# POWERS CREEK

## ASSESSMENT OF ALTERNATIVES

## TO

## ENHANCE OKANAGAN LAKE FISHERY

- All measurements used in this report are in metric
- To convert $m^3/s$ to cfs, multiply by 35.315
- To convert $dams^3$ to acre feet, multiply by 0.81


**Prepared by:**

**DOBSON ENGINEERING**
**Kelowna, British Columbia**



**SEPTEMBER 1990**

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# POWERS CREEK

## 1.0 INTRODUCTION

Powers Creek is located on the west side of Okanagan Lake at Westbank, opposite the Okanagan Mission area of Kelowna (see Figure 1). The watershed has a drainage area of approximately 144 $km^2$. There is an historic use of the creek for spawning and rearing of both rainbow trout and kokanee from Okanagan Lake. The intent of this report is to detail the opportunities that may exist to enhance either or both of the existing species through improvement of the water supply.

This report will identify the reach(es) of the stream that are accessible to the fish and the flows required to maintain spawning and rearing. Based on the required flows, for both trout and kokanee, the deficits will be determined using both the mean monthly and the one in 10-year low flows as indicators.

Once the deficits in flow have been determined, the available alternatives will be identified to supply the additional water needed to achieve the optimum flows. Included in the assessment will be: the present licenced use of the stream, a survey of the water licences with regards to their level of use, and the projected full utilization of the existing water licences.

Finally, a recommendation will be made regarding the cost effectiveness of each flow enhancement option and the consequences of failing to provide these flows.

The complete Terms of Reference are contained in Appendix 1.

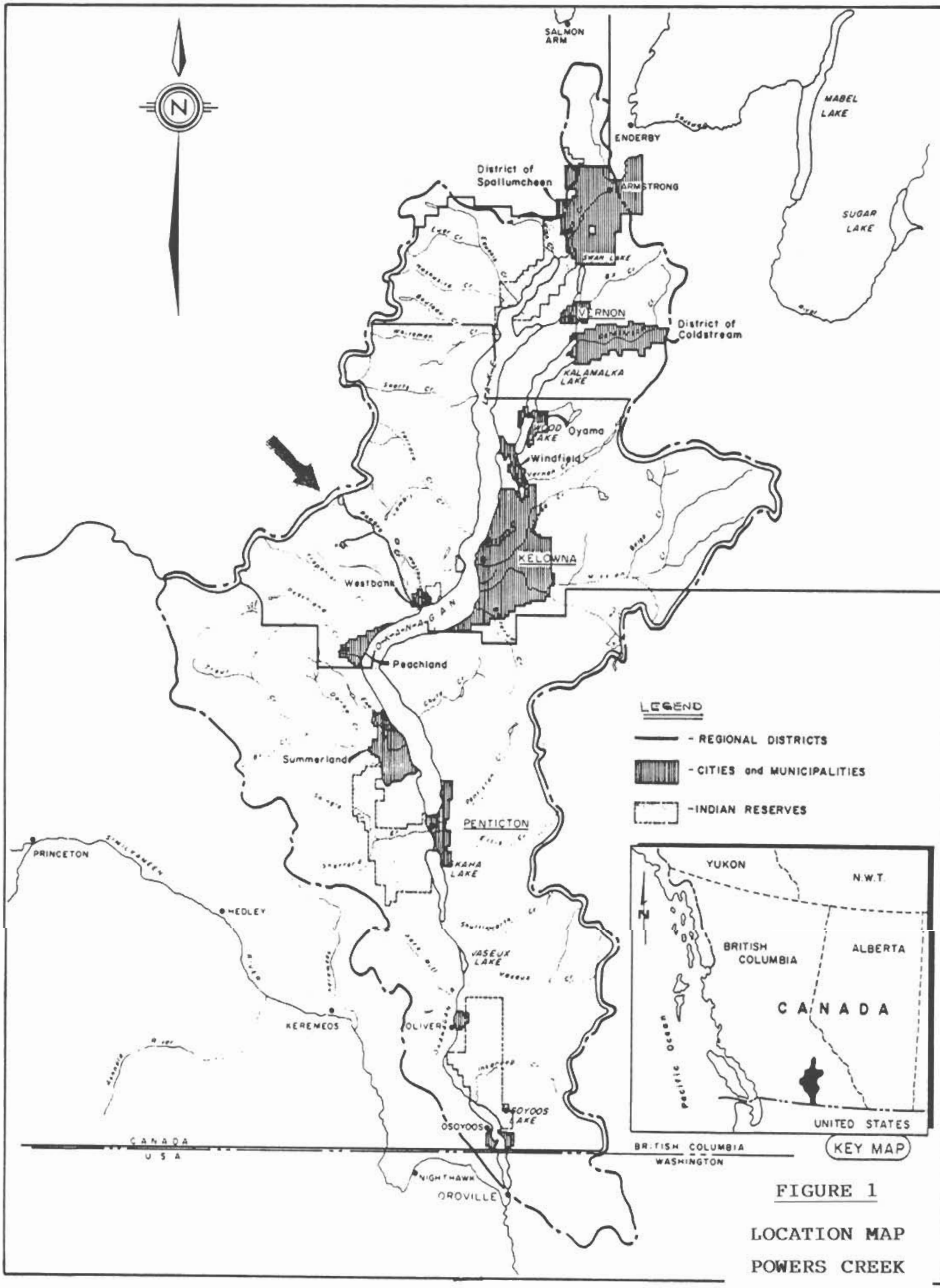


FIGURE 1

LOCATION MAP
POWERS CREEK

## 2.0 FISH REQUIREMENTS

Only the first 2.9 km of Powers Creek are accessible to fish entering from Okanagan Lake. Several obstructions present impassable barriers beyond this point.

There has been some previous work done over the years to investigate the flows for both the kokanee and the rainbow trout. The suggestions for flows range from a low of 0.085 $m^3/s$ to a high of 0.161 $m^3/s$. The most recent work was carried out by C. D. Tredger in 1986 and 1987. In his work Tredger visited the creek on three occasions and measured both the flow and the available habitat. Based on this work, but tempered with the additional local expertise available from the Fisheries staff of the Ministry of Environment in Penticton, the flow requirements were set as follows:

| | | |
|---|---|---|
| KOKANEE: | • Migrating and Spawning Flows (September and October) | 0.120 $m^3/s$ |
| | • Incubation Flows (November to March) | |
| | OPTION 1: 50% of spawning flow | 0.060 $m^3/s$ |
| | OPTION 2: 75% of spawning flow | 0.090 $m^3/s$ |
| TROUT: | • Flow (all year) | 0.120 $m^3/s$ |

These flows will form the basis for the computations in a later section that will determine whether or not there is adequate water available in the stream, under varying conditions, to support fish.

The flow level for each species is set according to the ability of the stream to accommodate the fish. Tredger found that the kokanee spawning capacity increased significantly between flows of 0.070 $m^3/s$ (12 138 spawners) and 0.120 $m^3/s$ (27,713 spawners) but only marginally when the flow doubled to 0.240 $m^3/s$ (30 142 spawners). Trout parr capacity showed a moderate, steady increase (1 068 to 1 526) over the same range of flows. In Tredger's opinion the optimum flow should be targeted at the fall period, when juvenile rainbow requirements are maximum and spawning kokanee are present. His studies indicated a high percentage of maximum capacity for both species could be preserved at a flow of 0.120 $m^3/s$.

## 3.0 HISTORICAL STREAMFLOW RECORDS

Hydrometric data on Powers Creek has been collected since 1920. Gauging stations, operated by Water Survey of Canada have been located at three sites on the creek. The period of record and the type of data collected is summarized in Table 1. The location of the stations are shown on the map in the back pocket of this report [see Figure 2].

It should be noted that a portion of Lambly Creek watershed (approximately 23 $km^2$) has been largely diverted to Powers Creek watershed since 1952 and entirely diverted since 1969.

There are also diversions of spring freshet water from other watersheds into storage reservoirs for summer release into Powers Creek, when required. These diversions are as follows:

- Alocin Creek (Nicola) into Dobbin Lake, 216 $dams^3$ - since 1923
- In addition to above, 370 $dams^3$ - since 1979
- N. Lambly Creek into Tadpole Lake, 2 467 $dams^3$ - beginning 1990

**TABLE 1**

**SUMMARY OF HYDROMETRIC DATA FOR POWERS CREEK**

| Station | Drainage Area ($km^2$) | Records |
|---|---|---|
| 08NM033<br>Powers Creek<br>above Westbank<br>Diversion | 128.0 $km^2$ | 1920-1922: Manual, seasonal<br>1965: Manual, partial<br>1967-1974: Manual, seasonal |
| 08NM059<br>Powers Creek<br>below Westbank<br>Diversion | 139.0 $km^2$ | 1924-1925: Recorder, seasonal<br>1927: Recorder, seasonal<br>1965-1981: Manual, continuous<br>1982-1984: Recorder, seasonal<br>1985-Present: Recorder, continuous |
| 08NM157<br>Powers Creek<br>at the Mouth | 144.0 $km^2$ | 1969-1974: Manual, continuous<br>1975: Manual, seasonal<br>1976-1982: Manual, continuous |

Powers Creek flow has been regulated by manipulation of storage since 1920 or perhaps earlier. The data from all hydrometric stations was reviewed. It was decided to use station 08NM157, "Powers Creek at the Mouth" for the data base for this report, even though it is below all diversions, because it provides an almost continuous record during the significant period and in the critical area.

## 4.0 WATER LICENCE REQUIREMENTS

A list of existing water licences is included with this report as Appendix 2.

There are a total of forty six licences; thirty eight on Powers Creek watershed and eight on licenced diversions from Lambly Creek watershed. These licences permit the use of 3 644 $dams^3$ per year for waterworks use (domestic, industrial, etc.); 6 583 $dams^3$ per year for irrigation use; and supplementary storage of 9 274 $dams^3$. One licence also permits the non-consumptive use of 0.085 $m^3/s$ for fish conservation purposes, however it is subsequent in priority to the other licences except for the most recent individual domestic licence.

Westbank Irrigation District is the major licensee holding some 98% of the total licenced quantity in the watershed. The District records of annual water consumption during 1984 - 1988 were analyzed to determine their present level of use. In the fall of 1989, a field survey was conducted to determine the level of use of non-Westbank Irrigation District licences at that time. For all licences in the watershed, the waterworks had been developed to approximately 57% of the allowable, the irrigation use was developed to approximately 53% and the storage to approximately 97% of the respective licenced levels. A summary of the licences is detailed in Table 2.

