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BLACK CREEK, VANCOUVER ISLAND, B.C.
HYDROLOGY, FISHERIES RESOURCE, AND WATERSHED DEVELOPMENT

by

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ABSTRACT

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The fisheries resource of Black Creek, a major coho salmon stream on Vancouver Island is described. Information on spawning escapement, distribution, and timing is provided. Hydrology of the 28 square mile watershed was studied using data from 16 staff gages and 3 water level recorders. The productivity of the system is attributed to the multiplicity of swamps, swampy depressions, and associated small tributaries characterizing the watershed which provide ideal habitat for rearing coho. Loss of this habitat occurs through swamp land reclamation and other land development activities. The extent of land development (logging, clearing, reclamation, ditching, and urbanization) in the watershed, and the detrimental effects on fish life is discussed. Recommendations for preservation of the fisheries resource are given. They include: restrictions on future water licences, reservation and development of storage, green strip reserves on all watercourses and swamps, suggestions on zoning and control of future land development.

Key words: Fisheries Resource, Hydrology, Habitat, Fish, Coho, Land Development, Watershed.

RÉSUMÉ

Nous décrivons les ressources halieutiques du ruisseau Black, dans l'Île Vancouver, qui joue un rôle important lors du frai du Saumon coho. Nous donnons des renseignements sur le Saumon de remonte, sa répartition et le calendrier de la remontée. Des études hydrologiques du bassin hydrographique de 28 mi^2 ont été effectuées à partir de données provenant de 16 échelles limnimétriques et de 3 limnigraphes. La productivité du bassin dépend du grand nombre de marécages, de dépressions marécageuses et de petits cours d'eau tributaires qui en font un habitat idéal pour la croissance des alevins. Cet habitat est cependant détruit peu à peu par l'assèchement des terres et d'autres projets de mise en valeur. Nous discutons de l'importance de cette mise en valeur du bassin (abattage, coupe à blanc, assèchement, creusage de fossés et urbanisation) et de son incidence sur le cycle biologique du Saumon. Nous formulons des recommandations visant à préserver cette ressource naturelle; y compris, des restrictions portant sur l'émission des futurs permis de mise en valeur, la protection ou la constitution de réservoirs et de corridors de verdure pour tous les cours d'eau et les marécages et des suggestions portant sur le zonage et la régulation des futurs travaux de mise en valeur.

Mots clés: ressources halieutiques, hydrologie, habitat, poisson, coho, mise en valeur des terres, bassin hydrographique.

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INTRODUCTION

Black Creek is located on the east coast of Vancouver Island, approximately 10 miles north of Courtenay. It is one of the most prolific coho producers on the east coast with an average annual return of 5,000 to 10,000 adult coho. It also supports some steelhead and considerable numbers of resident cutthroat trout. In recent years, and particularly since issuance of the first irrigation licence in 1958, there has been a great deal of concern expressed by Fisheries Service, local residents and conservation groups over low flow conditions and obstructions in the creek and its tributaries. There is a growing demand for irrigation water as the land is cleared and developed for farming, and the pressure of urbanization is beginning to be felt through increased water demands, altered hydrology and stream degradation.

The objective of this report is to review the problems associated with the fisheries resource and recommend the controls necessary on land and water use within the watershed to ensure future fisheries productivity.

Watershed Description

Black Creek watershed (Figure 1) has an area of approximately 28 square miles and an average annual rainfall of 67 inches at elevation 200 feet. The source of Black Creek is a series of swamps and small lakes at an elevation of 1,200 feet above sea level(Area 14). Most of the watershed, however, is below the 300 foot level. It is characterized by a multitude of small lakes, beaver ponds, swamps and depressions strikingly aligned in a north-south direction roughly parallel to the coastline. Figure 2, prepared from geological survey maps, shows the extent of the various soil types. Generally, these are marine or glacio-marine deposits overlying rock or glacial till. These deposits are deeper in the depressions and near the ocean, giving way inland to more frequent rock outcropping. More silty and peaty soils are found around the lakes and in the swampy areas. They vary from a few feet up to 30 feet or more in thickness. The glacio-marine soils occurring elsewhere and through which the creek flows are very mixed because of their origin. Lenses of gravel may be found interbedded with clay, silt and sand. Stream action has washed gravel, dispersed randomly in the soil, into the creek bed where over time it has collected in sufficient thickness for spawning purposes. These deposits may be easily lost through ditching and other in-stream activities. In other areas the creek passes through predominantly gravelly soils where, in dry weather, the residual flows may run underground.

Black Creek varies from a typical mountain stream at higher elevations to a sluggish, meandering flow through extensive swampy areas heavily overgrown and nearly impenetrable at lower levels. Twelve miles of the 19 mile long main channel are below elevation 300. The water is characteristically tea coloured from the organic action in the swamps,

FIGURE 1

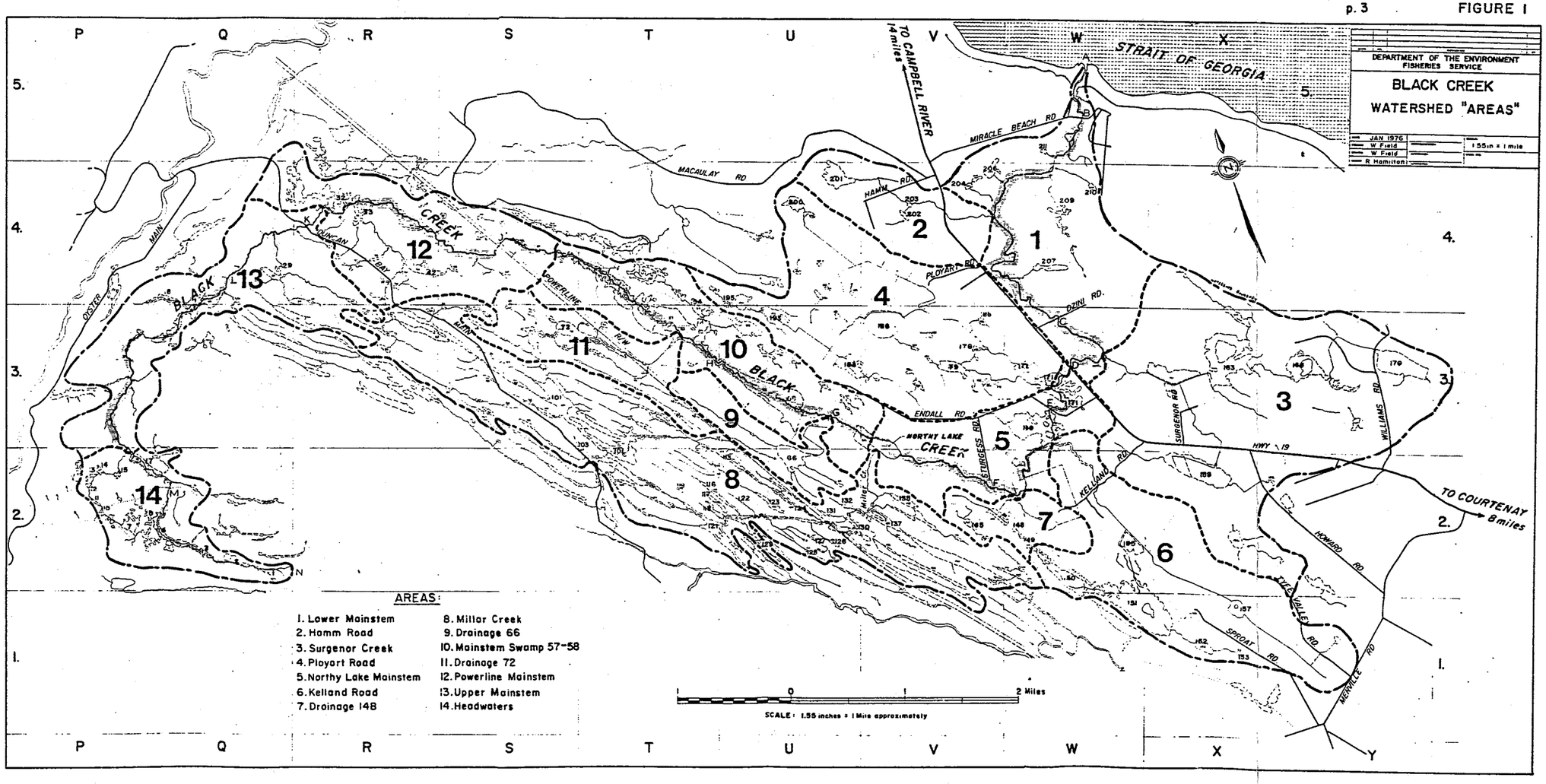

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE
BLACK CREEK
WATERSHED "AREAS"
JAN 1976
W Field
W Field
R Hamilton
1.55in = 1 mile
STRAIT OF GEORGIA
TO CAMPBELL RIVER
14 miles
MACAULAY RD
MIRACLE BEACH RD
HAMM RD
PLOYART RD
DZINI RD.
ENDALL RD
NORTHY LAKE CREEK
KELLAND RD
SURGENOR RD
WILLIAMS RD
HWY 19
TO COURTENAY
8 miles
HOWARD RD
TYEE VALLEY RD
SPROAT RD
MERRILLE RD
OYSTER
MAIN
BLACK CREEK
KWAMAN
BAY
POWERLINE
RAIN
P
Q
R
S
T
U
V
W
X
Y
1.
2.
3.
4.
5.
AREAS:
1. Lower Mainstem
2. Hamm Road
3. Surgenor Creek
4. Ployart Road
5. Northy Lake Mainstem
6. Kelland Road
7. Drainage 148
8. Millar Creek
9. Drainage 66
10. Mainstem Swamp 57-58
11. Drainage 72
12. Powerline Mainstem
13. Upper Mainstem
14. Headwaters
0
1
2 Miles
SCALE: 1.55 inches = 1 Mile approximately

FIGURE 2

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE

BLACK CREEK
SURFICIAL GEOLOGY

DRAWN:	DATE: JAN. 1976
CHECK: R. HAMILTON	SCALE: 1:50,000
APPROVED:	DRAWING NO.

