If more than one peak has occurred, or the gauge itself could have been shifted, then some uncertainty as to the quality of data will be introduced.

The same kind of shift of the rating curve occurred with the streamflow data collected at the mine's site 7 on Johnson Creek, a few kilometers downstream of Johnson Lake. A spot measurement in Oct 2004 generated a flow only 1/3 of that suggested by 1992 rating curve for the water level on that day. Several years of water level data are lost due to the lack of periodic flow measurements. Since 2004, the mine had observed this effect in their conductivity readings between effluent and stream and has not relied upon the uncertain streamflow data to determine acceptable effluent discharges to the stream.

5. Natural Streamflow Conditions

Primary areas of interest for determining natural flows are the inflow to Johnson Lake and in the “dry section” of Sinmax Creek on the Smith property. The Johnson Lake values are important to determine the historic range of flows into the lake, which form the basis for allocating the available water. The Sinmax Creek values are of interest to assess the natural occurrence of low flows in the section that went dry in 2003. To that end, simple analyses will be provided to indicate the natural range of flows at these two locations. More sophisticated analysis to generate a full natural hydrograph for each location is not warranted, at this time, due to the uncertainty regarding Johnson Lake data and the uncertainty regarding the relationship between flows upstream and downstream of the “dry section” in a variety of years. Data has been collected for 2003 and 2004, but certain limitations apply.

An attempt was made to reconstruct the natural hydrograph for Sinmax Creek at the old WSC station below Johnson Creek. The data is presented with a fish periodicity chart in Appendix B. An equivalent flow rate was added in for all irrigation diversions licensed to that date for each year: the 1920s data used with little change as only a few licenses were issued then; and the 1960 / 70s data with significant additions for licenses issued to those dates. The results do not appear to be reasonable as the “naturalized monthly flows” show a sharp drop following the end of irrigation (additions) in September, which suggests that this method is over-correcting for flow (assumed to be) diverted from the stream. This flow pattern, of a sudden drop in natural flow at the end of September, is not normal in the southern interior of BC, based on the review of historic natural streamflow hydrographs. The most plausible explanation for the lack of credibility of this flow naturalization is the significant interaction between surface and ground water. It cannot be safely assumed that a flow increase of one litre/second upstream will result in a flow increase of one litre/second downstream, unless surface / groundwater interaction is taken into account. This applies equally to a given reduction of diversion quantity upstream being difficult to relate to a flow increase downstream. For example, diversion of flow from tributaries that normally sink into alluvial fans before reaching Sinmax Creek does likely result in reduction of instream flow in Sinmax Creek, but not in a one-to-one manner over a short time frame. Changes in groundwater contribution to surface flow will be slower and less certain than changes in surface flow contribution.

The fish periodicity chart has useful data on fish activity timing and location. The stated flow requirements should be taken as only preliminary, in part due to the problem naturalizing the hydrograph discussed above. It should be noted that the actual streamflows recorded in the 1920s, which are likely valid unless there was large scale, unlicensed flood irrigation occurring, show that flows were well below the ideal instream flows shown on the chart for the reach upstream of the large spring on the Keller property. Downstream of the spring the “low flows” would be well above that normally expected, or specified as conservation flows on a typical interior BC small stream.

Johnson Lake Inflow

Data collected at the dam site can be used to develop a natural hydrograph for inflows to the lake, but the data is sufficiently unreliable that no strong conclusions can be drawn from it at this time. This is the most important data for planning reservoir operations as it dictates what you have to work with. See Table 3 for a monthly listing of estimated natural net inflows to Johnson Lake.

Given the natural occurrence of negative net inflows to Johnson Lake repeated in multiple years in the past 8, it is clear that there would be times when the outflow from the lake would cease completely. With a relatively small contributing watershed, and a large lake area, the evaporation off the lake surface would exceed the inflow in severe drought years for part of July and all of August and September. Without storing water in the spring to release during a dry summer the lake outflow could be zero for several weeks.

Sinmax Creek - "Dry Section"

To assess the frequency of low flows in Sinmax Creek it is important to first try to understand the movement of water in this reach of the stream. This stream shows dramatic variations in flow due to movement of water into and out of the ground. The following comments summarize what is known about flows in Sinmax Creek:

- During an average spring freshet there is a large contribution of flow from all sub-basins in the watershed. During a dry summer the only significant surface flows are from upper Sinmax Creek, Johnson Creek, and the large spring on the Keller property (see Figure 1 for locations). Between Johnson Creek and the Keller property marked "underflow" is evident as water filters into the ground below the streambed. This was demonstrated in the 1970's as the effective unit surface runoff for Sinmax Creek is less than 1/3 of that seen in Homestake Creek at the falls, where all water is (presumably) forced to the surface by bedrock, despite the fact that the watersheds have similar characteristics of elevation range, aspect, and size,
- This "underflow" means that although water may be available in tributary streams in the watershed during a given year / drought it will not necessarily be available in Sinmax Creek. The normal practice of assuming that a certain increase in release of water from Johnson Lake will lead to a corresponding increase in flow at all (most) points downstream is not necessarily true. The "dry section" of Sinmax Creek at the downstream end of Danny Smith's farm is the most extreme example. During the drought in 2003 this section of stream went dry for months, and the temporary reduction in diversion ditch flow upstream (after several weeks of no flow) was not sufficient to rewet the dry section, despite the increase in streamflow upstream of the dry section. It is not known if a sustained closure of the diversion ditch would have reestablished surface flow in the "dry section", but it is thought to be unlikely that it (alone) could have done so that year. It would presumably take a lot of recharging of the

groundwater levels in the area to rewet the "dry section". If the flow upstream of the dry section could have been maintained at a higher level it may have been possible to avoid the section going dry. This will have to be investigated further as a drought strategy for extremely dry years,

- Downstream of the "dry section" water gradually begins to infiltrate back into the channel and streamflow slowly increases. Several small springs appear and contribute to higher instream flows,
- On the Keller property a very large spring exists which can add more then 50 % to the flow at this point. The flow in the spring is remarkably constant and water temperatures are moderate, both summer and winter. The source of the spring water is not known. The volume is similar to the amount that infiltrates into the ground further upstream in Sinmax Creek, but this may not be the actual (or complete) source as the spring's flow rate does not seem to fluctuate with changing streamflow upstream in Sinmax Creek,
- Streamflow in Sinmax Creek downstream of the Keller spring is maintained at a moderate temperature and is remarkably well sustained during low flow periods. Low flows are in the order of 50 % of mean annual discharge, which is extremely rare for small streams in the southern interior of BC. This may account for the relatively ideal spawning and incubation flows for fall spawners, including early run sockeye.

Streamflow data collected potentially improves understanding of flow throughout the watershed and the impact of weir operations. Sporadic measurements are available in Sinmax Creek in 2003 and 2004 to describe the movement of water along the creek in the vicinity of the "dry section". The following points are made to summarize what is known about low flows in Sinmax Creek:

- WSC data in 1920's and 1960's/1970's on Sinmax creek is useful in indicating the natural flow patterns. There are 14 years of summer flow data,
- It appears certain that in 1926 the stream would definitively have gone dry naturally at Smith's property and likely for a considerable distance upstream. The flow data is thought to be "natural" as there were only a few small irrigation licenses (totaling less than 10 l/s) issued prior to summer of 1926 upstream of the WSC gauge. Local accounts of how rare this event was vary, but it is likely to be in the order of a 1 in 20 year drought,
- In 1973 this reach would likely have gone dry, given the irrigation use and lack of storage. This was likely in the order of a 1 in 10 year drought,
- 5 other years out of 14 may have had very low flows in the "dry section", but it is not possible to be sure of irrigation quantities and infiltration losses each year,
- In any case, the "dry section" can go dry naturally, but it is relatively rare. A rough estimate of the frequency would be a once in 15 years on average.

