PROGRESS REPORT ON THE PUNTLEDGE RIVER PROGRAM

1971 AND 1972

TECHNICAL REPORT 1973-8

BY

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TABLE OF CONTENTS

	PAGE
LIST OF TABLES	iii
LIST OF FIGURES	iv
PRINCIPAL STAFF ASSOCIATED WITH THE PUNTLEDGE PROJECT IN 1971 AND 1972	v
I. INTRODUCTION	1
II. BIOLOGICAL PROGRAM	
A. Enumeration of the 1970 and 1971 brood chinook fry emigrating from the spawning channel	6
B. Gravel cleaning operations at the channel	8
C. Increasing flow from 50 cfs. to 100 cfs. in the channel during the winter incubation period in an attempt to increase the incubation survival rate	11
D. Rearing of channel produced chinook fry at Big Qualicum Hatchery (1970 brood) and in improvised facilities at the Puntledge Channel (1971 brood)	12
E. Some observations of the distribution and habitat of juvenile summer-run chinook rearing in the Puntledge River between the diversion dam and powerhouse	19
F. An experimental transplant of 1970 brood channel produced chinook fry in the Puntledge River above the diversion dam and powerhouse intake works	24
G. Swim surveys to monitor the adult injury problem during the upstream migration period	25

PAGE

H. Enumeration of the 1971 and 1972 brood summer-run chinook escapements to the spawning channel and upper Puntledge River area ... 33

I. Enumeration of the 1971 and 1972 brood fall-run chinook escapements to the lower Puntledge River area ... 36

J. Egg-take from the 1972 brood summer and fall-run chinook ... 38

K. An experimental transplant of coho fry from the Big Qualicum Hatchery into "Bevan Creek", a small tributary of the Puntledge River ... 42

III. CONSTRUCTION PROJECTS

A. Fish migration baffle at upper Stotan Falls ... 49

B. Office-workshop-laboratory building at the Puntledge channel site ... 51

C. Two 75-foot concrete Burrows-type juvenile salmon rearing ponds at the Puntledge channel site ... 53

IV. APPENDIX

Summary of fisheries problems and remedial measures at the Puntledge River, 1954 - 1972 ... 56

LIST OF TABLES

TABLE		PAGE
1	Potential egg deposition and resultant fry production at the Puntledge Spawning Channel, 1965 - 1971 and available data for 1972	7
2	Summary of mortality, marking, growth and food conversion of Puntledge summer-run chinook juveniles reared at the Big Qualicum Hatchery, 1971	14
3	Summary of mortality, growth and food conversion of Puntledge summer-run chinook juveniles reared in the channel by-pass fishway	18
4	Escapement, prespawning mortality, egg deposition and incubation survival at the Puntledge Spawning Channel, 1965 - 1972	26
5	Number of severely injured adult summer-run chinook seen during swim surveys at the Puntledge River, 1969 - 1972	29
6	Fall-run chinook escapements to the Puntledge River, 1954 - 1972	39

LIST OF FIGURES

FIGURE		PAGE
1	Map of the Puntledge River showing the hydro-electric development scheme and location of the spawning channel	5a
2	Schematic diagram of the Puntledge River Spawning Channel, Rearing Ponds and Powerhouse Intake Channel	6a
3	Schematic diagram of the diversion dam and fish barrier racks showing the location of the deep pool adjacent to the barrier racks and location of the wood sill which diverts flow to the lower wing of the dam	34
4	Map of the lower portion of the Puntledge River showing the approximate numbers and distribution of fall run chinook in 1972 according to float surveys	37
5	Map of Bevan Creek showing the coho fry release sites and the smolt trapping site	44
6	Fish migration baffle or weir at Upper Stotan Falls	50
7	Fisheries building at the Puntledge Channel site	52
8	Burrows rearing ponds at the Puntledge Channel site	54

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I. INTRODUCTION

The biological program at the Puntledge River originated in 1953 when the British Columbia Power Commission (now the British Columbia Hydro and Power Authority) initiated a project for expanding hydro-electric facilities on the river. The project created several fisheries problems which led initially to the decline of the native summer chinook run and later to the decline of the native fall chinook run.

The expanded facilities commenced operation in March, 1955 with the final construction being completed in early 1958. Water diversion for power generation was increased from a former maximum of approximately 300 cfs to a maximum of 1000 cfs. The facilities include an impounding dam at the outlet of Comox Lake, a diversion dam and intake works located about 2.5 miles below the lake where flow enters a single penstock, and a powerhouse located on the lower river about 4.5 miles below the diversion dam. (Fig. 1)

A. Summer-Run Chinook

Summer-run chinook originally spawned in the section of river between the diversion dam and Comox Lake. Adults enter the river on their spawning migration in June, July and August and spawn in October. The juvenile downstream migration occurs during March to July.

Early escapement records place the summer-run chinook population in the river at a level of about 3,000 spawners but in recent years their numbers have declined to a level of about 400 spawners. The fisheries problems associated with the decline are the following:

1. A reduction in flow between the diversion dam and powerhouse which increased the hazard to migrating adult salmon at Stotan and Nib Falls.

2. Attraction to the increased flow at the powerhouse tailrace which delayed adult migration and caused injury to fish in the draft tubes.

3. Modification of the intake works* and an increase in diversion flow resulting in a major portion of downstream migrant chinook juveniles passing through the turbine**.

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* The previous intake works consisted of a flume leading to a forebay at which point a spillway diverted excess flow back into the river. It was felt that a majority of juveniles entering the flume escaped via the spillway.

** In 1955, tests conducted at the Puntledge indicated that mortality of juveniles passing through the turbine was in the order of 30 percent.

The adult injury problem was eventually reduced by two measures implemented during 1969. These were the construction of concrete migration baffles or weirs at a point of difficult fish passage at lower Stotan Falls, and the provision of moderate migration flows in the order of 300 cfs. at the falls. An earlier attempt at alleviating the problem by closure of the powerhouse (1963-1968) during the main adult migration period proved impractical as difficult fish passage occurred at the falls some years due to heavy flow.

In an attempt to resolve the problem of turbine mortality of juveniles, an artificial spawning channel*** was constructed by Hydro in 1965 at a location adjacent to the diversion dam. The channel replaced the natural spawning areas above the diversion dam and enabled downstream migrant juvenile chinook to enter the river below the intake works. This terminated efforts aimed at salvage of juveniles at the intake works (1956 - 1964) and night-time closures of the powerhouse (1965) during the juvenile migration period.

Additional measures aimed at resolving fisheries problems at the Puntledge which have been applied in recent years are the following:

*** The channel is 840 feet long with a gravel bottom width of 25 feet. Spawning capacity is approximately 1000 (400 female) chinook.

1. Construction of a concrete migration weir at a point of difficult adult passage at upper Stotan Falls (1971).

2. Remedial work on the fish barrier racks at the diversion dam (1970) which were found to be a source of injuries to adults.

3. Provision of moderate and stable flows in the falls section of the river (1971) during the early juvenile freshwater rearing period (March - May) to enhance natural rearing.

4. Hatchery propagation of juveniles utilizing temporary incubation facilities installed in the old Canadian Collieries Powerhouse and two 75 foot concrete Burrows-type rearing ponds constructed at the channel site (1972).

B. Fall-Run Chinook

Fall-run chinook spawn in the lower reaches of the Puntledge between the powerhouse and a point approximately ¼ mile below the Condensory Bridge (Fig. 4). Adults enter the river in September and October and spawn in October.

According to early escapement records, the fall chinook run was similar in numbers to the summer run, averaging approximately 3,000 spawners. In recent years the escapement has declined to a few hundred spawners. The decline is associated with accentuated fall-winter freshets at the Puntledge which commenced in 1958 affecting adult returns in 1961 and later years. The freshets appear to have affected the run through damage to eggs and alevins and through the eventual loss of much spawning gravel. The loss of gravel represents permanent damage as there is no apparent input of new material into the lower river area.

Remedial measures to date have been limited to a small-scale egg-take from the 1972 brood escapement and the propagation of juveniles (in 1973) in the new hatchery facilities. Long-term plans for rehabilitating the run are based on a proposal * for implementing a full-scale hatchery program utilizing a site in the lower river area.

A detailed summary of fisheries problems and remedial measures at the Puntledge River from 1954 to 1972 is presented in a table appended to this report.

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* D.E. Marshall - Development Potential of Puntledge River Chinook and Coho Salmon and Steelhead Stocks. Fisheries Service Management Report, July 1972.

* Anon. - Proposed Puntledge Salmon Hatchery. Engineering Feasibility Report by Acres Consulting Services Limited, Vancouver, B.C., April, 1973.

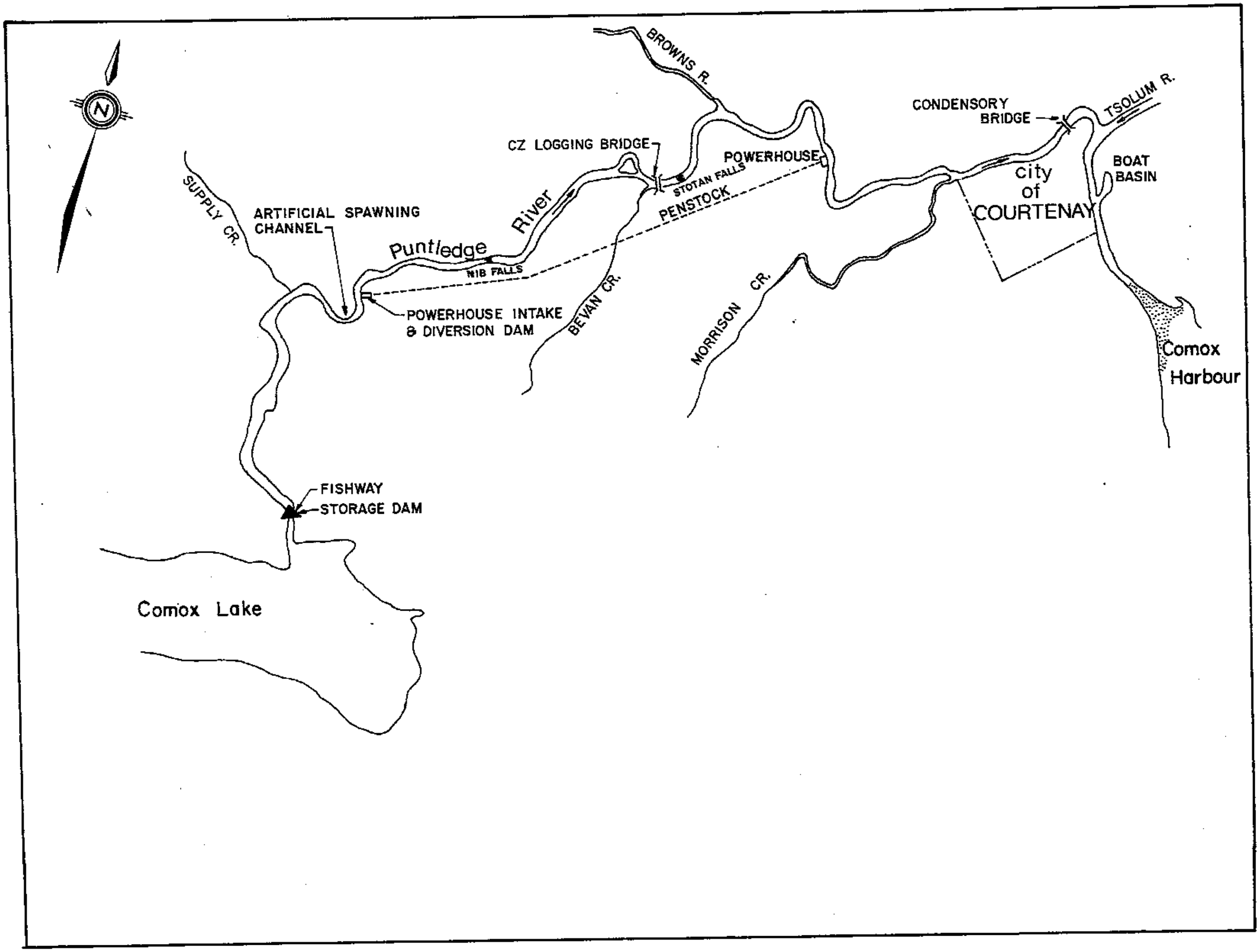

FIGURE 1 MAP OF THE PUNTLEDGE RIVER SHOWING THE HYDRO-ELECTRIC DEVELOPMENT SCHEME AND LOCATION OF THE SPAWNING CHANNEL.