The review of the licences carried out in late 1989 indicated that there were 4 674 $dams^3$ of unused licenced diversion and 269 $dams^3$ of undeveloped storage. The details are provided in Table 3.

| TABLE 2 | | |
|---|---|---|
| **POWERS CREEK WATER LICENCES** | | |
| Purpose | Licenced Use | Present Developed Use |
| 1. WATERWORKS (Dom./Ind./Etc.) | | |
| ~ $m^3$ / year | 3 644 437.0 | 2 087 428.0 |
| ~ average $m^3$ / day | 9 985.0 | 5 719.0 |
| ~ equivalent $m^3/s$ | 0.116 | 0.066 |
| ~ winter $m^3$ / day | 4 859.0 | 2 783.0 |
| ~ equivalent $m^3/s$ | 0.056 | 0.032 |
| ~ peak day use $m^3$ | 29 954.0 | 17 157.0 |
| ~ equivalent $m^3/s$ | 0.346 | 0.199 |
| 2. IRRIGATION | | |
| ~ $dams^3$ / year | 6 583.0 | 3 466.0 |
| ~ peak day use $m^3/s$ | 0.763 | 0.402 |
| 3. DIVERSION TOTAL | | |
| ~ $dams^3$ / year | 10 227.4 | 5 553.4 |
| ~ peak day use $m^3/s$ | 1.109 | 0.601 |
| 4. STORAGE | | |
| ~ $dams^3$ / year | 9 274.0 | 9 005.0 |
| ~ 100 days release $m^3/s$ | 1.075 | 1.044 |

**TABLE 3**

**UNUSED LICENCED DIVERSION AND STORAGE**

**1. UNUSED DIVERSION LICENCES**

| (1)<br>Licence No. | (2)<br>Source Name | (3)<br>Volume<br>(dams³) | (4)<br>Remarks |
|---|---|---|---|
| C 67990 | N. Lambly Creek | } 1 557.0 | ~ Undeveloped waterworks Westbank Irrigation District |
| C 67991 | Lambly Creek | | |
| | SUBTOTAL | 1 557.0 | |
| C 17582 | Lambly Creek | } 3 052.6 | ~ Undeveloped Irrigation Westbank Irrigation District |
| C 33404 | Lambly Creek | | |
| C 43507 | Powers Creek | 59.2 | ~ No Use - Byland's Nursery |
| F 21027 | Powers Creek | 5.2 | ~ No Use - Byland's Nursery |
| | SUBTOTAL | 3 117.0 | |
| | TOTAL | 4 674.0 | |

**2. UNUSED DIVERSION LICENCES**

| | | | |
|---|---|---|---|
| C 14419 | Powers Creek | 222.0 | |
| C 67990 | N. Lambly Creek | 47.0 | |
| | TOTAL | 269.0 | |

## 5.0 FLOW AVAILABILITY

Based on the flows for fish as set out in section 2.0 and the criteria set out in the Terms of Reference, there will be four flow scenarios examined. The short term situation is considered to be for the current utilization of the water licences. The long term scenario would be at full utilization of the water licences. In addition to mean monthly flows, both the scenarios will be examined under 10-year low flow conditions, which have an 88% probability of occurring at least once in any twenty year period.

Mean monthly flows are based on the historical hydrometric data from the Water Survey of Canada gauging station "Powers Creek at the mouth" (Station No. 08NM157). The data is summarized in Appendix 3. One in 10-year low flows are estimated based on the work by B. Letvak. Hydrographs for the two flows are shown in Figure 3.

**FLOW SCENARIOS**

| | |
|---|---|
| 1. Mean Monthly Flows (current utilization) | 3. Mean Monthly Flows (full utilization) |
| 2. 1 in 10-Year Low Flow (current utilization) | 4. 1 in 10-Year Low Flow (full utilization) |

Tables 4 through 7 present the flows and deficits for each of the scenarios described above for Kokanee. The impact of each case will be examined in section 5.1. Tables 8 through 11 present the flows and deficits for the same scenarios for rainbow trout. The results are discussed in section 5.2.

# POWERS CREEK
## Hydrograph

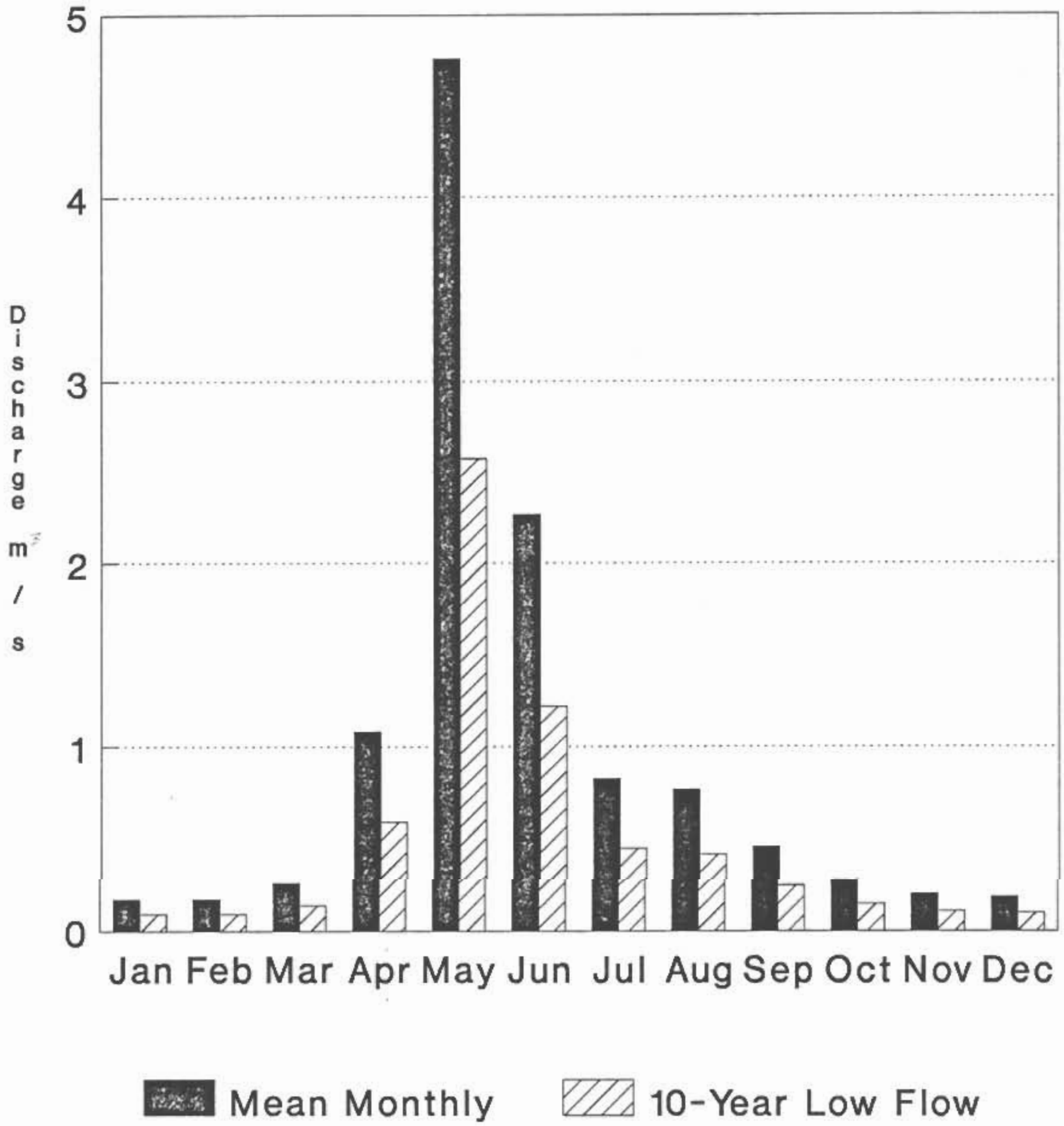


Figure 3

## 5.1 KOKANEE

### 5.1.1 Mean Monthly Flow at Current Utilization

The mean monthly flow at the current level of use is considered to be the "normal" situation at this time. Based on the flow requirements of 0.120 $m^3/s$ for migration and spawning, and incubation flows of either 0.060 $m^3/s$ (50% spawning flow) or 0.090 $m^3/s$ (75% spawning flow), there should be adequate water available for all situations [refer to Table 4].

### 5.1.2 One in Ten-Year Low Flow at Current Utilization

The one in ten-year low flow event represents the conditions that might occur once in any twenty year period. This scenario is presented to determine if it is possible to protect the kokanee over this time frame. Table 5 shows that there is a deficit in September of 0.058 $m^3/s$ or 48% of the required spawning flow. This is a critical time for the kokanee since they require adequate flows for both migration up the stream as well as to provide sufficient spawning habitat. The significance of this shortfall is that it has a low risk of occurrence and therefore may not warrant the cost of protection.

### 5.1.3 Mean Monthly Flows at Full Utilization

Full utilization of the water licences at mean monthly flow is considered the long term condition. With the amount of development that is occurring within the Westbank Irrigation District it is likely that full utilization will occur within the next ten to fifteen years. The only deficit has been identified in September [refer to Table 6] and is estimated to be 0.006 $m^3/s$ or 5% of the required flow. Since there are fluctuations in flow that occur naturally this deficit should be insignificant.

5.1.4 <u>One in Ten-Year Low Flow at Full Utilization</u>

Of the four scenarios presented for kokanee, this would be the worst case. The water licences would be fully developed with the additional impact of the one in ten-year low flow. There will be deficits from September through February at an incubation flow of 50% $Q_s$ and from September through March for an incubation flow of 75% $Q_s$. September is the worst month where 100% of the flow would be lost to diversions. There is a water licence (No. C 64293) held by the Fisheries Program for 0.085 $m^3/s$ but it is of such low priority that in a low flow situation it would not be useable.

The low probability of occurrence of this scenario must be considered when deciding whether or not to develop supplementary supplies to address this case.

## TABLE 4

## KOKANEE

### MEAN MONTHLY FLOW AT CURRENT UTILIZATION

| Month | Discharge ($m^3/s$) | Current Utilization ($m^3/s$) | $Q_k$ 50% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | $Q_k$ 75% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % |
|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.169 | 0.032 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| February | 0.169 | 0.032 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| March | 0.254 | 0.032 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| April | 1.081 | 0.088 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| May | 4.762 | 0.262 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| June | 2.262 | 0.422 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 0.82 | 0.462 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 0.762 | 0.476 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| September | 0.452 | 0.182 | 0.120 | 0 | 0 | 0 | 0.120 | 0 | 0 | 0 |
| October | 0.273 | 0.032 | 0.120 | 0 | 0 | 0 | 0.120 | 0 | 0 | 0 |
| November | 0.199 | 0.032 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| December | 0.184 | 0.032 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 |
| | | | | Total | 0 | | | Total | 0 | |

**NOTE:** $Q_s$ = Spawning Flow
$Q_k$ = Incubation Flow for Kokanee based on $Q_s$

## TABLE 5

# KOKANEE

### ONE IN 10-YEAR FLOW AT CURRENT UTILIZATION

| Month | Discharge ($m^3/s$) | Current Utilization ($m^3/s$) | $Q_k$ 50% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) | $Q_k$ 75% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.091 | 0.032 | 0.060 | 0 | 0 | 0 | 0.001 | 3 | 0.090 | 0 | 0 | 0 | 0.031 | 80 |
| February | 0.091 | 0.032 | 0.060 | 0 | 0 | 0 | 0.001 | 3 | 0.090 | 0 | 0 | 0 | 0.031 | 80 |
| March | 0.137 | 0.032 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| April | 0.584 | 0.088 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| May | 2.571 | 0.262 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| June | 1.221 | 0.422 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 0.443 | 0.462 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.019 | 51 |
| August | 0.411 | 0.476 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.065 | 174 |
| September | 0.244 | 0.182 | 0.120 | 0.058 | 150 | 48 | 0 | 0 | 0.120 | 0.058 | 150 | 48 | 0 | 0 |
| October | 0.147 | 0.032 | 0.120 | 0 | 0 | 0 | 0.005 | 75 | 0.120 | 0 | 0 | 0 | 0.005 | 13 |
| November | 0.107 | 0.032 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0.015 | 39 |
| December | 0.099 | 0.032 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0.023 | 60 |
| | | | | Total | 150 | | Total | 81 | | Total | 150 | | Total | 497 |