LEGEND

- MARINE VENEER DEPOSITS* — stony, gravelly, and sandy.
- MARINE VENEER DEPOSITS* — stony, loamy, and clayey.
- MARINE DEPOSITS — silt, clay, stony clay.
- BEDROCK — with patches of thin stony, loamy, and clayey marine-veneer deposits.
- GROUND MORAINE DEPOSITS — till, lenses of gravel, sand, silt.
- FLUVIAL DEPOSITS — gravel and sand commonly underlain by silt and clay.

* generally less than 5 feet thick and overlying ground moraine deposits of gravel, sand, and silt.

Scale 1:50,000
1.25 Inches to 1 Mile approximately

causing visibility to become severely restricted as the water becomes deeper. Observation of fish in the deep waters of the swamps and lakes is nearly impossible.

As of 1972, approximately 17 percent of the watershed had been cleared and sixty percent of this was under some form of cultivation (Table G).

History of Watershed Development

Fisheries records on Black Creek go back to the 1920's when log jams and beaver dams in the lower few miles of the creek were the primary concerns. By 1928 the middle reaches of Black Creek had been entirely logged. In 1936 five permits were issued for trapping beaver which were being blamed for flooding of lands then being farmed. Debris from land clearing also found its way into the creek during this preriod. Prior to issuance of the first, and largest, irrigation licence in 1958 it was well known that lower sections of the creek went dry in the late summer; an annual program had already been underway for salvaging fry trapped in pools and transporting them to nearby perennial lakes or swamps. In 1959 representatives of the B.C. Department of Agriculture and Federal Fisheries met to discuss the problem of low flows and the conflict between irrigation needs by the farmers and instream flows for fisheries, but the problem was not resolved. In 1963 a report on flood control in the Northy Lake area was prepared by Mr. Calver of the Department of Agriculture advocating widening of approximately a mile of Black Creek immediately downstream of Northy Lake to permit faster runoff. The improvement district necessary to implement the proposal was not formed so that the proposal fell by the way. However, some private work has reportedly been done on widening and deepening of the channel.

The Water Investigations Branch investigated the possibility of diversion from the Tsolum River into Black Creek during their study of Tsolum River flood control in 1968. The suggestion was to pump water into the Black Creek watershed from one of the reservoirs to be created on the Tsolum. Apparently, up to the present time, these proposals have not been economically justified.

Associated Engineering Services Limited have made several studies for water supply in the area. Their latest report, completed in 1974 for the Regional District of Comox-Strathcona, excludes the Black Creek watershed as a source of regional water supply, although they do indicate the possibility of an interim well water source in the vicinity of Endall Road and Highway 19 for the immediate area. Their water quality tests have shown the water to be of poor quality for domestic use because of its high colour index and high iron content.

Data Collection

In October, 1968, a counting fence was installed just above tidal limit which produced definite data on timing, species and number of migrating fish. In 1969, three water level recorders were installed and have been maintained intermittently since then. In 1974 a number of staff gauges were installed in the main lakes and swamps and the creek was metered to provide rating curves for the water level recorders. In the fall of 1974 a study of spawning distribution was made and in the spring and summer of 1975 a rearing study was undertaken.

In 1975 a new counting fence was installed for enumeration of upstream migrants. Ten thousand fish were counted. The fence was used again in the fall of 1976. In the spring of 1977 a count was made of the downstream smolt migration.

For purposes of this report, the watershed was divided into 14 "Areas", representing sub-watersheds - logical subdivisions for study.

WATERSHED HYDROLOGY

Watershed Characteristics

The Black Creek watershed is characterized by a multitude of elongated lakes, swamps and depressions lying in a near north-south alignment, parallel to the coastline. Bedrock outcropping is common in the higher, eastern part of the watershed. Overlying layers of mixed glacio-marine deposits increase in depth in the depressions and at the lower elevations. Lake and swamp basins contain up to 30 feet of silt and clay deposits underlain by rock or till (Figure 2).

The lower part of the watershed consists of thin layers (up to about 5 feet) of varied stony to clayey deposits overlying till containing lenses of gravel, sand and silt. Water is lost out of Black Creek into these permeable lenses, or aquifiers. During low flows, Black Creek goes completely dry in some sections (Figure 5). Flows may reappear downstream, depending on ground water conditions and swamp levels.

The average annual rainfall at elevation 230 feet above sea level is 66.7 inches. Average monthly rainfall is given in Table A.

The upper part of the watershed, above recorder No. 3 (Figure 3) and consisting of Areas 12, 13, and 14 (Figure 1), has the general characteristics of a mountain stream. It is within an elevation range of 300 to 1,400 feet and has an average annual precipitation of 85 inches. Because of a flow sustained throughout the year (except for a reach shown in Figure 5) and the prevalence of suitable substrate, this section supports a substantial part of the salmon resource.

TABLE A

BLACK CREEK

MONTHLY PRECIPITATION

MONTH	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	MEAN
JAN.	11.01	9.87	20.02	5.53	6.22	9.33	3.46	15.87	10.27	8.98	9.95
FEB.	3.83	2.99	5.28	10.00	3.82	3.57	7.14	3.37	10.78	6.32	5.92
MAR.	8.53	9.12	5.96	4.80	4.16	14.13	8.29	4.77	12.78	5.88	7.77
APR.	M	2.79	.32	6.13	3.33	2.89	6.17	.15	1.23	1.69	(2.74)
MAY	M	1.05	1.30	1.10	1.56	1.46	.65	3.23	1.86	3.67	(1.76)
JUN.	M	.42	1.11	.97	1.57	3.46	2.40	2.29	.72	1.84	(1.58)
JUL.	M	.51	M	.81	2.81	.87	1.12	1.89	3.60	.39	(1.50)
AUG.	M	.26	2.97	3.11	.30	.97	.94	.76	.10	4.96	(1.60)
SEP.	2.69	2.56	1.65	5.79	1.89	2.60	4.27	2.39	1.22	.16	2.52
OCT.	4.98	11.56	12.65	4.65	5.76	5.29	1.13	7.65	1.36	15.06	7.01
NOV.	14.93	5.40	12.03	8.28	8.73	14.36	8.25	10.84	13.48	20.50	11.68
DEC.	14.13	12.58	15.41	15.24	16.36	9.61	10.41	15.02	10.66	7.27	12.67
TOTAL	-	59.11	-	66.41	56.51	68.54	54.23	68.23	68.06	76.72	66.70

