The Koksilah River: Streamflows and Salmon Production

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THE KOKSILAH RIVER:

STREAMFLOWS AND SALMON PRODUCTION

by

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ABSTRACT

Critically low summer streamflows occur annually in areas of prime fish habitats in the Koksilah River watershed. This occurrence, typical of most east coast Vancouver Island streams, coupled with elevated water temperatures and demand for water for irrigation, domestic and industrial purposes, threatens the long-term production of coho salmon.

A major fishway was constructed in 1980 at Marble Falls in an attempt to provide salmon access to some upper reaches of the watershed. The Water Management Branch of the Provincial Ministry of the Environment has deferred issuance of water licences since November 5, 1980, pending a review of fisheries concerns. This report contains a summary of the documented fisheries of the Koksilah watershed. The Department of Fisheries and Oceans recommends that a cooperative interagency water management plan be developed to balance the current and future demand for water with the available options for supply.

Specific recommendations are as follows:

1. An objective of 15 c.f.s. as a minimum summer streamflow* to maintain the fisheries resource in the mainstem Koksilah River (measured below Kelvin Creek confluence).

2. All water licences for consumptive use from the Koksilah River and especially the Kelvin/Glenora systems should be reviewed. Delinquent or inactive licences should be revoked and licenced amounts recorded and verified as to actual consumption.

3. A review of headwater storage potential for summer release should be undertaken as part of an overall water management plan.

---

*The current licenced flow of approximately 11 cfs should be provided as summer storage if feasible.

4. Any future granting of water licences should occur only if off stream storage is possible.

5. A coho colonization program targeted for inaccessible headwater habitats would offset stock losses due to low flows.

6. An annual coho coho fry salvage and transplant from chronic summer low flow zones would be one method of colonizing inaccessible rearing habitats and offsetting losses due to dewatering. A coordinated Departmental program with the Cowichan Hatchery could greatly increase the flexibility of any coho colonization strategies if such a strategy can be carried out with a positive benefit /cost.

Resumé

Chaque été, le débit des cours d'eau devient dangereusement faible dans les secteurs qui constituent les principaux habitats du poisson du bassin versant de la riviére Koksilah. Ce phénomène, caractéristique de la plupart des cours d'eau de la côte est de l'Île Vancouver, lié à des températures d'eau élevées et à long terme de saumons cohos.

On a construit une grande échelle à poisson à Marble Falls en 1980, afin de permettre au saumon d'avoir accés aux tronçons supérieurs du bassin versant. La Direction de la gestion des eaux du ministére provincial de l'Environnment reporte la délivrance de permis d'utilisation de l'eau depuis le 5 novembre 1980, en attendant qu'une étude soit faite sur les statistiques sur les pêches dans le bassin versant de la riviére Koksilah. Le ministére des Pèches et des Océans recommande qu'un plan coopératif de gestion des eaux soit élaboré entre les organismes pour coopératif de demande actuelle et future, et que les choix disponibles pour l'approvisionnement soient indiqués.

Recommandations précises:

1. Objectif concernant le débitr estival minimum: 15 pi^3/s pour maintenir la ressource halieutique dans le bras principal de la riviére Koksilah (mesuré en aval du point de jonction avec le ruisseau Kelvin).

2. Tous les permis d'utilisation de l'eau de la riviére Koksilah, et particuliérement des bassins Kelvin et Glenora, à des fins de consommation, davraient être revus. Les permis échus ou non utilisés devraient être annulés et le quantités autorisées consignées et vérifiées relativement â la consommation réelle.

   *Le débit actuel autorisé d'environ 11 $pi^3/$ devrait, si cela est possible, servir à emmagasiner l'eau pendant l'été.

3. Une étude de la capacité d'emmagasinage de L,eau aux sources des riviéres pour mise en circulation pendant l'été devrait être entreprise dans le cadre d'un plan global de gestion des eaux.

4. On ne devrait à l'avenir octroyer de permis d'utilisation de l'eau que s'il est possible d'emmagasiner celle-ci en dehors des cours d'eau.

5. Un programme de colonisation par le saumon coho d'habitats inaccessibles à la téte des riviéres contrebalancerait les pertes de stock attribuables à de faibles débits et se traduirait par la production accrue de saumons cohos.

6. La récupération annuelle des alevins de saumon coho et leur transplantation à partir de zones caractérisées par un débit de faiblesse chronique pendant l'été serait une méthode de coloniser les habitats d'élevage inacessibles et de compenser les pertes dues à l'asséchement. Un programme coordonné avec la piscifacture Cowichan pourrait donner beaucoup plus de souplesse à toute stratégie de colonisation par les saumons cohos.

1.0 Introduction

1.1 Watershed Description

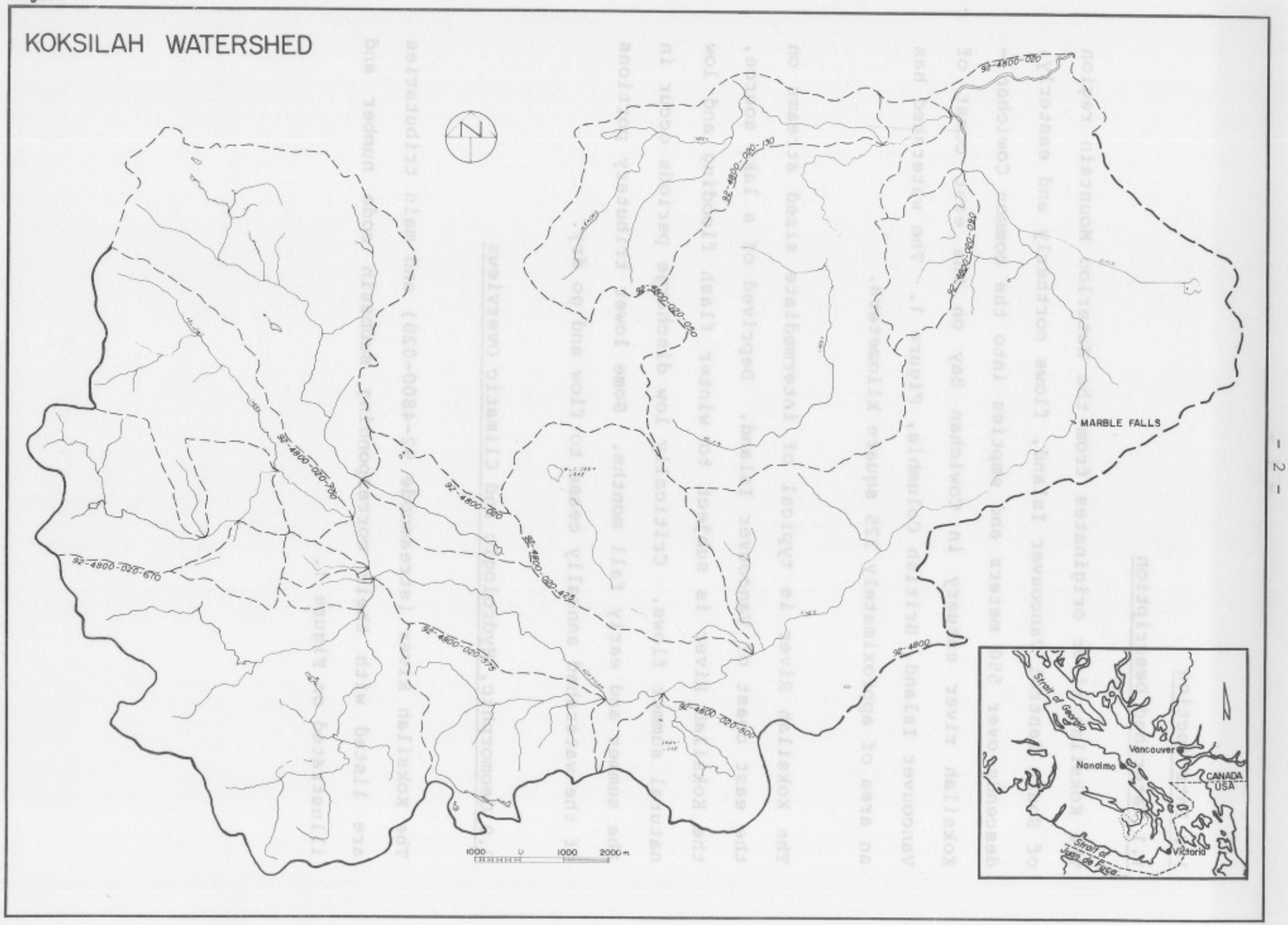
The Koksilah river originates from the Waterloo Mountain region of South Central Vancouver Island, flows northerly and easterly, descends over 550 meters and empties into the common Cowichan - Koksilah river estuary in Cowichan Bay on the east coast of Vancouver Island, British Columbia, Figure 1. The watershed has an area of approximately 325 square kilometers.

The Koksilah River is typical of intermediate sized streams on the east coast of Vancouver Island. Deprived of a lake source, the Koksilah River is subject to winter flash flooding and low natural summer flows. Critically low discharge periods occur in the summer and early fall months. Some lower tributary portions of the watershed annually cease to flow and go dry.

2.0 Geomorphic, Hydrologic and Climatic Overviews

The Koksilah River (streamcode 92-4800-020) and main tributaries are listed with their corresponding subbasin code number and illustrated on Figure 1.

Figure 1

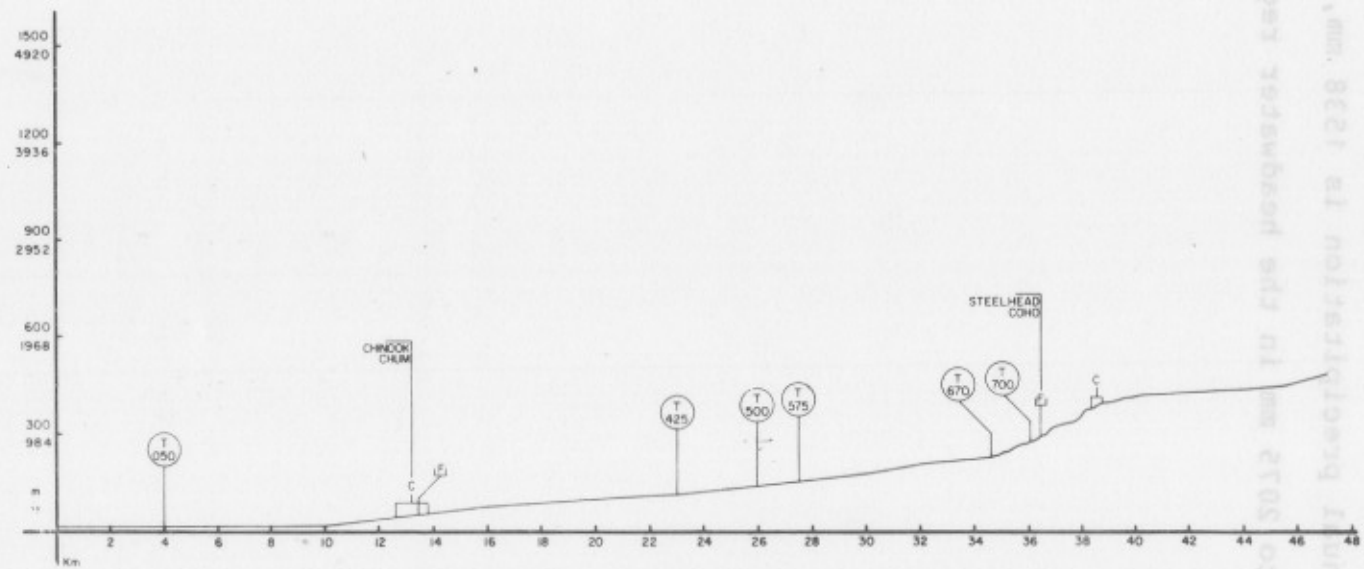

KOKSILAH WATERSHED
92-4800-020
92-4800-020-130
92-4800-020-250
92-4800-020-290
92-4800-020-700
92-4800-020-760
92-4800-020-425
92-4800-020-670
92-4800-020-575
92-4800-020-500
92-4800
MARBLE FALLS
N
1000 0 1000 2000 m
Strait of Georgia
Vancouver
Nanaimo
CANADA
USA
Victoria
Strait of Juan de Fuca

A stream gradient profile of the mainstem Koksilah and its tributary confluences are contained in Figure 2. The Koksilah River Watershed contains two lakes; Wild Deer and Grant of 12 and 70 acres respectively.

Average annual precipitation is 1538 mm, varying from 1000 mm at sea level to 2075 mm in the headwater region.

Figure 2

CHANNEL GRADIENT PROFILE



KOKSILAH RIVER
MAINSTEM PROFILE
42-4800-020

LEGEND

- Cascade Obstruction
- Obstruction
  - F Falls
  - R Rock
  - D Dam
  - Bd Beaver Dam
- Log Jam
- SEP Project Proposal
- DFO Information Source Dept. Fisheries and Oceans
- Lake
- Wetland
- Point of Difficult Passage

The extreme air temperature recorded during the previous 62 years by Atmospheric Environment Service was 35.6°C at Cowichan Bay. Historical streamflow data are available for the Water Survey of Canada Gauging Station #08HA003 at Cowichan Station recording the drainage from a 209 sq km catchment area, see Appendix I. Figure 3 displays the mean monthly discharge for the period of record. In 1981, a second gauging station #08HA045 was installed below the Kelvin Creek confluence.

2.1 Summary of Water Licences

Bryden (1978) summarized the current water licenses (now amended to February 1, 1981) from the Koksilah River and its tributaries.