This estimate is both supported and denied by valley residents recollections of the situation,

- The dry section could be at risk of going dry in half the years with current irrigation use and no storage,
- Based on a limited analysis of streamflow data gathered in 2003 and 2004 along Sinmax / Johnson Creeks the following rough statements can be made regarding net input / losses typical of various reaches:
    - The rate of infiltration into the streambed upstream of the “dry section” may typically be 90 l/s in the summer,
    - The main irrigation diversion ditch flows at about 65 l/s, very close to the licensed April to June quantity. Three licenses have no licensed use in the summer and so the measured diversion was about 15 l/s over the licensed summer quantity. Some extra diversion is allowed to account for seepage and other losses,
    - The Keller spring flows at a nearly constant rate of 90 l/s,
    - Other groundwater inflow to Sinmax Creek may be 65 l/s between the “dry section” and the mouth,
    - Two springs that enter Johnson Creek between Johnson Lake and the smaller outlet lake totaled 25 l/s in the summer of 2004, but there was almost no net gain in streamflow in the drought of 2003,
    - See Table 2 for details of how these estimates were developed. Measured values are stated, and estimated values are highlighted in the table (as uncertain), but together they enable this rough analysis to be completed with the limited data available.
- Other water consumption in the watershed would normally have a direct impact on the instream flows discussed above. This connection is blurred by the considerable movement of water in and out of the ground in this critical reach. It is not known if a reduction in water use on a tributary stream would be translate into a corresponding increase in streamflow in the mainstem of Sinmax Creek. The timing of groundwater vs. surface water movement is a factor that significantly blurs this connection between surface water flow rates.

As was mentioned previously, no detailed analysis of natural streamflow was conducted due to the existence of greater uncertainties in the data. These observations do, however, capture some critical information regarding the natural occurrence of times when streamflow is not continuous along Sinmax / Johnson Creeks.

Water temperatures were monitored in lower Sinmax Creek in 2003 and 2004. Spring fed inflows maintained water temperatures that were good for fish rearing and survival in lower Sinmax Creek downstream of the Keller spring. Upstream reaches affected by a lack of riparian vegetation and low flow events are more susceptible to high temperatures, however, groundwater inflow does have a moderating influence at some locations in the watershed. Lethal water temperatures were observed in 2003 upstream of the dry section with reported fish kill of juvenile salmonids. No continuous monitoring of water temperatures occurred in upstream reaches.

6. Operating Plan Goals

The review of the operating plan has the following goals and considerations taken into account:

- The purpose of the weir is to store water for later release to meet the needs of licensees downstream, as much as possible, given the range of drought and wet years that are possible,
- The main licensees are WLAP and irrigators with the WUC on Sinmax Creek. Only the storage licenses on Johnson Lake are considered directly. Other base flow licenses are assumed to be independent, except as the weir affects base flow downstream and the licensed use affects instream flows downstream,
- The goals of this operation review are to optimize the storage and release of water for use instream, while respecting the rights of those with irrigation intakes downstream. Understanding of past reservoir operation, actual water supply during a range of wet / dry years, and water needs are key to this review,
- An operating plan that is responsive to conditions in the watershed (drought or wet months / years) is sought to make better use of the available water in a given year,
- Specific objectives are to release flows sufficient for:

  Primary Objectives:
  - Maintaining the natural life cycle of downstream spawning trout in Johnson Lake,
  - Augmenting low flows downstream to maintain connectivity of flow through the "dry section" of Sinmax Creek and at the outlet of Johnson Lake,
  - Meeting all licensed demands for water downstream.

  Secondary Objectives:
  - Maintaining natural (or higher) flows in Sinmax Creek in the early fall to enable the natural spawning patterns of Sockeye, Kokanee, and Coho moving up from Adams Lake,
  - Maintaining natural flows in Johnson Creek downstream of the weir during the early part of freshet (April), and during drier fall periods, to facilitate the appropriate dilution of treated acid rock drainage releases from the Samatosum Mine treatment plant. The mine is required by WLAP permit to control effluent / creek dilution in Johnson Creek. Generally speaking, the natural flow in Johnson Creek enables the mine to fulfill their permit obligations. The treatment plan will be in place indefinitely and Inmet will be a long-term stakeholder in the weir operation.

Efficient Use of Existing Storage

Of primary importance in planning the efficient use of water is the development of an accurate rating curve (relating water level to flow) at the outlet of the lake. Otherwise, as has been the case in the past, too much (or too little) water has been released to try and achieve a desired flow rate. Maintaining an accurate rating curve will save a significant amount of water and is mentioned here as a mandatory component of reservoir operation.

Improved forecasting of water availability is also a method of making the most efficient use of the available water. In any given year, assumptions must be made regarding future inflows to the Johnson Lake. If the inflow is underestimated, water may be rationed unnecessarily. If inflows are overestimated, water shortages may be experienced later in the year. Forecasts will never be perfect, but can be of great assistance in optimizing reservoir operation.

Further improvements in instream flow, beyond those possible with optimizing weir operation, are not possible without additional water supply under the current licensing and use structure. Alternative methods of improving instream flows are discussed in section 8 below.

7. Draft Operating Plan

Improvements can be made to the previous Johnson Lake Weir operating plan. The primary area of improvement is to adjust the releases from the lake to better match the available water. The actual inflow to the lake is, of course, not known until the time of interest has passed. For example, setting summer releases based on the assumption of an average summer inflow to the lake will not work out well if the summer turns out to be much drier than normal. To improve the operation some indicators of upcoming water supply are examined. These include snowpack prior to freshet, and existing streamflow prior to summer.

Flow Forecast Indicators

Table 3 provides a summary of the estimated past inflows to the lake (based on somewhat suspect flow data). Also listed are snowpack (Snow Water Equivalent or SWE indicate the amount of water in the snow if it is melted), groundwater levels and monthly inflow volumes to the lake.

This table provides a tool to assess the water availability at key times in the year: prior to freshet and summer. The form can be completed using the ranges for each indicator that indicate wet, normal or dry runoff conditions. Input manual snow survey and groundwater data can be found at the following web site: http://wlapwww.gov.bc.ca/rfc/index.htm.

Revised (Draft) Operating Plan

An operating plan is a set of rules, or a line on a lake level chart, that dictates the quantity and timing of water releases from the reservoir. The operating plan takes into account the existing conditions, and the anticipated conditions, to attempt to come up with the best plan for releases. There is no right answer as to how to release the water, but an operating plan represents the best guess at making the most of the available water to balance uses downstream for instream and off-stream needs.