**NOTE:** $Q_s$ = Spawning Flow
$Q_k$ = Incubation Flow for Kokanee based on $Q_s$

## TABLE 6

### KOKANEE

#### MEAN MONTHLY FLOW AT FULL UTILIZATION

| Month | Discharge ($m^3/s$) | Full Utilization ($m^3/s$) | $Q_k$ 50% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | $Q_k$ 75% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.169 | 0.056 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| February | 0.169 | 0.056 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| March | 0.254 | 0.056 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| April | 1.081 | 0.16 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| May | 4.762 | 0.478 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| June | 2.262 | 0.783 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 0.820 | 0.859 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| August | 0.762 | 0.884 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.039 | 104 |
| September | 0.452 | 0.338 | 0.120 | 0.006 | 16 | 5 | 0.120 | 0.006 | 16 | 5 | 0 | 0 |
| October | 0.273 | 0.056 | 0.120 | 0 | 0 | 0 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| November | 0.199 | 0.056 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| December | 0.184 | 0.056 | 0.060 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| | | | | Total | 16 | | | Total | 16 | | Total | 104 |

**NOTE:** $Q_s$ = Spawning Flow
$Q_k$ = Incubation Flow for Kokanee based on $Q_s$

## TABLE 7

# KOKANEE

### ONE IN 10-YEAR FLOW AT FULL UTILIZATION

| Month | Discharge ($m^3/s$) | Full Utilization ($m^3/s$) | $Q_k$ 50% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) | $Q_k$ 75% $Q_s$ ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 0.091 | 0.056 | 0.060 | 0.025 | 67 | 42 | 0.056 | 150 | 0.090 | 0.055 | 147 | 61 | 0.056 | 150 |
| February | 0.091 | 0.056 | 0.060 | 0.025 | 60 | 42 | 0.056 | 134 | 0.090 | 0.055 | 133 | 61 | 0.056 | 134 |
| March | 0.137 | 0.056 | 0.060 | 0 | 0 | 0 | 0.056 | 150 | 0.090 | 0.009 | 24 | 10 | 0.056 | 150 |
| April | 0.584 | 0.16 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| May | 2.571 | 0.478 | 0.060 | 0 | 0 | 0 | 0 | 0 | 0.090 | 0 | 0 | 0 | 0 | 0 |
| June | 1.221 | 0.783 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| July | 0.443 | 0.859 | 0 | 0 | 0 | 0 | 0.416 | 1 114 | 0 | 0 | 0 | 0 | 0.416 | 1 114 |
| August | 0.411 | 0.884 | 0 | 0 | 0 | 0 | 0.473 | 1 267 | 0 | 0 | 0 | 0 | 0.473 | 1 267 |
| September | 0.244 | 0.338 | 0.120 | 0.120 | 311 | 100 | 0.094 | 243 | 0.120 | 0.120 | 311 | 100 | 0.094 | 243 |
| October | 0.147 | 0.056 | 0.120 | 0.029 | 77 | 24 | 0.056 | 150 | 0.120 | 0.029 | 77 | 24 | 0.056 | 150 |
| November | 0.107 | 0.056 | 0.060 | 0.009 | 23 | 15 | 0.056 | 145 | 0.090 | 0.039 | 101 | 39 | 0.056 | 145 |
| December | 0.099 | 0.056 | 0.060 | 0.017 | 45 | 28 | 0.056 | 150 | 0.090 | 0.047 | 126 | 52 | 0.056 | 150 |
| | | | | Total | 583 | | Total | 3 503 | | Total | 919 | | Total | 3 503 |

**NOTE:** $Q_s$ = Spawning Flow
$Q_k$ = Incubation Flow for Kokanee based on $Q_s$

**TABLE 8**

**TROUT - MEAN MONTHLY FLOW AT CURRENT UTILIZATION**

| Month | Discharge ($m^3/s$) | Current Utilization ($m^3/s$) | Trout ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % |
|---|---|---|---|---|---|---|
| January | 0.169 | 0.032 | 0.120 | 0 | 0 | 0 |
| February | 0.169 | 0.032 | 0.120 | 0 | 0 | 0 |
| March | 0.254 | 0.032 | 0.120 | 0 | 0 | 0 |
| April | 1.081 | 0.088 | 0.120 | 0 | 0 | 0 |
| May | 4.762 | 0.262 | 0.120 | 0 | 0 | 0 |
| June | 2.262 | 0.422 | 0.120 | 0 | 0 | 0 |
| July | 0.820 | 0.462 | 0.120 | 0 | 0 | 0 |
| August | 0.762 | 0.476 | 0.120 | 0 | 0 | 0 |
| September | 0.452 | 0.182 | 0.120 | 0 | 0 | 0 |
| October | 0.273 | 0.032 | 0.120 | 0 | 0 | 0 |
| November | 0.199 | 0.032 | 0.120 | 0 | 0 | 0 |
| December | 0.184 | 0.032 | 0.120 | 0 | 0 | 0 |
| | | | | Total | 0 | |

**TABLE 9**

**TROUT - ONE IN 10-YEAR LOW FLOW AT CURRENT UTILIZATION**

| Month | Discharge ($m^3/s$) | Current Utilization ($m^3/s$) | Trout ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|
| January | 0.091 | 0.032 | 0.120 | 0.061 | 163 | 51 | 0.032 | 86 |
| February | 0.091 | 0.032 | 0.120 | 0.061 | 148 | 51 | 0.032 | 77 |
| March | 0.137 | 0.032 | 0.120 | 0 | 0 | 0 | 0.032 | 86 |
| April | 0.584 | 0.088 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| May | 2.571 | 0.262 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| June | 1.221 | 0.422 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| July | 0.443 | 0.462 | 0.120 | 0.120 | 311 | 100 | 0.019 | 509 |
| August | 0.411 | 0.476 | 0.120 | 0.120 | 311 | 100 | 0.065 | 174 |
| September | 0.244 | 0.182 | 0.120 | 0.058 | 150 | 48 | 0 | 0 |
| October | 0.147 | 0.032 | 0.120 | 0.005 | 13 | 4 | 0 | 86 |
| November | 0.107 | 0.032 | 0.120 | 0.013 | 34 | 11 | 0.032 | 83 |
| December | 0.099 | 0.032 | 0.120 | 0.021 | 54 | 17 | 0.032 | 86 |
| | | | | Total | 1 184 | | Total | 1 187 |

**TABLE 10**

**TROUT - MEAN MONTHLY FLOW AT FULL UTILIZATION**

| Month | Discharge ($m^3/s$) | Full Utilization ($m^3/s$) | Trout ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|
| January | 0.169 | 0.056 | 0.120 | 0.007 | 19 | 16 | 0.056 | 150 |
| February | 0.169 | 0.056 | 0.120 | 0.007 | 17 | 14 | 0.056 | 134 |
| March | 0.254 | 0.056 | 0.120 | 0 | 0 | 0 | 0.056 | 150 |
| April | 1.081 | 0.160 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| May | 4.762 | 0.478 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| June | 2.262 | 0.783 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| July | 0.820 | 0.859 | 0.120 | 0.120 | 311 | 100 | 0.039 | 104 |
| August | 0.762 | 0.884 | 0.120 | 0.120 | 311 | 100 | 0.122 | 327 |
| September | 0.452 | 0.338 | 0.120 | 0.006 | 16 | 5 | 0 | 0 |
| October | 0.273 | 0.056 | 0.120 | 0 | 0 | 0 | 0.056 | 150 |
| November | 0.199 | 0.056 | 0.120 | 0 | 0 | 0 | 0.056 | 145 |
| December | 0.184 | 0.056 | 0.120 | 0 | 0 | 0 | 0.056 | 150 |
| | | | | Total | 674 | | Total | 1 310 |

**TABLE 11**

**TROUT - ONE IN 10-YEAR LOW FLOW AT FULL UTILIZATION**

| Month | Discharge ($m^3/s$) | Full Utilization ($m^3/s$) | Trout ($m^3/s$) | Deficit ($m^3/s$) | Deficit ($dams^3$) | Deficit % | Stor ($m^3/s$) | Stor ($dams^3$) |
|---|---|---|---|---|---|---|---|---|
| January | 0.091 | 0.056 | 0.120 | 0.085 | 228 | 71 | 0.056 | 150 |
| February | 0.091 | 0.056 | 0.120 | 0.085 | 206 | 71 | 0.056 | 134 |
| March | 0.137 | 0.056 | 0.120 | 0 | 0 | 0 | 0.056 | 150 |
| April | 0.584 | 0.160 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| May | 2.571 | 0.478 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| June | 1.221 | 0.783 | 0.120 | 0 | 0 | 0 | 0 | 0 |
| July | 0.443 | 0.859 | 0.120 | 0.120 | 311 | 100 | 0.416 | 1 114 |
| August | 0.411 | 0.884 | 0.120 | 0.120 | 311 | 100 | 0.473 | 1 267 |
| September | 0.244 | 0.338 | 0.120 | 0.120 | 311 | 100 | 0.094 | 243 |
| October | 0.147 | 0.056 | 0.120 | 0.290 | 78 | 24 | 0.056 | 150 |
| November | 0.107 | 0.056 | 0.120 | 0.069 | 178 | 58 | 0.056 | 145 |
| December | 0.099 | 0.056 | 0.120 | 0.021 | 206 | 64 | 0.056 | 150 |
| | | | | Total | 1 829 | | Total | 3 503 |

## 5.2 TROUT

### 5.2.1 Mean Monthly Flow at Current Utilization

There is adequate flow for the trout for the present conditions in Powers Creek [refer to Table 8].

### 5.2.2 One in Ten-Year Low Flow at Current Utilization

In the event of a one in ten-year low flow there will be deficits for the trout for eight months of the year [refer to Table 9]. The most serious period would be July and August where 100% of the flow is diverted.

For this case there must be careful management of the supply both by Water Management and the water licensees in order that the conditions of the licences are complied with. Westbank Irrigation District would have to manage their storage on a continuing basis in order to address their requirements during the non-irrigation period (ie: October through March). Unless a feasible source of additional water can be developed to supply at least the July - August period, this fishery will be seriously impacted.

### 5.2.3 Mean Monthly Flow at Full Utilization

This is the long term scenario when the water licences are fully developed. There would be deficits for trout during five months of the year [refer to Table 10]. As in the previous case, Table 9, 100% of the flow is diverted during July and August. If it is possible to develop a means of supplementing the flows for this period, then it should be possible to supply the shortfalls in September, January and February also. If alternative supplies are not available then this fishery will be lost.