Direct withdrawal from the Koksilah River:

Purpose	Amount	
Waterworks	0	= 0 cfs
Domestic	13,000 gpd (0.03 cfs)	= .02 cfs
Industrial	2 cfs (2.00 cfs)	= 2.0 cfs
Irrigation	463.2 acrefeet (2.34 cfs)	= 2.34 cfs
		Total = 4.36 cfs

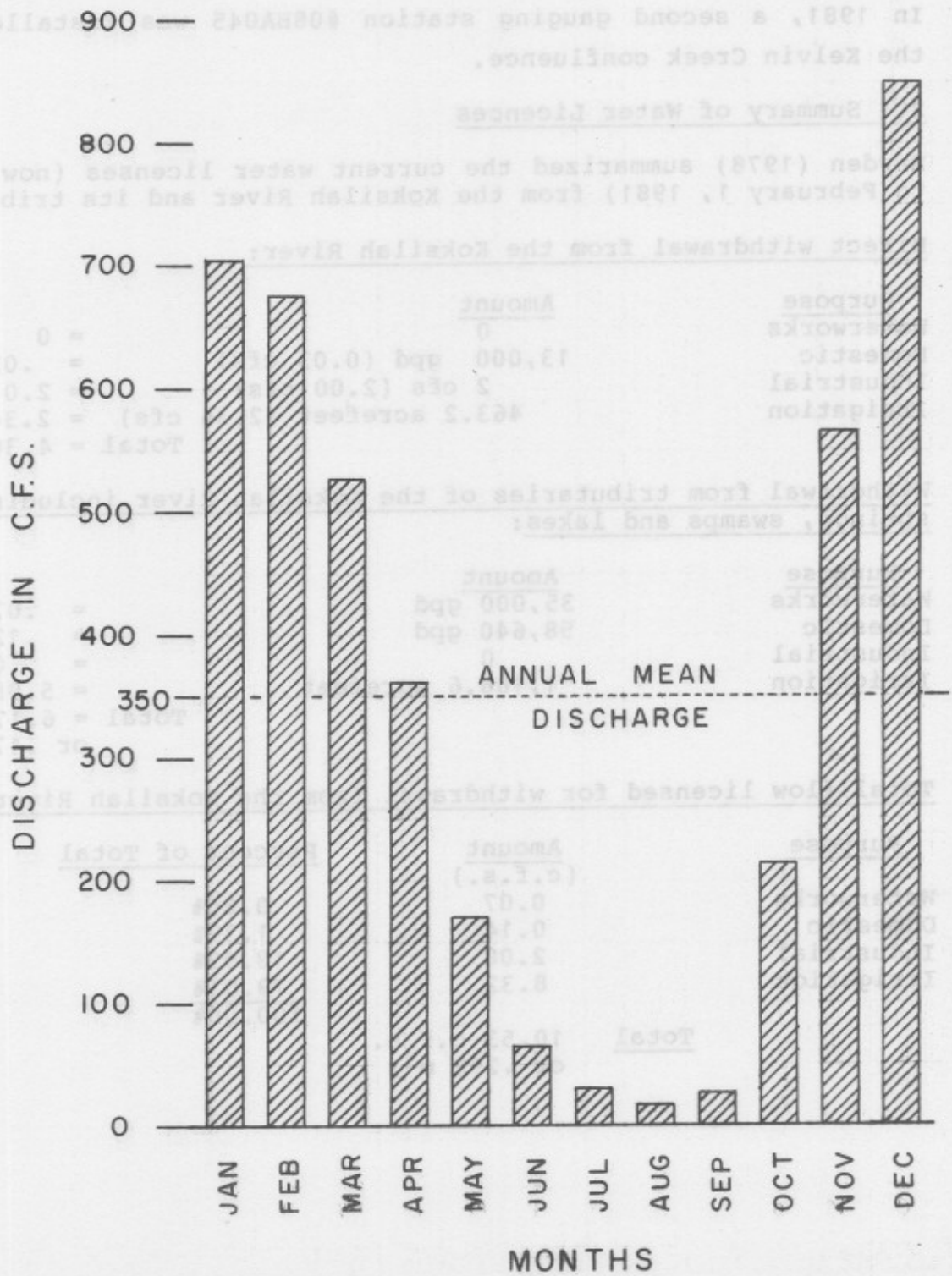
Withdrawal from tributaries of the Koksilah River including springs, swamps and lakes:

Purpose	Amount	
Waterworks	35,000 gpd	= .07 cfs
Domestic	58,640 gpd	= .12 cfs
Industrial	0	= 0
Irrigation	1,186.6 acrefeet	= 5.98 cfs
		Total = 6.17 cfs or .175 m^3

Total flow licensed for withdrawal from the Koksilah River

Purpose	Amount (c.f.s.)	Percent of Total
Waterworks	0.07	0.66%
Domestic	0.14	1.33%
Industrial	2.00	18.99%
Irrigation	8.32	79.01%
		100.00%
Total	10.53 c.f.s. or .298 m^3	

Figure 3 KOKSILAH RIVER, COWICHAN STATION.
MEAN MONTHLY DISCHARGE
1914 - 17 , 1954 - 1981



Approximately 80% of the total licensed flow is designated for irrigation purposes downstream from the Cowichan Station gauge.

A summary of licenses and status are included in Appendix #2.

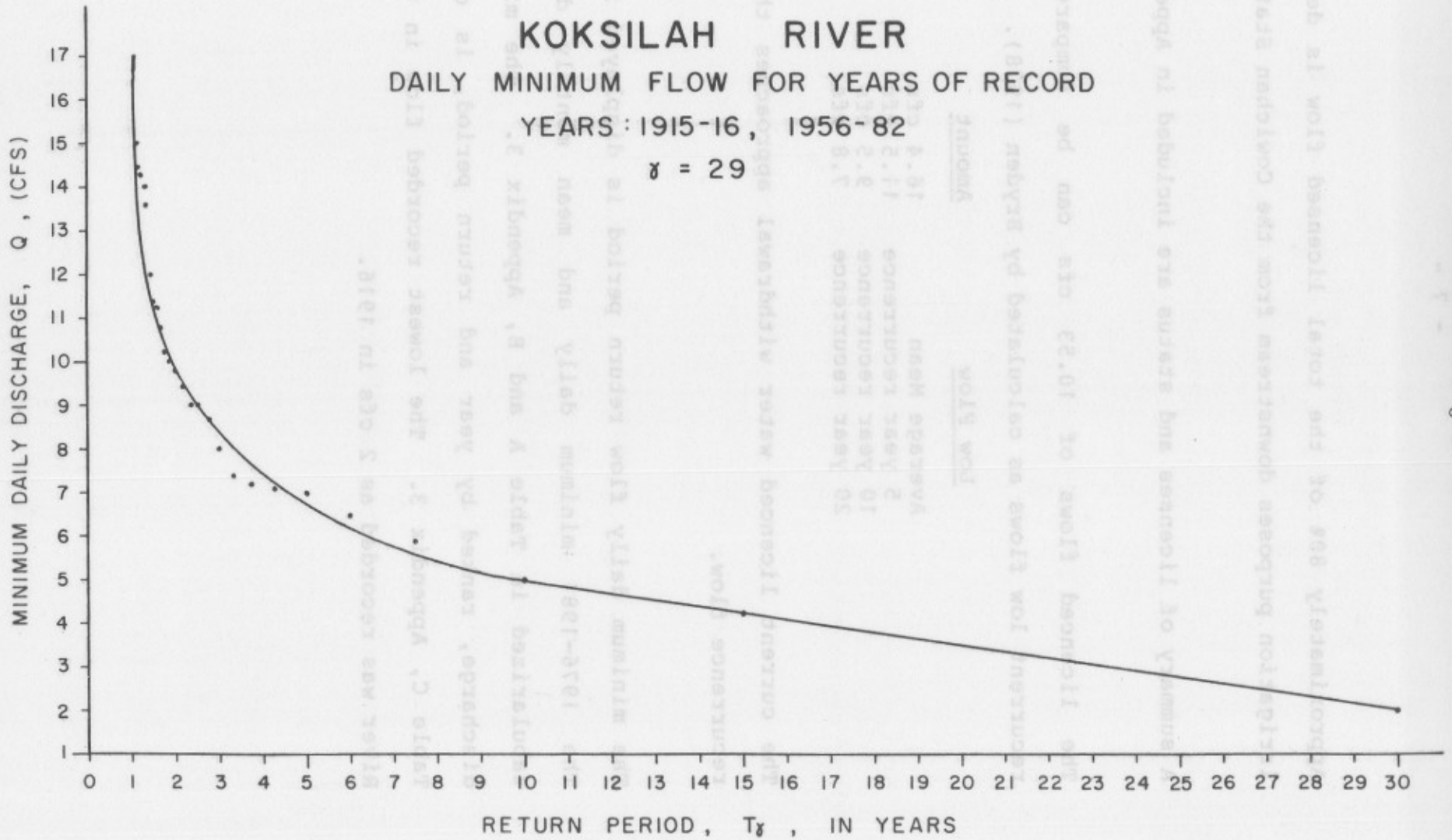
The licenced flows of 10.53 cfs can be compared with the recurrent low flows as calculated by Bryden (1978).

Low Flow	Amount
Average Mean	16.4 cfs
5 year recurrence	11.5 cfs
10 year recurrence	9.5 cfs
20 year recurrence	7.8 cfs

The current licenced water withdrawal approaches the five year recurrence flow.

The minimum daily flow return period is displayed in Figure 4. The 1976-1981 minimum daily and mean monthly discharge is tabularized in Table A and B, Appendix 3. The minimum daily discharge, ranked by year and return period, is contained in Table C, Appendix 3. The lowest recorded flow in the Koksilah River was recorded as 2 cfs in 1916.

Figure 4


KOKSILAH RIVER
DAILY MINIMUM FLOW FOR YEARS OF RECORD
YEARS : 1915-16, 1956-82
γ = 29
MINIMUM DAILY DISCHARGE, Q, (CFS)
RETURN PERIOD, Tγ, IN YEARS

3.0 Fisheries Resource

3.1 General Description

The Koksilah River system supports populations of chinook (Oncorhynchus tshawytscha), coho (O. kisutch) and chum (O. keta) salmon as well as steelhead trout (Salmo gairdneri), cutthroat trout (S. clarki), and Dolly Varden char (Salvelinus malma). The Salmon stocks of the system are valued in excess of $758,000 ($1982) annually and is a major contributor to the commercial, recreational and Indian food fisheries of Dept. of Fisheries and Marine Oceans Statistical Area 18. An evaluation of the Koksilah fisheries resource is contained in Appendix 4.

In efforts to enhance the salmon runs to the Koksilah, the Federal/Provincial Salmonid Enhancement Program (SEP) constructed a major fish passage project in 1980 at Marble Falls, 21 km from its mouth. Marble Falls had been the historical migration barrier to salmon. This $170,000 fishway facility is expected to provide salmon access into some of the previously unutilized habitats. Several years will elapse before the extent of the project's success is known.

Historical escapement data* indicate a ten (10) year average escapement (1970-1980) of chinook, coho and chum to be 558, 6,780 and 5,300 respectively[1], Table 1. This system also supports unknown numbers of steelhead and cutthroat trout.

Table 1: Ten Year Average Escapement for the Koksilah River System.

Period	Chinook	Coho	Chum
1970	300	10,000	2,000
1971	500	5,000	2,000
1972	275	1,800	4,000
1973	400	5,000	5,000
1974	600	10,000	5,000
1975	500	10,000	5,000
1976	1,000	9,000	4,000
1977	500	10,000	10,000
1978	300	5,000	10,000
1979	1,000	5,000	3,000
1980	500	7,000	5,000
10 year average	558	6,780	5,300

The distribution of major spawning areas are indicated in Figure 5. The freshwater life cycle of each species of salmon in the Koksilah watershed, along with the timing of each phase, is summarized in Figure 6.

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*Fisheries and Marine escapement records.

Figure 5

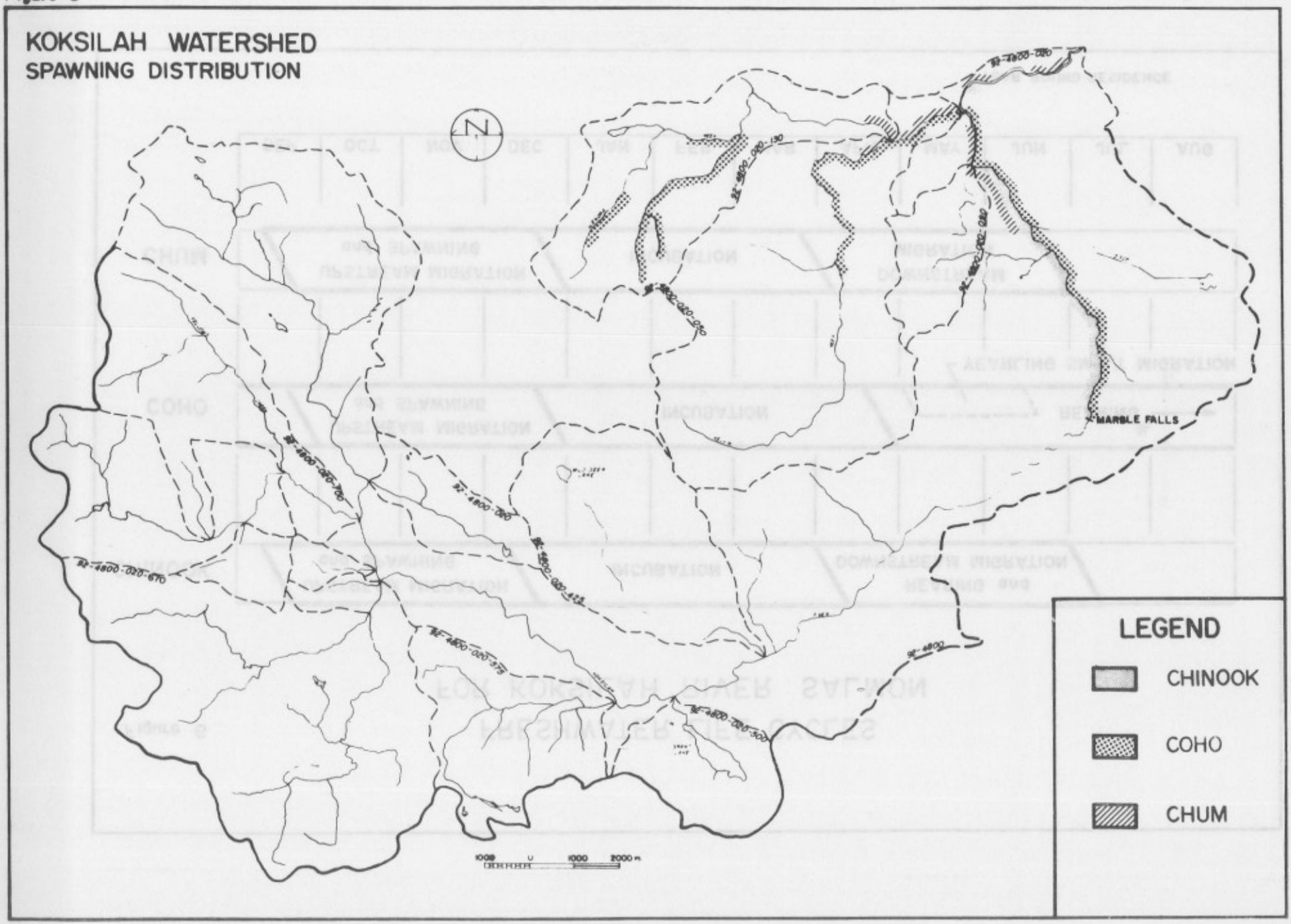
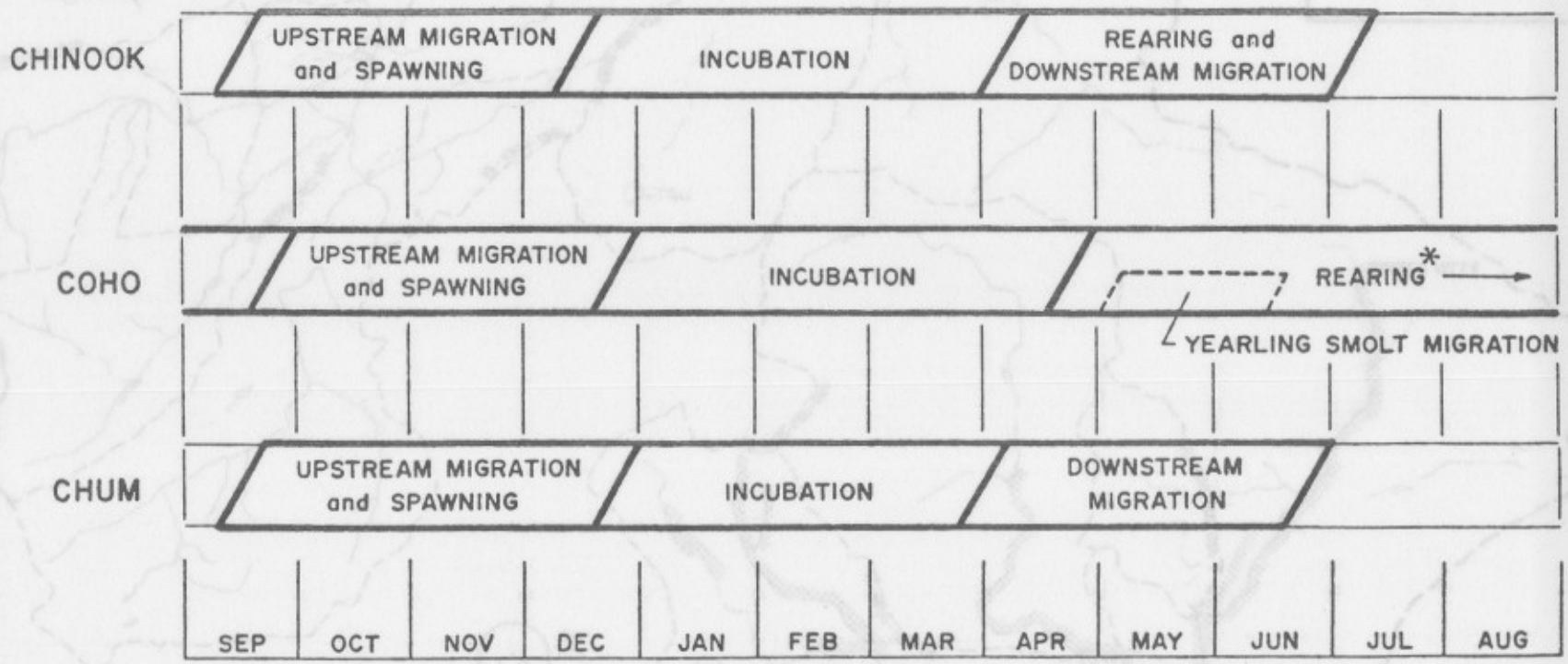