II. BIOLOGICAL PROGRAM

A. ENUMERATION OF THE 1970 AND 1971 BROOD CHINOOK FRY EMIGRATING FROM THE SPAWNING CHANNEL.

Enumeration of fry is conducted by means of three 6-inch wide inclined screen traps which are installed near the lower end of the fishway draining the channel (Fig. 2). Trapping efficiency is determined by the recovery of dye-marked (Bismark Brown) fry released in groups upstream of the gear. Efficiency has averaged 25 per cent during several trials each year and is equal to the proportion of the total volume of water in the fishway which passes through the traps. Traps are fished on alternate nights during the early part of the fry migration period and nightly during the main period. The fry emigration from the channel during non-fishing nights is calculated by averaging the preceding and following night's emigration.

Table 1 gives the number of female spawners, potential egg deposition, resultant fry production and per cent incubation survival rate for the 1965 to 1971 broods at the channel and the available data for the 1972 brood.

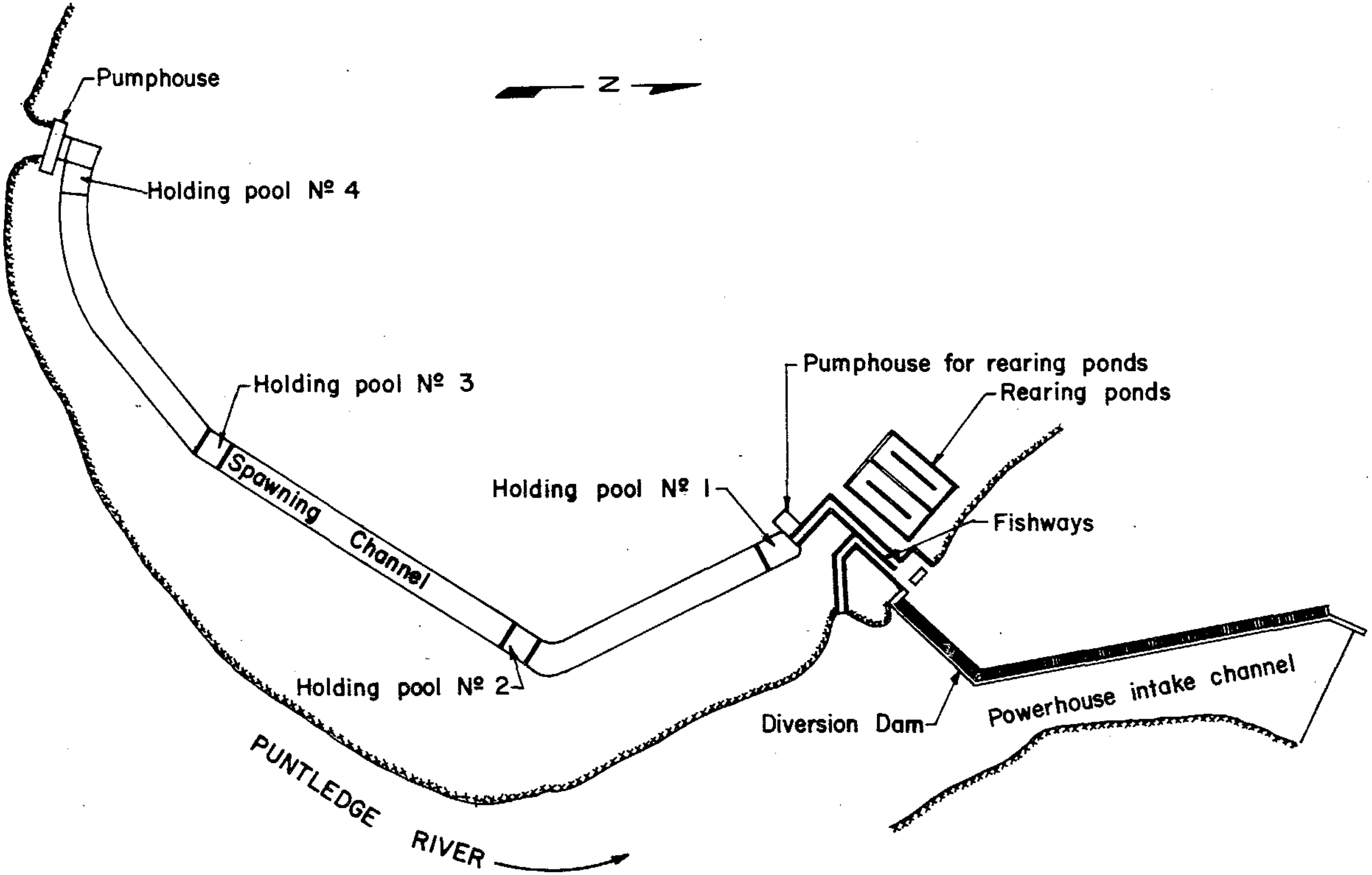

FIGURE 2 SCHEMATIC DIAGRAM OF THE PUNTLEDGE RIVER SPAWNING CHANNEL, REARING PONDS AND POWERHOUSE INTAKE CHANNEL.

TABLE 1. POTENTIAL EGG DEPOSITION AND RESULTANT FRY PRODUCTION AT THE PUNTLEDGE SPAWNING CHANNEL, 1965 - 1971 AND AVAILABLE DATA FOR 1972.

Brood Year	1965	1966	1967	1968	1969	1970	1971	1972
No. Female Spawners	92	46	147	89	46	175	94	115[a]
Potential Egg Deposition (x 1000)[b]	437	211	648	415	193	853	439	527
Fry Production (x 1000)	48	84	243	186	65	213	51	-
Percent Incubation Survival	10.9	39.9	37.6	45.0	33.7	26.1	11.6	-

[a] An additional 24 females were netter from the channel for hatchery egg-taking purposes.

[b] Based on the formula: fecundity = -5697 + 15.04 x hypural length. (mm)

A disappointing result of the 1970 and 1971 broods is the low incubation survival rates of 26.1 and 11.6 percent respectively, and the output of only 51,000 fry in 1971, the lowest sice 1965. These survival rates are substantially lower than the 39 percent average of the 1966 to 1968 broods which is the accepted norm for the channel. A downward trend beginning with the 1969 brood is indicated which appears to be related to deteriorating gravel quality due to siltation.

B. GRAVEL CLEANING OPERATIONS AT THE CHANNEL

In a previous memorandum (March 19, 1971) it was reported that gravel quality may have detiorated as a result of a deposition of fine organic material associated with the seasonal die-off of a filamentous algae which had become established at the channel. It is probable that leaf detritus, sloughing of clay banks and fine silt present during heavy rainfall periods have also contributed to the siltation problem.

When the low survival rate of the 1970 brood fry was known, Hydro officials agreed to the cost of a small bulldozer to clean and scarify the gravel. The work took place under Department supervision in early July, 1971 after the chinook and trout fry migration was complete. Early arriving adult chinook were prevented from entering the channel prior to cleaning by the use of screens to block the channel fishway. The bulldozer work was completed in one day following which the channel was dewatered for several days to dry the gravel and destroy any remaining algae and other organisms. Three of the four adult holding pools were drained with small pumps to salvage salmonids and remove sculpins. The uppermost pool (No. 4) could not be drained because of seepage from the river.

Unfortunately, the cleaning operation proved to be unsatisfactory. This was apparent from the low incubation survival rate again the following spring (1972), and from the results of hydraulic sampling and test holes dug with a hand shovel after fry emergence was complete. The hydraulic sampling and test holes revealed a heavy deposition of silt and many dead eggs in the deep gravel layers with relatively little silt and few dead eggs in surface gravel to a depth of one foot. The test holes also revealed that stratification of the gravel had occurred over the years with the finer sizes gravitating to the bottom.

The bulldozer operator, working in turbid, flowing water under poor viewing conditions, had wrongly reported that his blade was scraping the clay base material of the channel near the gravel surface at a number of places (although gravel depth should have been an average of 24 inches according to channel specifications). Consequently, the operator was instructed to avoid digging too deeply and only a shallow cleaning job was done. The work appeared satisfactory at the time because of the large amount of silt that was flushed from the gravel which diminished after repeated passes of the blade.

Hydro agreed to the cost of gravel cleaning again in 1972 and a larger bulldozer (D-7) was utilized. The work took place in early July over a period of two days. Following cleaning, the channel was again dewatered for several days but this time the pools were left filled with water to avoid the problem of disturbing the sediment on the bottoms of the pools when pumping resumed. This problem arose the previous year and may have contributed to the poor results. No effort was made to remove salmonids or sculpins which survived their confinement in the pools.

It is believed that a more thorough cleaning job was obtained on this second attempt although results will not be known until completion of the 1972 brood fry enumeration in the spring of 1973. Contradicting the report of the first bulldozer operator, this operator reported that the gravel depth was in excess of 24 inches in all areas of the channel. The gravel was cleaned to a greater depth and more thoroughly (two days work compared to one) than the previous year and the operator attempted to mix the underlying fine gravel with the coarser surface gravel.

To obtain an early check on incubation survival of the 1972 brood fry, two gravel-filled wire mesh baskets, each with 100 eyed eggs, were buried in the gravel of each of the three spawning sections of the channel during November 1972. The baskets will be examined in late February or March, 1973 to obtain comparative information on incubation survival in the three sections. The eggs were obtained during a hatchery egg-taking operation described in a later section of this report.

C. INCREASING FLOW FROM 50 CFS. TO 100 CFS. IN THE CHANNEL DURING THE WINTER INCUBATION PERIOD IN AN ATTEMPT TO INCREASE THE INCUBATION SURVIVAL RATE.

During the 1970 and 1971 brood winter incubation periods an experiment was carried out with the aim of increasing incubation survival. This simply involved maintaining a flow of 100 cfs. (two pump operation) in the channel until the beginning of fry emergence in mid-February. In previous years it had been the practice to reduce flow to 50 cfs. (one pump operation) immediately after spawning was complete. It was reasoned that the greater flow would result in a higher rate of subgravel flow, thus improving on the 39 percent average incubation survival rate obtained up to that time.

Unfortunately, any beneficial results that might have been forthcoming were negated by the high mortality due to poor gravel quality. It was decided to repeat the procedure a third time during the current (1972 brood) winter incubation period, but with flow being reduced to 50 cfs. when the advanced eyed-egg stage was reached in late November.

D. REARING OF CHANNEL-PRODUCED CHINOOK FRY AT BIG QUALICUM HATCHERY (1970 BROOD) AND IN IMPROVISED FACILITIES AT THE PUNTLEDGE CHANNEL (1971 BROOD).

Hatchery propagation is being conducted as a supplement to spawning channel production to rehabilitate the Puntledge summer-run chinook stock. As a preliminary step in this program, 2,526 fingerlings of the 1969 brood were reared at Big Qualicum Hatchery and released at the Channel in July, 1970. The success of this small experiment led to the rearing of larger groups of fry in 1971 and 1972 and to the construction of two 75 x 16 foot concrete Burrows ponds and pumping facilities at the channel site which were completed in September, 1972. A description of the ponds is given in a later section of this report.