5.2.4 <u>One in Ten-Year Low Flow at Full Utilization</u>

During a one in ten-year low flow, when the water licences are fully utilized, there will be inadequate flows for the trout for eight months of the year [refer to Table 11]. 100% of the available water will be diverted to meet licenced demands for July, August and September. If it was decided to develop additional supplies for the scenario in section 5.2.3 then it may be possible to supplement the shortfalls in this case also. If however, the decision was not to proceed for the previous scenario then there would be no need to act in this case because the fishery would already have been destroyed.

## 6.0 FLOW ENHANCEMENT ALTERNATIVES

The following opportunities are presented for consideration to enhance the flows in Powers Creek for the fish resource:

6.1 Negotiate the transfer of the unused water licences currently held by Byland's Nurseries Ltd. (Licence Nos. C 43507 and F 21027). The combined peak flow for these licences is 0.007 $m^3/s$ and they are for irrigation use only (ie: April through September). The acquisition of the licences would not result in any increase in flow since they are not being used at this time. If the Fisheries Program secured them it would prevent this water from being reallocated or their use being reactivated, further exacerbating the supply problems. The intakes for these licences are located within the spawning reach of the creek and the elimination of withdrawals from this area would be an additional benefit.

Preliminary contact with the licensee has been made and there appears to be some willingness to consider a transfer to Fisheries.

6.2 Negotiate with R. J. Bennett and Gellatly Investments Ltd. for the transfer of the remaining water licences that divert water from the spawning reach. There are two licences, C 33387 (R.J. Bennett) and F 21035 (Gellatly Investments Ltd.) with a combined peak flow of 0.0924 $m^3/s$. These licences are still in use, the licensee would require an alternate source (eg: Okanagan Lake or groundwater) as a replacement. As with those licences noted in the previous section, these are for irrigation use and therefore affect the April through September period only. The removal of the intakes from the lower reach of the creek would reduce the water extractions in this area plus eliminate the physical dangers to fish associated with intakes.

6.3 Cooperative use of the existing pumping facility from Byland's Nursery Ltd. to supply some or all of the additional water requirements. The source for this system is groundwater with some or all of the supply covered by a licence on Okanagan Lake. Although, the capacity of the system is not known, it does offer an opportunity to access water from works already in place. The availability of the supply will depend upon the plans that the nursery has for its use.

6.4 Make application for a water licence and develop a supply on Okanagan Lake. This would require a pumping facility and associated pipelines.

6.5 Make application for a water licence for additional storage in the Powers Creek watershed. This should be investigated in cooperation with the Westbank Irrigation District. The District is currently considering future plans for a major storage development in the upper watershed.

6.6 Develop groundwater well(s) near the mouth of Powers Creek to supply the supplementary water. The yield that would be required to supply all the required flow is 6 900 litres per minutes (1 800 USGPM). At present there are no wells anywhere near this capacity developed in the Powers Creek area.

## 7.0 ASSESSMENT OF ALTERNATIVES

Six alternatives have been suggested for consideration that could enhance the flows for the fishery in lower Powers Creek. In order of feasibility they are:

7.1 From an administrative consideration the transfer of the Byland's Nurseries Ltd. unused water licences (nos. C 43507 and F 21027) should be proceeded with. As discussed in the previous section these two licences do not amount to a lot of flow (0.007 $m^3$ /s) but they are not being used and the transfer to the Fisheries Program will ensure that they would not be reactivated. The point of diversion is located within the spawning reach of the creek which is undesirable. Preliminary discussions with the licensee have indicated a willingness to consider a transfer.

7.2 The opportunity to take advantage of the existing pumping facility belonging to Byland's Nurseries Ltd. should be investigated in detail. This system is licenced on Okanagan Lake and might have a capacity near what is needed to supply the fishery flows. If the nursery plans to continue to use the system, there may be some opportunity for a joint use. The advantage of this option is that the works are already in place and could be modified at a cost much less than establishing a separate system. The plans by the nursery for their lands that would be irrigated from the pump facility are not established. Prior to entering into discussions regarding the transfer or joint use it will be necessary to establish what the capacity of the works are and what additional works (ie: pipelines) would be required. If it was agreed to use the system, the Fisheries Program would have to apply for a water licence to cover their intended use.

7.3 Developing a pumping system from Okanagan Lake would be expensive but could be considered if the previous option was not available.

7.4 The use of groundwater could also be investigated. A review of the records for groundwater wells in the area indicated that of the seven identified wells, four produced water and the greatest yield was 40 GPM. The possibility of developing the required quantity is considered very low.

7.5 Developing storage in the upper watershed is a possibility but probability of prohibitive cost if it were to be carried out independently. There is a real possibility of joint venture development with the Westbank Irrigation District. The District is considering a new improvement at this time. Although there is no commitment to proceed, it is an appropriate time for the Fisheries Program to express their interest in an opportunity to be included in future discussions.

7.6 The acquisition of the water licences that remain in the spawning section of Powers Creek would not significantly improve the flows sincere their combined volume is only 0.024 $m^3/s$. However, the removal of the intakes would be a benefit to the juveniles that reside in the stream during the irrigation season and can be affected by these water withdrawals. When all the other recommendations have been addressed, this concern should not be overlooked. Since the water licences are still active any proposal to acquire them would have to include an alternate supply. This would most likely involve either the construction of a shallow groundwater gallery or an intake in Okanagan Lake (plus associated licences). Since there are pump systems already it is effectively a relocation of their point of diversion. There will be some costs associated with this but they should be manageable.

## 8.0 OPTIONS TO SATISFY SHORT TERM FLOW REQUIREMENTS

The short term is considered to be the situation at current utilization of the water licences on Powers Creek.

### 8.1 KOKANEE

The flows at current utilization for mean monthly discharges are adequate for the kokanee [refer to Table 4]. During the one in ten-year low flow event, September has a major deficit of 0.058 $m^3/s$ or 48% of the required flow [refer to Table 5]. The cost of developing an alternate supply for this one month would be very high and of questionable cost benefit. The risk of this event is one occurrence in a twenty year period, and as such, may not warrant protection.

However, over the long term the period of deficit expands with the result that a means of supplying additional flow would be more attractive. This scenario will be discussed further in section 9.1.

### 8.2 TROUT

Trout are not affected at mean monthly flows at the current level of diversion [refer to Table 8]. However during a one in ten-year low flow eight months are in deficit [refer to Table 9]. The deficits range from a low of 4% in October to a high of 100% in July and August. The total additional volume required is 1 184 $dams^3$.

As discussed in the previous section, any decision to develop the volume of water required must take into account the long term problems. In this case there are no viable short term options.

## 9.0 OPTIONS TO SATISFY THE LONG TERM REQUIREMENTS

"Long Term" implies the full development of the water licences within the watershed.

## 9.1 KOKANEE

At full utilization there would be a minor deficit in September during a normal year [refer to Table 6]. A deficit of 0.006 $m^3/s$ is 5% of the necessary flow and is considered to be within an acceptable range of fluctuation in flow that would occur naturally in the stream.

For the one in ten-year low flow scenario there are deficits for six months of the year [refer to Table 7]. They range from 15% in November to 100% in September. The month of September is critical to the kokanee since this is the time of migration into the stream. A 100% diversion of flow would mean the loss of the run for that year. Although this event has a low frequency of occurrence (once in a twenty year period), the kokanee potential for Powers Creek is the second highest for all of Okanagan Lake (Wightman and Taylor). Tredger estimates the capacity of the creek to be at least 27 000 fish at the flow of 0.120 $m^3/s$. With a run of this size there would be significant impacts should it be lost for a year or conversely, there is a significant value in protecting it.

The most attractive option would be to cooperate in the development of upstream storage with the irrigation district that would provide the flows even during a one in ten-year low flow period. This recommendation is premised on the assumption that there is sufficient flow in the upper watershed to allow for the Fisheries Program to secure the required water licence. This needs to be confirmed by the Water Management Program. The added advantage of this proposal is that there would be minimal ongoing operating costs. This is an important consideration.

In the event that the storage development does not occur, the next recommendation would be to secure a water licence on Okanagan Lake and to develop a pumping facility. A preliminary estimate of the cost for works that would provide 6 900 litres/min (1 800 USGPM) is between $150,000.00 and $200,000.00. The advantages of this option include the fact that the Fisheries Program would be in complete control of the system and that their licence, being non-consumptive, should be unaffected by low inflow to Okanagan Lake. The major disadvantages would be the initial capital cost and secondly, the ongoing operating cost. Although the capital cost may be less than for upstream storage, it is the annual operating costs that more than offset any possible short term savings between the two options.

To develop the justification for the cost of providing supplementary flows for the kokanee, it will require a thorough cost-benefit analysis of the value of this fishery. In particular the impact of an event such as the one in ten-year low flow where the probability of occurrence is low but the impact of such an event would have long term consequences.

For the long term there is only one concern and that is providing sufficient flow in the creek to sustain the fishery. The opportunities to accomplish this realistically are limited to the two options discussed.

## 9.2 TROUT

Whether or not the trout are enhanced over the long term is dependent upon the decision made for the kokanee. The impacts on the trout are significant even during normal flows at full development of the licences [refer to Table 10]. In this case there are 100% flow deficits for both July and August which would destroy this fishery since these deficits would occur annually.

During a one in ten-year low flow, the period covers all year except the spring freshet [refer to Table 11]. The significance of this scenario is meaningless if the shortfalls at the mean monthly discharge have not been addressed. If the fishery has already been destroyed due to annual low flows, further increases in the deficit make no difference.

The options to enhance the low flows for trout are the same as those for kokanee, as discussed in section 9.1. The fact that the trout fishery would benefit from a supplementary flow system improves the cost-benefit analysis. Powers Creek has been identified by the Fisheries Program as having a high potential for trout as well as kokanee. In his work on the creek carried out in 1987, Tredger estimates the capacity to be 1 300 parr at 0.120 $m^3/s$. If an alternate flow supply was developed, it is estimated that the trout would required about 700 $dams^3$ of additional water on an annual basis and about 1 800 $dams^3$ during a one in ten-year low flow. Although the deficits are greater for trout than for kokanee, if it was already decided to provide additional water for the kokanee than the trout should be included. If the cost of supplementary flow can be justified for the kokanee, the incremental increase in cost for the trout can also be justified.

## 10.0 IMPACT IF NOTHING DONE

If the decision is to leave the status quo and do nothing, the situation for the fish will deteriorate in Powers Creek as more water is diverted from the stream. For the mean monthly flow at the current utilization scenario, neither the kokanee nor the trout are affected.

In the event of a one in ten-year low flow at current utilization, the kokanee would be impacted by a 48% flow deficiency in September [refer to Table 5] which would affect both migration and spawning. This September deficit would increase to 100% even before full utilization of the licences occurs, during one in ten-year low flow events. Kokanee production, limited to October spawning, would be drastically reduced.