KOKSILAH WATERSHED
SPAWNING DISTRIBUTION
N
MARBLE FALLS
LEGEND
CHINOOK
COHO
CHUM
1000 0 1000 2000 m

Figure 6

FRESHWATER LIFE CYCLES FOR KOKSILAH RIVER SALMON



*YEAR ROUND RESIDENCE

3.2 Chinook

Chinook adults enter the Koksilah River beginning the last week of September with the first significant increase in discharge. Spawning activity peaks by the first week in November and ends by the last week of November. Due to the difficulty in determining annual counts of chinook in this system, spawning escapement and distribution must be considered preliminary at this time. The age composition (Table 2) and mean lengths of adult chinook returns (Table 3) to the Cowichan-Koksilah system have been compiled by Lister et al (1981).

Table 2: Age Composition of Adult Chinook Returns to the Cowichan-Koksilah System, with Breakdown by Sex (Lister et al., 1981)

Year	Male (%)				Combined Cow.-Kok. Estimated Return	Female (%)			Combined Cow.-Kok. Estimated Return
	2	3	4	5		3	4	5	
1976	78.5	8.8	11.6	1.1	5,783	11.0	85.0	4.0	1,717
1977	76.8	13.2	10.0	0	6,380	10.0	87.5	2.5	2,221
1978	80.3	4.9	13.8	1.0	7,471	7.0	79.0	14.0	2,730
1979	76.2	14.0	9.8	0	13,251	30.0	60.5	9.5	3,850

Table 3: Mean Lengths (cm) of Male and Female Chinook by Age Class, Cowichan-Koksilah Dead Recovery, 1977-1979 (Lister et al [1981])

Year	Male						Female				
	2_1	3_1	3_2	4_1	5_1	5_2	3_1	3_2	4_1	5_1	5_2
1977	42.8	59.6		72.5			64.6		71.6		
1978	40.1	58.9	44.0	68.0	70.7	71.6	58.7		67.6	72.1	63.5
1979		60.9		71.9			62.3		70.5	76.5	

Juvenile chinook rear for approximately 90 days after emergence from the gravel and the majority smolt by the end of July at an average fork length of 84 mm, (Argue et al, 1979). Data from Sparrow 1968 MS), Lister et al (1971), and summarized by Argue et al (1979) suggest that a large fraction of the chinook smolt population which reside in the Cowichan-Koksilah estuary originate as early downstream migrant fry.

3.3 Coho

Coho adults enter the river with the first increase in discharge during early fall with peak spawning occurring by mid November and ending by January. Lister et al (1981) compiled the age composition, Table 4, and mean lengths, Table 5, of adult coho returns to the Cowichan-Koksilah system. Due to the difficulty in determining annual counts of coho, spawning escapement and distribution must be considered preliminary at this time.

Table 4: Age Composition of Adult Coho Returns to the Cowichan-Koksilah Rivers (Lister et al 1981)

Return Year	Age at Return (%) 2_2	3_2	4_3
1976	4.2	92.2	3.6
1977	1.4	96.4	2.2

Table 5: Mean Lengths (cm) by Age Class of Male and Female Coho Salmon Spawning in Kelvin Creek During 1977

Stream	Male				Female		
	2_2	3_2	4_3	Sample Size	3_2	4_3	Sample Size
Kelvin Creek	27.7	52.3	-	25	50.8	-	27

Fry begin to emerge from the gravel during April and disperse throughout the stream and rear for one or two complete years and smolt during April - June, peaking in mid-May. Studies of the 1976 coho smolt migration from Kelvin Creek have been compiled by Argue et al., (1979), and is believed the normal coho smolt migration pattern, Figure 7.

Figure 7 KOKSILAH RIVER

COHO SMOLT MIGRATION in 1976

from Angue et.al. (1979)

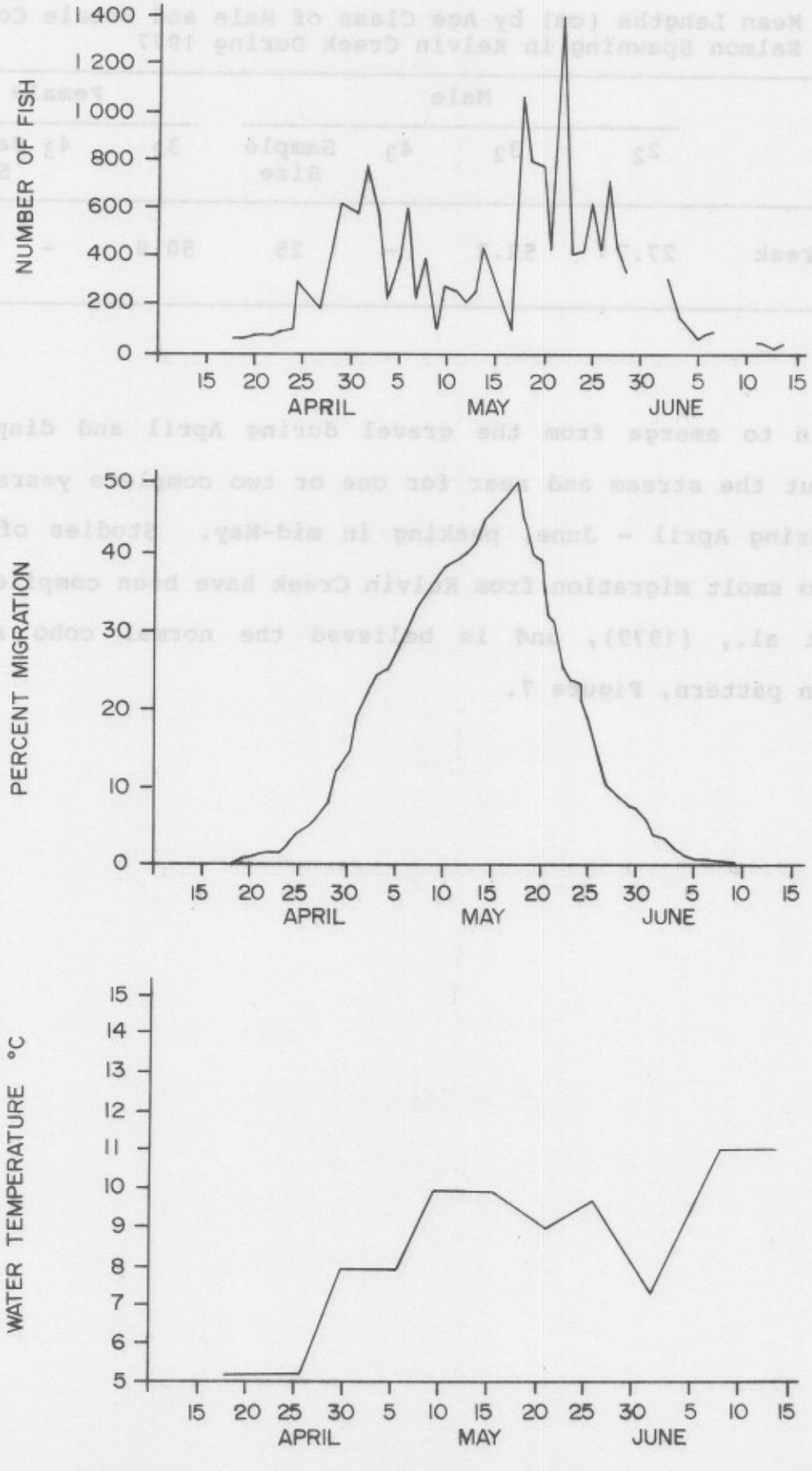
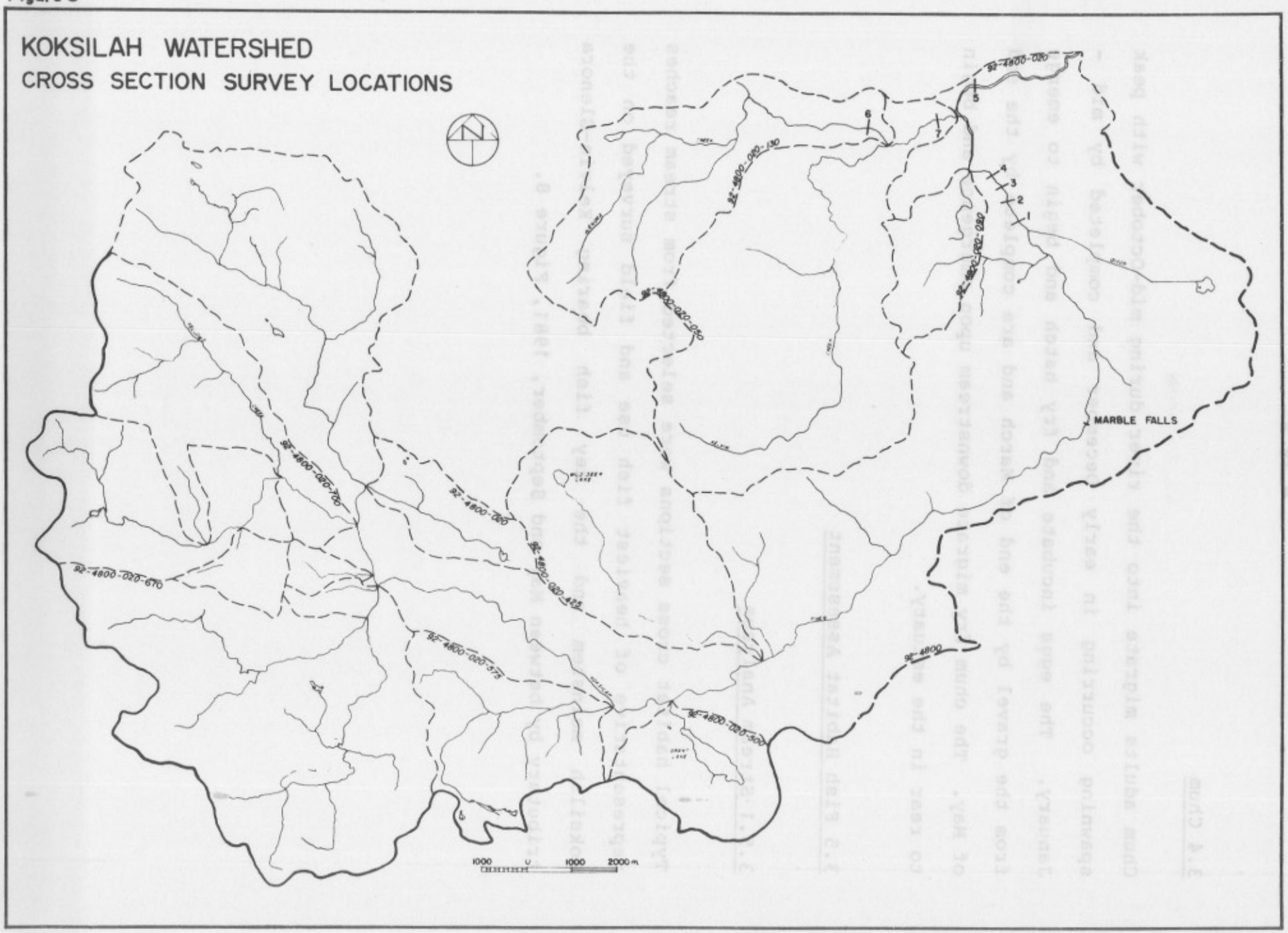


Figure 8


KOKSILAH WATERSHED
CROSS SECTION SURVEY LOCATIONS
92-4800-020
92-4800-020-130
92-4800-020-090
92-4800-020-050
92-4800-020-700
92-4800-020-670
92-4800-020-573
92-4800-020-500
92-4800-020-422
92-4800-020
92-4800
MARBLE FALLS
1000 0 1000 2000 m

3.4 Chum

Chum adults migrate into the river during mid-October with peak spawning occurring in early December and completed by mid - January. The eggs incubate and fry hatch and begin to emerge from the gravel by the end of March and are complete by the end of May. The chum fry migrate downstream upon emergence and begin to rear in the estuary.

3.5 Fish Habitat Assessment

3.5.1 Stream Analyses

Typical habitat cross sections were selected from stream reaches representative of heaviest fish use and field surveyed on the Koksilah mainstem and the key fish bearing Kelvin-Glenora tributary by between May and September, 1981, Figure 8.