1. <u>1970 Brood</u>

A total of 61,792 emergent channel fry were obtained for rearing and transported to the Big Qualicum Hatchery during the period March 24 - April 19, 1971. The majority of fry were obtained with a 4' x 4' fyke net and live box assembly which was installed at the upper end of the fishway draining the channel. The remainder were taken from the enumeration traps at the lower end of the fishway. After rearing for approximately three months in four circular fiberglas tubs at Qualicum, the fingerlings were transferred to Puntledge on July 15 and 16 and were held and fed for several weeks in the unused channel by-pass fishway (steelhead fishway) which was modified to serve as a raceway for rearing. A total of 49,568 fingerlings were transferred of which 9,816 (20 per cent) were marked with an adipose fin clip and 5,285 (11 per cent) with both an adipose fin clip and a color coded wire nose tag (white-blue-blue-light green). Unfortunately, transportation losses and rearing losses at Puntledge were not properly assessed. An estimate of losses is 2,000 fingerlings (including 620 marks) leaving a total of 47,600 fingerlings (including 14,500 marks) which were released on August 15, 1971.

A summary of rearing mortality, marking, growth and food conversion at Big Qualicum Hatchery is given in Table 2.

Although rearing losses (20 per cent) at Big Qualicum Hatchery were not considered excessive, a significant portion of the mortalities was attributed to the occurrence of a gill infection which was still in evidence at the time of transfer to Puntledge.

TABLE 2. SUMMARY OF MORTALITY, MARKING, GROWTH AND FOOD CONVERSION OF PUNTLEDGE SUMMER-RUN CHINOOK JUVENILES REARED AT BIG QUALICUM HATCHERY, 1971

1. Mortality and marking at Big Qualicum Hatchery

Rearing Tank No.	Fry Count	Total Mortality	AD/Wire Marks	AD/Only Marks	Unmarked Balance	Live Balance
1	15,572	3,344	1,313	2,422	8,493	12,228
2	15,500	3,852	1,313	2,438	7,897	11,648
3	15,220	2,063	1,329	2,501	9,327	13,157
4	15,500	2,965	1,330	2,455	8,750	12,535
TOTAL:	61,792	12,224	5,285	9,816	34,467	49,568

Total mortality - 19.8% of original fry count
Ad/wire marks - 10.7% of live balance
Ad only marks - 19.8% of live balance

2. Growth and food conversion at Big Qualicum Hatchery

Rearing Tank No.	Initial Weight (lb.)	Weight At Transfer (lb.)	Total Gain (lb.)	Amount of Food (lb.)	Conversion Rate
1	15.6	109.8	94.2	180.0	1.9:1
2	19.4	94.8	75.4	170.0	2.2:1
3	17.3	104.8	87.5	167.2	1.9:1
4	17.0	93.2	76.2	163.0	2.1:1
TOTAL:	69.3	402.6	333.3	682.2	2.0:1

Juveniles were transferred to the Puntledge on July 15, and 16, 1971

Table 2. Continued...

3. <u>Estimated number released on August 15, 1971</u>

Ad/wire marks	-	5,071
Ad only marks	-	9,420
Unmarked	-	33,077
TOTAL:		47,568

2. 1971 Brood

In 1972 the entire rearing operation took place at the Puntledge utilizing the channel by-pass fishway. A constant flow of water was supplied by means of an opening between stop logs at the top end of the fishway. Depth and velocity were regulated by adjusting stop logs at the lower end of the fishway. Juveniles were confined by means of wire-mesh screen partitions.

Because of the poor incubation survival of the 1971 brood eggs described earlier, only 33,000 fry were obtained from the channel for rearing. Trapping of fry took place over an extended period from March 19 to May 22 using the fyke net and the enumeration traps.

Two groups of 11,537 fingerlings at a weight of 102/lb. and 8,294 fingerlings at 106/lb. were released on July 6 and 13, 1972, respectively. The remaining juveniles, which totalled 7,335 when transferred to the new Burrows ponds on October 20, are being held for release as yearling "super-smolts" in 1973. Total production of juveniles to October 20, was 27,166 with losses totalling 5,843 (17.7 percent). A summary of rearing mortality, growth and food conversion is given in Table 3.

All fingerlings, including the super-smolt group, were "marked" with oxytetracycline. This drug, contained in a special medicated O.M.P. diet, is deposited as a growth layer on bone tissue and can be detected under U.V. light as a fluorescent ring in the vertebrae of returning adult chinook.

The main problem encountered during rearing was the lack of uniformity in the size of juveniles. This was the result of the protracted ponding period which spanned a total of 63 days. Two difficulties the size differential presented were obtaining accurate weekly weight samples on which to base the daily food ration, and getting the late-ponded fish up to a release size of 90 - 100/lb. at the proper release time. This appears to be late June and early July as indicated by smolting behavior observed among the larger fish.

Three disease problems arose which were tentatively identified as kidney disease (Corynebacterium), "crinkleback" disease (scoliosis and lordosis) and fungus disease (saprolegnia).

The kidney disease occurred in May and June and was of minor consequence, affecting the smaller fish mainly.

Of greater significance was the crinkleback disease which developed among the super-smolt group in July and August. The disease was not apparent in the two groups of fingerlings released in early July. The cause of the disease is uncertain but a dietary deficiency of vitamin C is suspected. This may have been the result of the use of outdated hatchery food or deterioration of the food during warm weather.

TABLE 3. SUMMARY OF MORTALITY, GROWTH AND FOOD CONVERSION OF PUNTLEDGE SUMMER-RUN CHINOOK JUVENILES REARED IN THE CHANNEL BY-PASS FISHWAY, 1972.

1. Mortality		
No. fry ponded	33,009	
Known rearing mortality to October 20	4,367	
Unexplained pond losses to October 20	1,476	
Total losses (percent)	5,843	(17.7)
Live balance:		
Release group 1 (July 6)	11,537	
Release group 2 (July 13)	8,294	
"Super-smolt" group (retained)	7,335	
Total	27,166	
2. Growth and food conversion		
Estimated initial weight [a]	37 lb.	
Release weight:		
Release group 1 (July 6)	115 lb.	
Release group 2 (July 13)	79 lb.	
"Super-smolt" group (as of Oct. 20)	341 lb.	
Total weight gain	498 lb.	
Total weight of food to October 20	1,143 lb.	
Conversion rate	2.3:1	

[a] based on 1971 sampling data at Big Qualicum Hatchery where fry averaged 892/lb.

Arrangements were made with Dr. Gorden Bell of the Nanaimo Biological Station to conduct a pathological examination. The examination revealed that both the normal and affected fish were heavily infected with a protozoan parasite (Myxobolus sp.) which is common to salmon in Vancouver Island streams. Dr. Bell was unable to relate the crinkleback condition with either the degree or location of infection.

The fungus disease developed among the super-smolt group after their transfer to the new Burrows ponds in the fall. In most instances the site of infection was the peduncle and caudal fin. A relatively small number of fish was affected and mortality was insignificant. It is thought that the outbreak stemmed from abrasions incurred during the transfer.

E. SOME OBSERVATIONS OF THE DISTRIBUTION AND HABITAT OF JUVENILE SUMMER-RUN CHINOOK REARING IN THE PUNTLEDGE RIVER BETWEEN THE DIVERSION DAM AND THE POWERHOUSE.

The objectives of this study are:

1. To determine the importance of the falls section of the river between the diversion dam and the powerhouse for rearing juvenile chinook emigrating from the channel.

2. To determine optimum flow in this part of the river for juvenile production.

In former years access by adults to spawning grounds above the diversion dam allowed juveniles to rear in what appears to be ideal habitat for chinook. This section has a low gradient and is wide and deep with numerous protected lagoons and bays. Fluctuations in flow would appear to have minimal effect on rearing conditions.

By contrast, the falls section is of a less stable nature. During the juvenile rearing period in the spring months the area typically experiences low flow with occasional sudden freshets caused by the discharging of surplus storage water over the diversion dam. Since juveniles from the channel migrate directly into the falls section it is important to consider measures such as flow control that may improve production.

The benefit of controlling discharge during the juvenile emergence and rearing period is suggested by the comparatively high survival rate of the 1966 brood fry. This survival is related to unusually moderate and stable flow conditions in the spring of 1967. The estimated rate of adult returns* to the channel from the 1966 brood fry was 0.54 percent - considerably higher than the 0.23, 0.10 and 0.29 percent returns from fry of the 1965, 1967 and 1968 broods respectively.

There is some flexibility in the operation of the Comox Lake Reservoir during medium to heavy snow pack years when ample runoff is expected. This was the basis for a request to Hydro officials in 1971 and 1972 to avoid spilling surplus storage water after early March, the beginning of the main fry emergence period, and to avoid a sudden,heavy release if a spill was later found to be

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* Age determination of adult chinook is based on analyses of length data for returns from the 1965-68 broods. Returns from more recent broods are incomplete.

necessary. Agreement was reached and the reservoir was drawn down prior to fry emergence to provide flood protection. Unfortunately, sudden warming of the weather necessitated heavy spills in the spring months both years. It is planned to continue this request each year with the aim of achieving at least partial success in the control of spring freshets.

Observations on the habitat and distribution of juvenile chinook were made in 1971 and 1972 but results are "spotty" because of difficulties in maintaining a continuous schedule of observations. The 1971 studies were hampered by freshets in May and June and in 1972 no special effort was made because of the low fry production from the channel. Some of the observations were as follows:

1. During foot surveys of the falls section on April 21 and 28, 1971 near the peak of the channel fry emigration, it was found that chinook fry were present only in quiet, shallow pools on the stream margins. Typically, these pools were less than four inches in depth with gravel, rubble, or rock crevices in which the fry, when alarmed, sought shelter. Fry were notably absent in flowing water, in deeper pools over twelve inches in depth, pools without bottom shelter, or quiet shallows that dropped off fairly sharply into deeper, flowing water.

2. On the first of these foot surveys (April 21) the majority of fry were distributed from the channel

downstream approximately one mile to Nib Falls. Below this point, fry were noticeably less abundant, disappearing entirely about ¼ mile below the falls. The end point of the foot survey that day was the Crown Zellerbach Logging Bridge near Stotan Falls.

3. On the second of these foot surveys (April 28) the fry distribution extended farther downstream to a point about ¼ mile below the lower Stotan Falls. The foot survey which began at the Crown Zellerbach Bridge ended a short distance upstream from the powerhouse, well below the last sightings of fry.

4. Further foot surveys were not attempted because of heavy discharge which continued during May and June. However, spot checks from the river bank on May 7th at a few locations between the channel and Nib Falls, and swimming inspections at these same locations found fry in the shallows as before, but also in somewhat deeper pools along the river margin with low water velocities. The swimming inspections found no fry in open waters of the large pools.

5. On this same date at the channel, small aggregates of fry were observed in the deep holding pools at the upper and lower ends. The fact that these fry occupied open, flowing waters suggests that they were early emergent fry at a more advanced stage of development than most fry seen in the river.

6. Swimming inspections were made in connection with adult chinook injury studies in June and July of 1971 and 1972 and at this time of year juveniles at an advanced rearing stage were found in open waters of the large, deep pools throughout the

falls section.

Although these observations are few and of a subjective nature, they indicate the following:

a. Juveniles appear to be most vulnerable to changes in flow during the first weeks after migration from the channel. At this early stage, rearing takes place in shallow, zero velocity pools along the stream margin. The transition toward deeper, faster flowing water probably occurs gradually as growth and development proceeds.

b. River flow that provides the greatest amount of the shallow-pool type rearing habitat necessary for initial rearing is estimated to be in the range of 100-200 cfs. It is apparent that many juveniles in this type of habitat could be stranded by a decrease in flow or displaced downstream by an increase in flow. The hazards of stranding are obvious while displacement may subject fry to additional predation and increased competition for suitable rearing space.

c. The observed transition from a shallow-pool, zero-velocity rearing habitat to deeper, faster-flowing habitat indicates that at progressively later stages of development, fluctuations in flow would probably diminish in importance as a survival factor.

d. The falls section of the river is an important rearing area, particularly during the early stages of development. Provision of moderate and stable flow conditions would probably be of significant value in rehabilitating the chinook run.

F. AN EXPERIMENTAL TRANSPLANT OF 1970 BROOD CHANNEL-PRODUCED CHINOOK FRY IN THE PUNTLEDGE RIVER ABOVE THE DIVERSION DAM AND POWERHOUSE INTAKE WORKS.