The new operating plan will include a number of decision points throughout the year, where watershed conditions are assessed, water demand is factored in and a best estimate of optimal releases is made. This should be re-assessed at key times during the year such as:

i. Prior to freshet to plan releases that will be acceptable while still trying to ensure the reservoir is filled by the end of June,
ii. Prior to summer to assess water supply (in reservoir and watershed) and plan releases for irrigation and fisheries maintenance flows,
iii. During summer and early fall to see if plan is actually working or if additional water conservation is required or additional water can be used that year,
iv. Prior to fall spawning of Sockeye, Kokanee and Coho to assess water supply and optimize access of spawning fish in light of the natural flows that will incubate the eggs in the gravel,
v. Prior to winter to assess whether water should be conserved / stored in an attempt to ensure the reservoir is filled next spring or should water be used to maintain natural flows instream for maintenance of resident and anadromous fish.

Figures 3 and 3a outline the target lake levels and releases for dry, average and wet years. The figures show target minimum lake levels for the start of each month of the year. Where possible the lake level should not be allowed to fall below these values. If the lake is below the target minimum steps should be planned to achieve the target levels as soon as practical. These levels are of greatest importance as the summer progresses, so that enough water is available to meet the needs until the end of the critical low flow period at the end of September when peak water demand ends. The two figures show the same lake level targets – Figure 3a has the target outflows and lake levels in tabular form.

Table 4 provides guidelines for each of the required decision points through the year. At each decision point, a review is made of the existing conditions and the flow indicators (as appropriate). Guidelines are given on achieving the targets for wet, normal or dry years. Guidelines are also given on balancing the flows in light of contradictory data (i.e. lake level is similar to the “dry” scenario but snowpack is above “normal”).

The dry and wet years used in Figure 3 represent relatively extreme conditions. Based on regional low flow analysis, 2003 was a very dry year, with what is estimated to be a 1 in 30 year summer low flow (which would on average occur only once in 30 years). The total annual volume was not as extreme, with only a 1 in 7 year annual runoff volume. The use of 1997 as a wet year is also somewhat extreme. In most years, conditions will be in between one of these extremes and an average year. As such, the releases from the lake will have to be set in between these stated values. The interpretation need not be precise, but rather if the conditions appear half way between average and dry, the releases also should be half way between the prescribed flows for dry and average years. As the conditions change, so should the releases.

Climate change may cause a slight increase in the frequency and severity of summer droughts. As the climate warms, the snowmelt period tends to end earlier than in the past. Potentially, this leaves a longer period of warm, dry weather over the summer until cool weather and increased rainfall dominate in the autumn.

<u>Other Operational Considerations</u>

Other possibilities should be considered to improve the future operation of the weir. These can be discussed to determine their merits, risks and acceptability to those directly involved. They are listed here for discussion purposes:

- Monitoring / feedback from the operation should be done to determine how well these decisions are being made / goals are being met,
- In a year like 2003 not all demands for water can be met. This becomes apparent during the later half of September at the end of the peak irrigation and instream flow demands (however, this is predictable earlier in the summer). Also, the lake level is typically low enough that it limits the amount of water that can physically be released from Johnson Lake. The required changes to meet various needs could include: regulation / early shutdown of water use downstream, pumping from Johnson Lake or other means of increasing instream flows in late-Sept when there may be water in the lake but it can’t be released at a high enough flow rate,
- Consider storing water over winter period by restricting flow through the fry fishway with the addition of a board blocking / restricting flow into the structure. There is a slot that should work for this purpose if a suitable board / steel plate was obtained. If this could be tolerated in upper Johnson Creek, then water could be stored during dry years for the coming summer. This would be purely a cautionary move, as the winter snowpack accumulation cannot be reliably predicted in the fall. A trial would have to be performed after the irrigation season (most likely in October) to assess the fisheries conditions during such low flows,
- Consider using a short-term increase in flow to allow fish migrating upstream to move through the dry section, and then ramp flow back down to normal fall flows. This would not take much water and would be possible if the lake level is high enough to physically be able to pass a high enough flow to make a difference. This could be tested for Kokanee in early October. It may be unnecessary for Coho since they spawn in Sinmax Creek in much smaller numbers and may have higher flows for migrating

upstream during late fall rains. A trial could be set up for the next dominant Kokanee run year, with suitable monitoring and manipulation of flows. Care should be exercised to avoid attracting fish in to spawn in the dry section as the redds may be dewatered or freeze following reduction in flows from Johnson Lake. The short-term increase in flow should only be sustained during a portion of the time of fish migration into the system and reduced prior to the initiation of spawning. This would be done so as to facilitate fish access to reaches of Sinmax Creek upstream of the "dry section". The Johnson Lake does not normally have the storage capacity to sustain higher than natural spawning and incubation flows throughout the fall and winter.

8. Other Flow Recovery Options Considered

The following other options were considered to assist in the flow recovery program, with the conclusions noted:

- Additional storage on Johnson Lake: the lake has not filled in 3 of the past 4 years; additional storage would only be of use during normal and wet years when flow increases are not as critical,
- Other storage reservoirs: Storage of water on Forest Lake has recently been investigated and developed to the maximum extent possible without causing flooding of adjacent properties. All other lakes have a relatively small surface area and may therefore not to be economic to develop large amounts of storage on. In any case, it is more economic to optimize the use of Johnson Lake storage first. Other lakes (e.g. Sams Lake) in the northern portion of the watershed could be investigated further. It is possible that in some cases a small weir, similar to that on Forrest Lake, could sustain lake levels higher than normal until late summer, when the water could be released for use during the period of lowest natural flows,
- Water conservation: on-farm water conservation is possible, such as newer, more efficient watering systems (with corresponding power savings), promoting early season crop optimization and late season shutdown, etc. Economic incentives may be required to get farmers to reduce on-farm water use to augment instream flows. Reductions in demand could be gained through re-allocation of water or more efficient irrigation practices, such as those described on the BC Guide To Irrigation Scheduling And Water Conservation page on the following web site:http://www.farmwest.com/index.cfm?method=pages.showPage&pageid=235,
- Improving main irrigation ditch efficiency: the existing ditch could be lined to reduce seepage or replaced with a pipeline. Both options would save the ditch losses and put more water instream through the "dry section". The pipeline option could potentially increase the water pressure at users diversion and reduce hydro costs of pressurizing the sprinkler

lines. The capital costs would be high and the benefit in increased instream flow would be in the order of 10 l/s,

- Moving diversions off the main ditch, particularly if they are using water below the “dry section”: If water could be allowed to flow further downstream before it was diverted it could provide improved fish habitat and possibly keep the “dry section” wetted. Economic incentives would likely be required to compensate for the cost of pumping water up from the creek instead of (partially) gravity fed from the ditch above. The benefits to instream flow through the ‘dry section” could be in the order of 25 l/s,
- Moving irrigation diversions to below the “dry section”: likely not cost effective as only a few diversion are within a few kilometers of Keller’s spring. This does make sense for Keller’s diversion and could be pursued, subject to a more accurate assessment of fish flow needs,
- Pumping water from Keller’s spring, upstream to top of “dry section”, to wet it and recirculating this water as long as the section is threatened to be dry: technically possible and at a moderate cost; potential pump failures suddenly dewatering the stream and resulting in fish kills make the option unattractive from a fisheries perspective,
- Modified irrigation schedule: Early shutdown on irrigation off of main ditch (and / or others) in mid September in extremely dry years. Two crops may be possible by mid-August, following which fields could be winter hardened. This would likely only be required in 1 year out of 10, on average, with an added instream flow of ~60 l/s,
- Inmet Mining staff has been keen to work with the other stakeholders to determine how they can make a positive contribution to instream flows during peak water usage and low flow periods. Treated effluent water can be released from storage in on the mine site to increase flows by up to 15 l/s (guideline of 10% of instream flow – although there is some flexibility in this figure due to variable water chemistry) during low flows in September. The duration of this contribution is not known, but can be determined through continued collaboration with mine staff. For this plan to work additional details would have to be sorted out, including giving sufficient notice of impending dry conditions to the mine (30 to 60 days in advance) to allow for proper planning and risk assessment regarding appropriate instream dilution of effluent.