The available rearing habitat for each section was plotted against discharge and displayed on the corresponding cross section profile, Figures 9 - 16. A computer model developed by Hamilton (1978) and criteria for rearing coho by Bovee (1978) noted below were employed.

Coho Rearing Criteria (Bovee, 1978)

a) Minimum depth .15 m

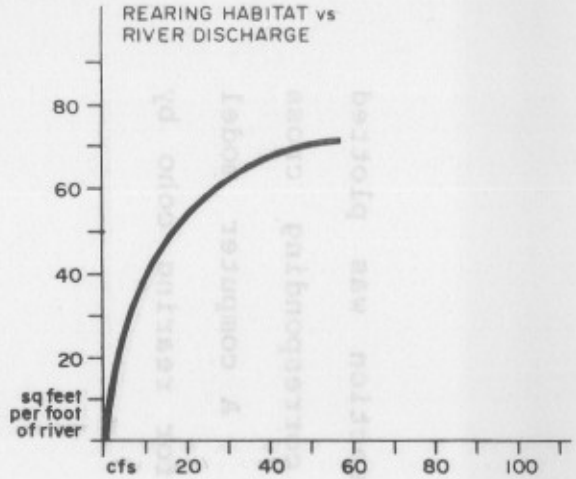
b) Minimum velocity 0 m/sec
Preferred velocity .15 m/sec
Maximum velocity .73 m/sec

The optimum coho rearing flow computed for each crossection is not a realistic or expected summer discharge regime. It is, therefore, necessary to select an interim recommended minimum flow:

Cross Section	Location	Optimum flow (c.f.s.)	Interim Recommended Minimum Flow (c.f.s.)
1	Mainstem	60	20
2	Mainstem	15	12
3	Mainstem	35	10
4	Mainstem	50	10
5	Mainstem	30	13
6	Glenora	9	3
7	Kelvin and Glenora	12	5

Figure 9

KOKSILAH RIVER
SECTION 1



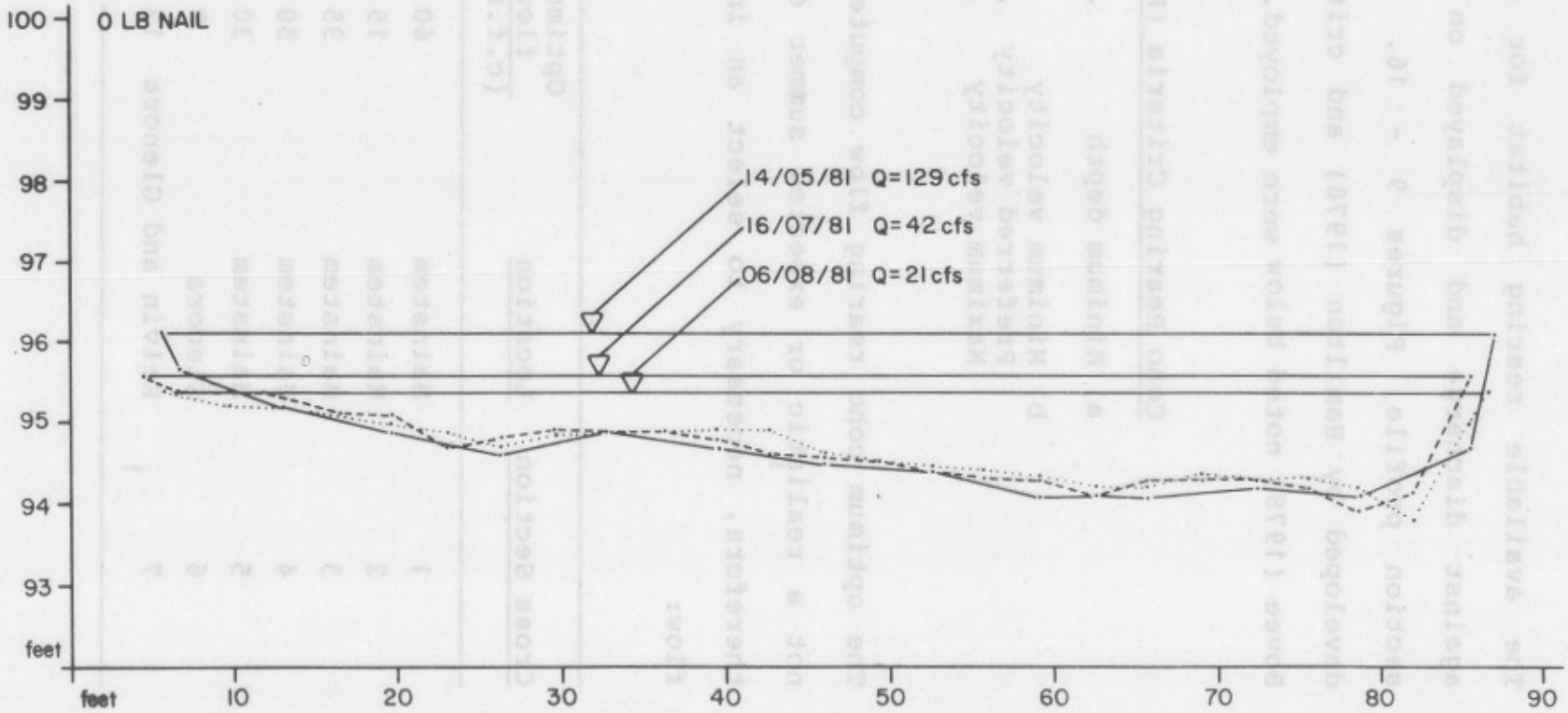


Figure 10

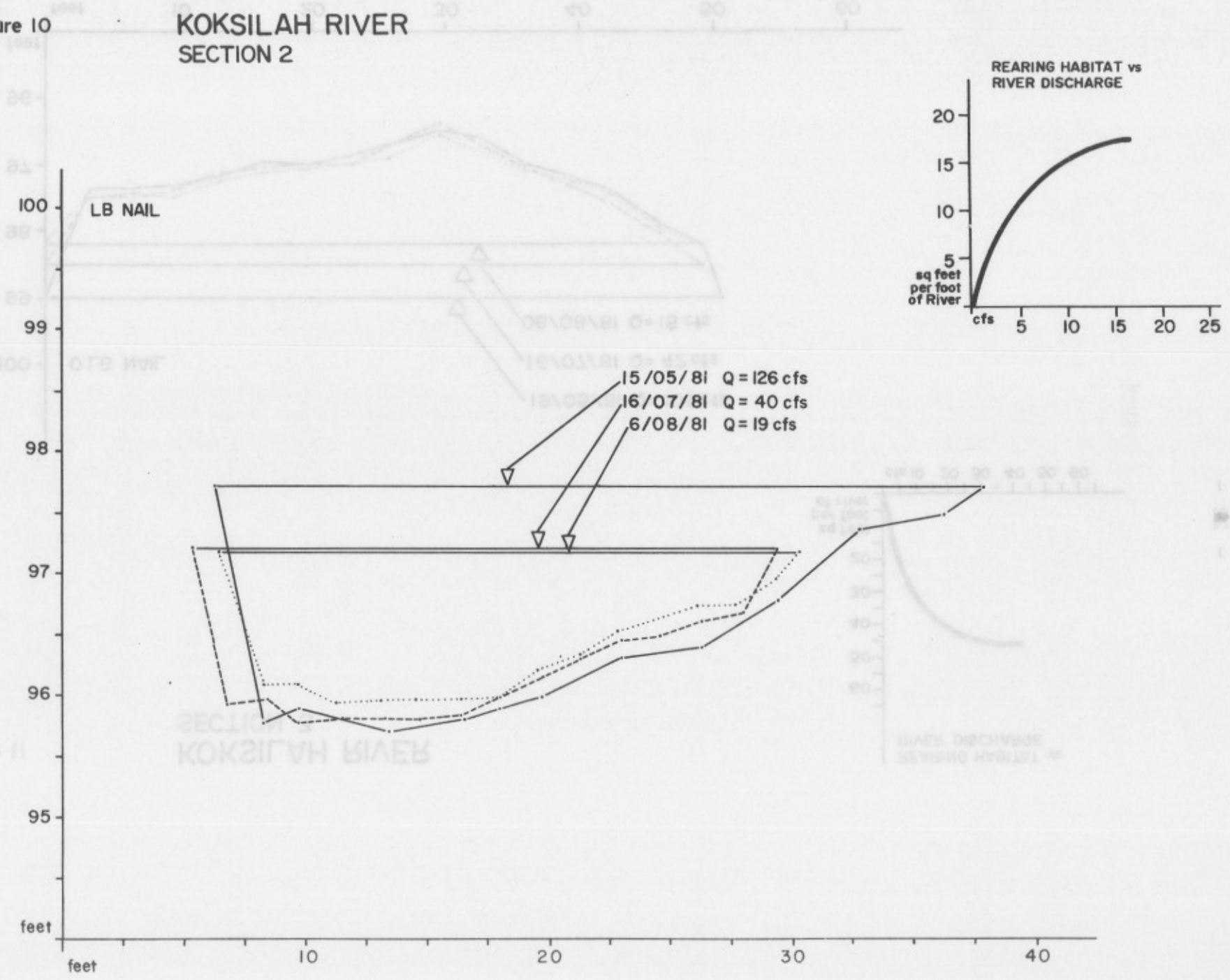
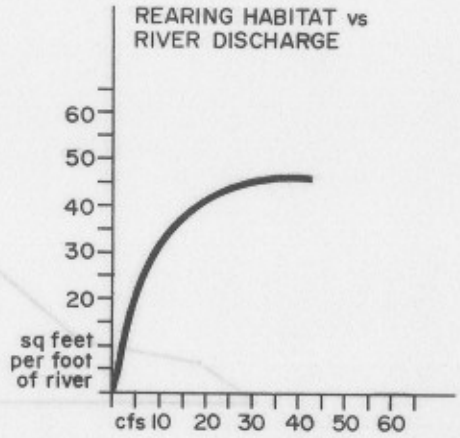

KOKSILAH RIVER
SECTION 2
LB NAIL
15/05/81 Q = 126 cfs
16/07/81 Q = 40 cfs
6/08/81 Q = 19 cfs
100
99
98
97
96
95
feet
10
20
30
40
feet
REARING HABITAT vs
RIVER DISCHARGE
20
15
10
5
sq feet
per foot
of River
cfs
5
10
15
20
25

Figure 11

KOKSILAH RIVER
SECTION 3



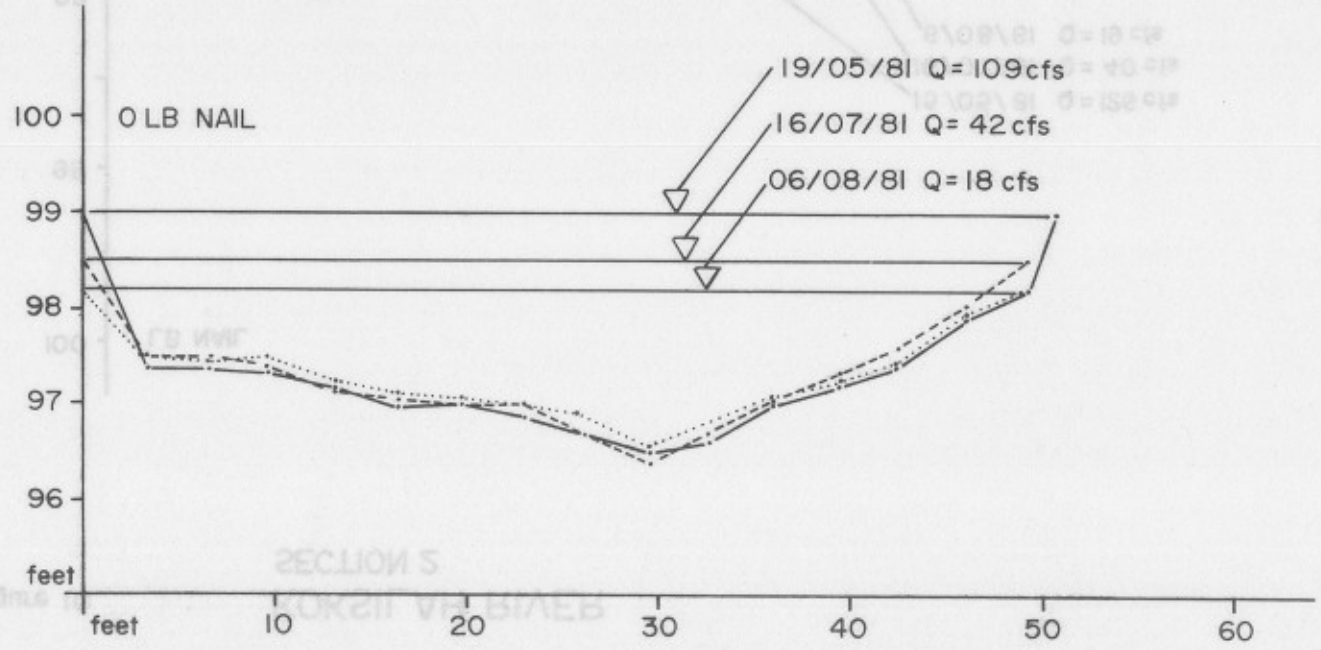
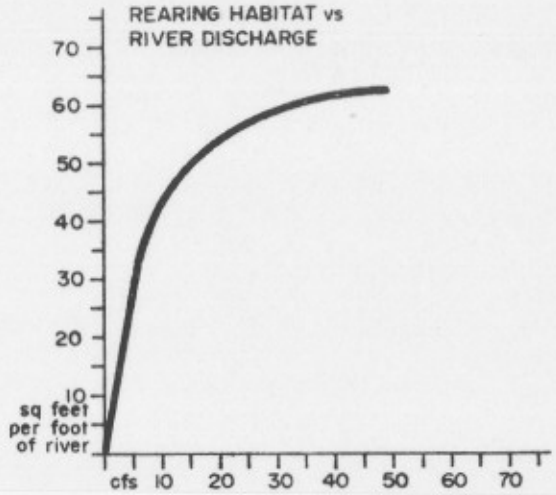