As mentioned in the preceding section, the river above the diversion dam and intake works appears to be a more productive rearing area than the falls section where fry presently enter the river from the channel. It is anticipated that the effect of a 30-40 percent turbine mortality rate of juveniles (as determined by 1955 Puntledge field tests) may be offset by a relatively high rate of pre-smolt survival under conditions of ideal habitat and low-density rearing.

In practice, any juveniles transplanted above the diversion dam would probably not all pass through the turbine with some being flushed over the diversion dam. The present flow agreement with Hydro provides moderate discharge in the range of 300 - 500 cfs. in the falls section of the river to assist adult migration during June to September. Most of this flow is spilled over the diversion dam (about 125 cfs. of the total is discharged through the spawning channel and ancillary attraction water system). This special flow provision coincides with the timing of seaward migration of chinook smolts which is thought to occur in June and July.

Two experimental groups totalling 11,690 fin-marked fry (L.V.) were released above the diversion dam and intake works on April 7 and 9, 1971 at a release site just below the Comox Lake impounding dam. On the same dates, two groups totalling 11,684 fry bearing a different fin mark (R.V.) were released as a control below the diversion dam at the outlet of the channel. It is planned to repeat the experiment over several years and compare adult returns from the two groups of marked fry. Unfortunately, the low output of the 1971 brood fry prevented repeating the experiment in 1972.

G. SWIM SURVEYS TO MONITOR THE ADULT INJURY PROBLEM DURING THE UPSTREAM MIGRATION PERIOD

The chronic adult injury problem at the Puntledge has resulted in a high level of prespawning mortality of summer run chinook at the channel some years (maximum of 38 percent of potential female spawners in 1967). The injuries, mainly in the head region, are sustained during upstream migration. Since channel construction in 1965 the problem was considered serious in 1966, 1967 and 1968 and again in 1972.

Escapement data, including the numbers of adult prespawning mortalities at the channel for the years 1965-1972 are given in Table 4.

The numbers of severely injured fish arriving at the channel appears to be related to the level of discharge in the section of river between the diversion dam and powerhouse. High flows result in difficult fish passage and increased probability of injury at the falls and low flows may result in delay and injury at the powerhouse tailrace such as occurred in 1955. An additional cause of the injury problem, identified in 1970, was the fish barrier

TABLE 4. ESCAPEMENT, PRESPAWNING MORTALITY, EGG DEPOSITION AND INCUBATION SURVIVAL AT THE PUNTLEDGE SPAWNING CHANNEL, 1965 - 1972

	BROOD YEAR							
	1965	1966	1967	1968	1969	1970	1971	1972
Unspawned Females	9	18	91	47	4	15	7	30
Spawned Females	92	46	147	89	46	175	94	139[a]
Total	101	64	238	136	50	190	101	169
% Mortality	(8.9)	(28.1)	(38.2)	(34.5)	(8.0)	(7.9)	(7.0)	(17.8)
Unspawned Females	3	58	128	36	17	8	11	5
Spawned Males	144	505	306	152	169	212	282	166
Total	147	563	434	188	182	220	293	171
% Mortality	(2.0)	(10.3)	(29.5)	(19.1)	(7.1)	(3.6)	(3.8)	(2.9)
Total Unspawned	12	71	219	83	17	23	18	35
Total Spawned	236	551	453	241	215	387	376	305
Total Escapement	248	627	672	324	232	410	394	340
% Mortality	(4.8)	(12.1)	(32.6)	(25.3)	(7.3)	(5.6)	(4.6)	(10.3)
Spawners Below Channel	34	24	7	20	59	27	25	85
Total Puntledge Escapement	282	651	679	344	291	437	419	425
Estimated Egg Deposition (x 1000)	437	211	648	415	193	853	439	527[b]
Estimated Fry Output (x 1000)	48	84	244	186	65	213	51	-
% Incubation Survival	(10.9)	(39.9)	(37.6)	(45.0)	(33.7)	(26.1)	(11.6)	-

[a] Includes 24 females and 26 males which were netted at the channel for hatchery egg-taking purposes.

[b] Channel egg deposition only - does not include the 67,523 eggs taken for the hatchery.

racks at the diversion dam which fish were striking while attempting to ascend the dam. The barrier racks represent a fairly recent injury source, having been installed in 1965 at the time of the construction of the spawning channel.

Remedial measures applied in recent years appear to have brought the problem under control. The incidence of prespawning mortality of females at the channel in 1969, 1970 and 1971 was reduced to a level of about 8 percent each year. In 1972, however, this increased to 18 percent, apparently as a result of a late freshet which occurred during the summer migration period. The remedial measures in chronological order of their implementation are the following:

1. Construction of three concrete migration baffles or weirs at a point of difficult fish passage at lower Stotan Falls in the spring of 1969.

2. Provision of moderate and stable flows in the range of 300-500 cfs. in the falls section during the adult migration period to assist fish passage. This procedure was implemented in 1969 and has been continued to date.

3. Raising the crest elevation of a section of the diversion dam by means of a wood sill to reduce attraction flow at a point of jumping activity below the fish barrier racks. This work was undertaken on July 23, 1970 by a Hydro crew with assistance from fisheries personnel. The wood sill is usually repaired or replaced each year because of damage from winter freshets.

4. Construction of a single concrete migration weir at a point of difficult fish passage at upper Stotan Falls in the spring of 1971.

Swim surveys have been conducted since 1969 to monitor the injury problem and to obtain information on the possible sources of injury. The counts of injured and uninjured fish at various locations are given in Table 5. A description of the swim surveys and discussion of the potential injury sources is given in the following:

1. <u>Powerhouse Tailrace</u>

The year 1972 was the fourth year of full operation of the powerhouse following six years (1963-68) of closure and part-time operation during the summer adult migration period. A condition agreed to by Fisheries and Hydro on resuming summer operation of the plant was the provision of 300 - 500 cfs. in the river above the powerhouse to discourage delay and injury of adult chinook at the tailrace and to assist fish passage at Stotan and Nib Falls. With the new schedule, swim surveys were conducted periodically each year at the tailrace pool to check for a recurrence of the injury problem of 1955 when fish attempted to enter the draft tubes.

In the four years of swim surveys at the tailrace few seriously injured fish were seen. Of a total of 265 chinook counted during this period only 4 (1.5 percent) were seen with what were judged to be serious injuries. There were also no large accumulations of fish indicating no serious delay at this location. The largest count on a given day was 27 chinook seen during an inspection on August 24, 1972.

TABLE 5. Number of severely injured adult summer-run chinook seen during swim surveys at the Puntledge River, 1969 - 1972

DATE	TAILRACE POOL		CEDAR POOL[1]		TRESTLE POOL[2]		DIVERSION DAM POOL[3]		SPAWNING CHANNEL	
	INJ.	TOT.	INJ.	TOT.	INJ.	TOT.	INJ.	TOT.	INJ.	TOT.
1969										
JULY 7			0	22						
9			1	14			0	2		
14			0	14						
17	0	6			0	5	0	3		
21	0	17	1	15	2	15	2	20	14	100
24	0	7			6	30	1	15		
28	0	11	1	14	2	17	5	17	13	160
31	0	15			1	31	2	18		
AUG. 4	0	6								
11	0	15			1	4	7	20		
19	0	10								
TOTAL	0	87	3	79	12	102	17	95	27	260
% INJ.	0		4		12		18		10	
1970										
JUNE 11									0	2
18	0	8-11			0	0	0	0	0	2
25	0	15-20	0	0	0	1	0	5	0	7
JULY 2	0	6	0	0	0	3	0	4-6	1	17-18
7	1	9			0	8	3	15		
16	0	4					2	40		
23	1	5			0	1	4	33		
30	0	1			3	8	4	10-15		
AUG. 6	0	10			1	4	3	25-30		
11							8	20-25	35	180-200
13	1	13					9	30		
TOTAL	3	75	0	0	4	25	33	190	36	219
% INJ.	4		-		16		17		16	
1971										
JUNE 30	0	0	0	0	0	0	0	0		
JULY 8	0	8-12			0	3	0	1		
22					3	20-30	2	30-40		
29	1	20			0	30	8	60-70		
AUG. 5					2	15	3	20		
TOTAL	1	30	0	0	5	73	13	121		
% INJ.	3		-		7		11			
1972										
JUNE 19	0	1	0	1	0	0				
JULY 13							1	12		
21	0	12					6	30-35	1	70
26	0	20			3	50	9	50-60	5	80
AUG. 3					3	25	8	60	22	170
10					2	30	18	85	27	160
17					3	5				
24	0	27			1	20	11	75	26	160
31	0	13	0	0	1	17	5	75-100	18	170
SEPT. 7					0	40	6	130	15	183
TOTAL	0	73	0	1	13	187	64	537	114	993
% INJ.	0		-		7		12		11	

1. Located between Stotan and Nib Falls.
2. Located between Nib Falls and Channel.
3. Located immediately below the spawning channel and powerhouse intake works.

The lack of a delay or injury problem indicates that the powerhouse tailrace is not a hazard to adult salmon under the flow conditions now provided. Adequate flow in the main river probably minimizes delay at the tailrace while at the same time preventing serious temperature differentials from developing during warm weather which might cause fish to be attracted to the cooler water of the tailrace.

Apart from flow conditions, a factor which may also be operating to discourage delay and injury at the tailrace is the homing of chinook to the spawning channel where returns from the 1965 and later broods originated. It seems logical that fish originating from the channel would show preference to the main river where they can sense the channel flow than to the tailrace, the source of which is upstream from the point of channel discharge. An example of such homing selectivity occurred at the Fulton River Artificial Spawning Channel at Babine Lake. Here the first sockeye utilizing the new channel required water pumped from the Fulton River to encourage entry into the channel. The first generation adult returns, however, entered the channel without this stimulus.

2. <u>Stotan and Nib Falls</u>

The majority of observations in the vicinity of these obstructions were made in the "Trestle" Pool and the Diversion Dam Pool, the former located about ½ mile below the Diversion Dam Pool. Both pools are above the two sets of falls. In 1969, observations were also made in the "Cedar" Pool between Stotan and Nib

Falls. Swim surveys were conducted on a regular basis during the summer months in conjunction with the surveys at the powerhouse tailrace.

In contrast to the situation at the powerhouse tailrace, severe injuries were fairly prevalent among fish seen at these up-stream locations. Counts in the Trestle and Diversion Dam Pools over the four-year period totalled 1,330 chinook of which 161 (12 percent) displayed severe injuries.

The low incidence of injury at the tailrace and the higher incidence above the falls indicates that the falls are the main injury source. Beyond this general assumption it is impossible to determine which of the many points of difficult fish passage are most likely to contribute to the injury problem. This can only be established by several years of observations of jumping activity such as was done prior to the construction of the migration weirs at upper and lower Stotan Falls.

It is believed that the migration hazard has been reduced at Stotan Falls by moderate flow conditions and the construction of the fish migration weirs. During occasional checks, jumping activity was noticeably lower at the weirs than was observed at these sites before their construction indicating that fish passage has been improved.

Fish passage at Nib Falls, however, remains a mystery. In the past four years, attempts at observing the routes taken by fish in ascending the falls have been frustrated by a lack of visible migration activity during periodic visits to the site. Previous records of observations have been of no assistance in this regard. An artificial migration channel by-passing Nib Falls on the right bank, constructed in 1968 with the use of a bulldozer, does not appear to be very functional. Entry into the channel is probably discouraged by its remote location relative to the falls, the lack of deep holding pools at the entrance and along its length, and a partial obstruction at the entrance formed by rubble.

3. Diversion Dam Fish Barrier Racks

Prior to the remedial work on the diversion dam in July of 1970, chinooks had been observed attempting to ascend the dam with some of the fish striking the barrier racks. Heavy flows over the dam probably encouraged jumping activity while at the same time delaying entry into the spawning channel. This, together with an increased migration hazard at the falls, would explain the high incidence of prespawning mortality at the channel in 1966, 1967 and 1968 with heavy flows and the relatively low incidence in 1965, 1969 and 1970 with moderate flows. After July of 1970 and in 1971, the barrier racks were probably not an injury source because of the remedial work, but the problem may have recurred in 1972 when the unexpected summer freshet caused water to spill over the raised section of the dam. Figure 3 is a schematic diagram of the diversion dam, barrier racks and diversion dam pool and illustrates the situation whereby fish were able to jump at the dam and sustain injuries on the racks.