For the trout, the deficits during a one in ten-year low flow event would destroy any fishery in the stream, even at current licence utilization. The deficits range from a winter low of 11% in November, to 24% in January - February, to summer deficiencies of 100% in July - August and 48% in September [refer to Table 9]. These conditions would affect not only the redds but also the parr. The impact of a single year such as this expands to affect more than just the production for that one year since the parr reside in the stream for up to two years.

Over the long term the trout fishery would be reduced to a very low level if it survived at all. For the kokanee, the production would be reduced due to the inability of the system to carry large numbers of fish at low migration and spawning flows.

## 11.0 WATER CONSERVATION

Water conservation practices by water users can have a significant impact on the volume of water used for both domestic uses and agricultural uses. It was observed in 1988, when there was a risk of inadequate water supplies in a number of areas in the valley, that as a result of the careful use of water there may have been as much as a 20% reduction in demand [pers. comm. SEKID]. A study was commissioned by the Association of British Columbia Irrigation Districts to investigate the most effective means to shift from supply management to demand management. This study, which was funded by both federal and provincial governments through the ARDSA Program, was the first time that a comprehensive look will have been made into this area. The consultant investigated all possible options including metering of use and the repricing of water to better reflect its true value. The final report was due March 31, 1990.

There are two ways in which water conservation can be implemented. The first is through public education and the use of literature campaigns. Public education, at the adult level, can be effective in the short term when there is an emergency situation. Over the long term, it will not be successful. Education of children through the school system, as part of the normal curriculum has a better chance of success. If a program was developed that focused on all the grades so that water conservation became a "matter of course", over the long term, for that school generation and beyond, there may be some real gains. The pay off is in the future, it would not be immediate.

Other means of public education, such as field trips and the use of newspaper and television will have a minor short term effect but the public soon forgets or becomes insensitive to the message.

The second means of effecting water conservation is through regulation. This may indeed be the conclusion of the study being done for the A.B.C.I.D. Regulations can be developed to enforce reduced demand through regulated use or demand can be reduced through increasing the cost of water to the user. If the price on the resource is high enough it becomes self regulating.

Of the two methods, the second is most likely to be successful. The Fisheries Program could invest substantial funds in a public education campaign with the resulting benefits being very marginal. The public has a limited appreciation of the fishery resource and the impact that development is having on it. The greatest potential return may come from implementation of the A.B.C.I.D. report and investing in a public information campaign that would explain the positive aspects of conserving water on the valley fishery.

The Westbank Irrigation District has initiated their own program for water conservation. Since 1988 there has been a by-law in place that allows for the water of lawns and gardens between the hours of 6:00 P.M. and 11:00 A.M. only. This has allowed for the District to have better control on their water supply but, more important, it has reduced the consumption of water.

## 12.0 RECOMMENDATIONS

Powers Creek has both a kokanee and rainbow trout fishery that warrants enhancement. This stream is estimated to be the second most important on Okanagan Lake. The deficits for kokanee occur first during a one in ten-year low flow at the current level of use of the water licences. When the water licences are fully developed the shortfall is made worse.

The options to enhance the flows in this stream are such that either all the deficits are addressed, or none of them are, because the cost involved in developing additional water is high. If the decision is made to protect the fishery it is recommended that the volumes be sufficient to meet all the long term, identified shortages.

The opportunity to develop storage in cooperation with the Westbank Irrigation District has the benefit of minimal long term operation costs, which is an important consideration. It is recommended that discussions commence with both Water Management regarding a water licence for at least 1 800 $dams^3$ of storage in Powers Creek and with the Irrigation District regarding a joint venture project. As stated previously in this report, the Irrigation District is not committed to further storage development but its advantages are under active consideration at this time.

Whereas upstream storage may occur over the long term, for the short term it is recommended that the use of the Byland's Nurseries Ltd. pumping facility be further investigated. It may be possible to negotiate an agreement for the use of this system to provide some of the water needed. It is unlikely that these works would be appropriate for continued use over the long term since the pump would not have either the efficiency or the capacity to meet the fishery needs. However, since the system is already in place, an agreement for its use to provide water in the event of an emergency should be considered.

If the development of upstream storage is not feasible than the alternative is to pump from Okanagan Lake. This would require a water licence for the same volume as the storage, that is 1 800 $dams^3$, and a pump system with a capacity of at least 6 900 litres / minutes (1 800 USGPM). A low head, high volume pumping facility and pipelines is estimated to cost between $150,000.00 and $200,000.00 excluding any land. Although this option has the advantage of being fully controlled by the Fisheries Program, it has the disadvantage of ongoing operating costs (electricity).

In any proposal to secure the funding necessary to provide the water for the fishery, a detailed cost-benefit analysis of both a storage and a pump system will be required. It is recommended that the Fisheries Program proceed with having this work done.

The remaining options, as discussed in section 6, regarding the acquisition of existing water licences should also be proceeded with. Whether or not a licence is currently in use, it is desirable to remove intakes from the spawning reach. The combined flow of all these licences amounts to 0.035 $m^3/s$ or 25% of that required for the fish. Because there are shortages up to 100%, significant water would be required even if these licences are acquired.

A final recommendation is that the opportunities to enhance the fishery in Powers Creek as presented in this report be reviewed in conjunction with those compiled for Trepanier, Lambly, Shorts, Equesis and Mission Creeks. The best use of water must be considered since, in all likelihood, the pressures from competing uses is going to increase in Powers Creek as in most other creeks in the Okanagan Valley. It may be that the water in this stream has greater benefits for uses other than fish. There may be more efficient means of producing the same numbers of fish while using less water (eg: hatcheries). Unless there is a major change in public attitude, water for people will continue to take precedence over all other uses.

## 13.0 REFERENCES



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# APPENDIX 1

## TERMS OF REFERENCE

# POWERS CREEK

## ASSESSMENT OF ALTERNATIVES
## TO
## ENHANCE OKANAGAN LAKE FISHERY

# HABITAT CONSERVATION FUND

**Project Name:** **Okanagan Tributary Assessment**

The purpose of this contract is to explore ways of providing and securing flows for fish in six spawning streams (Mission, Powers, Trepanier, Lambly, Shorts, and Equesis Creeks) tributary to Okanagan Lake. This contract will identify and priorize what options exist for each stream. These assessments will identify both short and long term solutions to water shortages for fish. Each stream is different and, as such, has different opportunities for enhancing or maintaining flows. Most stream flows are largely committed to other licensed uses.

It is intended that these plans, when completed, would be reviewed and accepted by Water Management and endorsed by the Ministry. They would also form the basis for ongoing consultation with other water users within the watershed and possibly result in the formation of a tributary management committee that would determine flow releases.

The solution to securing and providing flows for kokanee and rainbow fall into three categories:

(1) Reserve status and use of conditional water licences. Conditional water licences may only be useful where surplus water exists.

(2) Conduct a licence survey to determine if actual use of water represents licensed amounts. The purpose of this survey is two-fold; it would alert us to problems of non-beneficial use and indicate opportunities for Fisheries to acquire senior licences from individuals who no longer have a need for them.

(3) This category would consider a number of options for increasing supply, for example, storage, pumping from Okanagan Lake, or groundwater water development. These are expensive items and our resource values must be significant to justify such expenditures.

Other options involve operating agreements with Irrigation Districts. One is presently in place with Black Mountain Irrigation District, water conservation, etc.

THE MINISTRY OF ENVIRONMENT WILL:

(1) provide minimum flow objectives for fish for each of the six streams;

(2) make available to all relevant information in our files and library;

(3) identify the reach of stream of concern; and

(4) provide access to Fisheries and Habitat staff within Ministry of Environment.

THE CONTRACTOR WILL:

( 1) prepare separate reports for each of the following six streams: Mission, Lambly, Powers, Trepanier, Shorts and Equesis. Equesis Creek flows through an Indian Reserve and any access onto reserve lands will have to be negotiated with the band. These six reports will include a summary of existing licences and projected domestic and irrigation demands and what the fisheries implications are;

( 2) include a summary of active irrigation licences and those that are not presently utilized. The purpose of this licence survey would be to alert Water Management to non-beneficial use of water and provide documentation for possible forfeiture of licences to the Crown and indicate opportunities for Fisheries to acquire senior licences directly from individuals who no longer have a need for them. Application for Transfer of Appurtency forms will be completed by the contractor and forwarded to the Habitat Section of the Ministry of Environment for processing;

( 3) include a summary of historical flow records for each stream from Surface Water Records or Irrigation Districts;

( 4) meet with the appropriate Irrigation Districts to determine their long range plans for distribution and operation and what impacts they may have on present flows;

( 5) assess the impact of Black Mountain Irrigation District's Gopher Flat proposal on flows in Mission Creek for fish;

( 6) use existing information, where it exists, to determine the most cost effective means of ensuring and providing minimum flows for fish. The information available includes, but is not restricted to, the reports given in Appendix 1;

( 7) examine and report on all reasonable cost effective options for obtaining and securing minimum flows for both kokanee and rainbow trout in each stream (flow throughout the year) for both the short term (five years) and the long term (twenty years). In addition, the contractor will determine the most cost effective way of providing flows for only kokanee (September 1st through May 31st) for each stream for the short and long term;

( 8) address consequences of failure to achieve minimum flow objectives;

( 9) negotiate operating agreements with the Irrigation Districts on Powers, Lambly and Mill Creeks similar to the agreement in place on Mission Creek with Black Mountain Irrigation District and Fisheries;

(10) identify any water conservation measures that would be effective in providing more water for fish and the costs of implementing such a program for each stream.

# APPENDIX 2

## CURRENT WATER LICENCES
## ON
## POWERS CREEK

| WATER LICENCES | | | | | |
|---|---|---|---|---|---|
| **POWERS CREEK AND TRIBUTARIES** | | | | | |
| **License No.** | **Licensee** | **Source** | **Quantity** | **Purpose** | **Remarks** |
| C 23404 | Westbank Irrigation | Lambly Cr. | 182,500,000 GY | Wwk | Permanent diversion from Bear Lake |
| C 67990 | Westbank Irrigation | N Lambly Cr | 542,944,000 GY | Wwk | See also storage from Tadpole Lake through Alocin Creek |
| C 67991 | Westbank Irrigation | Lambly Cr. | 73,300,000 GY | Wwk | See also storage Permanent diversion from Bear Lake |
| C 03778 | Westbank Irrigation | Powers Creek | 1,000 GD | Dom | See also Irrigation |
| C 14701 | Poulsen | Stevens Br. | 1,500 GD | Dom | |
| C 33388 | Scottish Cove | Powers Creek | 500 GD | Dom | See also Irrigation |
| C 41558 | Harrison | Powers Creek | 500 GD | Dom | |
| F 19711 | Stewart | Powers Creek | 500 GD | Dom | |
| F 48208 | Shoaf | Powers Creek | 500 GD | Dom | April-Sept. - see below |
| F 48209 | Shoaf | Powers Creek | (500)GD | Dom | Oct.-March - see above |
| F 48210 | Tajico Inc. | Powers Creek | 3,500 GD | Dom | April-Sept. - see below |
| F 48211 | Tajico Inc. | Powers Creek | (3,500)GD | Dom | Oct.-March - see above |
| *(C 03778)* | *Westbank Irrigation* | *Powers Creek* | *500 AF* | *Irr* | *See also Domestic* |
| C 14418 | Westbank Irrigation | Powers Creek | 87.50 AF | Irr | |
| C 15442 | Westbank Irrigation | Powers Creek | 381.25 AF | Irr | |
| C 15443 | Westbank Irrigation | Powers Creek | 728.75 AF | Irr | |
| C 15444 | Westbank Irrigation | Powers Creek | 387.50 AF | Irr | |
| C 17582 | Westbank Irrigation | Lambly Cr. | 1,305 AF | Irr | Permanent diversion from Bear Lake |
| C 33404 | Westbank Irrigation | Lambly Cr. | 1,425 AF | Irr | Permanent diversion from Bear Lake |