Figure 12

KOKSILAH RIVER
SECTION 4



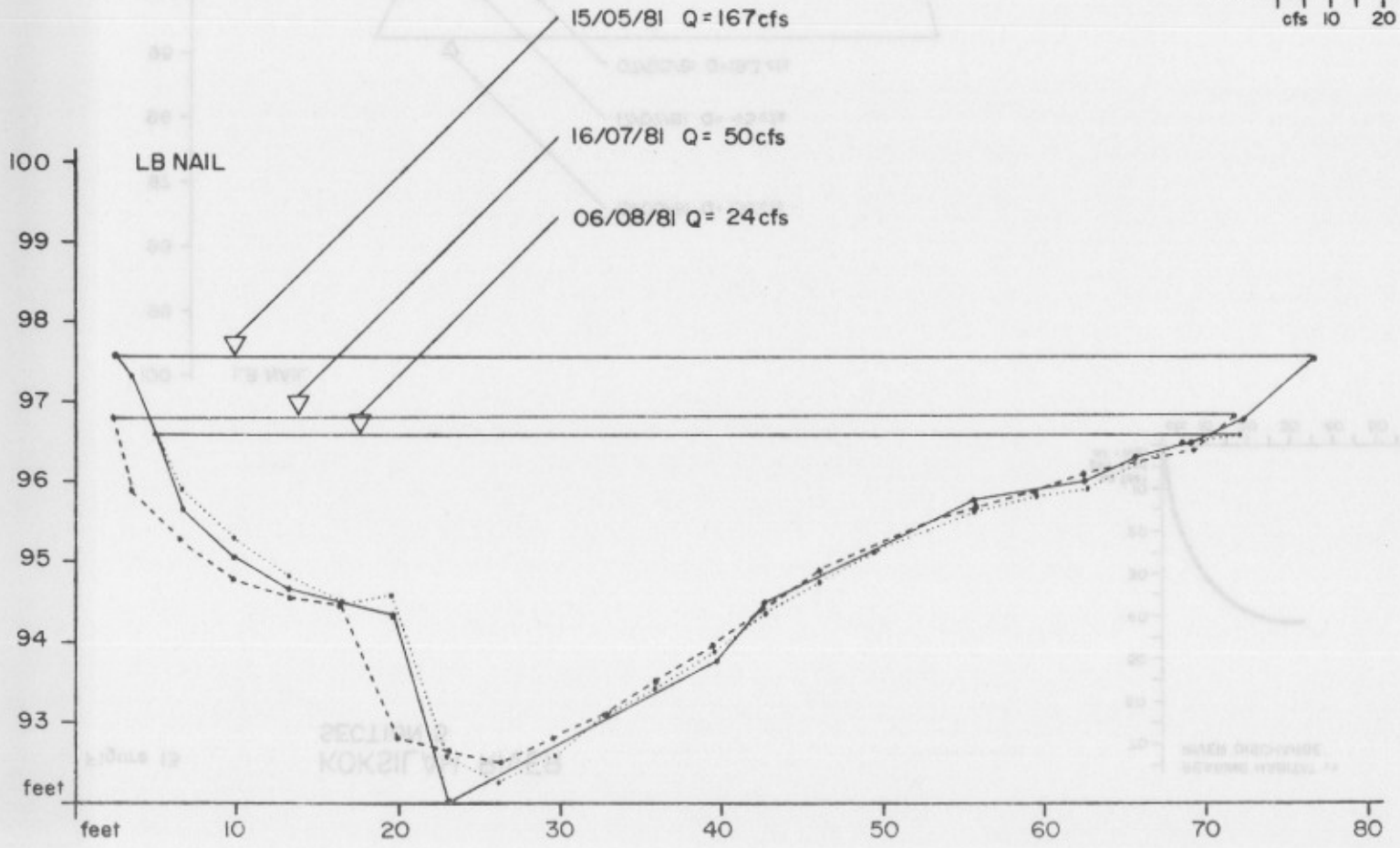
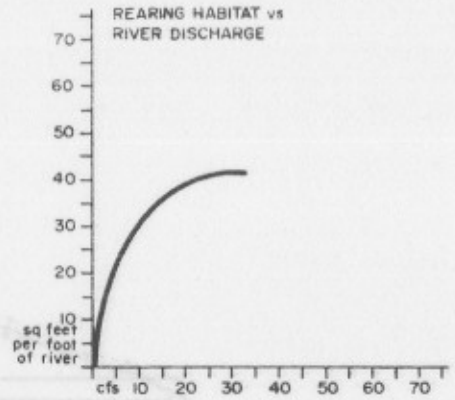


Figure 13

KOKSILAH RIVER
SECTION 5



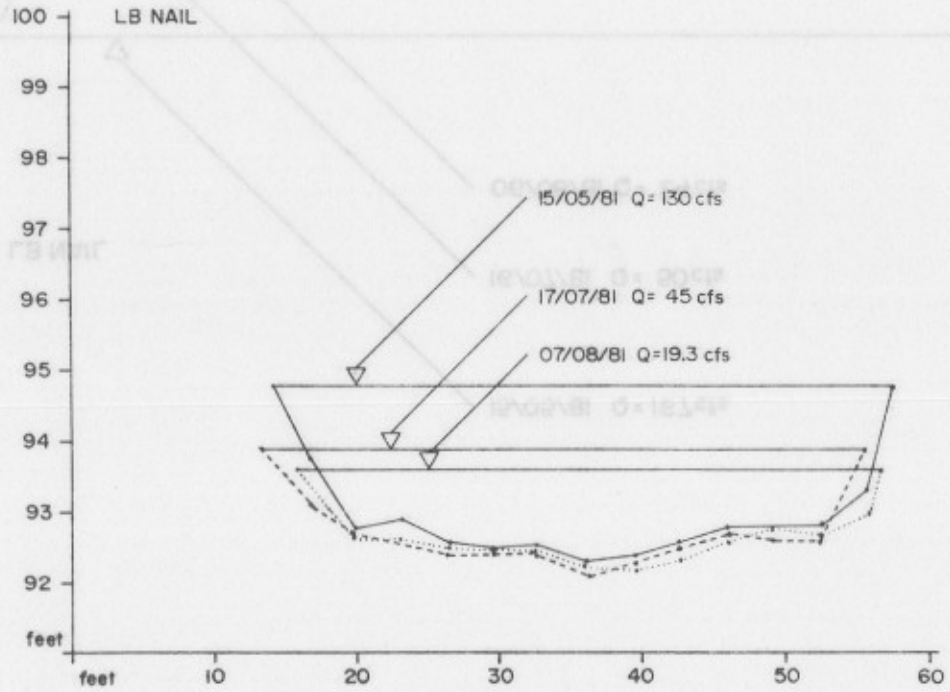
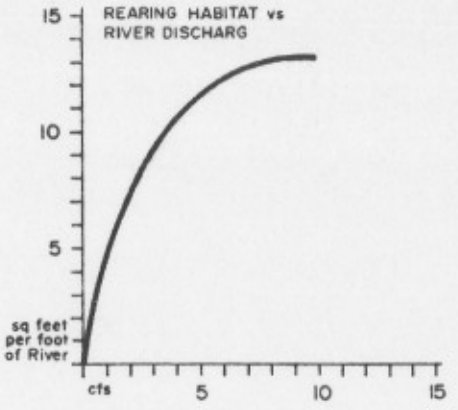


Figure 14

GLENORA CREEK
SECTION 6



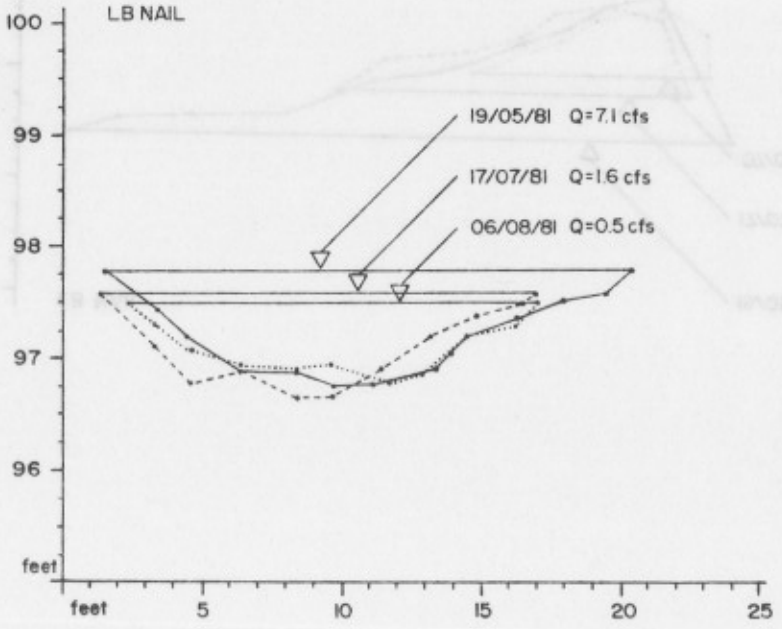
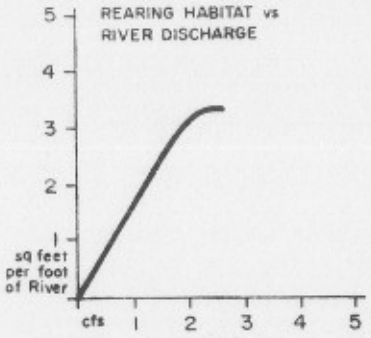
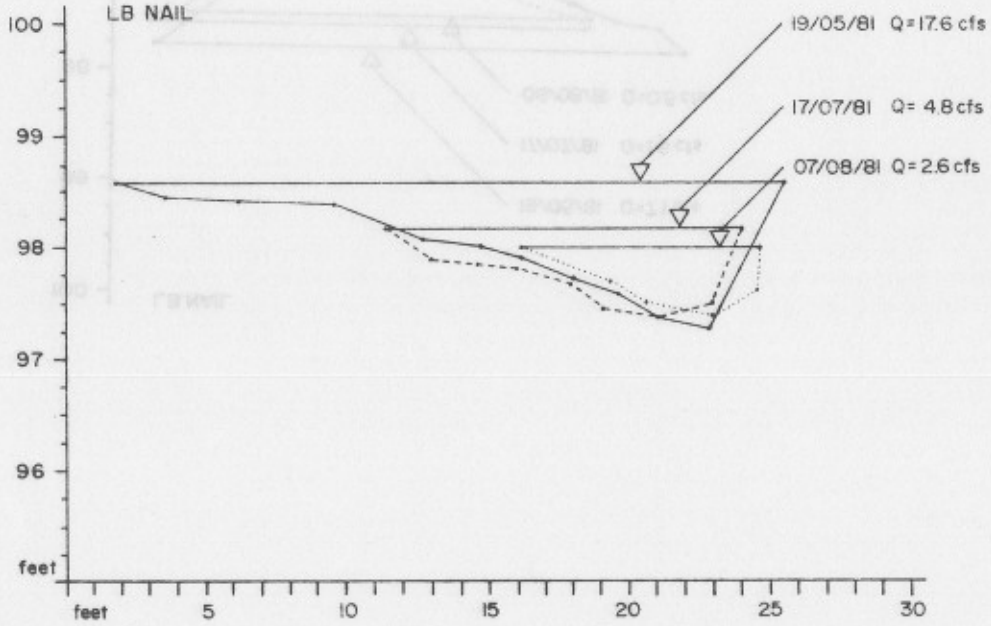


Figure 15

D/S CONFLUENCE GLENORA & KELVIN CREEK
SECTION 7





3.5.2 Stream Temperatures

Continuous water temperature records were obtained from Ryan thermographs during the summer of 1981 at Cross Sections No. 2 (Br. Angle Park), No. 6 (Glenora Creek), and No. 7 (Kelvin Creek). The maximum 1981 recorded temperatures were:

Location	Cross Section	Max. Temp. Date
Bright Angel Park	2	21.5°C (70.7°F) Aug. 10&11/81
Glenora Creek	6	22°C (71.6°F) Aug. 9/81
Kelvin/Glenora Creek	7	17 C (62.6 F) July 28&29/81

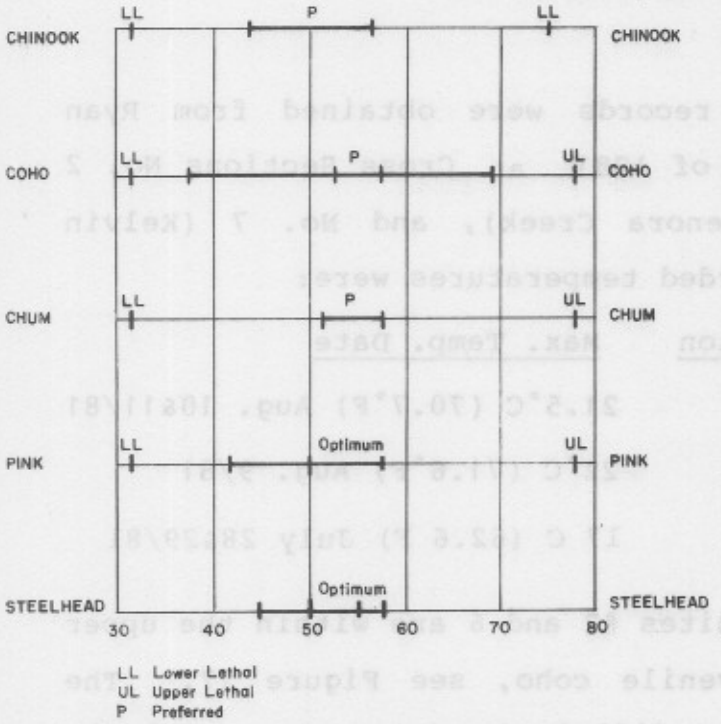
These maximum temperatures in sites #2 and 6 are within the upper threshold for survival of juvenile coho, see Figure 17. The cooler Kelvin Creek tributary modified the temperatures of the warmer Glenora discharge in 1981 and was considered to be a cool water refugia for rearing salmonid juveniles.

Elevated water temperatures, especially during years of combined drought and warm weather is thought to be a significant control on the rearing of salmonids.