Further evidence that the barrier racks are an injury source is seen in the results of the swim surveys (Table 5). On each of the four years of swim surveys a higher incidence of severe injuries was found in the Diversion Dam Pool than in the Trestle Pool ½ mile downstream. The difference is significant (P.05) for two of the four years - 1969, prior to remedial work, and 1972 when jumping activity may have resumed due to the summer freshet overtopping the raised portion of the dam.

H. ENUMERATION OF THE 1971 AND 1972 BROOD SUMMER-RUN CHINOOK ESCAPEMENTS TO THE SPAWNING CHANNEL AND UPPER RIVER AREA.

Enumeration of the adult escapement to the spawning channel is carried out by the recovery of carcasses each day when adults are in the channel. Hypural length measurements, weight, sex, egg retention and data on injuries are recorded for each fish. Spawners not entering the channel are enumerated by visual estimation. The majority of these fish spawn on a gravel riffle about 300 yards below the diversion dam.

Data on escapement, sex composition, prespawning mortality and estimated egg deposition for the years 1965-1972 are given in Table 4.

1. 1971 Brood

The escapement of 1971 brood summer-run chinook to the Puntledge totalled 419 chinook of which 394 spawned in the

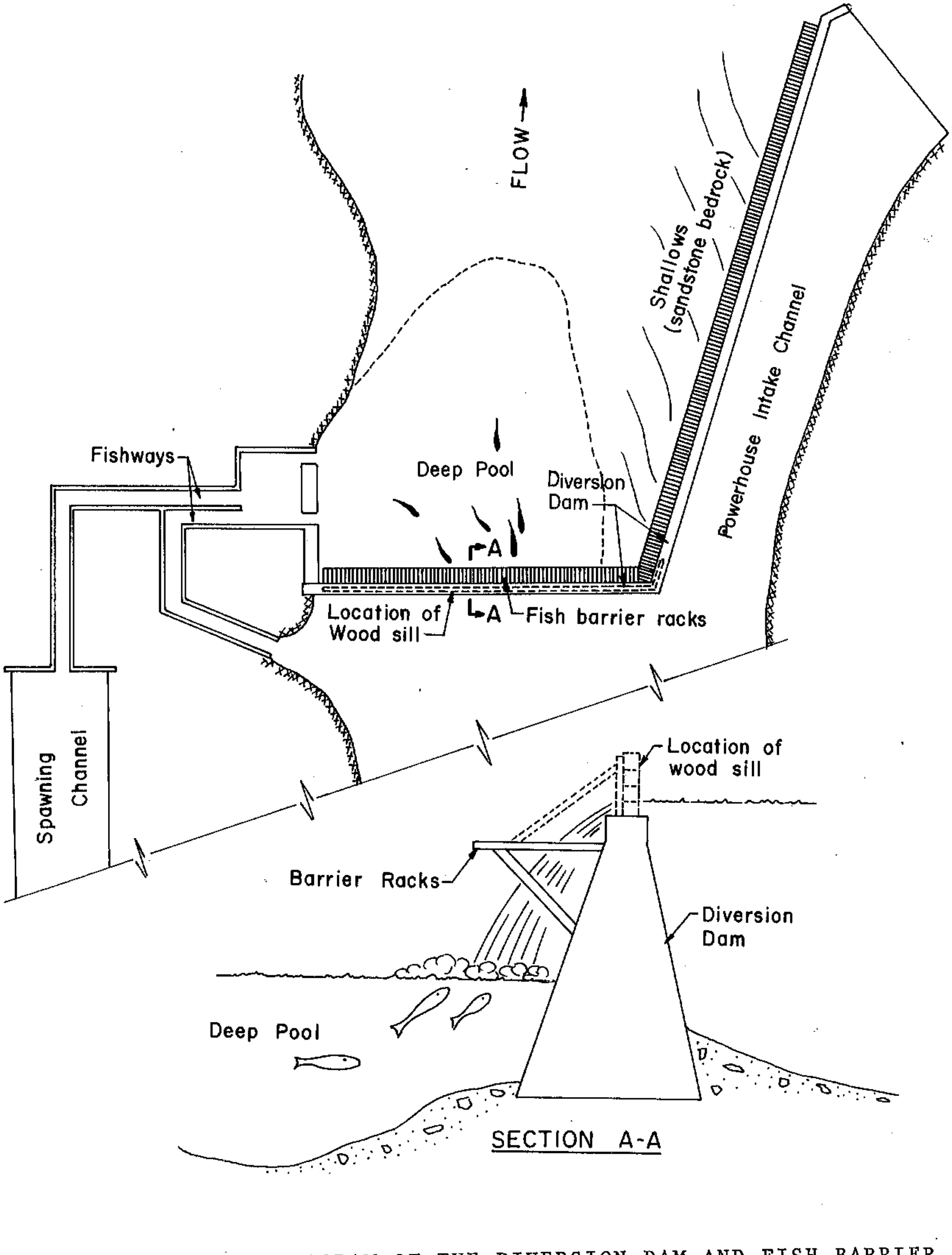


FIGURE 3. SCHEMATIC DIAGRAM OF THE DIVERSION DAM AND FISH BARRIER RACKS SHOWING THE LOCATION OF THE DEEP POOL ADJACENT TO THE BARRIER RACKS AND LOCATION OF THE WOOD SILL WHICH DIVERTS FLOW TO THE LOWER WING OF THE DAM.

channel and an estimated 25 spawned in the river below the diversion dam. Female chinook at the channel totalled 101 of which 7 (7.0 percent) died unspawned due to injuries. Males at the channel totalled 293 of which 11 (3.8 percent) died unspawned due to injuries. The overall prespawning mortality rate at the channel was 4.6 percent.

The calculated egg deposition from the 94 successfully spawned females is 439,000. This is below the average of 460,000 for the preceding six years of channel operation. Calculation of egg deposition is based on the formula:

fecundity = -5697 + 15.04 x hypural length (mm).

The average hypural length of spawned females was 690mm, the calculated fecundity, 4,681 eggs, and the total estimated egg retention, excluding prespawning mortality, 1,350.

2. <u>1972 Brood</u>

The total 1972 brood summer-run escapement to the Puntledge was 425 of which 340 entered the channel and an estimated 85 spawned below the diversion dam. In the channel, female chinook numbered 169 of which 30 (17.8 percent) died unspawned due to injuries. Male chinook numbered 171 of which 5 (2.9 percent) died unspawned. The overall prespawning mortality rate at the channel was 10.3 percent.

The first egg take from summer-run chinook was conducted at the channel in 1972. A total of 24 females and

26 males were netted from the channel for this purpose. This operation will be described in a later section.

The calculated egg deposition at the channel from the remaining 115 females spawning naturally is 527,000. The average hypural length of spawned females was 686 mm., the fecundity, 4,620 eggs, and the estimated total egg retention was 3,000.

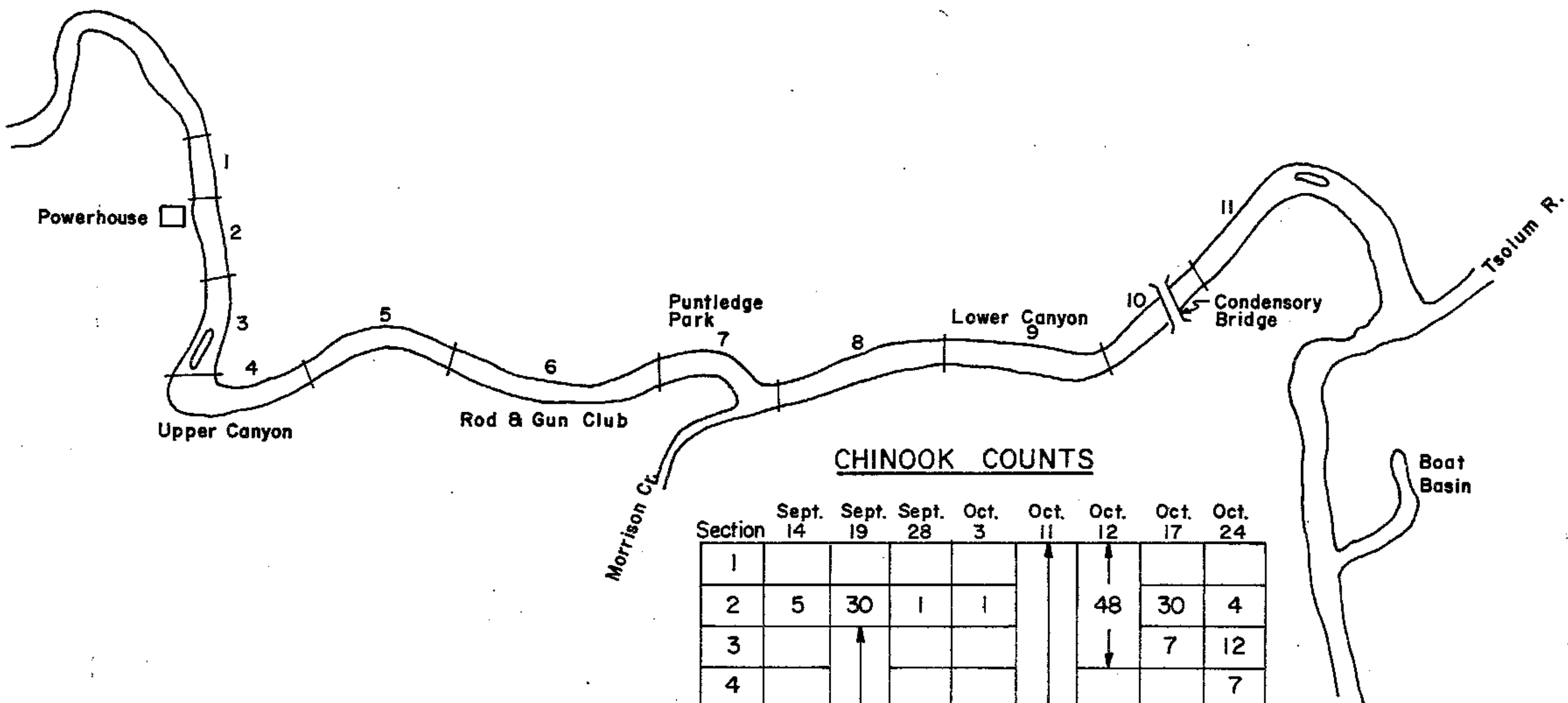
3. Fin-Marked Recoveries

A total of three adipose fin clipped chinook carcasses were recovered at the channel in 1972. Using length measurement as an age determinant, these are three-year old fish originating from the 2,526 fingerlings of the 1969 brood reared at Big Qualicum Hatchery and released at the channel in July of 1970. Adult returns from the brood should be virtually complete in 1973. The sex and lengths of the three chinook are:

Female - 658 mm; Male - 630 mm; Male - 496 mm.

I. ENUMERATION OF THE 1971 AND 1972 BROOD FALL-RUN CHINOOK ESCAPEMENTS TO THE LOWER PUNTLEDGE RIVER AREA

Periodic float surveys were carried out in September and October of 1971 and 1972 to determine the escapement and spawning distribution of fall-run chinook in the lower Puntledge River area. The river was floated from the powerhouse at the upper end of the spawning distribution to Lewis Park in the town of Courtenay, the lowest point where carcasses could be seen. The approximate spawning distribution of the 1972 stock is indicated by the October 17 and 24 float surveys shown in Figure 4.