## WATER LICENCES

## POWERS CREEK AND TRIBUTARIES

| License No. | Licensee | Source | Quantity | Purpose | Remarks |
|---|---|---|---|---|---|
| F 11739 | Westbank Irrigation | Powers Creek | 48.25 AF | Irr | |
| F 11740 | Westbank Irrigation | Powers Creek | 56.75 AF | Irr | |
| F 11741 | Westbank Irrigation | Powers Creek | 27.50 AF | Irr | |
| F 11742 | Westbank Irrigation | Powers Creek | 14.75 AF | Irr | |
| F 11743 | Westbank Irrigation | Powers Creek | 42.00 AF | Irr | |
| F 11744 | Westbank Irrigation | Powers Creek | 9.50 AF | Irr | |
| F 11748 | Westbank Irrigation | Powers Creek | 12.50 AF | Irr | |
| F 15806 | Westbank Irrigation | Powers Creek | 32.75 AF | Irr | |
| F 15807 | Westbank Irrigation | Powers Creek | 29.25 AF | Irr | |
| F 15808 | Westbank Irrigation | Powers Creek | 26.72 AF | Irr | |
| | | | | | |
| C 33387 | Bennett | Powers Creek | 3.48 AF | Irr | |
| (C 33388) | Scottish Cove | Powers Creek | 140.40 AF | Irr | See also Domestic |
| C 43507 | Byland's Nurseries | Powers Creek | 48.0 AF | Irr | **No Use** |
| F 21027 | Byland's Nurseries | Powers Creek | 4.20 AF | Irr | **No Use** |
| F 21036 | Gellatly Ltd. | Powers Creek | 26.10 AF | Irr | |
| | | | | | |
| C 03779 | Westbank Irrigation | Powers Creek | 600 AF | Stor | In Jackpine Lake |
| C 14419 | Westbank Irrigation | Powers Creek | 180 AF | Stor | In Webber Lk - Breached |
| C 15445 | Westbank Irrigation | Powers Creek | 350 AF | Stor | In Paynter Lake |
| C 15446 | Westbank Irrigation | Powers Cr * | 500 AF* | Stor | In Islaht & Dobbin Licences - *175 AF Diversion from Alocin Creek |
| C 17583 | Westbank Irrigation | Lambly Cr. | 1,305 AF | Stor | In Lambly (Bear) Lake |
| C 33405 | Westbank Irrigation | Bit/Powers C | 450 AF | Stor | In Islaht Lake |
| C 33406 | Westbank Irrigation | Lambly Cr. | 500 AF | Stor | In Lambly Lake |
| C 49771 | Westbank Irrigation | Lambly Cr. | 755 AF | Stor | In Lambly Lake |

## WATER LICENCES

## POWERS CREEK AND TRIBUTARIES

| License No. | Licensee | Source | Quantity | Purpose | Remarks |
|---|---|---|---|---|---|
| C 56010 | Westbank Irrigation | Powers Crk * | 425* AF | Stor | In Dobbin Lake<br>*300 AF Diversion from Alocin Creek |
| (C 67990) | Westbank Irrigation | N Lambly Cr | 2,000 AF | Stor | In Tadpole Lake<br>Diversion to Powers<br>See also Waterworks |
| (C 67991) | Westbank Irrigation | Lambly Cr | 270 AF | Stor | In Lambly Lake<br>See also Waterworks |
| F 11745 | Westbank Irrigation | Powers Creek | 63 AF | Stor | In Jackpine Lake |
| F 11746 | Westbank Irrigation | Powers Creek | 42 AF | Stor | In Jackpine Lake |
| F 11747 | Westbank Irrigation | Powers Creek | 66.25 AF | Stor | In Jackpine Lake |
| F 11749 | Westbank Irrigation | Powers Creek | 12.5 AF | Stor | In Islaht Lake |
| C 64293 | Fishery Branch | Powers Creek | 3 cfs | Cons | Non-Consumptive for conservation of fish |

## WATER LICENCES - SUMMARY

## POWERS CREEK AND TRIBUTARIES

| Source | No. Lic. | Waterwrks GY | Domestic GD | Irrigation AF | Storage AF | Conserv. cfs | Remarks |
|---|---|---|---|---|---|---|---|
| Powers Creek | 36 | - | 6,500 | 2,607.15 | 2,238.75 | 3 | Two Licences Domestic and Irrigation |
| Bit / Powers Creeks | 1 | - | - | - | 450 | - | Diversion within Powers Watershed |
| Stevens Brook | 1 | - | 1,500 | - | - | - | - |
| Lambly Creek | 7 | 255,800,000 | - | 2,730 | 2,830 | - | Permanent Diversion |
| N. Lambly Creek | 1 | 542,944,000 | - | - | 2,000 | - | Diversion 1 April to 30 June |
| Alocin Creek | (2) | - | - | - | (475) | - | Diversion from Nicola w'shed |
| TOTALS | 46 | 798,744,000 | 8,000 | 5,337.15 | 7,518.75 | 3 | 8,000 GD x 355 = 2,920,000 GY |
| Peak Day Equiv. (cfs) | | 12.16 | 0.015 | 26.96 | 37.97 | 3 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Totals in Metric | 3,631,162 $m^3/y$ | 13,275 $m^3/y$ | 6,583 $dam^3/y$ | 9,274 $dams^3/y$ | | |
| Peak-Day Flows in Metric | 0.345 $m^3/s$ | 0.001 $m^3/s$ | 0.763 $m^3/s$ | 1.075 $m^3/s$ | 0.085 $m^3/s$ | |

**NOTE:** Figures in (parenthesis) are not included in totals

# APPENDIX 3

## HYDROMETRIC DATA
## for
## POWERS CREEK

# HYDROMETRIC DATA FOR POWERS CREEK

POWERS CREEK ABOVE WESTBANK DIVERSION - STATION NO. 08NM022

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1920 | --- | --- | --- | --- | 2.12 | 1.56 | 0.298 | 0.141 | --- | --- | --- | --- | --- | 1920 |
| 1921 | --- | --- | --- | --- | --- | 2.47 | 0.312 | 0.129 | --- | --- | --- | --- | --- | 1921 |
| 1922 | --- | --- | --- | --- | --- | 3.46 | 0.224 | --- | --- | --- | --- | --- | --- | 1922 |
| 1966 | --- | --- | --- | --- | --- | --- | --- | 0.226 | --- | --- | --- | --- | --- | 1966 |
| 1967 | --- | --- | --- | --- | 2.91 | 1.88 | --- | --- | --- | --- | --- | --- | --- | 1967 |
| 1968 | --- | --- | --- | --- | --- | 2.16 | 0.572 | 0.625 | --- | --- | --- | --- | --- | 1968 |
| 1969 | --- | --- | --- | --- | --- | 0.856 | 0.941 | 0.532 | 0.200 | --- | --- | --- | --- | 1969 |
| 1970 | --- | --- | --- | 0.253 | 1.86 | 0.976 | 0.664 | 0.457 | 0.193 | --- | --- | --- | --- | 1970 |
| 1971 | --- | --- | --- | 0.534 | 5.02 | 2.32 | 0.861 | 0.563 | 0.229 | --- | --- | --- | --- | 1971 |
| 1972 | --- | --- | --- | 1.03 | 7.20 | 3.75 | 0.527 | 0.536 | 0.319 | --- | --- | --- | --- | 1972 |
| 1973 | --- | --- | --- | 0.577 | 2.49 | 0.807 | 0.533 | 0.510 | 0.338 | --- | --- | --- | --- | 1973 |
| 1974 | --- | --- | --- | 2.89 | 7.55 | 4.92 | 0.664 | 0.542 | 0.524 | --- | --- | --- | --- | 1974 |
| MEAN | --- | --- | --- | 1.06 | 4.14 | 2.29 | 0.564 | 0.458 | 0.317 | --- | --- | --- | --- | MEAN |

LOCATION - LAT 49 51 31 N DRAINAGE AREA, 128 km²
LONG 119 40 13 W NATURAL FLOW

POWERS CREEK WESTBANK DIVERSION - STATION NO. 08NM034

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

| YEAR | MAXIMUM INSTANTANEOUS DISCHARGE ($m^3/s$) | MAXIMUM DAILY DISCHARGE ($m^3/s$) | MINIMUM DAILY DISCHARGE ($m^3/s$) | TOTAL DISCHARGE ($dam^3$) | YEAR |
|---|---|---|---|---|---|
| 1920 | --- | --- | 0 ON MAY 1 * | --- | 1920 |
| 1921 | --- | --- | --- | --- | 1921 |
| 1922 | --- | 0.110 ON JUN 23 | 0 ON JUL 23 | --- | 1922 |
| 1923 | --- | --- | 0 ON MAY 1 | --- | 1923 |
| 1924 | --- | 0.269 ON MAY 9 | 0 ON JUN 28 | --- | 1924 |
| 1925 | --- | --- | --- | --- | 1925 |
| 1926 | --- | 0.235 ON AUG 6 | 0 ON AUG 22 | --- | 1926 |
| 1927 | --- | --- | --- | --- | 1927 |
| 1928 | --- | 0.266 ON JUL 3 * | 0 ON APR 1 | --- | 1928 |
| 1929 | --- | 0.269 ON JUN 10 | 0 ON APR 1 | --- | 1929 |
| 1930 | --- | 0.249 ON JUN 8 | 0 ON APR 1 | --- | 1930 |
| 1931 | --- | 0.260 ON JUL 1 | 0 ON APR 1 | --- | 1931 |
| | | * - EXTREME RECORDED FOR THE PERIOD OF RECORD | | --- | MEAN |