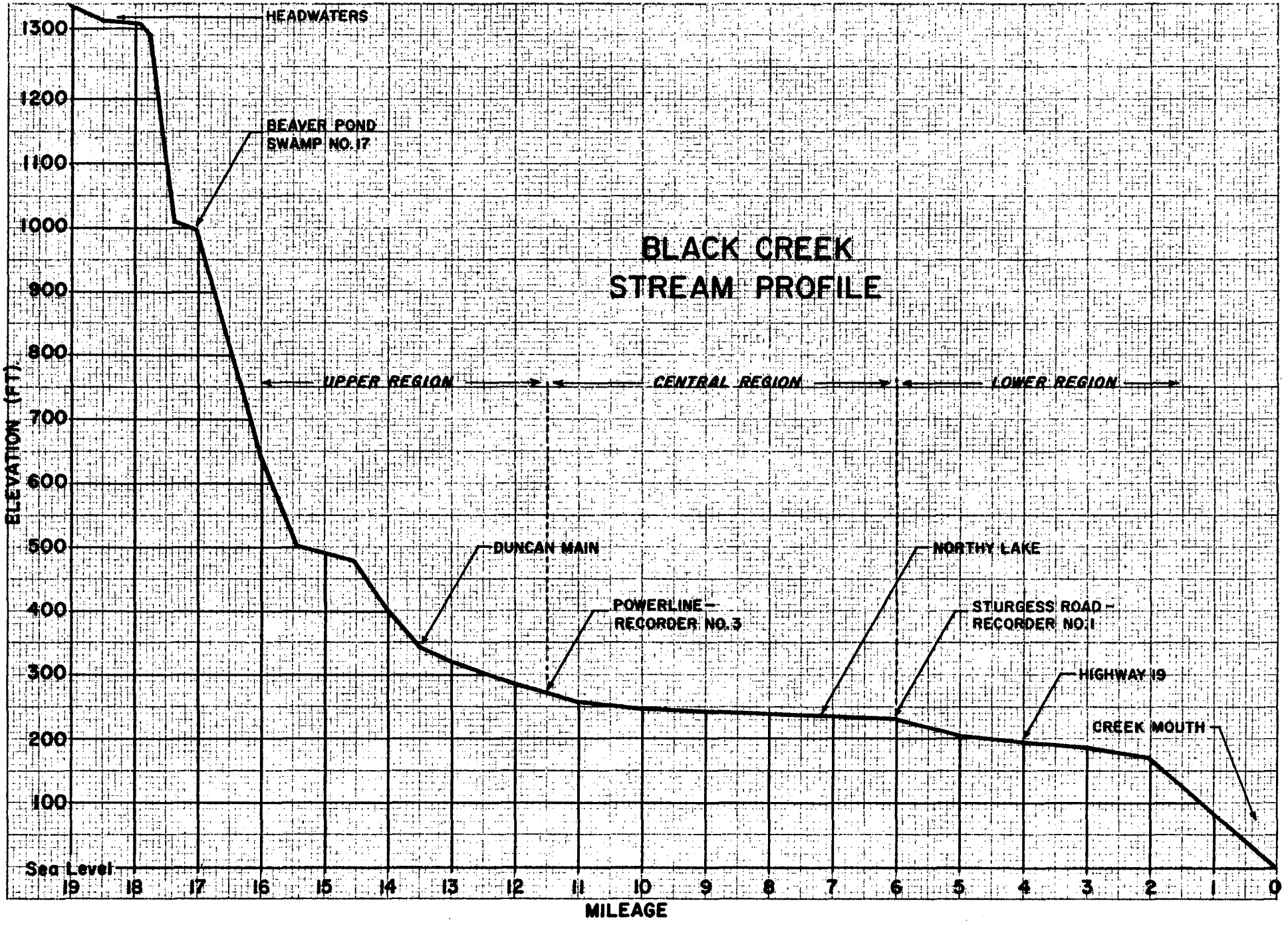

BLACK CREEK
STREAM PROFILE
HEADWATERS
BEAVER POND
SWAMP NO. 17
UPPER REGION
CENTRAL REGION
LOWER REGION
DUNCAN MAIN
POWERLINE –
RECORDER NO. 3
NORTHY LAKE
STURGESS ROAD –
RECORDER NO. 1
HIGHWAY 19
CREEK MOUTH
ELEVATION (FT).
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
Sea Level
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
MILEAGE

FIGURE 3

The central part of the watershed, between recorders No. 1 and No. 3 and consisting of Areas 9, 10, and 11, has a very low profile governed by geology. The numerous swamps in this region retain water throughout the year.

Black Creek at and below recorder No. 1 usually goes dry for a period in late summer (Figure 4). A combination of low stream gradient and pervious subsurface strata results in a disappearance of surface flow in some places and a reappearance further downstream.

At a reading of 5.36 feet at No. 1 recorder the flow is zero (Figure 4). As the figure shows, the stream goes dry in this location during August and September each year, on the average; and may go dry,in extreme cases, any time between the last part of June and the first part of November. Daily flows at the three recorders for the years 1969 to 1974 are given in Appendix A.

The swampy areas flanking Endall Road near Highway 19 always contain some water, even though the creek both above and below may be dry (Figure 5). Apparently, there is good potential for well water supply in this immediate area; however, wells would tend to draw down the watertable and cause the creek to go dry sooner than would naturally be the case.

The swamps in Areas 3 and 6 (Figure 1) retain water that maintains some flow in the tributaries in these areas during the low flow period.