CHINOOK COUNTS

Section	Sept. 14	Sept. 19	Sept. 28	Oct. 3	Oct. 11	Oct. 12	Oct. 17	Oct. 24
1								
2	5	30	1	1		48	30	4
3							7	12
4								7
5						8		
6		8			43		13	12
7							10	
8								7
9							9	7
10	1	8		4			7	2
11		1					11	
Tot.	6	47	1	5	43	56	87	51*

* An additional 77 dead Chinook were counted on Oct. 24 for a total of <u>128</u>

FIGURE 4. MAP OF THE LOWER PORTION OF THE PUNTLEDGE RIVER SHOWING THE APPROXIMATE NUMBERS AND DISTRIBUTION OF FALL-RUN CHINOOK IN 1972 ACCORDING TO FLOAT SURVEYS.

The stock remains at a low abundance with estimates of only 150 chinook spawning in 1971 and 200* in 1972.

Escapement data for the years 1954 to the present are given in Table 4.

J. EGG TAKE FROM THE 1972 BROOD SUMMER AND FALL-RUN CHINOOK

Permission was obtained from local Hydro personnel to place a small-scale, temporary hatchery incubation unit in the old Canadian Collieries Powerhouse. The incubation unit consisted of four 16-tray Heath cabinets and an overhead flow distribution box. A water supply of 12 Igpm. was drawn from plumbing in the building connected to the penstock. The unit drained through an opening in the floor of the building and into the Puntledge River.

1. Summer-Run

A total of 24 female and 26 male chinook were taken at the channel with gillnets during the period from September 21 to 27, 1972. The fish were netted in holding pools No. 2 and 3 (Figure 2). Ripening pens were formed in the Burrows rearing ponds using screen partitions. Fish were transferred to the pens in a 133 gallon capacity fry transport tank. Water in the tank was supplied with oxygen using a cylinder, regulator and airstones.

Fish were separated in the pens according to sex and were sorted periodically for ripeness. Females were killed and stripped of eggs when ripe. Ripe

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* Includes 41 chinook netted for a hatchery egg-taking operation.

TABLE 6. FALL-RUN CHINOOK ESCAPEMENTS TO THE PUNTLEDGE RIVER, 1954 - 1972

YEAR	ESCAPEMENT	YEAR	ESCAPEMENT
1954	6,000	1964	590
1955	4,500	1965	850
1956	900	1966	550
1957	2,400	1967	200
1958	6,000	1968	285
1959	2,000	1969	185
1960	1,800	1970	225
1961	1,275	1971	150
1962	1,175	1972	200
1963	900		

males were anaesthetized in a 2-phenoxyethanol solution and returned to the holding pen after milting. Two or three males were used for fertilizing the eggs of each female. Eggs were fertilized and water hardened at the channel and transported in plastic pails to the hatchery, a distance of about five miles.

Of the 24 female chinook, 8 died prematurely, mainly due to fungus (Saprolegnia) infection. The 16 surviving fish were stripped of eggs along with two of the dead females which had died in a ripe condition.

According to volume measure, a total of 67,523 eggs were obtained including the eggs from two partially spawned females. The accumulated mortality of eggs after the third picking on November 27 was 12,426 or 18 percent leaving a live egg balance of 55,097. Only limited success was achieved with the eggs from the dead females with an almost complete loss occurring with one of the two egg batches. If these eggs had been discarded initially, as would have been normal procedure in most hatchery operations, mortality would have been approximately 13 percent which is an acceptable level.

As mentioned previously, the excessive adult mortality (6 of 24 females, no record kept of males) is attributed to fungus infection of injuries. Some minor injuries were sustained during gillnetting but the majority were the result of collisions with the heavy chain-link screen of the pen partitions when fish were alarmed, such as occurred during sorting. A softer, more yielding material such as knotless nylon netting might have reduced the injury problem and will be used in future.

One measure which appeared to arrest the fungus problem after its onset was the provision of additional flow to the holding pens with the gravity water supply system, a feature of the new Burrows ponds to safeguard against a power or pumping failure.

Another measure which will be applied in future will be the swabbing of injuries at intervals with a concentrated malachite green solution. This method has been used successfully at the Capilano Hatchery and many U.S. facilities.

2. <u>Fall Run</u>

A total of 16 female and 25 male fall-run chinook were taken from the lower Puntledge during the period from September 20 to October 5, 1972 and transported in the fry tank to the holding pens at the channel. Fish were captured by means of a beach seine at the Condensory Bridge Pool and by gillnet at the Powerhouse Tailrace Pool. The gillnetting at the tailrace was accomplished during a two-week closure of the powerhouse for annual maintenance work.

Premature mortality due to injuries and fungus infection was more prevalent among the fall than the summer-run chinook. The larger fall-run fish were more easily alarmed and appeared less tolerant of their confinement. Of the 16 females, 12 died prematurely. The 4 surviving females and 3 females which died in a ripe condition were stripped of eggs for the hatchery.

An estimated 32,804 eggs were obtained by volume count. The accumulated mortality after the third egg picking on November 27 was 14,625 or 44 percent leaving a live egg balance of 18,179, As was the case with the summer-run, only limited success was achieved with the eggs from the dead females with complete mortality occurring in two of the three egg batches.

In order to obtain maximum adult returns from the small numbers of fall-run chinook fry which will be available for rearing, it is tentatively planned to rear the juveniles for a full year for release as "super-smolts" (approximately 10/lb. or larger) in 1974.

K. AN EXPERIMENTAL TRANSPLANT OF COHO FRY FROM THE BIG QUALICUM HATCHERY INTO "BEVAN CREEK", A SMALL TRIBUTARY OF THE PUNTLEDGE RIVER

Swamps and beaver ponds are common to many of the small streams on Vancouver Island. Where these areas are utilized for rearing of juvenile coho salmon they appear to be very productive. Frequently, coho are lacking, but the potential for rearing juveniles to the yearling smolt stage exists if fry were to be introduced. The lack of coho may be due to one or both of the following reasons:

1. Entry of adults may be prevented by obstructions or insufficient flow.

2. Spawning is prevented by a lack of suitable gravel.

In view of the large number of barren swamps and beaver ponds in existence, a significant contribution of adult coho to the fisheries could probably be made if a substantial program of fry transplants could be implemented. With this in mind, a pilot study was carried out on a small unnamed stream tributary to the Puntledge to test the feasibility of transplants into such waters. For the purposes of this report the stream will be called Bevan Creek after the townsite of Bevan near its headwaters. Fry introductions were made in 1971 and 1972 and smolts resulting from the first plant were enumerated in 1972.

1. Description of the Stream

Figure 5 shows the location of the creek, the fry release points and the smolt trapping site.

The stream consists of three small tributaries which originate in the Bevan area and coverage in a large

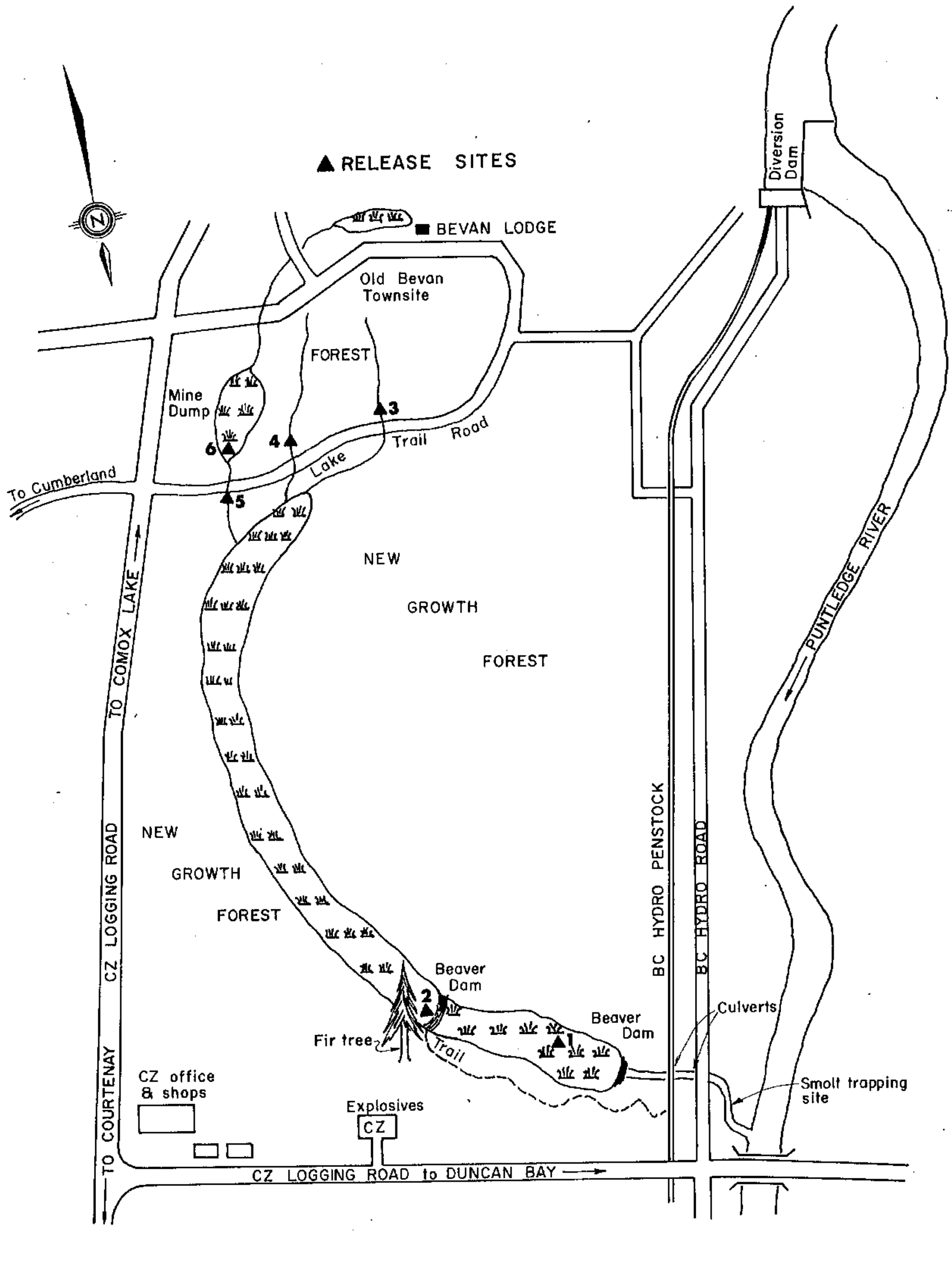


FIGURE 5. MAP OF BEVAN CREEK SHOWING THE COHO FRY RELEASE SITES AND THE SMOLT TRAPPING SITE.

swamp below the Lake Trail Road. The nature of the stream between this point and the No. 2 beaver dam shown on the map is unknown because of the dense bush in the area. In the vicinity of the B. C. Hydro penstock, two swamps formed by beaver dams flood an area of a few acres. Flow from the lowest swamp overtops the dam into a channel which enters three parallel culverts beneath the penstock and the B. C. Hydro service road. From the culverts the stream flows about 200 yards to join the Puntledge immediately above the Crown Zellerbach Logging Bridge. This lower section of the stream on both sides of the culverts appears to have been channelized by dredging machinery at the time of construction of the penstock. The overall length of the stream is an estimated two miles.

Vegetation fringing the swampy areas is typical of wetland growth in this climate zone (alder, willow, etc...) and is extremely dense. The surrounding forest consists of second growth fir, hemlock and cedar mixed with deciduous species. The swamps and stream bed have abundant aquatic vegetation. The stream does not appear to be subject to severe freshets judging from the stability of stream-bank vegetation and the lack of flood debris. Flows are probably in the order of 3-5 cfs. during continuous rainfall dropping to less than ¼ cfs. during prolonged dry periods. Water temperatures as high as 75°F were recorded at the outlet in 1971. The highest temperature for the three headwaters tributaries taken at about the same time as the outlet temperature was 65^{o} F.

The absence of coho in the stream is probably due mainly to the obstruction to adult migration at Stotan Falls on the Puntledge River. Obstructions on Bevan Creek include the culverts from which water drops 2-3 feet to the stream bed and the beaver dams. Spawning gravel is present near the headwaters and may also be present in the unexplored area between the second beaver dam and Lake Trail Road.