9. Conclusions

The enclosed operating plan is an improvement over the previous version in that it enables the operator to set releases that better reflect the current water supply conditions in the watershed. Preliminary releases are given for a broad range of runoff conditions, from severe droughts (2003) to very wet years (1997).

It appears that all demands for water can be met in normal and wet years. Through efficient operation of the Johnson Lake weir all demands can likely be met in moderately dry years (i.e. ~1 in 5 year droughts). To generate a reasonable outcome for all involved, some reductions in demand will be required during severe droughts such as occurred in 2003 (~1 in 20 year event); specifically, very low trout spawning releases from Johnson Lake in May and June and early shutdown (Sept 15) for some or all irrigators.

Local measurements suggest that flows less than 90 l/s immediately downstream of the main irrigation ditch off of Sinmax Creek may lead to dewatering of the "dry section" downstream.

10. April 2005 Open House and Johnson Creek Rating Curve Update

An open house was held in the watershed on 28 April 2005. Water licensees, government agencies, watershed residents and other interested parties were invited to attend this information session and discuss draft results of this study and water management options.

The session included a review of watershed characteristics and past problems. Input from locals was useful in better understanding local lakes and the water related history of the area. A list of attendees and a summary of the discussion is included in Appendix E. Some very positive feedback was gained regarding early shutdown of irrigation, provided some flexibility is possible in allowing some irrigation in October (outside normal licensed period). There was general agreement on taking steps to improve the water management, including pursuing some formal agreement on Johnson Weir operation and ownership.

Another flow measurement was also done on Johnson Creek at the outlet of Johnson Lake to extend the range of flows over which the rating curve is applicable. This updated curve is shown in Appendix E, along with a table of creek levels and flows for the new curve to aid in the operation of the weir. The latest measurement plots to the right of the 2003 / 2004 rating curve. This could be just because of the new, better, definition to the upper portion of the curve, or may reflect a shift in the streambed that has altered the rating curve. Additional flow measurements will have to be done at low and moderate flows to confirm the applicability of the rating curve (as is always the case).

11. Further Work Required

The conclusions that can be drawn at this time are preliminary at best. The poor quality of the historic streamflow data (for years prior to 2003) does not support final decisions on water availability and weir operating plans. To achieve a final decision on the best operating plan and following items should be considered:

- Quality control and possible inclusion of historic (1990 – 1995) streamflow data recently obtained from Inmet Mining,
- Additional streamflow gauging in critical sections, such as: just downstream of the main ditch intake on Sinmax Creek, the outlet of Johnson Lake, Johnson Creek at the mine site and Agate Bay Road,
- Discussions should be held with the Water Allocation staff regarding:
  - If there is any flexibility in the licensing to allow for early shutdown during the critical low flow period in September (in extremely dry years only) and resumption of limited irrigation in October (to "winter harden fields"), after the end of the normal irrigation season,
  - Legal ownership of the weir and associated responsibilities,
  - Procedure for officially adopting the revised operating plan, once it is finalized in the future,
- Continued discussions with Inmet Mining to sort out the details of possible contribution of treated effluent mine water during low flow periods (in conjunction with flow measurements to document the benefits realized),
- Subsequent review of dam operations,
- Review of forecasting indicators when solid inflow data is available for Johnson Lake.

12. Recommendations

The enclosed operating plan is an improvement over the previous version in that it enables the operator to respond to changing water supply conditions and make the most of the available water. The weaknesses in the historic streamflow data prevent final decisions on water availability and weir operating plans. The following steps are recommended as we work towards flow recovery on Sinmax and Johnson Creeks:

- Do regular flow measurements to maintain rating curve at outlet of Johnson Lake,
- Operating under this draft operating plan for 5 years, while monitoring to evaluate the stream / fish / habitat / irrigators response to the revised operating plan,
- Two brief meetings per year (April and July) between the dam operator, WUC, WLAP and Inmet would be very helpful for sharing information regarding water supply and planned dam operations for the coming few months. This would also provide an opportunity to plan and required water contribution by the mine, early irrigation shutdowns or other in stream flow recovery options,
- Conduct trials of the following ideas:
  - Mine water releases during low flow periods,
  - Early irrigation shut down during very dry September with limited October irrigation allowed,
  - Determine lowest acceptable over-wintering flow at outlet of Johnson Lake,
  - Determine lowest acceptable April flow at outlet of Johnson Lake,
  - Short-term flow increase in Sept to assist migrating Kokanee past "dry section",
- Review data / operations after 5 years,
- Officially adopt the operating plan (between WUC, WLAP and LWBC), with appropriate modifications based on experience in the application of the draft plan,
- Evaluate other alternatives with the benefit of reliable data gathered in the intervening time.

13. Closure

This document, in its current form, can be the basis for proceeding with flow recovery in the Sinmax Creek watershed. Continued discussions and cooperation between the interested parties can significantly improve the instream flow recovery and overall water management.