FIGURE 4

BLACK CREEK

STAGE AND DISCHARGE FOR STURGESS ROAD RECORDER #1

1969 – 1975

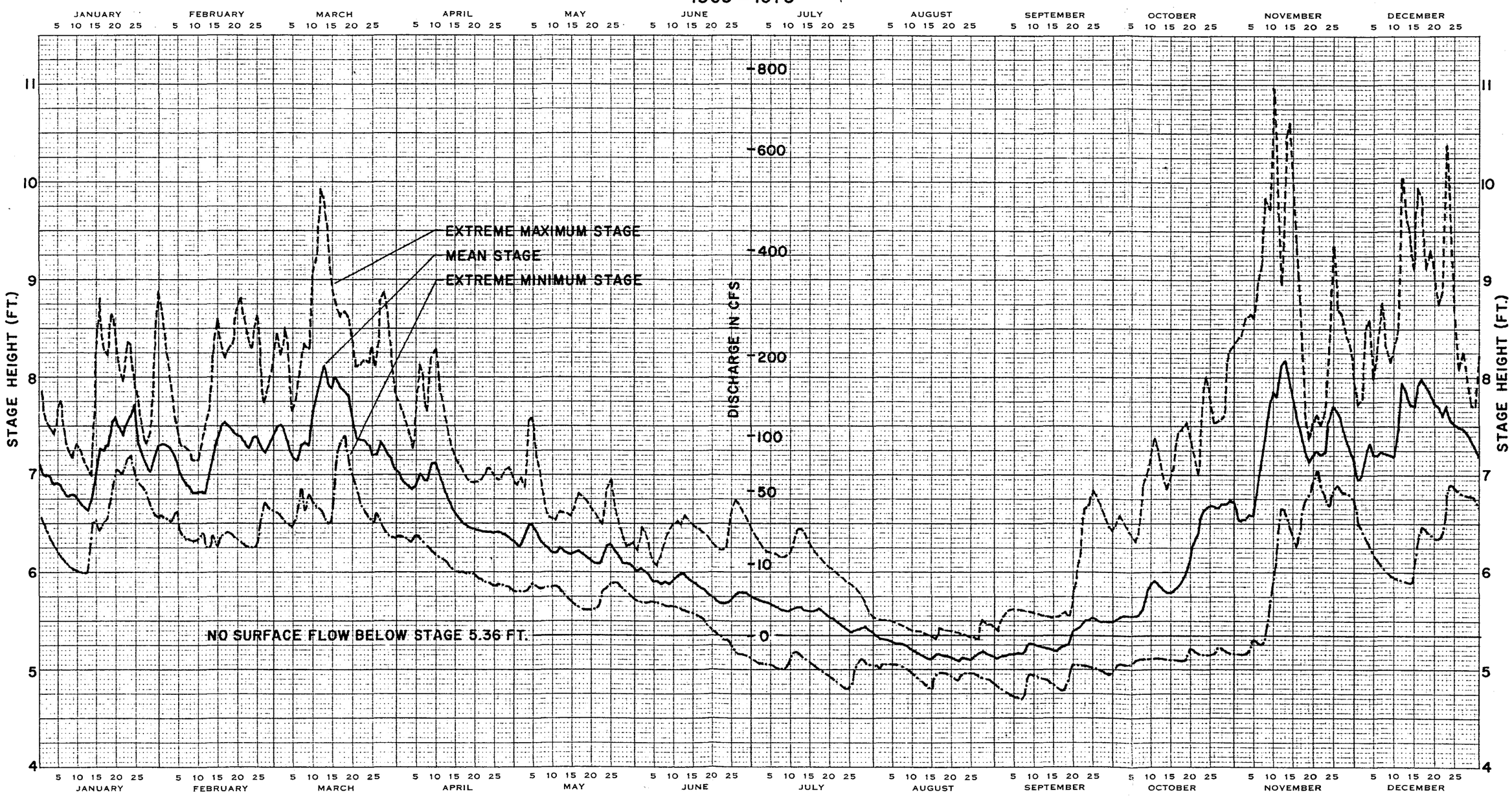


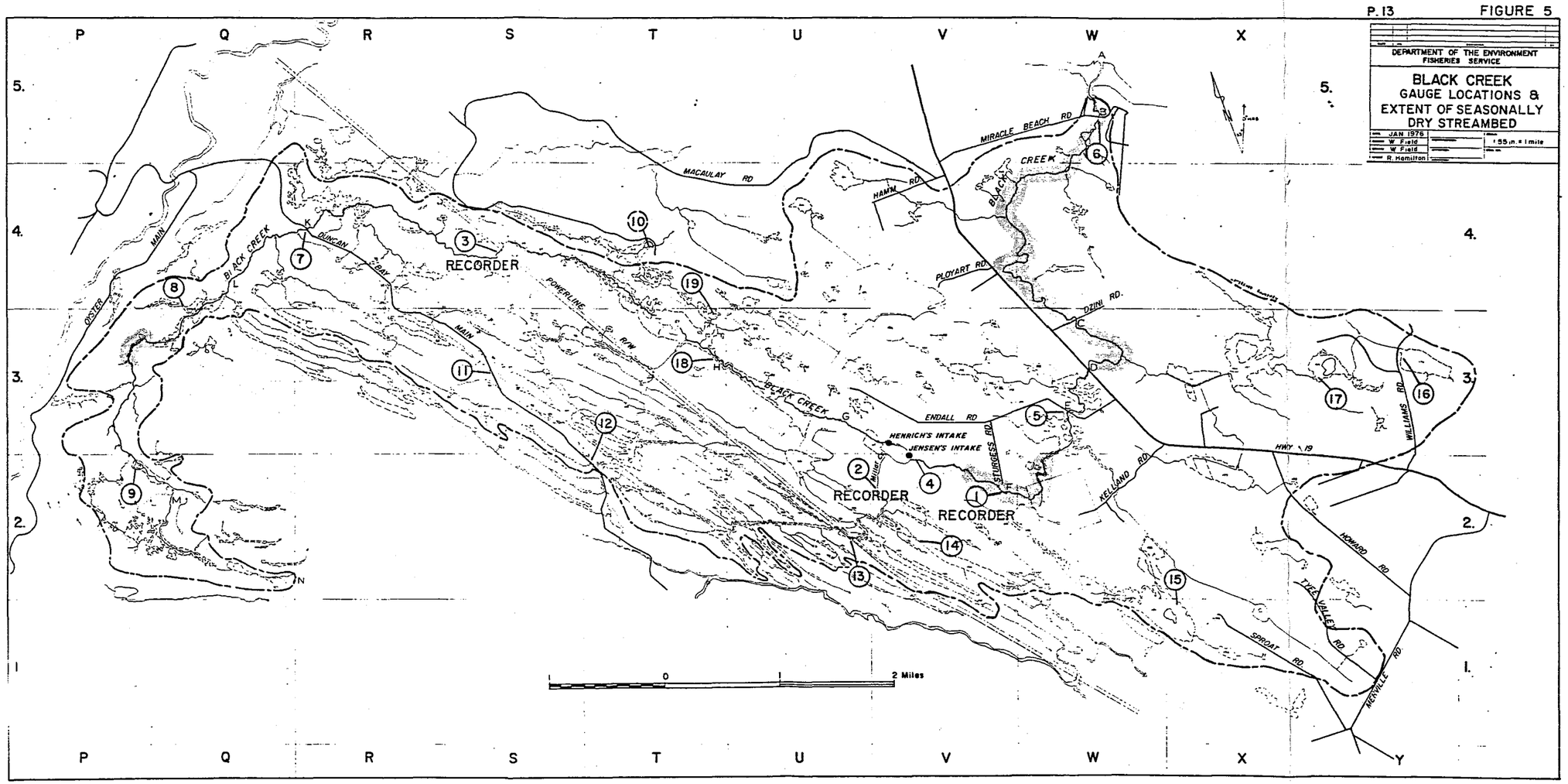
FIGURE 5

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE

BLACK CREEK
GAUGE LOCATIONS & EXTENT OF SEASONALLY DRY STREAMBED

JAN 1976
W. Field
W. Field
R. Hamilton

1.55 in. = 1 mile



Natural Storage

The natural swamps of the Black Creek watershed regulate storm water runoff. Peak flows are reduced and dry weather flows are improved. The beaver population has played an important part in the hydrology of the watershed by building many substantial dams which have increased considerably the total storage capacity in the system.

In 1974 sixteen staff gauges were installed to record water levels in the swamps. Gauge locations are shown in Figure 5; the drainage area tributary to each gauge and its elevation above sea level are shown in Table B; gauge readings to 1975 are given in Table C.

As an example of the effect of storage on streamflow, Millar Creek (Area 8) will be examined for the month of May 1975. Figure 6 shows the rainfall, the estimated amount of storage in the swamps of the Millar Creek watershed, and the runoff at recorder No. 2. A main rainfall event occurred on May 2nd and 3rd which resulted in an increase in flow, peaking to 31 cfs on May 4th. There was a corresponding increase in level of 0.6 feet in the 465 acres of swamp, representing a storage of 276 acre feet. Because of the retention effect of the storage, it was not until May 20th that storage and streamflow diminished to the values of May 2nd (other lesser rainfalls had occurred after the main event which contributed to some extent in maintaining low flows). If there had been little or no storage in the Millar Creek watershed the peak streamflow would have occurred earlier and been much higher, and the recession of the flow would have been much faster after the end of rainfall. This example shows the important effect of swamps in reducing peak flows and maintaining dry weather flows. It is evident that

FIGURE 6

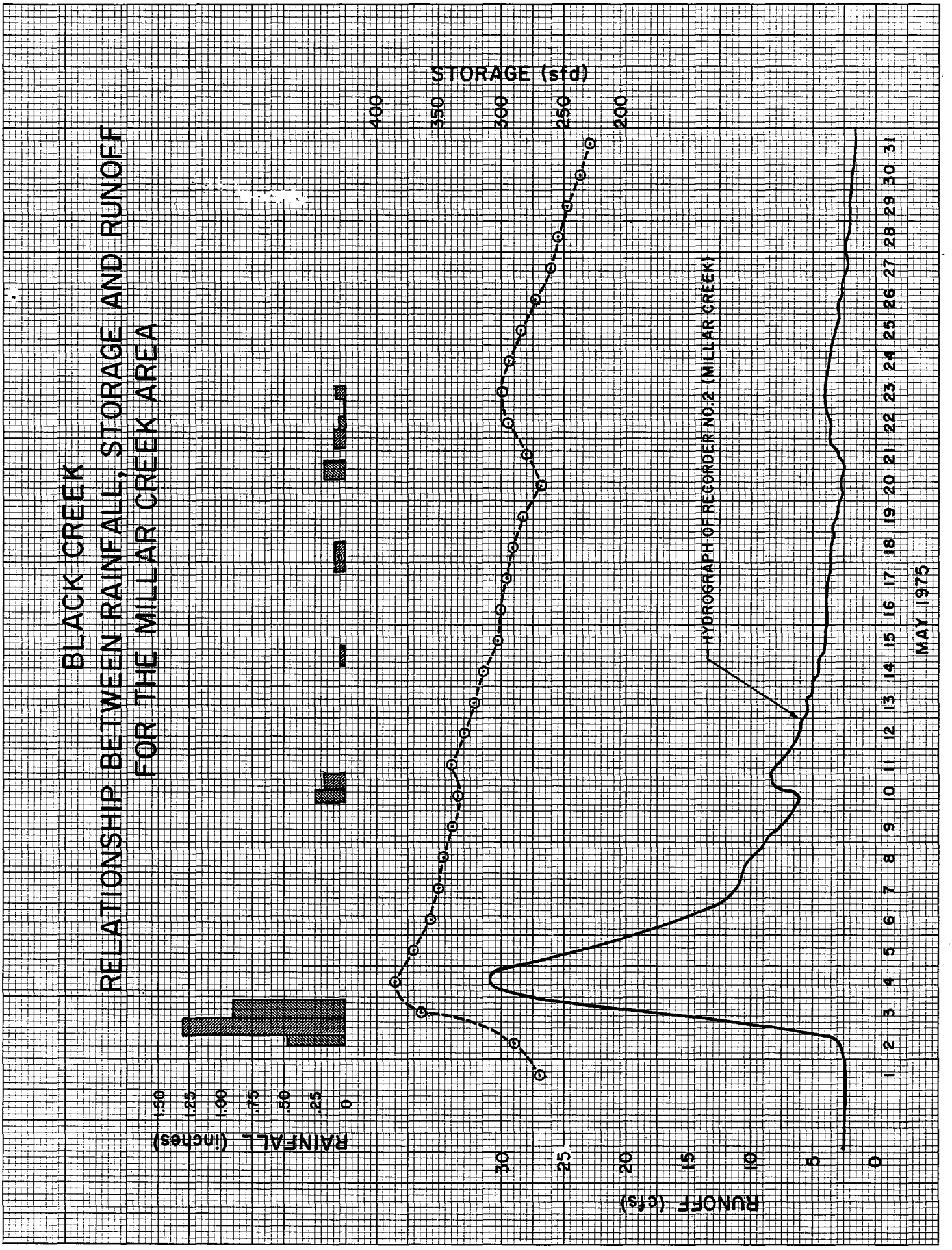

BLACK CREEK
RELATIONSHIP BETWEEN RAINFALL, STORAGE AND RUNOFF
FOR THE MILLAR CREEK AREA
STORAGE (std)
400
350
300
250
200
HYDROGRAPH OF RECORDER NO.2 (MILLAR CREEK)
MAY 1975
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
RUNOFF (cfs)
30
25
20
15
10
5
0
RAINFALL (inches)
1.50
1.25
1.00
.75
.50
.25
0

TABLE B

BLACK CREEK

GAGE DATA

GAGE NO.	DRAINAGE AREA ABOVE GAGE ac.	GAGE ELEVATION ABOVE SEA LEVEL ft.
(RECORDER) 1.	8778	235
(RECORDER) 2.	2815	265
(RECORDER) 3.	3040	270
4.	8484	240
5.	11066	200
6.	18334	4
7.	1984	350
8.	140	520
9.	455	1000
11.	330	375
12.	109	360
13.	2148	280
14.	184	270
15.	370	240
16.	164	270
17.	484	248
18.	4520	240
19.	114	250