A few fish species and many invertebrate species are present in the system. Fish seen at various times include trout (species not known), stickleback, sculpins and brook lamprey.

A noteworthy feature of the stream is the finding that one of the three small headwaters tributaries may be polluted. This was indicated by the heavy mortality of a small group of fry introduced in this tributary. It was later found that the tributary originates near an old coal minetailings pile located a few hundred yards upstream from the point where the fry were released.

2. Fry Introductions

Fry were transported from Big Qualicum Hatchery by truck in a 105 gallon capacity fry transportation tank in 1971 and a 133 gallon capacity tank in 1972. Water in the tank was oxygenated with equipment consisting of oxygen cylinder, regulator and air stones. Fry were dip-netted from the tank into plastic pails with water-tight lids and carried from the closest road access point to the various release sites shown on Figure 5.

The 1971 fry introduction on June 1 totalled 25,000 of which approximately 10,000 were planted in the three headwaters branches and 15,000 in the two swamps formed by the beaver dams in the lower portions of the stream. The 1972 introduction on May 4 totalled 30,000 fry divided about evenly between the upper and lower release sites. Release points 2 and 6 on the map were omitted in the 1972 introduction.

Occasional inspections were made during the summer months following the two years of transplants. As already mentioned, heavy and perhaps complete mortality occurred among the group of fry released in the headwaters branch near the mine tailings pile. The only release site where fry could be seen during the summer both years was in the lowest swamp.

Fry sampling was not conducted but growth in the lower swamp appeared to be very rapid compared with fry released in 1971 and 1972 in Woodhus Creek, a transplant stream tributary to the Oyster River. As was mentioned, the 1971 release group in the lower swamp was able to survive where surface temperatures were as high as $75^{o}F$. This temperature was recorded below the swamp on July 18, 25 and August 1 of that year.

3. <u>Smolt Output from the 1971 Introduction</u>

A downstream migrant trap was installed in Bevan Creek on April 5, 1972 about 100 yards above the junction with the Puntledge River. The trapping gear consisted of a 3' x 3' square opening fyke net connected to a length of 4" diameter flexible hose leading to a live box. The live box was covered with wire screen to prevent fish from jumping out and to prevent predation. To achieve 100 percent trapping efficiency a wall of sandbags was built from each bank to the fyke net opening. This funnelled the entire stream flow through the net. The traps were checked daily during the smolt migration period.

The total output resulting from the 1971 fry transplant was 314 coho smolts or 1.2 percent of the number of fry introduced. Of this total, 81 smolts were marked with a single fin clip (R.V.) to enable positive identification of adult returns. The migration commenced about May 4 and continued until May 23 with the peak output occurring on May 17 near the end of the migration. Smolts were fairly large and uniform in size compared to those at Woodhus and ranged in length from 88mm to 120mm with a mean of 96mm.

The fact that no coho fry were seen the previous summer near release sites in the headwaters branches or above the second beaver dam suggests that most or possibly all of the smolt production occurred in the lower swamp between the first and second beaver dams.

It is significant that the smolts were able to locate the small, constricted outlet of the swamp and successfully negotiate the beaver dam. At the time of the fry introduction there was some concern about passage through the dense tangle of twigs and branches forming the crest of the dam.

It is planned to repeat the smolt enumeration in the spring of 1973 but fry will not be available for a third introduction because of a limited egg take at Big Qualicum Hatchery resulting from a scarcity of adult coho in 1972.

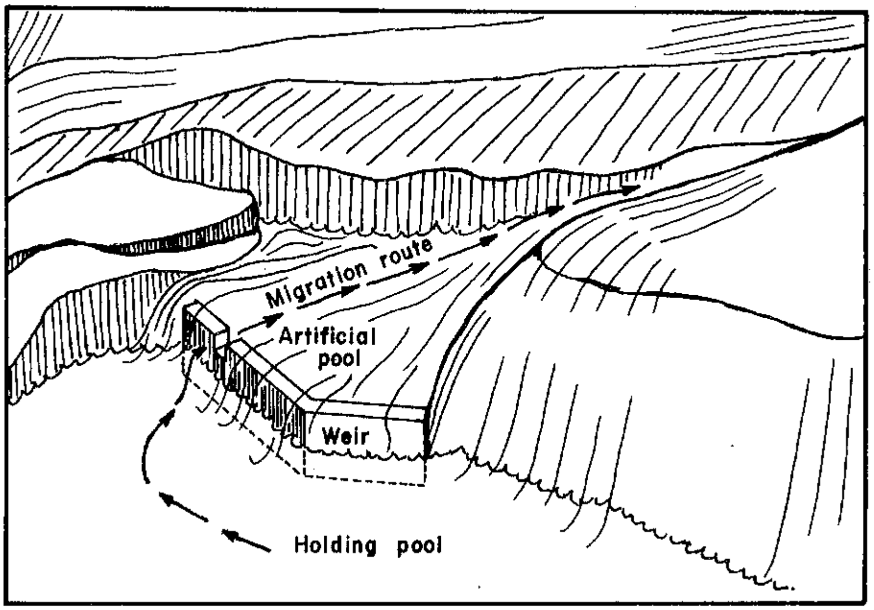
III <u>CONSTRUCTION PROJECTS</u>

A. FISH MIGRATION BAFFLE AT UPPER STOTAN FALLS

The fish migration baffle constructed on the left bank of upper Stotan Falls is shown in Figure 6.

Construction was carried out by a Fisheries Service engineering crew during low river flow conditions in April and May of 1971 following two years of observations of jumping activity at this difficult fish passage point. The baffle creates a holding pool part way up the face of the falls eliminating a long, shallow slope which fish had difficulty negotiating.

The construction is of reinforced concrete utilizing bagged concrete in dry-mixed form. The baffle wall is



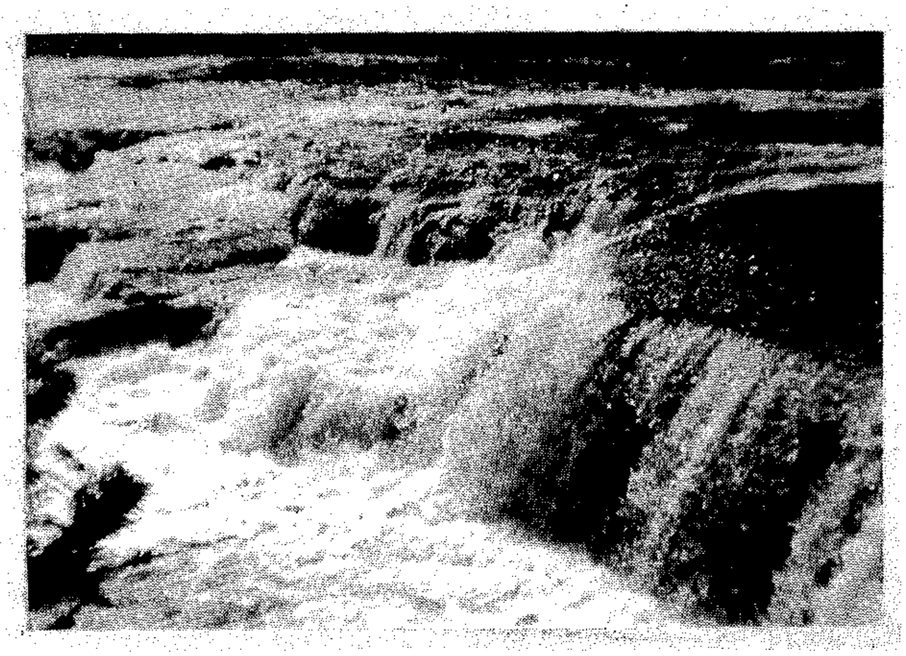


FIGURE 6. FISH MIGRATION BAFFLE OF WEIR AT UPPER STOTAN FALLS

about 12 inches wide, 30 inches high and 20 feet long with a vertical slot centering on the pool immediately below. Some blasting of rock was required prior to the concrete work to add depth to the pool formed behind the baffle. A simple sand bag coffer dam was built to divert river flow from the work area during construction.

B. OFFICE-WORKSHOP-LABORATORY BUILDING AT THE PUNTLEDGE CHANNEL SITE.

An exterior view of the building is shown in Figure 7. The building site is located on the high bank overlooking the lower end of the channel and the new rearing ponds.

The building is of frame-type construction on a concrete foundation housing an equipment storage area, an office-laboratory area, washroom and closet. Outside dimensions are 18 by 32 feet enclosing an area of 576 square feet. Plumbing includes a toilet, wash basin, laboratory sink and a deep-well pump drawing water from the channel. Heating is provided by an oil-fired space heater. Sewage disposal is by septic tank and tile drainage field.

Construction was carried out in February and March 1971 by a local carpenter and helper employed on an hourly basis and supervised by Fisheries Service staff. The Electrical installation and site preparation work were contracted locally.

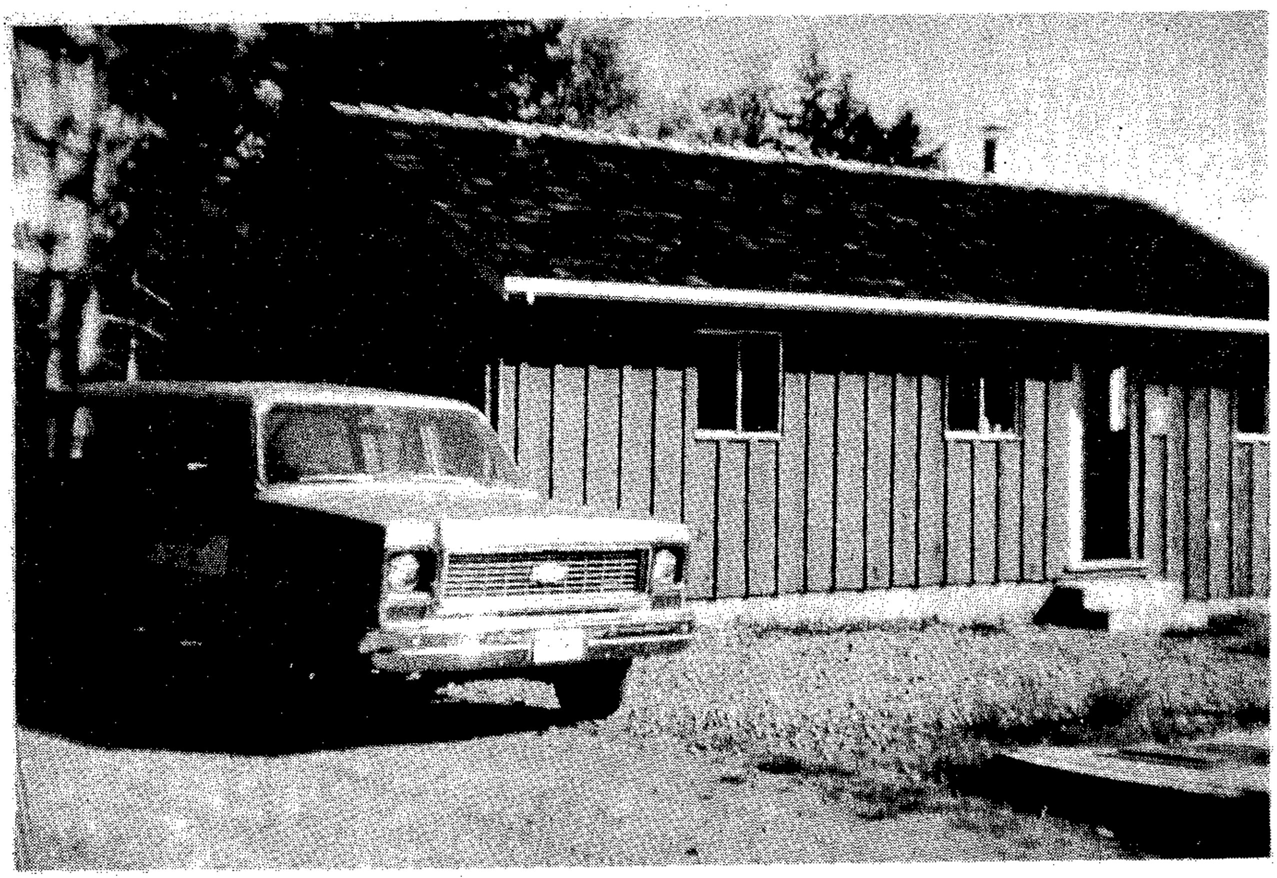


FIGURE 7. FISHERIES BUILDING AT THE PUNTLEDGE CHANNEL SITE

C. TWO 75-FOOT CONCRETE BURROWS-TYPE JUVENILE SALMON REARING PONDS AT THE PUNTLEDGE CHANNEL SITE

Figure 8 shows the completed ponds situated at the lower end of the channel.