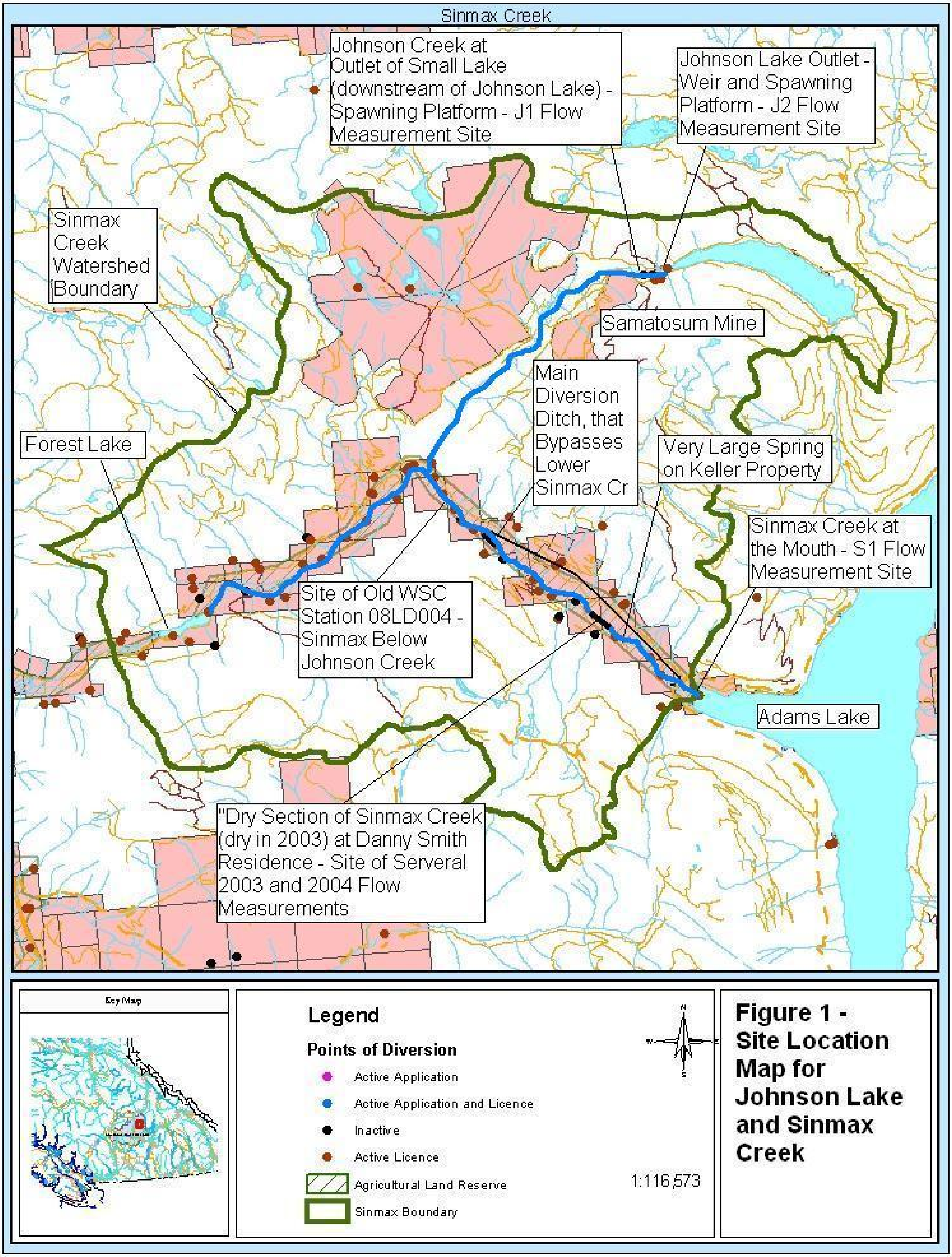


Figure 1 - Site Location Map for Johnson Lake and Sinmax Creek

Figure 2 - Johnson Creek Rating Curves Immediately Downstream of Weir

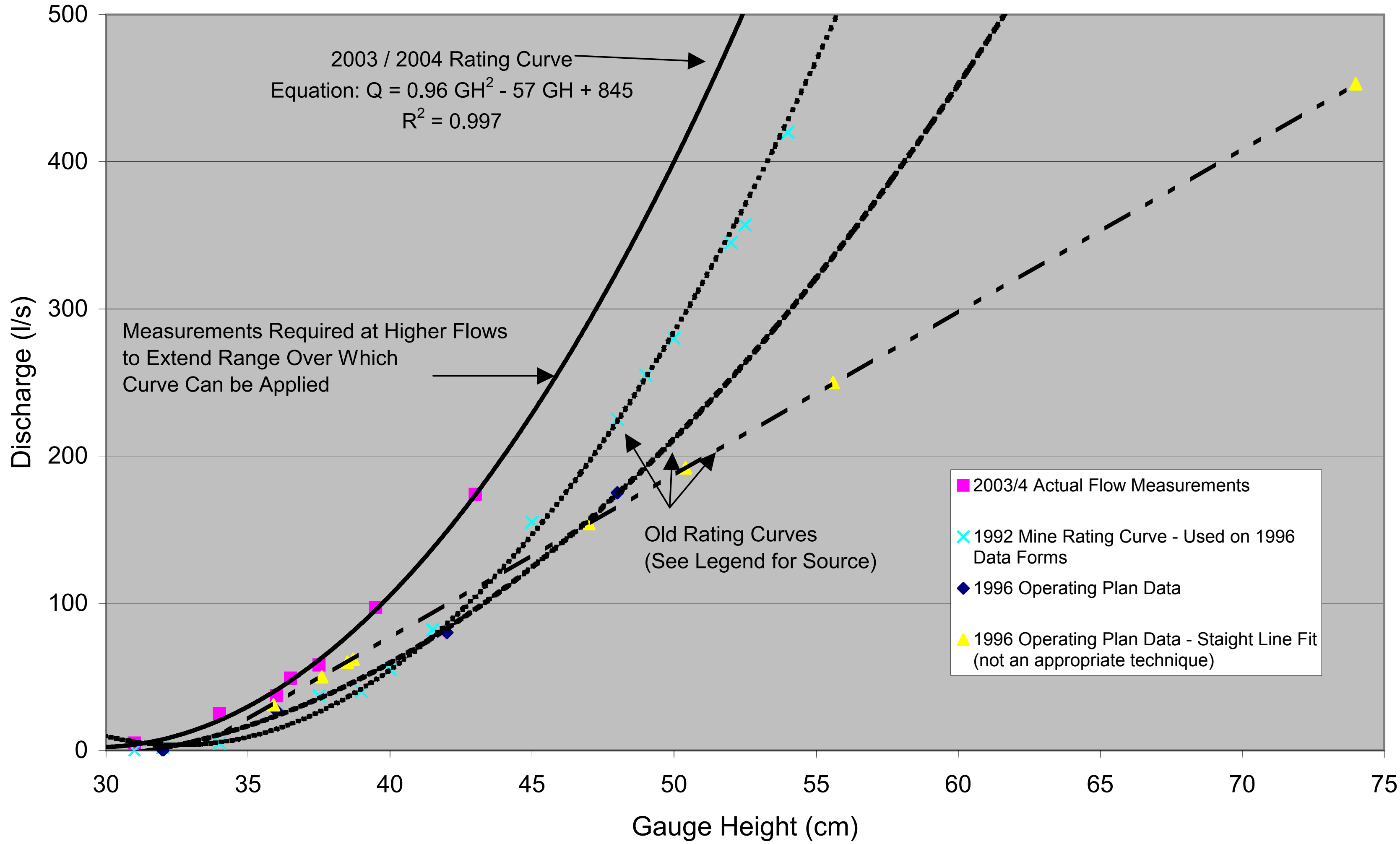


Table 1 - Sinmax Watershed Flow Measurements for 2004 / 2005 (Listed From Upstream to Downstream In Each Watershed)