TABLE C

BLACK CREEK

GAUGE READINGS

GAUGE #4

1972	
Nov. 1	2.38
1973	
Mar. 1	5.30
May 5	2.75
May 22	2.36
Jun 3	2.94
Jul 5	2.32
Jul 13	2.40
Jul 19	2.05
Jul 28	1.98
Aug 6	1.62
Aug 18	1.16
Sep 7	0.96
Oct 8	1.26
1974	
Jan 3	3.95
Mar 7	4.75
Apr 8	5.90
May 9	2.95
May 21	2.82
Jun 10	2.44
Jun 17	2.18
Jul 10	2.08
Jul 17	2.82
Jul 31	2.20
Aug 9	1.84
Aug 16	1.20
Sep 6	1.05
Sep 9	1.15
Sep 23	1.05
Oct 4	1.05
Oct 7	1.02
Oct 24	0.94
Nov 5	1.10
Nov 7	1.43
Nov 13	4.37
1975	
Mar 23	6.35
Apr 1	4.24
Apr 18	3.91
Apr 30	3.52
May 7	5.84
May 20	3.26
May 26	3.25
May 30	2.96
Jun 9	2.51
Jun 18	2.21
Jun 30	2.78
Jul 7	2.00
Jul 10	1.90
Jul 13	1.80
Aug 2	1.20
Aug 21	1.20
Oct 3	1.98
Nov 1	6.40

GAUGE #5

1974	
Sep 9	0.40
Sep 23	0.36
Oct 7	0.36
Oct 23	0.38
Oct 28	0.40
Nov 5	0.40
Nov 6	0.50
Nov 7	0.48
Nov 8	0.52
Nov 13	2.26
Nov 24	6.15
Nov 25	6.75
Dec 5	3.80
Dec 13	4.38
Dec 17	4.90
Dec 18	5.52
Dec 30	2.45
1975	
Jan 3	3.38
Jan 6	3.98
Jan 14	2.34
Jan 20	3.26
Jan 23	3.82
Feb 1	2.40
Feb 2	2.27
Mar 1	4.48
Mar 2	5.15
Mar 22	4.44
Mar 23	4.62
Apr 1	1.94
Apr 10	1.86
Apr 11	1.80
Apr 18	1.69
May 7	2.30
May 8	2.00
May 20	1.24
May 26	1.21
May 30	1.06
Jun 2	0.95
Jun 9	0.85
Jun 12	0.80
Jun 18	0.74
Jun 21	0.70
Jun 25	0.73
Jun 30	0.98
Jul 3	0.96
Jul 7	0.85
Jul 12	0.78
Jul 27	0.46
Aug 2	0.44
Aug 21	0.48
Oct 2	0.60
Oct 11	3.24
Oct 26	4.20
Nov 1	5.32
Nov 14	8.82
Dec 2	2.48

GAUGE #6

1974	
Aug 21	0.35
Sep 8	0.39
Sep 24	0.34
Oct 6	0.35
Oct 23	0.37
Oct 28	0.35
Nov 5	0.36
Nov 6	0.40
Nov 7	0.42
Nov 8	0.40
Nov 9	0.75
Nov 10	0.70
Nov 11	0.82
Nov 12	1.55
Nov 13	1.49
Nov 16	1.20
Nov 17	1.55
Nov 19	1.65
Nov 22	2.00
Nov 23	2.12
Nov 24	3.88
Dec 2	2.00
Dec 9	2.00
Dec 12	2.30
Dec 13	2.85
Dec 17	3.10
Dec 20	2.36
Dec 23	1.88
Dec 27	1.95
Dec 31	1.70
1975	
Jan 2	2.25
Jan 6	2.65
Jan 15	1.41
Jan 23	2.60
Jan 31	1.59
Feb 1	1.58

TABLE C
(cont'd.)

BLACK CREEK

GAUGE READINGS

GAUGE #6

1975 - (Con't)

Mar 1	2.89
Mar 11	1.80
Mar 23	2.73
Mar 25	2.06
Mar 30	1.50
Mar 31	1.42
Apr 2	1.48
Apr 5	1.80
Apr 7	1.60
Apr 10	1.40
Apr 11	1.40
Apr 15	1.28
Apr 16	1.25
Apr 18	1.23
Apr 20	1.34
Apr 23	1.28
Apr 28	1.15
Apr 30	1.08
May 5	2.15
May 7	1.65
May 8	1.48
May 20	0.95
May 26	0.92
May 30	0.76
Jun 2	0.65
Jun 9	0.57
Jun 11	0.51
Jun 16	0.48
Jun 18	0.46
Jun 21	0.43
Jun 25	0.44
Jun 30	0.60
Jul 5	0.48
Jul 6	0.46
Jul 8	0.45
Jul 10	0.42
Jul 12	0.42
Jul 27	0.42
Aug 10	0.38
Aug 27	0.38
Aug 30	0.46
Sep 1	0.45
Sep 11	0.42
Oct 2	0.40
Oct 3	0.60
Oct 4	0.58
Oct 11	1.85
Oct 14	1.80
Oct 26	3.20
Oct 27	3.05
Oct 29	3.25
Oct 30	3.25
Nov 1	3.05
Nov 14	5.10
Dec 3	1.78

GAUGE #7

1974

Sep 10	1.79
Sep 11	1.78
Sep 23	1.75
Oct 6	1.77
Oct 24	1.79
Oct 27	1.82
Nov 7	1.81
Nov 13	2.21
Nov 23	2.16
Dec 9	2.30

1975

Apr 11	2.42
Apr 17	2.43
Apr 18	2.43
Apr 25	2.40
Apr 28	2.30
May 10	2.16
May 11	2.19
May 12	2.16
Jul 13	1.90
Aug 7	1.90
Aug 24	1.90
Aug 30	1.92
Sep 7	1.86
Oct 4	1.92
Oct 10	2.72
Oct 18	2.20
Oct 30	2.58
Dec 7	2.20

GAUGE #8

1974

Sep 23	0.59
Oct 6	0.52
Oct 24	0.53
Nov 7	0.57
Nov 13	1.85

1975

Apr 17	1.43
Apr 25	1.40
Jun 12	1.31

GAUGE #9

1974

Sep 10	2.39
Sep 23	2.30
Oct 6	2.45
Oct 24	2.78
Nov 7	2.88
Nov 23	2.87

1975

Apr 28	2.92
May 10	2.87
Jun 13	2.96

GAUGE #11

1974

Sep 10	1.83
Sep 23	1.51
Oct 6	1.59
Oct 24	1.52
Oct 27	1.58
Nov 7	2.31
Nov 13	2.84
Nov 23	3.18

1975

Apr 17	2.85
Apr 28	2.76
May 10	2.85
Jul 13	2.46
Aug 7	1.92
Aug 24	1.80
Aug 30	2.46
Sep 7	2.42
Oct 11	4.14
Oct 18	5.12
Oct 31	3.74
Nov 20	3.04
Dec 7	3.02

GAUGE #12

1974

Sep 10	2.44
Sep 23	2.29
Oct 6	2.27
Oct 24	2.2
Oct 27	2.25
Nov 7	2.40
Nov 13	3.07
Dec 12	4.18

TABLE C
(cont'd.)

BLACK CREEK

GAUGE READINGS

1975

Apr 17	3.90
May 10	3.99
Jul 13	3.02
Aug 7	2.70
Aug 24	2.58
Aug 30	2.76
Sept 7	2.68
Oct 10	2.96
Oct 18	4.62
Oct 30	4.94
Nov 8	4.88
Nov 20	4.74
Dec 7	4.88

GAUGE #13

1974

Sep 10	1.78
Sep 22	1.73
Oct 7	1.75
Oct 25	1.75
Nov 7	1.81
Nov 13	3.02
Nov 24	5.13
Dec 12	3.75

1975

Apr 1	3.08
Apr 18	2.85
Apr 30	2.78
May 27	2.94
Jul 13	2.50
Aug 16	1.84
Sep 16	2.00
Oct 2	1.90
Oct 14	3.32

GAUGE #14

1974

Sep 22	0.60
Oct 7	0.60
Oct 25	0.60
Nov 7	0.85
Nov 13	1.43
Nov 24	1.73
Dec. 13	1.58

1975

Apr 18	1.47

GAUGE #15

1974

Sep 10	1.68
Sep 22	1.53
Oct 7	1.54
Oct 23	1.58
Nov 7	1.89
Nov 13	2.35
Nov 24	2.75
Dec.31	2.50

1975

Jan 23	2.62
Feb 4	2.70
Apr 4	2.47
Apr 19	2.37
Jun 9	2.20

GAUGE #16

1974

Aug 22	2.00
Sep 8	1.80
9	1.89
23	1.77
Oct 6	1.74
Oct 23	1.75
Nov 7	1.93
13	2.26
24	2.60
Dec 27	2.70