POWERS CREEK BELOW WESTBANK DIVERSION - STATION NO. 08NM085

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1924 | ... | ... | ... | ... | 3.86 | 0.368 | 0.068 | 0.088 | ... | ... | ... | ... | ... | 1924 |
| 1926 | ... | ... | ... | ... | 3.81 | 0.474 | 0.061 | 0.020 | ... | ... | ... | ... | ... | 1926 |
| 1927 | ... | ... | ... | 1.02 | 3.01 | 1.60 | 0.142 | 0.106 | 0.267 | ... | ... | ... | ... | 1927 |
| 1965 | ... | ... | ... | ... | ... | ... | ... | 0.076 | 0.027 | 0.018 | 0.027 | 0.042 | ... | 1965 |
| 1966 | 0.041 | 0.032 | 0.220 | 0.568 | 1.63 | 0.307 | 0.111 | 0.057 | 0.026 | 0.012 | 0.044 | 0.063 | 0.262 | 1966 |
| 1967 | 0.066 | 0.100 | 0.095 | 0.581 | 3.23 | 1.68 | 0.061 | 0.020 | 0.006 | 0.017 | 0.072 | 0.063 | 0.515 | 1967 |
| 1968 | 0.116 | 0.177 | 0.480 | 0.560 | 3.81 | 2.03 | 0.236 | 0.361 | 0.151 | 0.132 | 0.175 | 0.073 | 0.676 | 1968 |
| 1969 | 0.031 | 0.025 | 0.127 | 2.04 | 4.09 | 0.853 | 0.200 | 0.133 | 0.100 | 0.064 | 0.107 | 0.060 | 0.640 | 1969 |
| 1970 | 0.075 | 0.073 | 0.122 | 0.268 | 1.76 | 0.567 | 0.160 | 0.112 | 0.077 | 0.051 | 0.164 | 0.023 | 0.281 | 1970 |
| 1971 | 0.030 | 0.075 | 0.058 | 0.698 | 5.27 | 2.66 | 0.366 | 0.120 | 0.202 | 0.043 | 0.062 | 0.051 | 0.806 | 1971 |
| 1972 | 0.026 | 0.030 | 0.402 | 1.04 | 5.64 | 3.16 | 0.364 | 0.166 | 0.163 | 0.047 | 0.029 | 0.027 | 1.03 | 1972 |
| 1973 | 0.064 | 0.025 | 0.057 | 0.421 | 1.82 | 0.523 | 0.133 | 0.160 | 0.152 | 0.064 | 0.103 | 0.176 | 0.300 | 1973 |
| 1974 | 0.222 | 0.208 | 0.364 | 3.21 | 7.16 | 4.34 | 0.648 | 0.226 | 0.362 | 0.136 | 0.065 | 0.036 | 1.41 | 1974 |
| 1975 | 0.042 | 0.040 | 0.074 | 0.802 | 5.36 | 3.67 | 0.215 | 0.210 | 0.143 | 0.145 | 0.058 | 0.058 | 0.803 | 1975 |
| 1976 | 0.084 | 0.040 | 0.066 | 0.646 | 5.71 | 1.56 | 0.326 | 1.26 | 0.516 | 0.350 | 0.372 | 0.330 | 0.864 | 1976 |
| 1977 | 0.210 | 0.105 | 0.063 | 0.571 | 0.958 | 0.267 | 0.236 | 0.229 | 0.162 | 0.053 | 0.067 | 0.121 | 0.283 | 1977 |
| 1978 | 0.104 | 0.121 | 0.508 | 1.77 | 4.84 | 1.46 | 0.213 | 0.103 | 0.322 | 0.203 | 0.310 | 0.276 | 0.673 | 1978 |
| 1979 | 0.170 | 0.150 | 0.176 | 0.842 | 2.40 | 0.307 | 0.221 | 0.160 | 0.071 | 0.061 | 0.068 | 0.026 | 0.376 | 1979 |
| 1980 | 0.011 | 0.024 | 0.057 | 1.06 | 2.97 | 0.526 | 0.106 | 0.146 | 0.217 | 0.137 | 0.132 | 0.066 | 0.536 | 1980 |
| 1981 | 0.108 | 0.148 | 0.231 | 0.706 | 3.21 | 1.03 | 0.267 | 0.233 | 0.227 | 0.309 | 0.133 | 0.090 | 0.561 | 1981 |
| 1982 | 0.062 | 0.119 | 0.218 | 0.724 | 5.00 | ... | ... | ... | 0.318 | 0.276 | 0.063 | 0.164 | ... | 1982 |
| 1983 | ... | ... | 0.679 | 0.964 | 0.969 | 1.19 | 0.423 | 0.109 | ... | ... | ... | ... | ... | 1983 |
| 1984 | ... | ... | ... | 1.17 | 4.16 | 3.12 | 0.268 | 0.160 | 0.210 | 0.136 | ... | ... | ... | 1984 |
| 1985 | 0.037 | 0.023 | 0.072 | 0.562 | 2.06 | 0.516 | 0.062 | 0.093 | 0.066 | 0.064 | 0.038 | 0.030 | 0.307 | 1985 |
| 1986 | 0.036 | 0.048 | 0.226 | 0.663 | 3.06 | 0.641 | 0.310 | 0.171 | 0.140 | 0.092 | 0.061 | 0.051 | 0.501 | 1986 |
| 1987 | 0.048 | 0.047 | 0.328 | 1.63 | 3.03 | 0.279 | ... | ... | ... | ... | ... | ... | ... | 1987 |
| MEAN | 0.077 | 0.061 | 0.230 | 1.02 | 3.86 | 1.40 | 0.225 | 0.199 | 0.161 | 0.115 | 0.106 | 0.084 | 0.530 | MEAN |

LOCATION - LAT 49 50 27 N DRAINAGE AREA, 130 km²
LONG 119 39 06 W REGULATED

POWERS CREEK BELOW WESTBANK DIVERSION - STATION NO. 08NM085

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

| YEAR | MAXIMUM INSTANTANEOUS DISCHARGE ($m^3/s$) | MAXIMUM DAILY DISCHARGE ($m^3/s$) | MINIMUM DAILY DISCHARGE ($m^3/s$) | TOTAL DISCHARGE ($dam^3$) | YEAR |
|---|---|---|---|---|---|
| 1924 | ... | 8.34 ON MAY 13 | ... | ... | 1924 |
| 1926 | ... | 6.23 ON MAY 14 | ... | ... | 1926 |
| 1927 | ... | 6.66 ON MAY 17 | ... | ... | 1927 |
| 1965 | ... | ... | ... | ... | 1965 |
| 1966 | ... | 4.03 ON MAY 7 | 0.003 ON JUN 30 | 8 300 | 1966 |
| 1967 | ... | 6.13 ON MAY 21 | 0.0068 ON JUL 14 | 16 200 | 1967 |
| 1968 | ... | 7.11 ON MAY 21 | 0.007 ON NOV 28 | 21 400 | 1968 |
| 1969 | ... | 6.76 ON MAY 9 | 0 ON AUG 7 * | 20 100 | 1969 |
| 1970 | ... | 3.17 ON JUN 5 | 0.004 ON OCT 7 | 9 100 | 1970 |
| 1971 | ... | 10.2 ON MAY 13 | 0.0008 ON OCT 13 | 25 500 | 1971 |
| 1972 | ... | 10.1 ON MAY 29 | 0.020 ON NOV 27 | 32 600 | 1972 |
| 1973 | ... | 4.07 ON MAY 24 | 0.0128 ON OCT 4 | 9 740 | 1973 |
| 1974 | ... | 9.60 ON MAY 26 | 0 ON OCT 16 | 44 500 | 1974 |
| 1975 | ... | 12.8 ON JUN 1 * | 0.011 ON NOV 16 | 31 300 | 1975 |
| 1976 | ... | 6.52 ON MAY 11 | 0.0260 ON FEB 20 | 30 500 | 1976 |
| 1977 | ... | 2.41 ON MAY 3 | 0 ON SEP 13 | 8 300 | 1977 |
| 1978 | ... | 9.66 ON MAY 15 | 0.013 ON JUN 28 | 27 500 | 1978 |
| 1979 | ... | 7.02 ON MAY 6 | 0.007 ON SEP 6 | 11 800 | 1979 |
| 1980 | ... | 6.14 ON MAY 5 | 0.0058 ON JAN 6 | 17 000 | 1980 |
| 1981 | ... | 4.83 ON MAY 29 | 0.005 ON JUL 28 | 17 700 | 1981 |
| 1982 | ... | ... | ... | ... | 1982 |
| 1983 | ... | 2.26 ON MAR 10 | ... | ... | 1983 |
| 1984 | ... | 9.66 ON MAY 30 | ... | ... | 1984 |
| 1985 | 5.06 AT 22:48 PST ON MAY 24 | 4.29 ON MAY 24 | 0.008 ON NOV 11 | 9 680 | 1985 |
| 1986 | 8.63 AT 01:26 PST ON MAY 26 | 7.07 ON MAY 26 | 0.012 ON JAN 11 | 16 800 | 1986 |
| 1987 | 10.8 AT 02:36 PST ON MAY 1 * | 8.00 ON MAY 1 | ... | ... | 1987 |
| MEAN | | | | 18 900 | MEAN |

B - ICE CONDITIONS * - EXTREME RECORDED FOR THE PERIOD OF RECORD
E - ESTIMATED

POWERS CREEK WESTBANK DIVERSION - STATION NO. 08NM034

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1920 | ... | ... | ... | ... | 0.025 | 0.053 | 0.080 | 0.081 | ... | ... | ... | ... | ... | 1920 |
| 1921 | ... | ... | ... | ... | 0.046 | 0.071 | 0.086 | 0.062 | ... | ... | ... | ... | ... | 1921 |
| 1922 | ... | ... | ... | ... | ... | 0.097 | 0.063 | 0.050 | ... | ... | ... | ... | ... | 1922 |
| 1923 | ... | ... | ... | ... | 0.092 | 0.132 | 0.176 | 0.100 | ... | ... | ... | ... | ... | 1923 |
| 1924 | ... | ... | ... | ... | 0.206 | 0.170 | 0.137 | 0.094 | ... | ... | ... | ... | ... | 1924 |
| 1925 | ... | ... | ... | ... | 0.162 | 0.168 | 0.213 | 0.187 | ... | ... | ... | ... | ... | 1925 |
| 1926 | ... | ... | ... | ... | 0.200 | 0.215 | 0.160 | 0.085 | ... | ... | ... | ... | ... | 1926 |
| 1927 | ... | ... | ... | ... | ... | 0.220 | 0.234 | 0.222 | ... | ... | ... | ... | ... | 1927 |
| 1928 | ... | ... | ... | 0 | 0.062 | 0.192 | 0.234 | 0.210 | 0 | ... | ... | ... | ... | 1928 |
| 1929 | ... | ... | ... | 0.027 | 0.207 | 0.230 | 0.206 | 0.115 | 0 | ... | ... | ... | ... | 1929 |
| 1930 | ... | ... | ... | 0.063 | 0.104 | 0.220 | 0.218 | 0.100 | 0.011 | ... | ... | ... | ... | 1930 |
| 1931 | ... | ... | ... | 0.023 | 0.221 | 0.263 | 0.234 | 0.218 | 0.001 | ... | ... | ... | ... | 1931 |
| MEAN | ... | ... | ... | 0.026 | 0.144 | 0.173 | 0.172 | 0.136 | 0.003 | ... | ... | ... | ... | MEAN |