The project was undertaken on a cost-sharing basis with B.C. Hydro. The Authority contributed approximately 18 percent of capital costs and agreed to maintain the pumping facilities and provide electric power without charge.

Construction was contracted to Quadra Construction Company of Vancouver, B.C. Work commenced in the early spring of 1972 and was completed in the late summer. A temporary work stoppage occurred during May and June due to a labour dispute.

The water supply is drawn from the channel by two electric pumps, each servicing a separate pond. An emergency gravity system maintains flow in the event of a mechanical or electrical failure. Water enters the ponds under pressure through submerged nozzles or jet headers and drains through screened openings in the floor of the ponds. A feature of the Burrows ponds is the circulating flow. This results in a continuous turnover of water and a self-cleaning action. The discharge from the ponds enters an outlet sump through a standpipe which can be adjusted to regulate pond depth. The water then drains into the Puntledge River below the diversion dam.

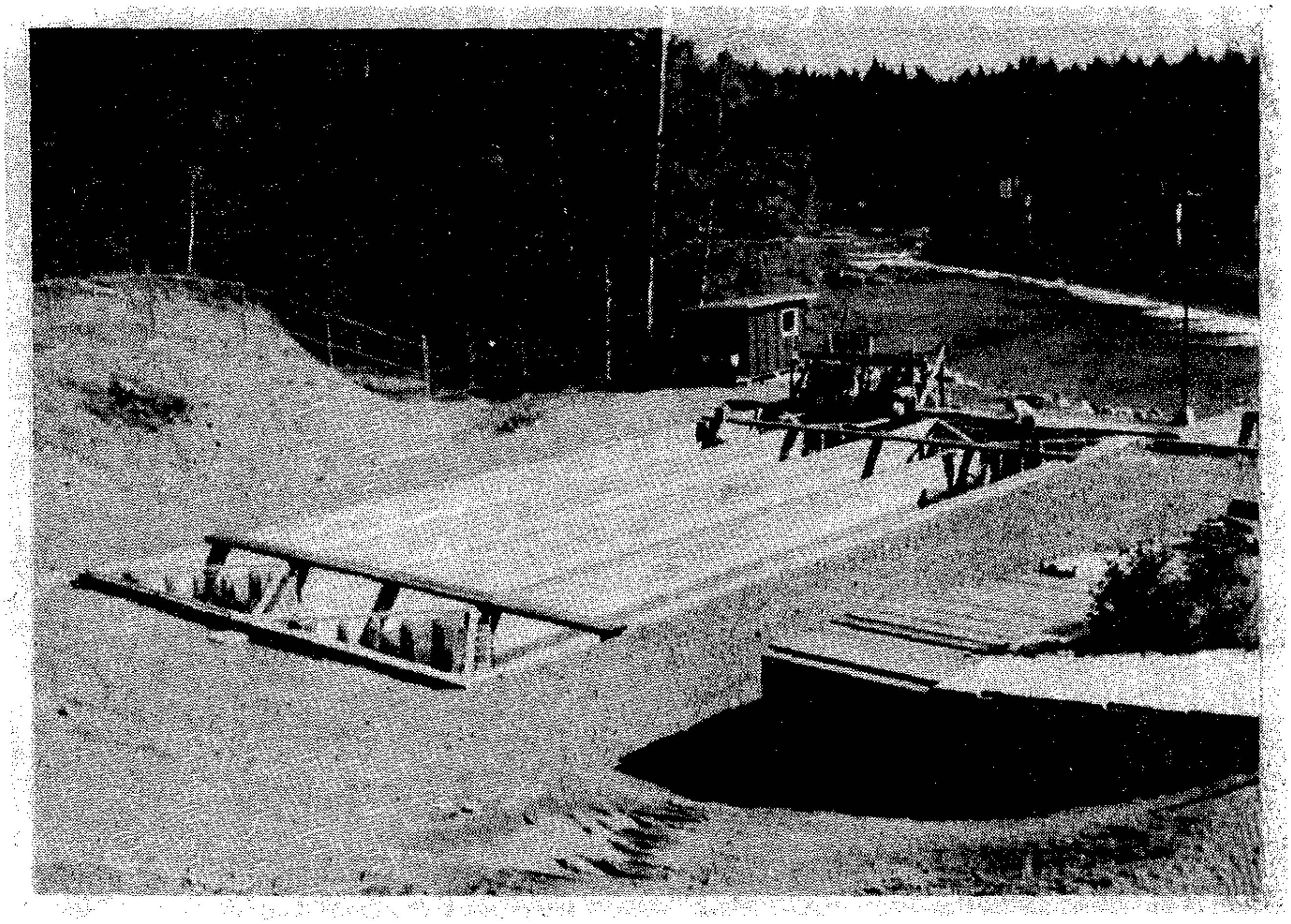


FIGURE 8. BURROWS REARING PONDS AT THE PUNTLEDGE CHANNEL SITE

Some specifications of the rearing ponds are as follows:

Overall dimensions of the two ponds including the outlet sump	37 ft. x 82 ft.
Interior dimensions of one pond excluding the center wall	16 ft. x 75 ft.
Available rearing space of one pond at 3 ft. depth	3,600 ft.^{3}
Water volume of one pond at 3 ft. depth	22,464 Imp. gals.
Rated capacity of each pump	600 Igpm.
Turnover rate of each pond at rated capacity and 3 ft. depth	37.4 min.
Rearing capacity of each pond @ 4.8 lb/Igpm.	2,880 lb. of fish

IV APPENDIX

SUMMARY OF FISHERIES PROBLEMS AND REMEDIAL MEASURES AT THE PUNTLEDGE RIVER, 1954-1972

A. Delay and injury of adults at the powerhouse tailrace and Stotan and Nib Falls, and injury at the diversion dam fish barrier racks

1. 1954 - Experiments by B.C. Power Commission indicated that optimum flow for adult chinook migration at the falls is approximately 200 cfs with minimum and maximum flows of 150 and 250 cfs. (These data were derived from a discharge curve established prior to re-metering the river in 1959 and are perhaps 20-30% low).

2. 1955 and 1956 - A counting fence was operated at the Puntledge between the powerhouse and Stotan Falls (in conjunction with a tagging program in 1955) to study adult summer-run chinook migration.

3. 1955 to 1962 - Artificial freshets or flushes were carried out when necessary during low flow conditions to assist adult migration.

4. 1956 - Protective gratings were installed over the powerhouse draft tube to prevent entry of adult chinook.

5. 1963 to 1968 - During 1963-65 a 24-hour powerhouse closure was implemented from June 1-July 31 and a 12-hour closure (6:00 A.M. - 6:00 P.M.) from August 1-31. During 1966-68 the procedure was relaxed somewhat by implementing the closure when adult summer-run chinook first arrived at the tailrace pool, usually about mid-June. It was further relaxed in 1968 with the daily 12-hour closure being terminated in early August when the migration was complete.

6. 1968 - Blasting and rock removal were carried out at a number of points of difficult fish passage at Stotan and Nib Falls.

7. 1969 - A series of three concrete migration baffles were constructed at a point of difficult fish passage at lower Stotan Falls.

8. 1969 to present - Continuous but restricted operation of the powerhouse is permitted during the summer months in order to provide optimum flow (300-500 cfs) for fish passage in the falls section of the river. Flow in excess of migration requirements is discharged through the powerhouse.

9. 1970 - A wood sill was installed on the crest of a section of the diversion dam which diverted flow away from an area where adults attempted to ascend the dam. Fish were frequently colliding with the fish barrier racks at this point.

10. 1971 - A concrete migration baffle was constructed to aid fish passage at upper Stotan Falls.

B. Turbine mortality of seaward migrant juveniles

1. 1955 - Tests conducted at the Puntledge indicated mortality of juveniles passing through the turbine was in the range of 30-40%.

2. 1956 to 1964 - Fyke net rafts were installed at the powerhouse intake channel to salvage downstream migrants. No salvage operation was conducted in 1955 when the expanded hydro-electric facilities commenced operation.

3. 1957 and 1959 - Louvre deflection studies were conducted to assess the feasibility of this method for diverting juveniles from the powerhouse intake works. Test facilities were constructed in 1957 and removed after 1959.

4. 1965 - A powerhouse closure was implemented during March and April to prevent juveniles from entering the intake works.

5. 1965 - Construction of the spawning channel by B.C. Hydro avoided the turbine mortality problem. Migrant juveniles from the channel enter the Puntledge downstream from the intake works.

C. Siltation of the spawning beds resulting from construction work at the impounding dam site

1. 1957-58 - A heavy silt deposit blanketed spawning beds between the diversion and impounding dams during construction work at the latter site in the winter of 1957-58. This was followed by an extremely low chinook fry output in the spring of 1958. The silt was later washed clear by the action of the river. Lower than average four-year cycle returns originating from the 1957 brood reflect the damage inflicted on this brood stock.

D. Loss of juvenile freshwater rearing area between diversion and impounding dams since channel construction

1. 1970 and 1971 - Experiments in the rearing of channel-produced chinook fry in Big Qualicum Hatchery ponds were conducted both years. In 1970, 2,500 fingerlings were released at the channel. In 1971, 48,000 fingerlings were released at the channel.

2. 1971 - Approximately 12,000 channel-produced chinook fry were marked (L.V.) and released in the section of river between the two dams. A similar number of marked fish (R.V.) were released below the diversion dam. Adult returns from the two groups will be compared to determine the feasibility of transplants above the intake works.

3. 1971 - Discussions were held with Hydro at the local level and an agreementwas reached whereby moderate, stable flow conditions would be provided, when possible, in the early spring months, commencing in 1971, to improve juvenile rearing conditions. This provision will depend on the storage and runoff situation which varies from year to year.

4. 1972 - Channel-produced chinook fry were reared in an improvised raceway (channel by-pass fishway) at the Puntledge Channel site. A total of 20,000 fingerlings were released at the channel. An additional 7,000 fingerlings were retained for release in 1973 as yearling "super-smolts".

E. Fisheries closures

1. Tidal sport fishery closures (Goose Spit - Gartley Point boundary).

Year	Summer chinook run	Fall chinook run
1952	none	Sept.27-Oct. 21 (first closure)
1953	"	none
1954	"	"
1955	"	Sept.25-Dec. 15
1956	"	none
1957	"	Sept.29-Nov. 9
1958	"	Sept.28-Nov. 5
1959	"	none
1960	"	Sept.18-Oct. 31
1961	"	Sept.4-Oct. 20
1962	"	Sept.16-Nov. 2
1963	"	Sept. 6-Oct. 29
1964	"	Sept.13-Nov. 27

Year	Summer chinook run		Fall chinook run
1965	May 21-June 25		Sept. 4-Nov. 26
1966	May 8-June 26		Sept.5-Nov. 16
1967	May 15-June 30		Sept.4-Nov. 17
1968	May 12-June 28		Aug. 25-Nov. 3
1969	May 11-June 29		Aug. 3-Nov. 16
1970		April 14-Nov. 15	
1971		April 30-Nov .15	

2. Commercial troll fishery closures (Union Bay Wharf-Longbeak Point; Denman Island-Cape Lazo boundary)

Year	Closed Period
1969	Aug. 3-Sept. 30
1970	All season (April 15-Sept. 30)
1971	All season (April 15-Sept. 30)