1975

Jan 23	2.76
Apr 2	2.64
Apr 16	2.64
May 5	2.70
Jun 9	2.46
Jun 21	2.30
Jul 12	2.15
Jul 22	2.04

GAUGE #17

1974

Aug 22	2.00
Sep 8	1.80
Sep 9	1.89
Sep 23	1.76
Oct 6	1.74
Oct 23	1.75
Nov 7	2.01
13	2.46
24	2.62
Dec.27	2.46

1975

Jan 23	2.64
Apr 2	2.47
Apr 16	2.72
Jun 9	2.60

GAUGE #18

1974

Sep 24	0.43
Oct 7	0.53
Oct 25	0.60
Nov 7	1.42
Nov 13	1.72
Nov 25	4.05
Dec. 13	2.38
Dec. 18	2.78

1975

Apr 1	1.70

GAUGE #19

1974

Oct 25	2.06
Nov 7	2.31
Nov 13	3.79
Nov 24	4.70
25	3.73
Dec. 13	3.92
18	4.00
30	3.82

1975

Apr 1	3.78
18	3.60

development of storage in some of the main swamps of the Black Creek watershed would help considerably to improve low flow conditions. The most likely prospects are described below:

1. Swamp #17, Area 14

It should be possible to develop storage in this swamp, or lake, because it is in an area of the watershed undeveloped except for logging. Surrounding banks are steep and the narrow outlet, presently dammed by beaver, appears to be a good site for a permanent dam. There is road access to within a short distance of the site. The property is owned by Crown Zellerbach who have indicated a willingness to co-operate in such a project.

A structure at the outlet might also be used to control flow releases from upstream storage in swamp #5. Flow control would benefit the heavily utilized section of Black Creek in Area 13 and may significantly improve flow conditions further downstream.

2. Swamp #5, Area 14

This is an elongated swamp containing over a dozen beaver dams of various ages and sizes. It receives drainage from other adjacent and upstream swamps. Storage could be developed by a dam near the outlet but additional dams or dykes may be necessary to prevent spill out through lower drainages. Water could be released from time to time to replenish storage in swamp #17. The swamp is within T.F.L. #2 owned by Crown Zellerbach.

3. Millar Creek Watershed, Area 8

This subwatershed is almost entirely within T.F.L. #2, owned by Crown Zellerbach and is undeveloped except

for some logging activity. Storage could be developed in several locations above the powerline where there are numerous swamps and depressions. Crown Zellerbach may be favourably disposed to storage development as it would provide water for fire protection, but they would likely be concerned if high water levels were to flood their logging access roads.

As there are coho spawning areas in this subwatershed (Figure 14), fish passage, both upstream and downstream, may have to be considered,depending on dam locations. Water releases from storage could be allowed to flow directly into Northy Lake or, possibly, diverted by a ditch to a point downstream of Northy Lake. Storage in Millar Creek watershed would benefit Millar Creek and Black Creek mainstem below Northy Lake. As lower Millar Creek passes through developed farm land and as Northy Lake itself is surrounded by developed farm land, protective measures may have to be taken to maintain water quality.

4. Swamps 150-151, Area 6

It is possible that a foot or two of storage could be developed in these swamps to improve flows in the Kelland Road tributary and in the lower mainstem of Balck Creek. There could be some conflict, however, with existing and proposed land development in the vicinity.

5. Swamp #166, Larkin Lake, Area 3

Storage in this swamp appears feasible because of the higher surrounding land. As with other potential storage sites in the lower Black Creek watershed there could be conflict with future land development and irrigation demand. At the present time, salmon do not migrate above the swamp because of existing beaver dams at the outlet.

Parts of the Surgenor tributary and the lower mainstem would benefit by storage in this area.

Each of the possible storage sites would require a detailed study to check geological suitability, potential storage volume, land ownership, and cost/benefit ratio.

Water Licences

Table D lists the water licences issued by the Comptroller of Water Rights to June 1978. Additional applications have been made but have been turned down or held in abeyance. Up to June 1978, irrigation licences totalled 205 acre feet. If all irrigation licences were being used at once it would amount to a total withdrawal of about 1.02 cfs over the irrigation period April 1st to September 30th. If all domestic and stock watering licences (totalling 10,500 gal. per day) were used at once it would represent a withdrawal of 0.02 cfs. Irrigation, then, is the major water use and can represent a very significant part of the flow in Black Creek in the dry period (Appendix A). Some of the diverted water (perhaps 30 percent) will find its way back to the creek but it may be contaminated with insecticides, fertilizers, and other pollutants.

The first licence was issued in 1958 to Mr. B. Henrich. It is by far the largest and most important licence on Black Creek with 115 acre feet for irrigation use and 5,000 gal. per day for domestic use and stock watering. The location of his diversion is shown on Figure 5.

The many swamps or swampy depressions in the watershed suggests the possibility of development of storage for irrigation or conservation purposes. The Water Act requires

TABLE D

BLACK CREEK

WATER LICENCES

(To June 1978)

DATE	LICENCE		LICENSEE	QUANTITY	PURPOSE	PERIOD OF DIVERSION
	COND'L.	FINAL				
5 Nov. 1958	25291		B. Henrich	115 ac.ft. 5000 g/d	Irrigation. Domestic and Stock Watering.	Apr.1-Sep.30. Whole year.
22 Jun. 1964	29964		J. Westdorp	10 ac.ft.	Irrigation	Apr.1-Sep.30
5 Oct. 1965	30989	21371	J.H. Girard	1000 g/d	Domestic	
21 Sep. 1966	37766		R.J.&W. Elgie	25 ac.ft. 1000 g/d	Irrigation Domestic and Stock Watering.	
21 Sep. 1966	37767		R.J.&W. Elgie	25 ac.ft.	Storage.	
15 May 1967	32798		J.L. Baskin	500 g/d	Domestic and Stock Watering.	
26 May 1967	32666		Jenson	Whole flow	Land Improvement.	
12 Sep. 1967	41147		D. Halstead	10 ac.ft.	Irrigation.	
14 Mar. 1968	33495		H.J.V. & I.R. Offersen	1000 g/d	Domestic and Stock Watering.	
28 Aug. 1974	45727		J.F.&C. Lister	1000 g/d	Domestic	
30 Aug. 1974			K.&B. Hoopes	20 ac.ft. 500 g/d	Irrigation Domestic and Stock Watering.	
30 Aug. 1974			K.&B. Hoopes	20 ac.ft.	Storage	
13 Jul. 1976	48692		P.&M. Wedel	500 g/d	Domestic	

that a separate licence be acquired for storage purposes in addition to the licence for irrigation or conservation which the storage supports. Certain areas in the watershed are more suitable for storing water for conservation purposes than others. A reserve could be placed on them or storage licences could be obtained by the Department of the Environment for the purpose of conservation (see Watershed Hydrology, Natural Storage).

FISHERIES RESOURCE

Black Creek is one of the major producers of coho salmon *(Oncorhynchus kisutch)* on Vancouver Island, with annual escapements of up to 15,000 (Table E). Average timing of the several phases of their freshwater cycle is shown in Figure 7. Chum salmon *(O. keta)*, last recorded in 1949, at one time utilized the lower Black Creek area. Two resident species of trout, coastal cutthroat *(Salmo clarki clarki)* and rainbow *(Salmo gairdneri)*, and their anadromous forms, sea-run cutthroat and steelhead, are found in the system. They tend to be concentrated in the lakes and beaver ponds. Steelhead spawning begins in December or January, peaks in March, and ends in April or May.

An accurate enumeration of salmon escapements has been difficult in the past because of the poor access to the many swampy areas and the dark tea coloured water. Since installation of a counting fence in 1975, more accurate counts have been made.

Migration Timing

Upstream migration is governed by the arrival of the fall rains (Figures 8, 9 and 12) as there is often insufficient flow in Black Creek for upstream migration after the late summer and early fall dry period and extensive reaches of the creek below Northy Lake may even be dry. The flow at the mouth may not be sufficient to allow access beyond tidewater for fish wishing to migrate. It is not uncommon (as observed in 1974 when 250 dead unspawned fish were found) for coho to move in at high tide and be trapped in tidal pools and logging debris as the tide recedes.