Figure 16

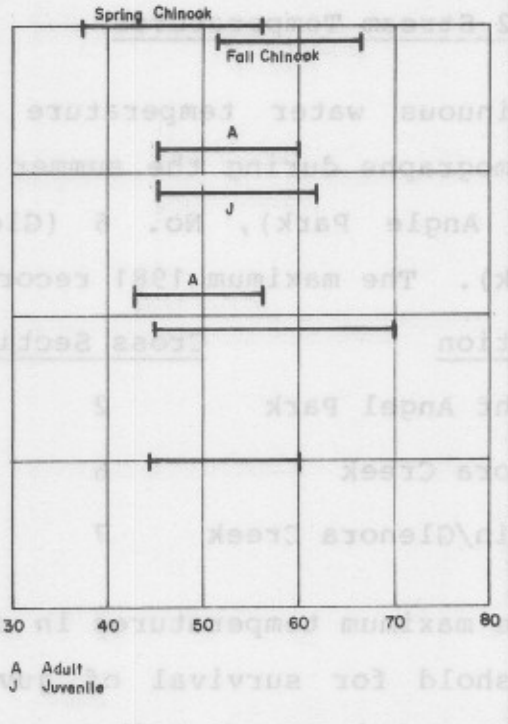
TEMPERATURE LIMITS on the DEVELOPMENT STAGES of the PACIFIC SALMON

(from M.C. BELL, 1973)



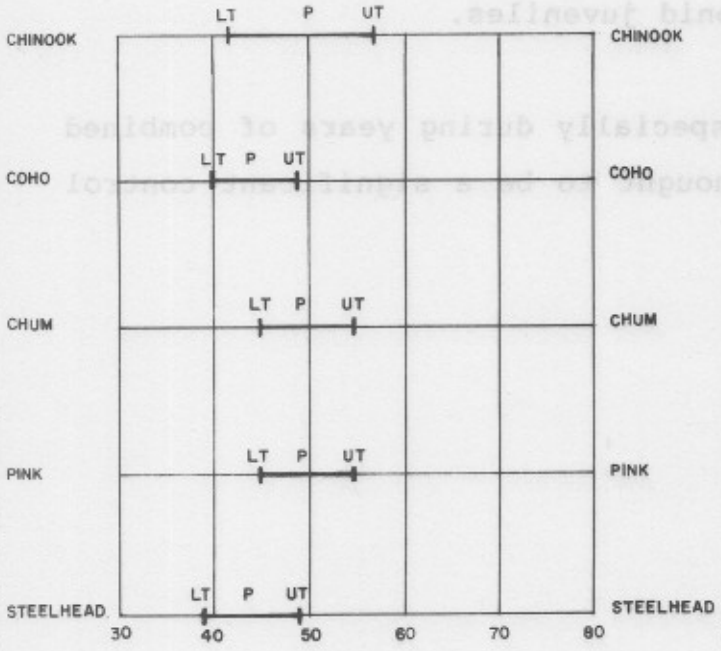
LL Lower Lethal
UL Upper Lethal
P Preferred

OPTIMUM RANGE



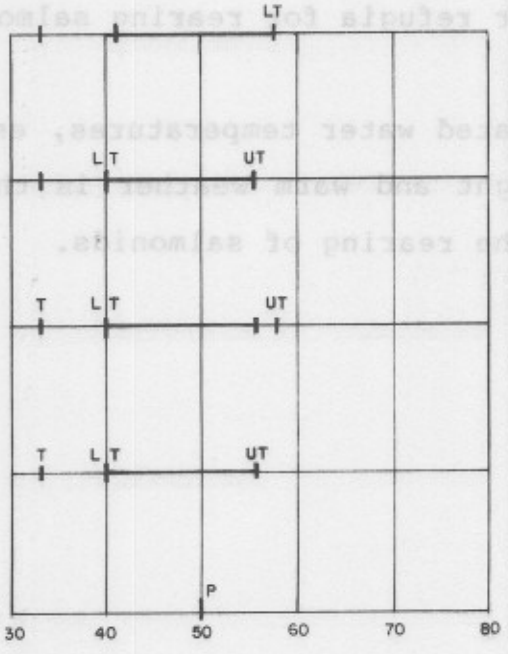
A Adult
J Juvenile

MIGRATION RANGE



LT Lower Threshold
UT Upper Threshold
P Preferred

SPAWNING RANGE



LT Lower Threshold
UT Upper Threshold
T Toleration
P Preferred

HATCHING RANGE

Virtually all rearing salmonid fry were lost in 1981 from the Upper Glenora system that ceased to flow and surface dried.

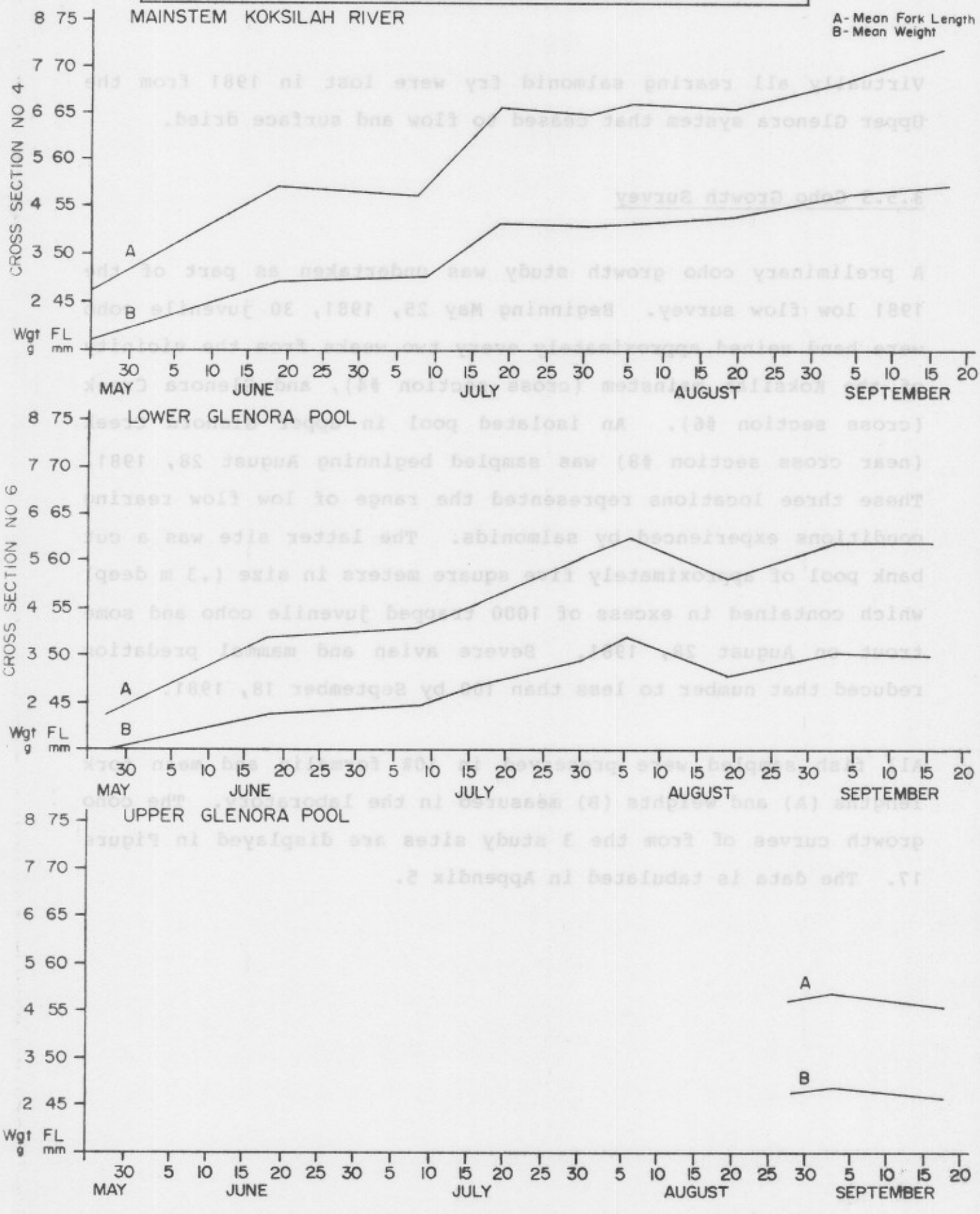
3.5.3 Coho Growth Survey

A preliminary coho growth study was undertaken as part of the 1981 low flow survey. Beginning May 25, 1981, 30 juvenile coho were hand seined approximately every two weeks from the vicinity of the Koksilah mainstem (cross section #4), and Glenora Creek (cross section #6). An isolated pool in upper Glenora Creek (near cross section #8) was sampled beginning August 28, 1981. These three locations represented the range of low flow rearing conditions experienced by salmonids. The latter site was a cut bank pool of approximately five square meters in size (.3 m deep) which contained in excess of 1000 trapped juvenile coho and some trout on August 28, 1981. Severe avian and mammal predation reduced that number to less than 100 by September 18, 1981.

All fish sampled were preserved in 10% formalin and mean fork lengths (A) and weights (B) measured in the laboratory. The coho growth curves of from the 3 study sites are displayed in Figure 17. The data is tabulated in Appendix 5.

Figure 17

COHO GROWTH SURVEYS of SELECTED REARING SITES of the KOKSILAH WATERSHED



There was a rather striking weight difference between the rearing coho in the mainstem, tributary and isolated pool. The mean weight of the coho sample taken from the isolated Upper Glenora pool (2.25 gm) on September 18, 1981 was comparable to the weight of the lower Glenora sample of July 16, 1981 and to the Koksilah mainstem sample of June 12, 1981. This remarkable difference in mean weight of coho between the extremely low flow stressed population in the upper Glenora pool and that population found in the Koksilah mainstem presents several critical life history and low flow related questions requiring further research:

i) How do reduced flows affect coho growth and carrying capacity?

ii) What is the relationship between reduced size of coho to overwintering survival?

iii) What is the relationship of reduced size[1] of coho smolts to ocean survival?

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[1]Reduced overwintering coho survival is believed to result from reduced size based on preliminary finding from Quinsam Hatchery, (pers. comm. J. van Tine, Manager, Quinsam Hatchery).

4.0 Discussion

The current flow withdrawal licenced for consumptive use in the Koksilah watershed is 10.53 cfs. which has been calculated to recur approximately every 5 - 6 years, Bryden (1978).

The Koksilah watershed is able to provide the consumptive use of the current water licences by seriously stressing rearing salmonid populations in some years. Since the watershed is naturally prone to the recurrent low summer flows, (lowest flow on record - 2 cfs October 10, 1916) a comprehensive water management plan is needed to balance water supply with in-stream fisheries flows and present and future water demand.

Opportunities for headwater storage have not been identified in this report. However, initial contact appeared positive in 1982 with Ducks Unlimited, a private corporation interested in increased water pondage for waterfowl production. Their co-operation is based on the creation of impounded water being made available during the spring waterfowl nesting period. Thereafter, flow released subsequent to the end of nesting (mid June) from an impoundment structure would benefit downstream rearing coho. This is an ideal fish/waterfowl cooperative program to be considered in future water management plans or as a joint salmonid/waterfowl enhancement project.

The inaccessible coho habitat less than 5% stream gradient present in the Koksilah watershed has been identified by the Salmonid Habitat Information Project (S.H.I.P.) Chamberlin et.al., 1984. This prereconnaisance inventory found 73.84 km of channel, .84 sq. km of lakes and 1.84 sq. km of wetland inaccessible to coho (see Appendix 6). An increased production potential of 81,000 to 162,000 coho smolts is postulated if all the inaccessible habitat is found viable (using 1000-2000 smolts/km). This would represent a major increase in coho production from this watershed.

5.0 Summary of Recommendations

It is recommended that a Federal/Provincial cooperative water management plan be developed for the Cowichan/Koksilah Basins. The following recommendations are specifically made for the Koksilah Subbasin:

1. An objective of a minimum summer flow of 15 cfs to maintain the fisheries resource in the mainstem Koksilah River (measured below Kelvin Creek confluence).

2. All water licences for consumptive use from the Koksilah River and especially the Kelvin/Glenora systems should be reviewed. Delinquent or inactive licences should be revoked and licenced amounts recorded and verified as to actual consumption.

   *The current licenced flow of approximately 11 cfs should be provided as summer storage if feasible.

3. A review of headwater storage potential for summer release should be undertaken as part of an overall water management plan.

4. Any future granting of water licences should occur only if off stream storage is possible.

5. A coho colonization program targeted for inaccessible headwater habitats would offset stock losses due to low flows.

6. An annual coho fry salvage and transplant from chronic summer low flow zones would be one method of colonizing inaccessible rearing habitats and offsetting losses due to dewatering. A coordinated program with the Cowichan Hatchery could greatly increase the flexibility of any coho colonization strategies.

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Appendix 1. Koksilah River at Cowichan Station - Station No 08HA003

Monthly and Annual Mean Discharges in Cubic Feet per Second for Period of Record

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Mean	Year
1914	-	-	-	-	-	51.8	23.5	14.0	35.8	364	765	260	-	1914
1915	552	359	480	439	114	41.9	21.9	14.6	7.9	391	926	1380	395	1915
1916	427	755	988	766	470	181	145	18.9	9.3	96.0	520	436	400	1916
1917	634	723	400	-	-	-	-	-	-	-	-	-	-	1917
1954	-	-	-	-	-	-	-	-	21.3	-	-	-	-	1954
1955	-	-	-	-	202	83.1	40.1	29.7	22.5	-	-	-	-	1955
1956	-	-	-	-	397	271	34.8	23.8	37.3	-	-	-	-	1956
1957	-	-	-	-	-	37.2	29.0	28.4	23.1	-	-	-	-	1957
1958	-	-	-	-	99.9	40.0	13.0	8.0	13.9	-	-	-	-	1958
1959	-	-	-	-	259	69.9	17.6	9.4	61.8	-	-	-	-	1959
1960	583	799	406	563	152	57.6	21.1	15.6	17.4	142	550	584	322	1960
1961	1220	1320	835	237	188	43.3	17.1	8.8	14.4	162	380	861	436	1961
1962	552	210	268	319	254	76.7	29.5	21.0	15.8	248	1020	1100	344	1962
1963	512	672	254	294	161	26.7	31.0	15.0	10.7	448	1010	945	362	1963
1964	1090	590	544	296	127	61.0	29.5	18.7	26.5	98.6	232	295	283	1964
1965	490	984	285	283	161	41.1	17.7	13.0	15.8	208	483	713	303	1965
1966	919	465	607	374	123	39.6	33.5	13.6	15.8	168	477	1630	407	1966
1967	1240	649	645	218	128	30.9	11.8	7.7	11.0	714	463	1080	434	1967
1968	1370	841	621	235	87.0	45.5	21.8	18.7	69.0	360	620	800	424	1968
1969	341	386	702	719	213	50.7	23.7	17.6	66.8	108	216	829	306	1969
1970	641	495	315	427	87.9	28.8	11.7	7.8	15.7	74.5	346	779	268	1970
1971	1060	776	727	546	310	81.1	38.0	14.0	22.6	132	540	418	386	1971
1972	836	1040	961	366	145	34.7	49.4	16.7	49.5	35.	247	1240	417	1972
1973	757	271	248	104	85.5	50.4	20.2	9.1	11.3	113	689	1150	293	1973
1974	1070	876	877	395	165	118	42.4	18.0	15.6	17.1	515	768	404	1974
1975	567	389	489	361	221	35.8	12.6	34.2	29.1	698	1170	1010	418	1975
1976	861	615	494	462	198	71.0	25.0	18.9	17.4	25.6	99.7	279	263	1976
1977	274	394	602	108	62.4	32.3	12.3	8.1	19.4	113	870	764	279	1977
1978	477	387	300	150	108	42.4	14.8	12.0	52.9	41.1	143	314	169	1978
1979	114.4	935.7	533.1	180.8	78.4	25.6	16.3	10.8	34.8	201.6	112.3	1384.1	302	1979
1980	582.6	964	462.6	284.2	73.8	68.5	45.9	18.4	20.4	30	939	1335	402	1980
1981	434	967	163	420	169	118	46	18	51	345	826	1006	380	1981
Mean	704	675	528	360	173	65	30	15.6	27	213	566	854	350	