Creek	Date	Location	Flow (l/s)	GH (m)	Comments
Alex Creek	8-Jul-04	Johson Lk Rd crossing	2		
Johnson	8-Jul-04	J2 - below weir		1.385	Lake level 0.73 m
Johnson	4-Aug-04	J2 - below weir		1.40	
Johnson	13-Aug-04	J2 - below weir		1.39	Lake level is 0.64 m
Johnson	20-Aug-04	J2 - below weir	117	1.39	Flow is suspect when plotted on rating curve
Johnson	1-Sep-04	J2 - below weir	97	1.395	
Johnson	15-Sep-04	J2 - below weir	49	1.365	
Johnson	21-Sep-04	J2 - below weir	58	1.375	Lake level is 0.625 m
Johnson	26-Oct-04	J2 - below weir	37	1.360	Lake level is 0.59 m
Johnson	4-Mar-05	J2 - below weir	174	1.430	Lake level is 0.895 m and is just starting to spill over sill
Johnson	28-Apr-05	J2 - below weir	436	1.535	Lake level is well over sill
Johnson	8-Jul-04	J1 - road bridge d/s lake	124	1.385	at weir upstream; lake level is 0.73 m
Johnson	29-Jul-04	J1 - road bridge d/s lake	183	1.4	
Johnson	11-Aug-04	J1 - road bridge d/s lake	149	1.39	at weir upstream; lake level is 0.65 m
Johnson	20-Aug-04	J1 - road bridge d/s lake	149	1.39	at weir upstream
Johnson	1-Sep-04	J1 - road bridge d/s lake	155		seems too high - somewhat suspect
Johnson	15-Sep-04	J1 - road bridge d/s lake	102	1.365	at weir upstream
Johnson	21-Sep-04	J1 - road bridge d/s lake	74		
Johnson	26-Oct-04	J1 - road bridge d/s lake	56	1.360	at weir upstream
Johnson	4-Mar-05	J1 - road bridge d/s lake	198	1.430	at weir upstream
Johnson	26-Oct-04	Samatosum Site 7 - d/s mine	83		No GH recorded. Mine records show GH approx 0.21m. Actual Q = 1/3 Q from old rating table.
Johnson	1-Sep-04	J3 - lower FSR bridge	130		
Johnson	13-Aug-04	J4 - Agate Bay Road	180		Rough estimate. Johnson Lake 0.64 m; outlet 0.39 m
Johnson	1-Sep-04	J4 - Agate Bay Road	132		
Johnson	2-Sep-04	J4 - Agate Bay Road	106		
Johnson	2-Nov-04	J4 - Agate Bay Road	103		
Johnson	4-Mar-05	J4 - Agate Bay Road	600		Rough estimate
Sinmax	20-Aug-04	At the outlet of Forrest Lake	30		Rough estimate
Sinmax	23-Aug-04	At the outlet of Forrest Lake	12		Estimate based on depth, avg vel and width
Sinmax	23-Aug-04	above Johnson	18		
Sinmax	2-Nov-04	above Johnson	75		
Sinmax	2-Nov-04	above main diversion ditch	249		Near old WSC station 08LD004
Sinmax	4-Mar-05	above main diversion ditch	736		Near old WSC station 08LD004
Sinmax ditch	23-Aug-04	d/s intake (ditch flow)	63		Estimate based on depth, avg vel and width
Sinmax	13-Aug-04	"Dry Section"	40		Estimate based on depth, avg vel and width
Sinmax	23-Aug-04	"Dry Section"	19		Johnson Lake 0.395 m; outlet 0.605 m
Sinmax	26-Oct-04	"Dry Section"	151		
Sinmax	2-Nov-04	"Dry Section"	161		
Sinmax	4-Mar-05	"Dry Section"	663		
Sinmax	23-Aug-04	D/S "Dry Section"; d/s coho spring; ι	38		
Sinmax	20-Aug-04	S6 - Keller Spring (largest)	100		Rough estimate
Sinmax	2-Sep-04	S6 - Keller Spring (largest)	92		
Sinmax	26-Oct-04	S6 - Keller Spring (largest)	87		
Sinmax	4-Mar-05	S6 - Keller Spring (largest)	84		
Sinmax	20-May-04	Site 1 - d/s road	497		No staff gauge at that time
Sinmax	10-Jun-04	Site 1 - d/s road	719	1.385	
Sinmax	8-Jul-04	Site 1 - d/s road	368	1.34	
Sinmax	20-Jul-04	Site 1 - d/s road	213	1.31	
Sinmax	22-Jul-04	Site 1 - d/s road	237	1.32	
Sinmax	29-Jul-04	Site 1 - d/s road	200	1.31	
Sinmax	4-Aug-04	Site 1 - d/s road		1.315	
Sinmax	11-Aug-04	Site 1 - d/s road		1.31	
Sinmax	20-Aug-04	Site 1 - d/s road		1.31	
Sinmax	2-Sep-04	Site 1 - d/s road	312	1.3405	
Sinmax	7-Sep-04	Site 1 - d/s road		1.340	
Sinmax	15-Sep-04	Site 1 - d/s road	403	1.3525	
Sinmax	21-Sep-04	Site 1 - d/s road		1.340	
Sinmax	5-Oct-04	Site 1 - d/s road	219	1.330	No irrigation. Sockeye spawning, see email for photos
Sinmax	18-Oct-04	Site 1 - d/s road		1.345	
Sinmax	26-Oct-04	Site 1 - d/s road		1.345	
Sinmax	2-Nov-04	Site 1 - d/s road	330	1.350	
Sinmax	4-Mar-05	Site 1 - d/s road	887	1.412	

<u>Table 2- Flow Summaries for Given Days in 2004/2005</u>

Note: Where possible, a summary of streamflow patterns from upstream to downstream was developed. The purpose of this table is to roughly assess the groundwater inflow / outflow in various reaches, and at different times. The shaded cells are streamflow estimates used to complete the data set.

Location	Flow (l/s) on Given Day 13-Aug-04	20-Aug-04	01-Sep-04	15-Sep-04	21-Sep-04	26-Oct-04	02-Nov-04	04-Mar-05	Average	Drought Assumptio	Minimum Flow
Johnson Lake Outlet	122	117	97	49	58	37		174			120
Input Between Lakes	*27*	*32*	*33*	*53*	*16*	*19*		*24*	*29*	25	25
FSR Br Below Small Lake	149	149	130	102	74	56		198			145
Input In Lower Johnson	*31*	*11*	*2*			*47*		*402*	*99*	0	0
Johnson Cr at Agate Bay Rd	180	160	132			103	103	600			145
Sinmax Cr Above Johnson	18	18	40			75	75	136		20	20
Sinmax Cr Below Johnson	198	178	172			178	249	736			165
Main Irrigation Diversion	63	63	63			0	0	0		60	60
Loss to Groundwater	*90*	*96*				*27*	*88*	*73*	*75*	90	90
"Dry Section" @ D. Smith	45	19				151	161	663			15
Groundwater + Other Inflow	*65*	*91*				*142*	*82*	*140*	*104*	65	65
Keller Spring	100	100	92			87	87	84	*92*	90	90
Sinmax Cr @ Mouth	210	210	312	403	368	380	330	887		200	170