BLACK CREEK
COHO FRESHWATER LIFE CYCLE

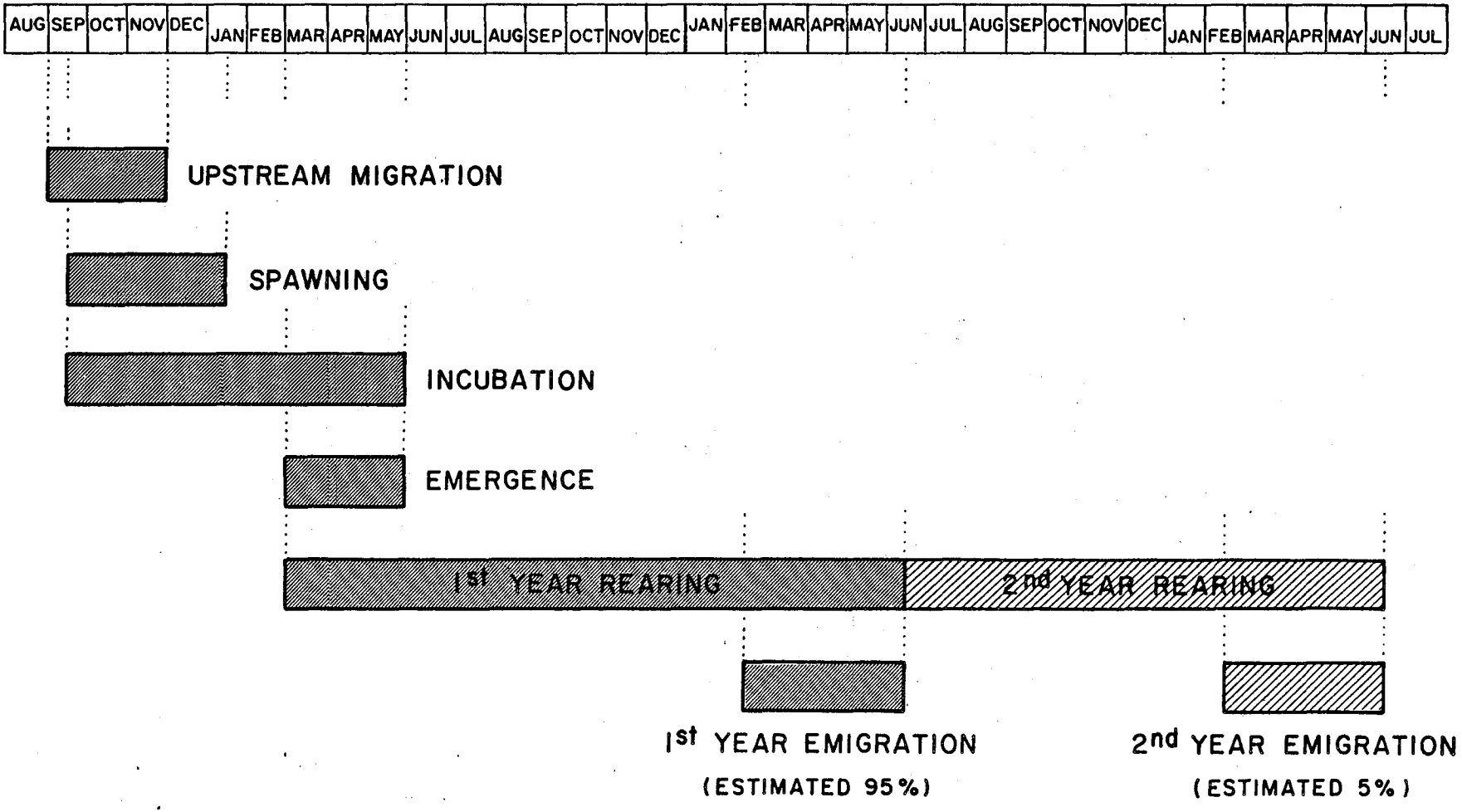


FIGURE 7

FIGURE 8

BLACK CREEK
START OF UPSTREAM MIGRATION OF COHO RELATED TO DAILY PRECIPITATION & STREAM FLOW 1969 – 1972

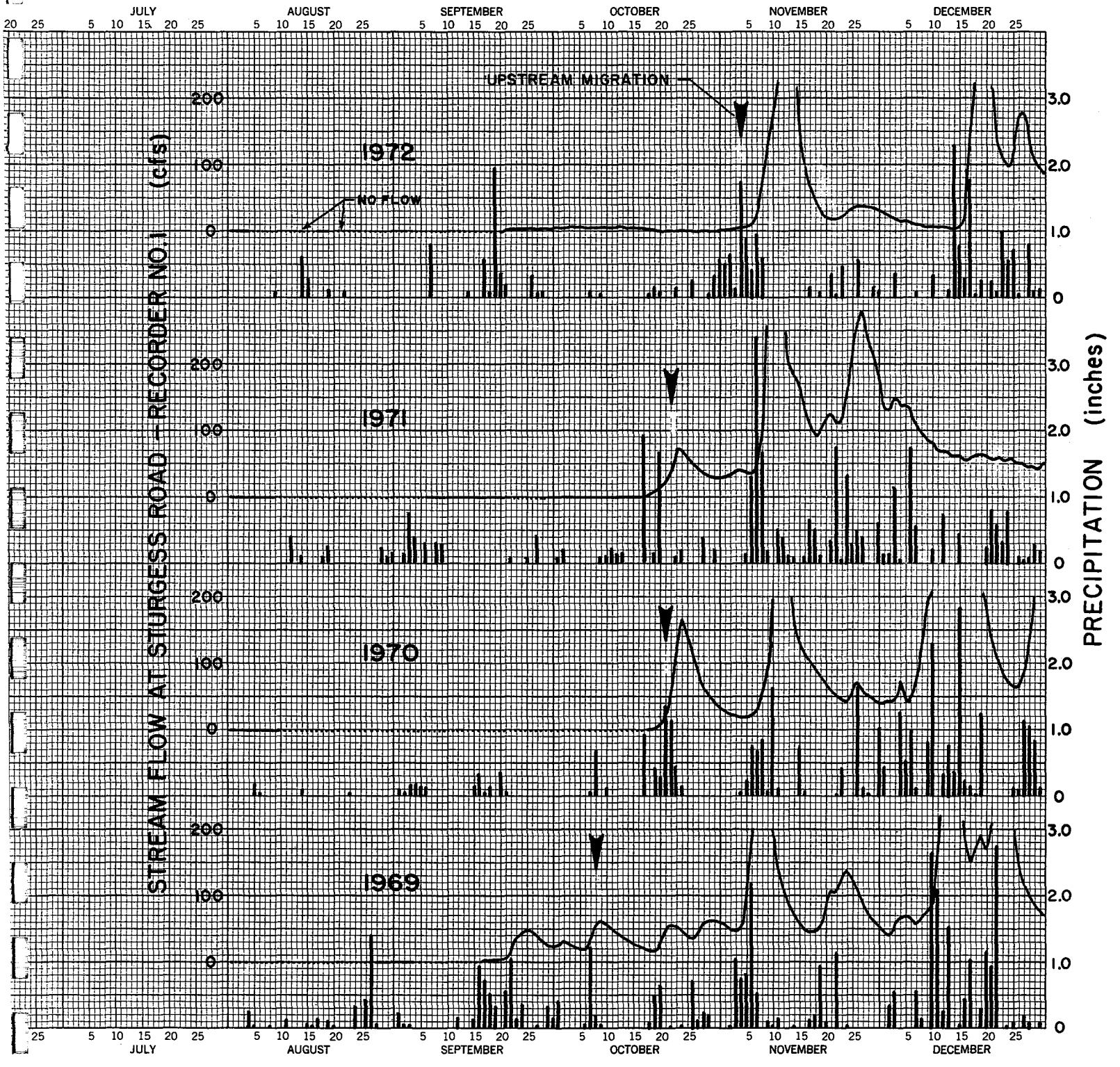


FIGURE 9

BLACK CREEK

START OF UPSTREAM MIGRATION OF COHO RELATED TO DAILY PRECIPITATION & STREAM FLOW 1973 – 1976

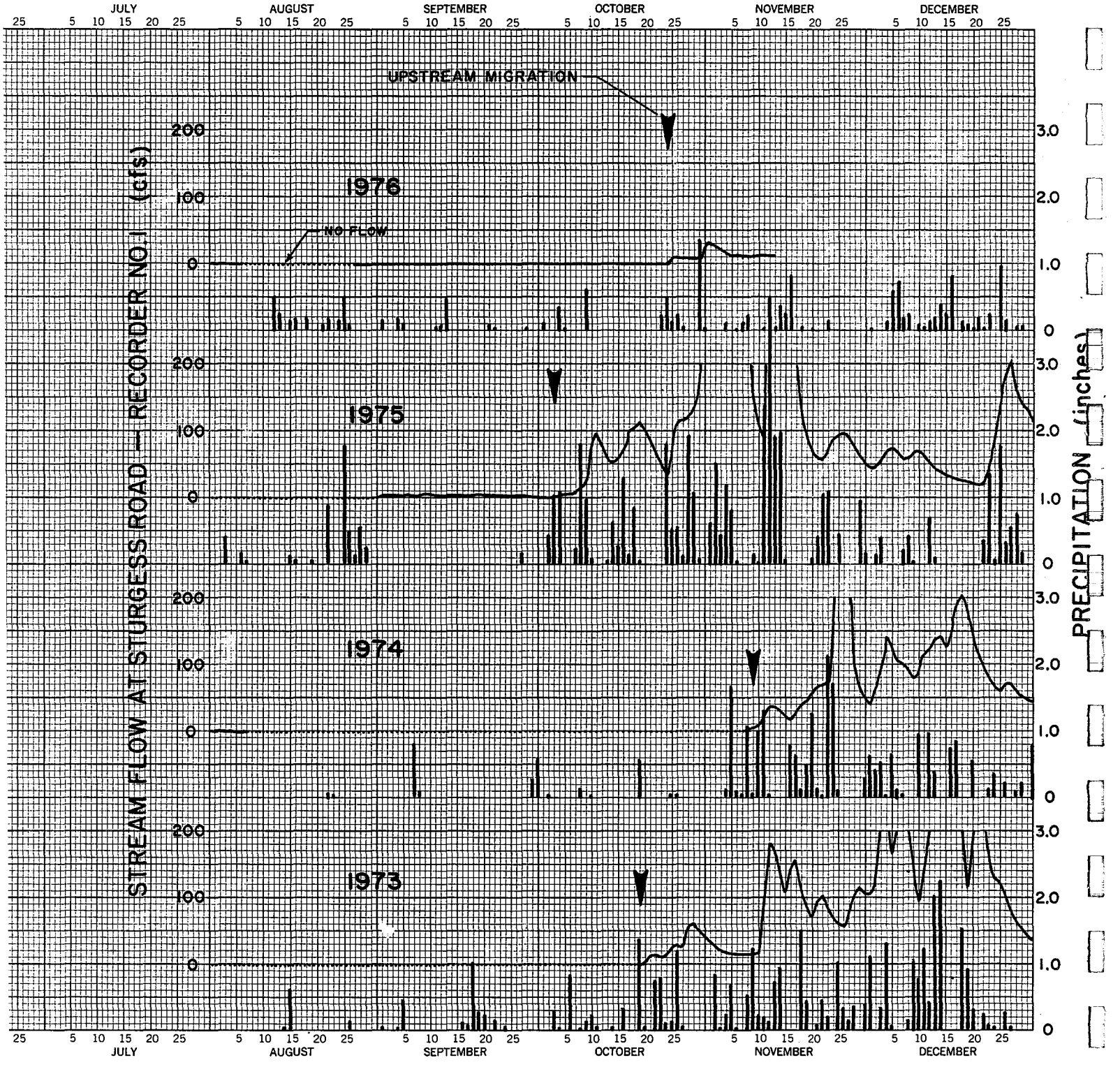


TABLE E

BLACK CREEK

ESCAPEMENT RECORD

YEAR	COHO	CHUM	STEELHEAD	YEAR	COHO	CHUM	STEELHEAD
1935	7500	15000	-	1956	1500	-	75
1936	15000	7500	-	1957	7500	-	200
1937	3500	7500	-	1958	1500	-	750
1938	-	-	-	1959	7500	-	400
1939	3500	3500	-	1960	400	-	200
1940	3500	-	-	1961	7500	-	300
1941	3500	7500	-	1962	7500	-	200
1942	3500	-	-	1963	3500	-	200
1943	750	-	-	1964	15000	-	-
1944	3500	-	-	1965	7500	-	-
1945	1500	400	-	1966	15000	-	-
1946	1500	-	-	1967	6000	-	-
1947	3500	-	-	1968	4650	-	-
1948	1500	-	-	1969	1200	-	-
1949	1500	750	-	1970	8000	-	-
1950	1500	-	-	1971	10000	-	-
1951	1500	-	200	1972	4500	-	-
1952	1500	-	200	1973	6000	-	-
1953	1500	-	200	1974	8000	-	-
1954	1500	-	200	1975	10000	-	-
1955	1500	-	200	1976	3500	-	-

As a rule, coho are ready to enter the river in the 3rd or 4th week of October. As soon as it rains sufficiently to bring the water level up to about the 0.7 foot mark on gauge 6 (at Miracle Beach Road), the coho are able to negotiate their way upstream in large numbers (Figures 10 and 11). Up to 50 percent of the total escapment may be in the initial run, which tends to spawn in the lower part of the watershed below Northy Lake. Later runs follow; their timing depends on rainfall and run-off conditions. Later migrants, apparently induced by the higher flows, tend to go into the upper watershed.