Drainage Area 80.8 sq. miles (209 sq. kilometers) Location - Lat. 48° 43' 39"N

Natural Flow - Long. 123° 40' 11"W

Appendix 2. Summary of Existing Licences - Koksilah River and Tributaries

Licence #	Name	Date	Water Source	Use	Quantity	Remarks
CL 19745	Cuthbert	22/07/05	Koksilah	Irrigation	100 ac. ft.	F.L. survey 44.0 ac. ft.
CL 22480	Budde	09/11/54	Koksilah	Domestic	1000 gpd	
				Irrigation	2 ac. ft.	
CL 23731	Frueh	13/03/57	Koksylah	Irrigation	5 ac. ft.	
CL 30991	Armour & Saunders	04/11/65	Koksilah	Industrial	0.5 cfs	
CL 32161	Len	16/11/66	Koksilah	Irrigation	100 ac. ft.	F.L. survey 96.8 ac. ft.
CL 32516	Woolam	18/04/67	Koksilah	Irrigation	10 ac. ft.	F.L. survey 3.1 ac. ft.
CL 32975	Girl Guides	15/05/67	Koksilah	Domestic	1000 gpd	
CL 36936	Anderson	18/09/70	Koksilah	Irrigation	30 ac. ft.	
CL 38835	Vaux	06/08/71	Koksilah	Irrigation	10 ac. ft.	
CL 89646	Solo Deo	02/07/70	Koksilah	Domestic	5000 gpd	
CL 41660	LaFlam	17/08/72	Ko silah	Domestic	1000 gpd	
CL 43131	Armour & Saunders	15/11/73	Koksilah	Industrial	1.5 cfs	
CL 43429	Roberts	05/04/74	Koksilah	Domestic	500 gpd	
CL 46475	Famer-Goult	25/08/75	Koksilah	Domestic	500 gpd	
CL 46711	Frueh	18/09/75	Koksilah	Irrigation	39.5 ac. ft.	F.L. survey 34.0 ac. ft.
FL 13994	Standen	11/07/47	Koksilah	Domestic	1000 gpd	
				Irrigation	96.2 ac. ft.	
FL 45509	Wikkerink	28/08/67	Koksilah	Irrigation	38.5 ac. ft.	
FL 48573	Meadow Green	13/05/53	Koksilah	Irrigation	20.0 ac. ft.	
FL 52081	Long	15/08/67	Koksilah	Domestic	1000 gpd	
FL 52155	Lindsay	06/03/73	Koksilah	Irrigation	1.0 ac. ft.	C.L. 41663, 10 ac. ft.
FL 53198	Fleetwood	17/02/59	Koksilah	Domestic	1000 gpd	C.L. 24965, 2 ac. ft.
				Irrigation	0.5 ac. ft.	
FL 04788	Len	01/12/04	Battys Creek	Domestic	1500 gpd	
CL 21293	Zanatta	31/12/52	Glenora Creek	Irrigation	18 ac. ft.	
CL 47541	Newall	30/04/76	Glenora Creek	Domestic	1000 gpd	
CL 26536	Devitt	17/11/60	Kelvin Creek	Domestic	1000 gpd	
FL 21377	Kelvin Ranch	07/07/54	Kelvin Creek	Irrigation	13.2 ac. ft.	
FL 21620	Kelvin Ranch	09/03/71	Kelvin Creek	Irrigation	5.0 ac. ft.	
FL 48236	Chilcott	07/05/64	Kelvin Creek	Irrigation	50.0 ac. ft.	
FL 48574	Meadow Green	13/05/53	Kelvin Creek	Irrigation	116 ac. ft.	
FL 48575	Meadow Green	26/11/47	Kelvin Creek	Domestic	1000 gpd	
				Irrigation	20.0 ac. ft.	
CL 48587	Dimmen	10/07/76	Boucicault	Domestic	500 gpd	
CL 50963	Cuthbert	27/05/77	Villiars Spr.	Domestic	3000 gpd	
Subsquently Approved, February 1, 1981						
	Read			Domestic	750 gpd	
				Irrigation	5 ac. ft.	
	Carrol			Irrigation	60 ac. ft.	
	Parks Board			Industrial	35 ac. ft.	

Appendix 3. Koksilah River at Cowichan Station

Table 3.1 - Minimum Daily Discharge in CFS

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1981	193	175	106	261	96	77	25	14	14	62	160	201
1980	187	242	197	127	54	43	24	14	15	25	178	251
1979	85	90	111	99	42	15	10	9	13	20	75	122
1978	112	150	108	97	69	24	10	7	30	32	46	116
1977	87	101	226	96	40	16	7	4	11	16	216	140
1976	360	229	195	280	84	35	14	12	13	14	38	57
Mean	171	165	157	160	64	35	15	10	16	28	119	148

Table 3.2 - Mean Monthly Discharge in CFS

Year	Jan	Feb	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec
1981	434	967	163	420	169	118	46	18	51	345	826	1006
1980	583	964	463	284	74	69	46	18	20	30	939	1335
1979	114	936	533	181	78	26	16	11	35	202	112	1384
1978	477	388	300	150	108	42	15	12	53	41	143	314
1977	274	395	600	208	63	32	12	8	19	113	869	763
1976	862	614	494	463	198	71	25	19	17	26	100	279
Mean	457	711	425	284	115	60	27	14	33	126	498	847

Appendix 3.3

Table C: Minimum Daily Discharge, Rank by Year and Return Period

Year	Date of Occurrence	Min. Daily Discharge	Rank	Return Period
1916	October 10	2.0 cfs	1	30.00
1977	August 17	4.2	2	15.00
1958	July 9	5.0	3	10.00
1970	September 2	5.9	4	7.50
1982	August 25	6.5	5	6.00
1915	September 19	7.0	6	5.00
1978	August 11	7.1	7	4.29
1967	August 6	7.2	8	3.75
1973	September 14	7.4	9	3.33
1961	August 29	8.0	10	3.00
1979	August 8	8.7	11	2.73
1975	August 13	9.0	12	2.50
1959	August 2	9.0	13	2.31
1963	September 13	9.4	14	2.14
1962	September 12	9.8	15	2.00
1965	August 19	10.0	16	1.88
1960	September 13	10.2	17	1.76
1972	September 4	10.8	18	1.67
1971	August 19	11.2	19	1.58
1966	August 26	11.4	20	1.50
1976	August 8	12.0	21	1.43
1964	September 1	13.6	22	1.36
1968	August 12	14.0	23	1.30
1980	August 14	14.1	24	1.25
1981	September 15	14.3	25	1.20
1974	September 3	14.4	26	1.15
1969	September 11	15.0	27	1.11
1956	August 20	17.0	28	1.07
1957	September 3	17.0	29	1.03

Appendix 4. Economic Valuation of Cowichan and Koksilah Salmon Stocks

Tables A, B and C present current information on the total catch associated with Cowichan and Koksilah stocks, and the annual value of the catch by sector.

There are some basic methodological differences between the DFO submission to the Cowichan Estuary Task Force (1978, Appendix 15 of the Cowichan Estuary Task Force Report) and the methodology used here to value the salmon stocks. These differences are outlined below:

1. Escapement figures are consistent with those used in 1978 but have been updated to reflect current information.

2. Production Distribution Tables are now available for the Georgia Strait Vancouver Island Area and these tables were used to allocate the catch to the various fisheries (commercial, native and sport) by geographical area and gear type.

3. In the 1978 Task Force Report, it was assumed that all catch was taken in the commercial fishery. Sport catch was estimated from results of the report, Resident Boating in Georgia Strait. These estimates reflected catch of other stocks as boaters would not be targetting specifically on local stocks.

4. As in the 1978 Task Force Report, commercial benefits are herein assumed to be equivalent to gross wholesale values. When current estimates of the marginal costs of harvesting and processing become available this analysis may be adjusted to provide estimates of net commercial benefits. Marginal costs would reflect only the variable costs of catching and processing fish and would not include any capital costs of additional catching and processing capacity.

5. The sport value in the 1978 Task Force Report was measured using consumer surplus and was based on an estimate of total angler days associated with sport fishing. These figures are taken from the report Resident Boating in Georgia Strait. In this analysis, total angler days are calculated using the demand response model developed in 1977 by W.A. Masse and Ken Peterson, Evaluation of Incremental Recreational Benefits from Salmonid Enhancement Program. Measures of consumer surplus are calculated using the willingness-to-pay methodology.

Tables A1 and A2 present escapement, catch/escapement ratios and resulting estimates of total catch for the Cowichan and Koksilah Rivers respectively. In Tables B1 and B2 the catch by species is allocated to the various fisheries. In Tables C1 and C2 the annual values of the catch to the domestic fisheries are calculated. Also presented in these tables are the present values of the annual catches. Present values were computed using real discount rates of 5, 10 and 15 percent. For social benefit/cost purposes, a discount rate within the range of 5% to 10% is considered appropriate. The present values of the Cowichan and Koksilah catch is therefore within the range of $36.4 to $72.6 million and $7.6 to $15.2 million respectively.

Table A1

TOTAL ESTIMATED CATCH OF THE COWICHAN SALMON STOCKS

Species	Escapement[1]	Catch/Escapement Ratio[2]	Total Catch (000)
Chinook	6,100	5.5.1	33.6
Coho	37,470	4.5.1	168.8
Chum	71,050	0.6.1	42.6

[1] 1973-1982 escapement figures taken from DFO Spawning Escapement Records.

[2] Catch to escapement ratios taken from Appendices 14 and 15 of the Cowichan Estuary Task Force Report, August, 1980.

Table A2

TOTAL ESTIMATED CATCH OF THE KOKSILAH SALMON STOCKS

Species	Escapement[1]	Catch/Escapement Ratio[2]	Total Catch (000)
Chinook	470	5.5.1	2.6
Coho	6,150	4.5.1	27.7
Chum	4,400	0.6.1	2.6

[1] 1973-1982 escapement figures taken from DFO Spawning Escapement Records.

[2] Catch to escapement ratios taken from Appendices 14 and 15 of the Cowichan Estuary Task Force Report, August, 1980.

Table B1

COWICHAN RIVER SALMON CATCH BY SPECIES AND SECTOR*

Species	US Interceptions		Canadian Commercial Fisheries		Canadian Sport Fishery		Native Fishery		Total	
	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)
Chinook	3.6	1.2	57.9	19.4	38.5	12.9	0	0	100	33.6
Coho	10.1	17.0	48.7	82.2	41.2	69.5	0	0	100	168.8
Chum	0	0	97.0	41.3	0	0	3.0	1.3	100	42.6
Total		18.2		142.9		82.4		1.3		95.0

* Based on 10-year average escapements (1973-1982), SEP production standards and SEP catch allocation ssumptions.

Table B2

KOKSILAH RIVER SALMON CATCH BY SPECIES AND SECTOR*

Species	US Interceptions		Canadian Commercial Fisheries		Canadian Sport Fishery		Native Fishery		Total	
	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)	%	Pieces (000)
Chinook	3.6	0.1	57.9	1.5	38.5	1.0	0	0	100	2.6
Coho	10.1	2.8	48.7	13.5	41.2	11.4	0	0	100	27.7
Chum	0	0	97.0	2.6	0	0	3.0	0.1	100	2.6
Total		2.9		17.6		12.4		0.1		32.9

* Based on 10-year average escapements (1973-1982), SEP production standards and SEP catch allocation assumptions.

Table C1

VALUE* OF COWICHAN RIVER SALMON CATCH BY SPECIES AND SECTOR

Species	Canadian Commercial Fisheries		Canadian Sport Fishery		Native Fishery		Total			
	Average Value $/Piece	Total Value $ 000	Average Value $/Piece	Total Value $ 000	Average Value $/Piece	Total Value $ 000	Annual Value $ 000	Present Value $ (000,000) 5%	10%	15%
Chinook	33	640.2	40	425.7	-	-	1065.9	21.3	10.7	7.1
Coho	13	1068.6	40	903.5	-	-	1972.1	39.4	19.7	13.1
Chum	14	578.2	-	-	14	18.2	596.4	11.9	6.0	4.0
Total		2287.0		1329.2		18.2	3634.4	72.6	36.4	24.2

* 1982 prices

Table C2

VALUE* OF KOKSILAH RIVER SALMON CATCH BY SPECIES AND SECTOR

Species	Canadian Commercial Fisheries		Canadian Sport Fishery		Native Fishery		Total			
	Average Value $/Piece	Total Value $ 000	Average Value $/Piece	Total Value $ 000	Average Value $/Piece	Total Value $ 000	Annual Value $ 000	Present Value $ (000,000) 5%	10%	15%
Chinook	33	49.5	40	40.0	-	-	89.5	1.8	0.9	0.6
Coho	13	175.5	40	456.0	-	-	631.5	12.6	6.3	4.2
Chum	14	36.4	-	-	14	1.4	37.8	0.8	0.4	0.3
Total		261.4		496.0		1.4	758.8	15.2	7.6	5.1

*1982 prices

Appendix 5 - Coho Growth Survey Data

Table A. Koksilah River Study Site 4.

	A) 25/5/81		B) 19/6/81		C) 9/7/81		D) 17/7/81		E) 30/7/81	
	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)
1	69	3.5	75	5.3	68	4.1	74	4.6	63	3.1
2	43	.7	55	1.9	49	1.3	75	5.6	71	5.0
3	49	1.6	46	1	64	3.7	61	3.1	69	4.4
4	58	2.2	60	2.3	64	3.8	65	3.77	62	3.18
5	44	1	53	1.6	59	2.6	64	3.4	70	4.7
6	50	1.4	60	2.6	62	2.9	67	3.9	72	5.1
7	48	1.3	59	2.7	66	3.4	68	4.3	65	3.6
8	52	1.7	62	3	48	1.15	54	1.62	47	1.2
9	47	1.3	36	.5	60	2.5	73	5.6	70	4.5
10	44	1	66	3.2	45	1.2	59	2.5	65	3.45
11	45	1.2	65	3.3	65	3.7	68	3.9	75	4.9
12	43	.7	68	3.9	63	3.3	70	3.8	68	3.97
13	50	1.6	59	2.6	35	.52	69	4.1	59	2.7
14	40	.5	52	1.5	64	3.4	68	3.9	61	3.1
15	35	.4	50	1.6	38	.76	68	4.2	74	5.3
16	42	.6	69	3.5	64	3.3	70	4.18	66	3.6
17	46	1	59	2.5	43	1.08	60	2.8	56	2.05
18	43	.9	63	3.2	64	3.4	62	2.8	63	3.4
19	54	1.9	51	1.7	64	3.4	62	3.15	68	3.8
20	43	1	63	3	54	1.8	63	3.5	65	3.8
21	42	.8	56	2	45	1.22	61	3.1	64	3.03
22	42	.8	57	2.4	69	4.5	64	3.0	73	4.35
23	50	1.2	58	2.5	57	2.5	66	3.6	68	3.94
24	45	1.1	61	2.6	43	1	67	3.7	62	2.95
25	53	2	63	2.8	63	3.2	68	4.4	62	3.8
26	47	1.2	35	.6	62	3.0	66	3.4	63	3.1
27	48	1.2	64	3.0	59	2.7	69	4.0	73	4.6
28	35	.5	58	2.5	57	2.6	62	3.47	65	3.2
29	53	1.7	33	.4	53	1.9	66	3.78	63	3.1
30	57	1.9	63	3	57	2.4	67	3.9	65	3.1
31	40	.9	63	2.7						
32	43	1.8	57	2.2						
33	48	1.5	61	2.6						
$\bar{X}$	47.24	1.23	57.58	2.43	56.8	2.54	65.87	3.7	65.57	3.67
S	6.81	.62	9.34	1.0	9.35	1.1	4.59	.81	5.81	.92
S'	44.97	.37	84.67	.96	84.56	1.17	20.38	.63	32.65	.82
Mx.	60.86	2.47	76.26	4.43	75.50	4.74	75.05	5.32	77.19	5.51
to	-	-	-	-	-	-	-	-	-	-
Min.	33.62	.01	38.9	.43	38.10	.34	56.69	2.08	53.95	1.83

Appendix 5

Table A. Koksilah River Study Site 4 (Cont'd.)