LOCATION - LAT 49 51 15 N
LONG 119 40 02 W REGULATED

POWERS CREEK ABOVE WESTBANK DIVERSION - STATION NO. 08NM033

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

| YEAR | MAXIMUM INSTANTANEOUS DISCHARGE ($m^3/s$) | MAXIMUM DAILY DISCHARGE ($m^3/s$) | MINIMUM DAILY DISCHARGE ($m^3/s$) | TOTAL DISCHARGE ($dam^3$) | YEAR |
|---|---|---|---|---|---|
| 1920 | ... | 3.17 ON MAY 17 | ... | ... | 1920 |
| 1921 | ... | ... | ... | ... | 1921 |
| 1922 | ... | 14.2 ON MAY 31 * | ... | ... | 1922 |
| 1966 | ... | ... | 0 ON SEP 15 * | ... | 1966 |
| 1967 | ... | 4.26 ON MAY 30 | ... | ... | 1967 |
| 1968 | ... | 5.72 ON MAY 22 | ... | ... | 1968 |
| 1969 | ... | ... | 0.110 ON SEP 26 | ... | 1969 |
| 1970 | ... | 2.56 ON JUN 5 | 0.008 ON SEP 30 | ... | 1970 |
| 1971 | ... | 11.3 E ON MAY 13 | 0.113 ON SEP 20 | ... | 1971 |
| 1972 | ... | 11.5 ON MAY 31 | 0.102 ON SEP 30 | ... | 1972 |
| 1973 | ... | 5.16 ON MAY 25 | 0.085 ON SEP 30 | ... | 1973 |
| 1974 | ... | 10.5 ON MAY 6 | 0.536 ON SEP 30 | ... | 1974 |
| | | | | ... | MEAN |

* - EXTREME RECORDED FOR THE PERIOD OF RECORD

E - ESTIMATED

POWERS CREEK AT THE MOUTH - STATION NO. 08NM157

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

| YEAR | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC | MEAN | YEAR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1969 | ... | ... | ... | ... | ... | ... | 0.212 | 0.150 | 0.146 | 0.094 | 0.141 | 0.130 | ... | 1969 |
| 1970 | 0.117 | 0.120 | 0.151 | 0.253 | 1.46 | 0.882 | 0.175 | 0.132 | 0.141 | 0.095 | 0.175 | 0.073 | 0.294 | 1970 |
| 1971 | 0.073 | 0.157 | 0.106 | 0.623 | 5.82 | 2.18 | 0.390 | 0.151 | 0.166 | 0.088 | 0.106 | 0.089 | 0.620 | 1971 |
| 1972 | 0.064 | 0.075 | 0.465 | 0.950 | 8.02 | 4.36 | 0.430 | 0.226 | 0.243 | 0.134 | 0.136 | 0.090 | 1.26 | 1972 |
| 1973 | 0.060 | 0.065 | 0.126 | 0.437 | 1.99 | 0.560 | 0.146 | 0.207 | 0.174 | 0.120 | 0.142 | 0.143 | 0.364 | 1973 |
| 1974 | 0.369 | 0.309 | 0.361 | 2.61 | 7.82 | 4.72 | 0.636 | 0.261 | 0.364 | 0.109 | 0.121 | 0.111 | 1.50 | 1974 |
| 1975 | 0.099 | 0.097 | 0.116 | 0.651 | 6.06 | 4.13 | 0.263 | ... | ... | ... | ... | ... | ... | 1975 |
| 1976 | 0.139 | 0.116 | 0.121 | 0.721 | 5.42 | 1.62 | 0.361 | 1.10 | 0.947 | 0.358 | 0.373 | 0.333 | 0.934 | 1976 |
| 1977 | 0.200 | 0.109 | 0.114 | 0.567 | 0.916 | 0.336 | 0.216 | 0.168 | 0.169 | 0.112 | 0.162 | 0.172 | 0.274 | 1977 |
| 1978 | 0.148 | 0.159 | 0.805 | 2.02 | 5.80 | 1.80 | 0.274 | 0.264 | 0.336 | 0.267 | 0.269 | 0.260 | 1.00 | 1978 |
| 1979 | 0.163 | 0.179 | 0.212 | 0.432 | 2.40 | 0.398 | 0.230 | 0.237 | 0.230 | 0.133 | 0.088 | 0.077 | 0.404 | 1979 |
| 1980 | 0.051 | 0.053 | 0.114 | 1.84 | 3.15 | 0.647 | 0.263 | 0.216 | 0.317 | 0.165 | 0.173 | 0.154 | 0.582 | 1980 |
| 1981 | 0.167 | 0.155 | 0.269 | 0.947 | 3.03 | 0.862 | 0.275 | 0.275 | 0.354 | 0.316 | 0.176 | 0.131 | 0.563 | 1981 |
| 1982 | 0.082 | 0.171 | 0.201 | 0.836 | 6.81 | 1.76 | 1.30 | 0.317 | 0.366 | 0.347 | 0.087 | 0.206 | 1.04 | 1982 |
| MEAN | 0.137 | 0.137 | 0.222 | 0.893 | 4.50 | 1.84 | 0.358 | 0.260 | 0.270 | 0.168 | 0.167 | 0.152 | 0.757 | MEAN |

LOCATION - LAT 49 46 54 N DRAINAGE AREA, 144 $km^2$
LONG 119 37 40 W REGULATED

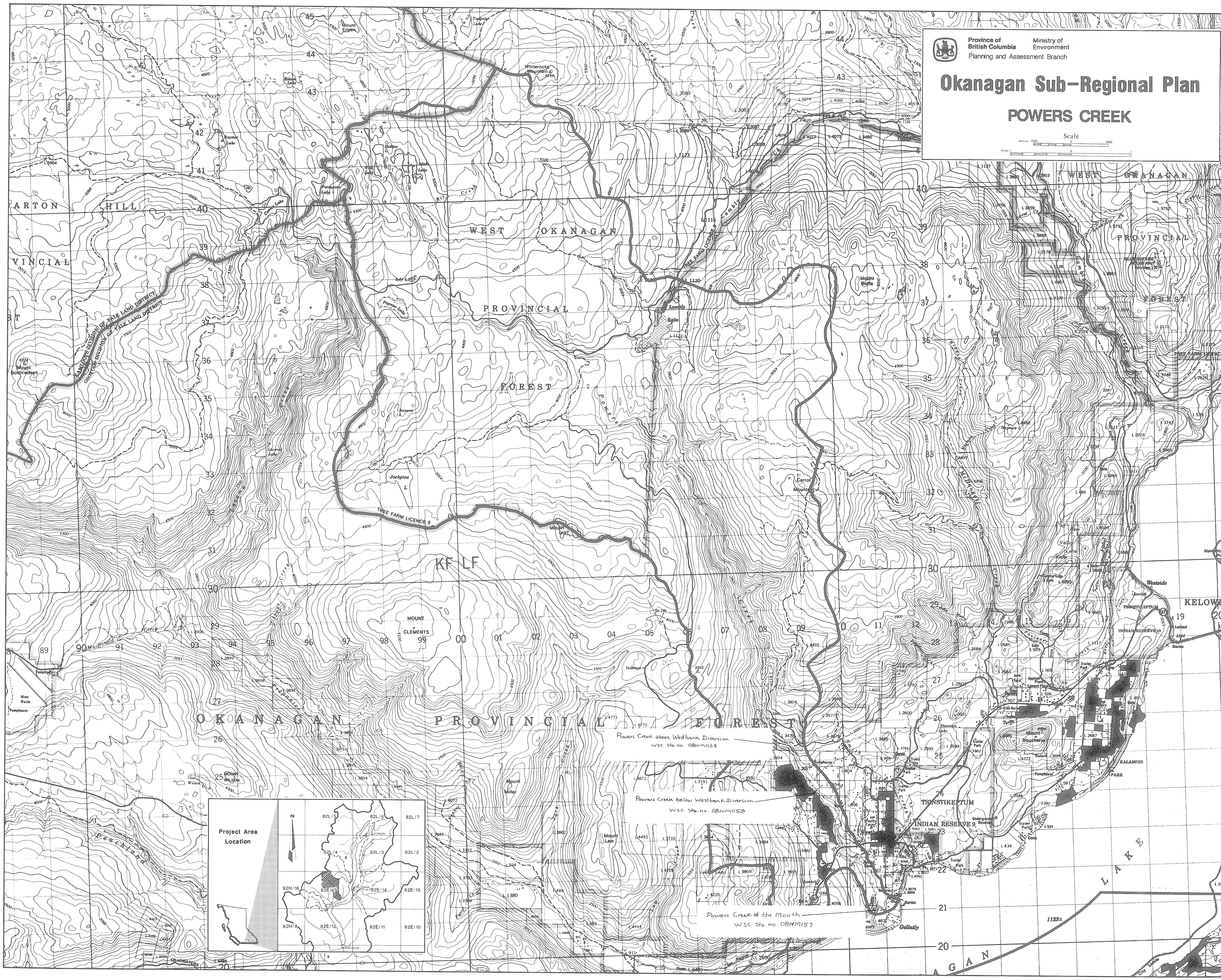
POWERS CREEK AT THE MOUTH - STATION NO. 08NM157

ANNUAL EXTREMES OF DISCHARGE AND ANNUAL TOTAL DISCHARGE FOR THE PERIOD OF RECORD

| YEAR | MAXIMUM INSTANTANEOUS DISCHARGE ($m^3/s$) | MAXIMUM DAILY DISCHARGE ($m^3/s$) | MINIMUM DAILY DISCHARGE ($m^3/s$) | TOTAL DISCHARGE ($dam^3$) | YEAR |
|---|---|---|---|---|---|
| 1969 | ... | ... | 0.036 ON SEP 12 * | ... | 1969 |
| 1970 | ... | 4.05 ON JUN 4 | 0.071 ON NOV 25 | 9 250 | 1970 |
| 1971 | ... | 14.2 E ON MAY 13 | 0.0620 ON JAN 12 | 26 200 | 1971 |
| 1972 | ... | 14.4 ON MAY 30 * | 0.059 ON JAN 30 | 40 500 | 1972 |
| 1973 | ... | 5.30 ON MAY 24 | 0.0570 ON JAN 10 | 11 100 | 1973 |
| 1974 | ... | 13.6 ON MAY 26 | 0.068 ON DEC 2 | 47 300 | 1974 |
| 1975 | ... | 14.0 ON JUN 4 | ... | ... | 1975 |
| 1976 | ... | 8.80 ON MAY 10 | 0.062 ON FEB 20 | 29 500 | 1976 |
| 1977 | ... | 1.84 ON MAY 3 | 0.057 ON AUG 19 | 8 620 | 1977 |
| 1978 | ... | 9.40 ON MAY 15 | 0.122 ON JUL 10 | 31 500 | 1978 |
| 1979 | ... | 3.51 ON MAY 4 | 0.055 ON NOV 14 | 12 700 | 1979 |
| 1980 | ... | 5.86 ON MAY 7 | 0.0420 ON JAN 27 | 18 700 | 1980 |
| 1981 | ... | 5.04 ON MAY 15 | 0.076 ON JAN 14 | 18 400 | 1981 |
| 1982 | ... | 14.0 R ON MAY 26 | 0.067 ON NOV 1 | 32 700 | 1982 |
| | | | | 23 900 | MEAN |

B - ICE CONDITIONS
E - ESTIMATED
* - EXTREME RECORDED FOR THE PERIOD OF RECORD
R - REVISED SINCE JAN 01 1987

FIGURE 2




POWERS"