Flow Summaries for Given Days in 2003

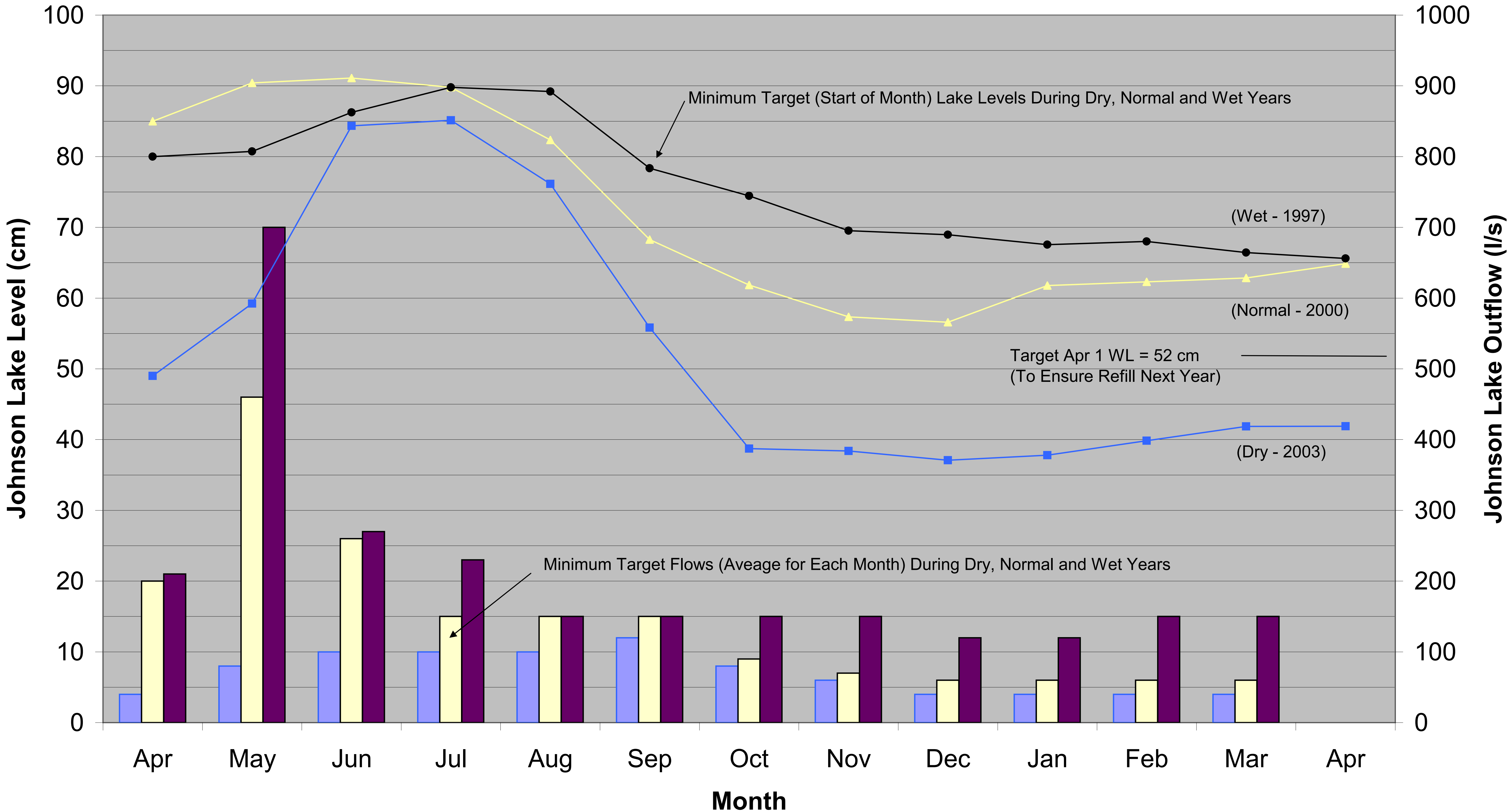
Location	Flow (l/s) on Given Day 04-Sep-03	15-Sep-03	30-Sep-03	17-Oct-03	Comments
Johnson Lake Outlet	25	5	1		
Input Between Lakes	*1*	*5*	*2*		*Very low inflow between lakes; evaporation off small lake could explain this.*
FSR Br Below Small Lake					
Input In Lower Johnson	*0*	*0*	*0*	*0*	
Johnson Cr at Agate Bay Rd	26	10	3	29	
Sinmax Cr Above Johnson	39	40	35		
Sinmax Cr Below Johnson	65	50	38		
Main Irrigation Diversion	30	30	10		Actual diversions not known, but were less then total Q..
Loss to Groundwater	*35*	*20*	*28*		*Losses are less than in 2004, only because there is less water to lose. Effectively the streamflow numbers in the "dry section" should be negative as an increase in flow (reduced diversion) did not result in re-wetting channel.*
"Dry Section" @ D. Smith	0	0	0	0	Stream Went Dry For Entire Period
Groundwater + Other Inflow	*79*	*58*	*80*	*110*	
Keller Spring	90	90	90	90	
Sinmax Cr @ Mouth	169	148	170	200	

Table 3 - Flow Forecast Indicators for Johnson Lake

Data Set for the Common Period of Record with Preliminary Ranges Given for Dry, Normal and Wet Years

	Johnson Lake Net Inflow Data				**Snow Course Data**				**Johnson Lake Monthly Inflow Data**			**Groundwater Data**	
Year	**Johnson Lake Net Inflow Volume (cubic dam)**				**Knouff Lake SWE (mm)**		**Adams River SWE (mm)**		**Monthly Net Inflow (cubic dam)**			**Westwold Well (m below ground)**	
	Apr-Jun	**Jul-Sept**	**Oct-Mar**	**Apr-Mar**	**Feb-01**	**Apr-01**	**Feb-01**	**Apr-01**	**June**	**July**	**August**	**Apr-01**	**Jul-01**
1996	3,078	28	1,242	4,347	117	152	588	706	680	4	-20	8.47	7.48
1997	3,327	954	1,903	6,184	139	189	582	787	792	577	98	8.54	7.81
1998	2,274	-271	1,711	3,714	76	112	429	685	327	39	-171	9.06	8.88
1999	3,870	899	1,297	6,066	131	160	654	1069	1453	675	105	10.24	8.09
2000	2,511	413	1,054	3,977	90	154	554	780	637	187	12	9.80	8.34
2001	1,604	64	958	2,625	86	122	334	540	446	342	17	9.97	9.05
2002	4,170	1,552	1,012	6,735	134	153	528	810	1237	844	420	10.24	8.33
2003	1,489	-414	794	1,869	60	96	334	520	271	14	-283	10.42	10.95
2004	1,394	163	1,401	2,958	117	86	406	564	305	1	43	9.32	8.87
Hist. Avg					116	150	442	693				9.80	7.65
Period Avg	2,635	376	1,264	4,275	106	136	490	718	683	298	25	9.56	8.64
Approximate Ranges:													
Dry	<2300	<100	<1100	<3500	<90	<125	<430	<690	<550	<150	<0	**>**9.9	**>**8.8
Average	2300-2900	100-600	1100-1400	3500-4900	90-130	125-150	430-540	690-780	550-750	150-300	0-100	9.9-9.3	8.8-8.4
Wet	>2900	>600	>1400	>4900	>130	>150 (Best Freshet Indicator)	>540	>780	>750 (Best Summer Indicator)	>300	>100	**<**9.3	**<**8.4
Example Forecast - Completed													
2010					80	110	400	700	500	Not Avail.	Not Avail.	9.90	8.50
Wetter / Drier / Average		Local Observations:			Dry	Dry	Dry	Average	Dry	Not Avail.	Not Avail.	Dry	Average
Conclusion:		Snowpack is near normal, groundwater into Mine is higher volume then normal, lake is higher than normal.			Snowpack and net inflow to the lake are generally slightly lower than average leading into summer. Plan for slightly below normal releases from the lake during freshet to ensure the lake fills. Relase more water as available in May / June. Local observations suggest more water than regional data. Truth may be somewhere in the middle. Plan in slightly below normal releases in summer and adjust as weather unfolds and net inflows for July and August are available. A cautious approach of starting with releases slightly less than average is recommended - monitor lake level and adjust accordingly.								
Blank Forecast - To Be Completed Each Year													
Year:													
Wetter / Drier / Average		Local Observations:											
Conclusion:													

Figure 3 - Minimum Target Flows and Water Levels With New Operating Plan



Note: Target lake levels are shown in the middle of each month, but are intended to be "Start of Month" values.