	F) 6/8/81		G) 21/8/81		H) 4/9/81		I) 18/9/81	
	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)
1	67	4.1	82	7.4	74	4.7	74	4.8
2	68	4.4	65	3.8	68	3.7	72	4.4
3	68	3.8	65	3.6	72	4.5	68	3.8
4	65	3.5	64	3.2	75	5.1	81	1.5
5	70	4.6	69	4.3	63	3.1	70	4.8
6	75	5.4	65	3.8	71	4.8	70	4.5
7	65	3.2	71	5.0	65	3.7	70	4.1
8	70	4.2	61	3.5	68	3.8	70	4.6
9	60	2.7	63	3.4	70	4.4	70	5.2
10	62	2.9	60	3.0	63	3.7	69	4.3
11	64	3.8	65	3.9	69	4.1	75	6.0
12	70	3.9	70	4.8	64	3.5	63	3.1
13	75	5.1	65	3.7	64	3.5	73	4.4
14	66	2.4	65	3.8	70	4.2	79	5.6
15	64	3.1	70	5.2	69	4.1	77	5.2
16	75	5.2	57	2.7	71	4.6	67	3.4
17	62	3.1	62	3.4	70	4.5	76	5.2
18	70	4.2	60	3.4	67	3.8	75	5.3
19	60	2.7	62	3.5	65	4.9	72	4.3
20	66	3.8	68	4.5	67	3.8	60	3.0
21	65	3.2	61	2.8	71	4.4	75	5.7
22	67	4.0	68	4.3	71	4.6	73	4.9
23	60	2.4	58	2.8	79	6.6	69	4
24	68	4.1	58	2.7	63	4.9	72	4.9
25	65	3.7	68	4.4	69	4.2	72	4.8
26	69	4.0	64	3.3	74	4.8	70	4.3
27	65	3.6	68	4.4	64	3.1	63	3.2
28	62	3.2	66	3.7	69	4.3	67	3.8
29	65	3.4	64	3.8	78	5.7	68	4.5
30	66	3.6	68	3.8	73	4.7	65	3.3
31					72	4.7		
32					72	4.8		
33								
$\bar{X}$	66.47	3.71	65.07	3.86	69.38	4.35	70.83	4.53
S	4.13	.77	4.93	.93	4.21	.72	4.71	.86
S'	16.45	.57	23.53	.84	17.17	.50	21.41	.72
Mx.	74.73	5.25	74.93	5.72	77.8	5.79	80.25	6.25
to	-	-	-	-	-	-	-	-
Min.	58.21	2.17	55.21	2.0	60.96	2.91	61.41	2.81

Appendix 5

Table B. Lower Glenora Creek - Study Site 6.

	A) 28/5/81		B) 19/6/81		C) 9/7/81			D) 17/7/81		E) 30/7/81	
	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	K	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)
1	43	.5	57	2.4	58	2.6	1.32	50	1.5	62	3.0
2	42	.8	55	2	52	1.7	1.2	55	1.96	63	3.1
3	43	1	55	2.2	40	.9	1.39	58	2.58	59	2.68
4	39	.5	54	1.8	45	1.35	1.48	53	2.19	74	4.7
5	36	.6	43	1.1	54	1.9	1.21	58	2.37	64	3.4
6	50	1.7	51	1.5	54	2.0	1.27	64	3.45	64	3.3
7	54	1.8	58	2.4	50	1.7	1.38	56	2.38	62	3.4
8	41	.8	50	1.5	55	2.1	1.25	52	2.0	58	2.5
9	50	1.6	47	1.3	48	1.43	1.29	59	2.63	58	2.78
10	40	.7	68	3.9	72	4.4	1.18	54	3.15	56	2.34
11	57	2	50	1.7	48	1.3	1.18	49	1.62	63	3.06
12	38	.6	50	1.6	48	1.41	1.27	63	3.0	70	4.41
13	40	.7	58	2.5	47	1.38	1.33	53	2.15	59	2.81
14	48	1.2	51	1.5	50	1.4	1.12	47	1.47	64	3.7
15	51	1.7	44	1.1	54	2.1	1.36	53	1.9	52	2.0
16	35	.4	54	2	45	1.2	1.32	52	1.95	64	3.2
17	43	1	47	1.4	47	1.4	1.35	73	5.3	56	2.21
18	48	1.2	57	2.4	58	2.5	1.31	53	1.95	64	3.27
19	46	1.1	58	2.4	47	1.32	1.27	55	2.2	64	3.18
20	48	1.4	59	2.7	55	2.18	1.31	54	2.1	62	3.02
21	55	1.9	48	1.2	55	2.13	1.28	55	1.9	47	1.41
22	40	.8	56	2.2	55	2.15	1.29	56	2.4	62	3.04
23	41	.8	60	2.6	54	2.21	1.4	63	3.9	59	2.65
24	47	1.4	54	2.1	63	3.05	1.22	54	2.0	59	2.47
25	35	.4	48	1.5	53	2.05	1.38	55	2.1	60	2.7
26	45	1	43	.9	55	2.4	1.44	54	2.0	57	2.41
27	48	1.3	45	1	60	2.77	1.28	68	4.2	69	4.6
28	46	1.1	44	1.1	50	1.7	1.36	45	1.3	55	2.08
29	35	.4	45	1.1	50	1.75	1.4	60	2.75	62	2.5
30	39	.7	48	1.1	49	1.73	1.47	45	1.11	54	1.97
31	43	.7	51	1.9							
32	40	.6	44	.9							
33											
$\bar{X}$	43.94	1.01	51.63	1.78	52.37	1.94	1.31	55.53	2.38	60.73	2.93
S	5.89	.47	6.05	.68	6.17	.69	.09	6.21	.89	5.39	.75
S'	33.62	.21	35.42	.44	36.83	.46		37.25	.77	28.06	.55
Mx.	55.72	1.95	63.73	3.14	64.71	3.32	1.49	67.95	4.16	71.51	4.43
to	–	–	–	–	–	–	–	–	–	–	–
Min.	32.16	.07	39.53	.42	40.03	.56	1.13	43.11	.6	49.95	1.43

Appendix 5

Table B. Lower Glenora Creek - Study Site 6 (Cont'd.).

	F) 6/8/81		G) 21/8/81		H) 3/9/81		I) 18/9/81	
	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)
1	57	2.7	58	2.3	67	3.7	62	2.6
2	68	4.5	55	2.2	74	4.8	60	2.9
3	67	4.5	55	2.6	68	4.0	57	2.2
4	73	5.4	62	3.4	56	2.2	68	4.1
5	64	3.8	60	2.7	59	2.5	61	3.1
6	63	3.2	59	3.1	55	2.2	59	2.7
7	58	2.6	53	2.2	64	3.2	65	3.3
8	65	3.5	66	4.0	76	4.2	62	2.9
9	57	2.5	57	2.2	65	3.2	62	2.9
10	67	3.9	62	3.4	64	2.9	62	3.7
11	60	2.9	54	2.1	58	2.4	57	2.2
12	63	3.0	56	2.5	63	3.0	62	2.9
13	67	3.8	70	4.8	69	3.7	56	2.2
14	56	2.6	58	2.4	68	3.8	62	3.0
15	66	3.4	63	3.4	63	3.3	70	4.2
16	57	2.5	55	2.3	64	3.3	66	3.8
17	63	3.6	65	3.6	57	2.3	71	4.1
18	61	3.2	53	2.1	50	1.6	62	2.6
19	58	2.7	55	2.2	57	2.2	60	2.7
20	60	3.0	58	2.7	63	3.0	61	3.0
21	48	1.5	59	2.3	71	4.3	63	2.9
22	67	4.2	48	1.5	58	2.4	61	3.0
23	57	2.5	60	2.7	65	3.5	68	3.0
24	51	2.0	57	2.1	62	3.0	58	2.6
25	69	4.3	57	2.2	52	1.9	66	3.4
26	74	5.4	62	3.2	65	3.5	53	2.0
27	59	2.9	55	2.1	63	3.3	64	3.3
28	74	5.5	60	2.8	56	2.2	54	2.2
29	64	3.4	60	2.7	57	2.5	62	3.0
30	63	3.4	57	2.4	65	2.9	68	4.1
31								
32								
33								
X	62.53	3.41	58.3	2.67	62.47	3.03	62.07	3.02
S	6.23	.98	4.41	.69	6.14	.77	4.42	.61
S'	37.52	.94	18.81	.45	36.45	.58	18.86	.36
Mx.	74.99	5.37	67.12	4.05	74.75	4.57	70.91	4.24
to	-	-	-	-	-	-	-	-
Min.	50.07	1.45	49.48	1.29	50.19	1.49	53.23	1.8

Appendix 5

Table C. Upper Glenora (Isolated Pool) Approximately 2 Km upstream of Study Site #6

	A) 28/8/81		B) 3/9/81		C) 18/9/81	
	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)	f.l. (cm)	Wgt. (gm)
1	56	1.7	62	3.	53	1.6
2	60	2.9	58	2.3	57	3.2
3	55	2.1	54	2.1	53	1.9
4	60	3.1	68	4.	58	2.6
5	54	2.0	60	2.7	73	4.8
6	53	2.1	66	3.8	65	3.
7	66	3.9	66	3.7	61	2.6
8	66	4.0	54	2.2	66	2.4
9	49	1.6	54	2.2	57	2.2
10	58	2.6	56	2.3	46	1.4
11	60	3.0	61	2.9	52	1.8
12	54	1.9	60	2.	66	3.
13	57	2.5	56	2.2	60	2.7
14	58	2.5	58	1.9	55	2.
15	59	3.0	59	2.4	57	2.4
16	53	1.9	53	2.1	55	2.
17	53	1.8	50	1.5	56	2.3
18	55	2.3	58	2.3	55	2.2
19	53	2.0	54	1.9	49	1.6
20	68	4.0	55	1.7	46	1.3
21	54	2.1	50	1.6	49	2.4
22	55	2.3	60	2.8	52	2.
23	50	1.5	53	1.9	56	2.1
24	58	2.4	54	2.	52	1.8
25	49	1.6	59	2.6	52	1.8
26	54	2.0	52	1.9	51	1.7
27	54	2.1	52	2.	55	2.
28	51	1.8	58	2.6	55	2.4
29	53	2.0	60	2.8	59	2.5
30	49	1.2	57	2.2	48	1.5
31					56	2.3
32						
33						
$\bar{X}$	55.8	2.33	57.23	2.35	55.65	2.24
S	4.87	.72	4.55	.62	6.05	.67
S'	22.96	.5	20.05	.37	35.39	.43
Mx.	65.54	3.77	66.33	3.59	67.75	3.58
to	-	-	-	-	-	-
Min.	46.06	.89	48.13	1.11	43.55	.9

APPENDIX 6: Summary of Coho Habitat by the Salmonid Habitat Information Project by Chamberlin et al (1984)
Cowichan - Koksilah Watershed

COHO SUMMARY

Accessible Habitat		CHAN km	L km^2	WL km^2
0 - 2% gradient		192.7	63.99	1.45
2.1 - 5% gradient		67.9		
	TOTAL	260.6	63.99	1.45

Inaccessible Habitat		CHAN km	L km^2	WL km^2
0 - 2% gradient		107.4	4.75	4.01
2.1 - 5% gradient		124.9		
	TOTAL	232.3	4.75	4.01

CRITERIA FOR FISH HABITAT EVALUATION

SPECIES	CHANNEL SLOPE		LAKES	WETLANDS
	High	Moderate		
Coho	0 to 2.0	2.1 to 5.04	High	High

COHO

STREAM NAME	STREAM NUMBER	ACCESSIBLE HABITAT					INACCESSIBLE POTENTIAL HABITAT				
		Channel		km	lake	wetlnd	Channel		km	lake	wetlnd
		High	Mod.	Total	km^2	km^2	High	Mod.	Total	km^2	km^2
Kelvin Creek	92-4800-020-050	6.4		6.4			3.0	1.7	4.7		0.10
Glenora Creek	92-4800-020-050-130	8.8	3.1	11.9	0.06	0.05					
Unnamed Creek	92-4800-020-090	1.5	2.3	3.8							
Patrolas Creek	92-4800-020-110						3.8		3.8	0.12	
Neel Creek	92-4800-020-125	1.4	1.0	2.4	0.01						
Heather Bank Creek	92-4800-020-180							0.9	0.9		
Humes Creek	92-4800-020-300		0.1	0.1							
Unnamed Creek	92-4800-020-330		0.1	0.1							
Unnamed Creek	92-4800-020-420										
Wild Deer Creek	92-4800-020-425		0.3	0.3			1.3	4.7	6.0	0.09	0.02
Grant Lake Creek	92-4800-020-500						0.3	0.2	0.5	0.54	0.04
Unnamed Creek	92-4800-020-575		0.9	0.9				2.7	2.7	0.04	0.05
Unnamed Creek	92-4800-020-670	1.1	0.6	1.7			4.4	5.6	10.0	0.04	0.12
Unnamed Creek	92-4800-020-670-150		1.7	1.7			1.2	3.6	4.8		0.03
Fellows Creek	92-4800-020-700	0.4	1.7	2.1			2.9	3.1	6.0		0.04
Unnamed Creek	92-4800-020-700-200		0.1	0.1			5.1	4.1	9.2	0.03	0.48
Unnamed Creek	92-4800-020-730						2.0	2.3	4.3	0.05	0.21
Koksilah River to Marble Falls		13.4		13.4							
Marble Falls to	92-4800-020-730	21.8	1.7	23.5		0.02					
Koksilah River above	92-4800-020-730						13.1	6.0	19.1	0.06	0.73