Figure 3a - Minimum Target Water Levels And New Operating Plan Details

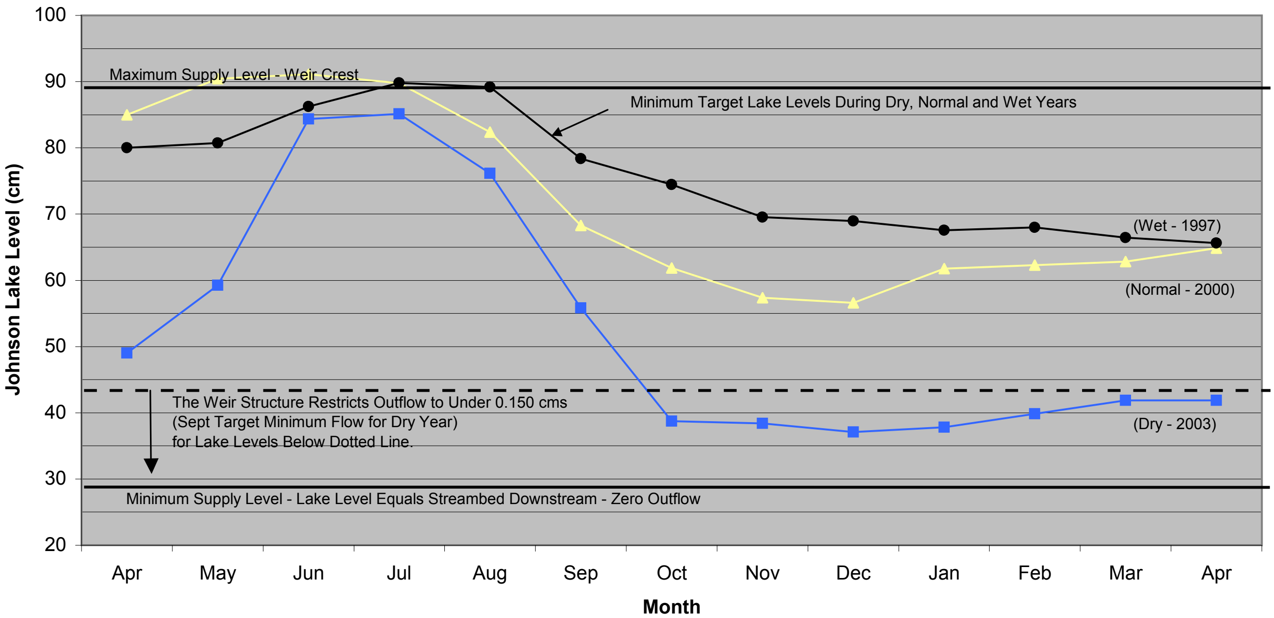


Table of Specific Values for Minimum Target Outflow and Lake Levels for Various Scenarios

	Revised Draft Operating Plan - Average Monthly Outflows and Start of Month WL						1996 Operating Plan (for Comparison)
Month	**"Dry Year Scenario"**		**"Normal Year Scenario"**		**"Wet Year Scenario"**		**"Average Year"**
(starting level)	**Outflow (l/s)**	**Lake Level (cm)**	**Outflow (l/s)**	**Lake Level cm)**	**Outflow (l/s)**	**Lake Level (cm)**	**Outflow (l/s)**
Apr	40	49	200	85	210	80	50
May	80	59	460	90	700	81	192
Jun	100	84	260	91	270	86	453
Jul	100	85	150	90	230	90	250
Aug	100	76	150	82	150	89	154
Sep	120	56	150	68	150	78	154
Oct	80	39	90	62	150	74	60
Nov	60	38	70	57	150	70	60
Dec	40	37	60	57	120	69	31
Jan	40	38	60	62	120	68	62
Feb	40	40	60	62	150	68	62
Mar	40	42	60	63	150	66	31
Apr		42		65		66	50

Table 4 – Decision Point Guidelines for Draft Revised Operating Plan

Item / Date	Feb 1	Apr 1	June 1	July 1	Aug 1	Sept 1	Oct 1	Dec 1
Watershed Conditions:								
Current Lake Level	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum	_____ cm Above / Below Target Minimum
Forecast Indicator	Knouff Lake SWE = _____ mm. Adams River SWE = _____ mm. Westwold	Knouff Lake SWE = _____ mm. Adams River SWE = _____ mm. Westwold Groundwater Level = ____ m Below Grd.		June Net Inflow to Lake = _____ cubic dam. Westwold Groundwater Level = ____ m Below Grd.	June Net Inflow to Lake = _____ cubic dam. July Net Inflow to Lake = _____ cubic dam.	June Net Inflow to Lake = _____ cubic dam. August Net Inflow to Lake = _____ cubic dam.		
Conclusion as to Current Watershed Condition	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry	Wet / Above Average / Below Average / Dry
Guideline / Action Required:								
Conditions for Wet Year	Either WL above 70 cm, or Knouff SWE Above 130 mm; Releases to Match Inflow	Either WL above 70 cm, or Knouff SWE Above 150 mm; Ramp up Releases to 200 l/s or higher.	WL Above 90 cm; Allow Outflow to Match Inflow	June Inflow Above 750 cu. dam and WL Above 90 cm; Use Wet Outflow	WL Above 85 cm and July Inflow Above 300 cu. dam; Use Wet Outflow	WL Above 85 cm and July Inflow Above 300 cu. dam; Use Wet Outflow	WL above 70 cm; Use Wet Outflow	WL above 70 cm; Use Wet Outflow
Conditions for Average Year	WL Above 50 cm and Knouff SWE Above 90 mm; Releases to Match Inflow	WL Above 55 cm and Knouff SWE Above 90 mm; Ramp up Releases to 100 l/s or higher.	WL Above 85 cm; Restrict Outflow to 150 l/s Until Lake Fills	June Inflow Above 550 cu. dam and WL Above 89 cm; Use Normal Outflow	WL Above 80 cm and July Inflow Above 150 cu. dam; Maintain Normal Outflow	WL Above 65 cm and Aug Inflow Above 0 cu. dam; Maintain Normal Outflow	WL Above 60 cm; Maintain Normal Outflow	WL Above 50 cm; Maintain Normal Outflow
Conditions for Dry Year	WL Below 50 cm or Knouff SWE Below 90 mm; Restrict Releases to Below Inflow to Target WL > 50 cm by Apr 1	WL Below 55 cm or Knouff SWE Below 90 mm; Keep Releases at Approx. 60 l/s Until Lake is Clearly Going to Fill	WL Below 80 cm; Restrict Outflow to 80 l/s Until Lake is Clearly Going to Fill	June Inflow Below 550 cu. dam or WL Below 89 cm; Use Dry Outflow	WL Below 80 cm or June Inflow Below 550 cu. dam or July Inflow Below 150 cu. dam; Use Dry Outflow	WL Below 65 cm or June Inflow Below 550 cu. dam or Aug Inflow Below 0 cu. dam; Use Dry Outflow and Discuss Mid-Sept Measures Req'd	WL below 60 cm; Use Dry Outflow	WL below 50 cm; Use Dry Outflow

Note: Record existing conditions in the top half of chart, referring to the lower portion of the chart for guideline on characterizing the type of year and recommended course of action.
Abbreviations: SWE = Snow Water Equivalent, WL = Lake Water Level.
Net Inflow Calculation for One Month: Net Inflow (in cubic dam) = [Average Outflow (in l/s) x 2.635] + [WL end – WL start (in cm)] x 26.24

Appendix A

Full Sized Map Of Sinmax Creek Watershed

(Similar to Figure 1)