In 1974, migration was delayed by inadequate flow until November 9th when the level at gauge #6 rose to 0.7 feet. A small number of coho moved upstream on this date. A large number of adult coho were observed below the Miracle Beach bridge on November 19th, and on the 11th, between 1500 and 1700 hours, at a gauge reading of 1.6, 1,380 fish were counted. Another surge in upstream migration occurred on November 17 when the gauge reading rose from 1.2 to 1.6 feet, but numbers of fish were not recorded.

Peak spawning took place in Black Creek below Northy Lake between November 12th and 19th. On November 24th #6 gauge (Miracle Beach bridge) read 3.9 feet, and on the 25th coho were observed passing under the Duncan Bay Main road bridge in Area 13. Peak spawning above Northy Lake occurred between November 25th and 30th. The last spawning activity was seen in the upper reaches on December 9th. By December 17th no live spawning coho could be found in the system.

On October 9, 1975, after a heavy rainfall, a large number of upstream migrating fish (1,739 coho, 1,413 jacks, and 57 trout) were counted through the Black Creek counting

FIGURE 10

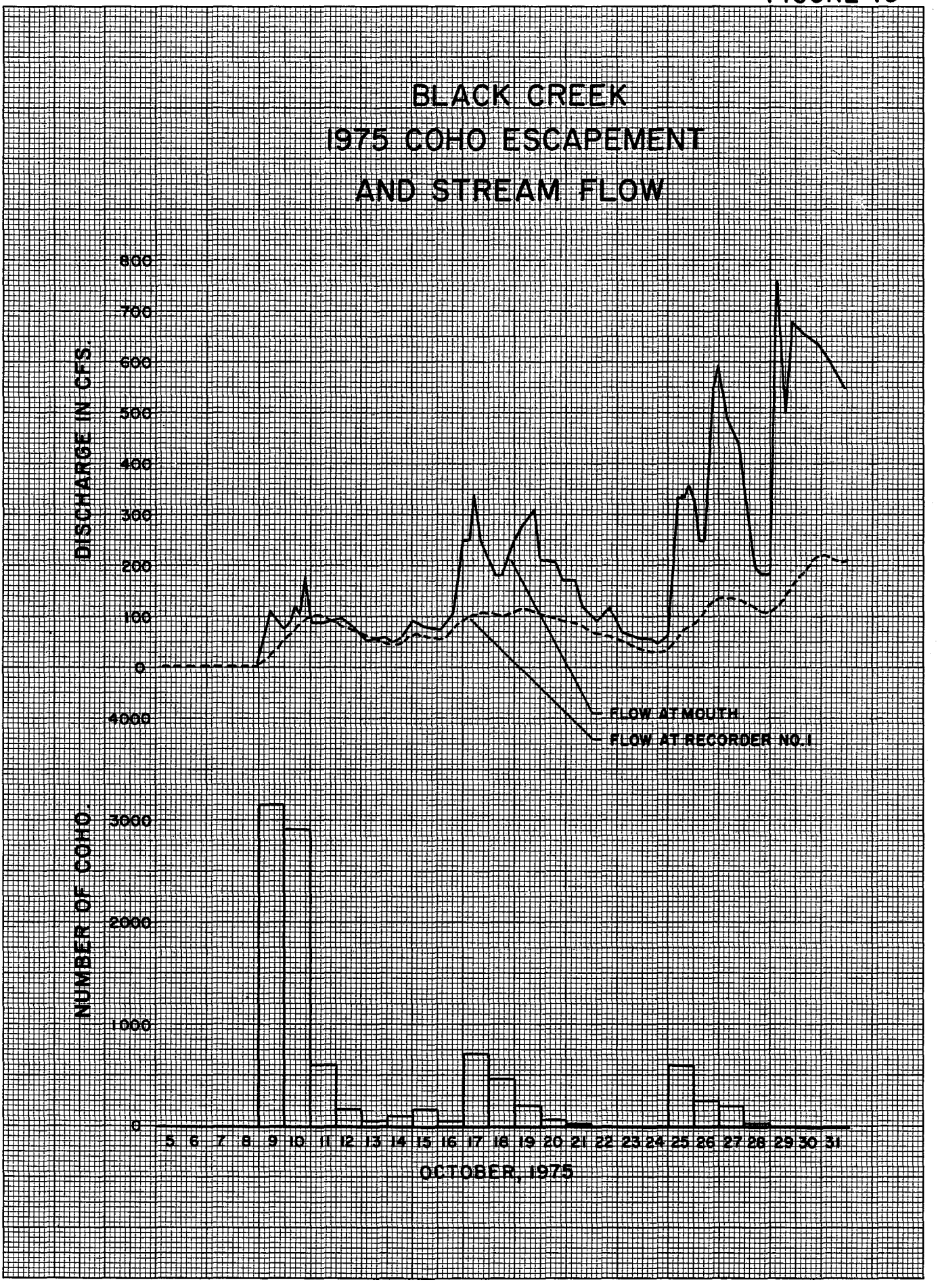

BLACK CREEK
1975 COHO ESCAPEMENT
AND STREAM FLOW
DISCHARGE IN C.F.S.
800
700
600
500
400
300
200
100
0
4000
FLOW AT MOUTH
FLOW AT RECORDER NO. 1
NUMBER OF COHO
3000
2000
1000
0
5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
OCTOBER, 1975

FIGURE 11

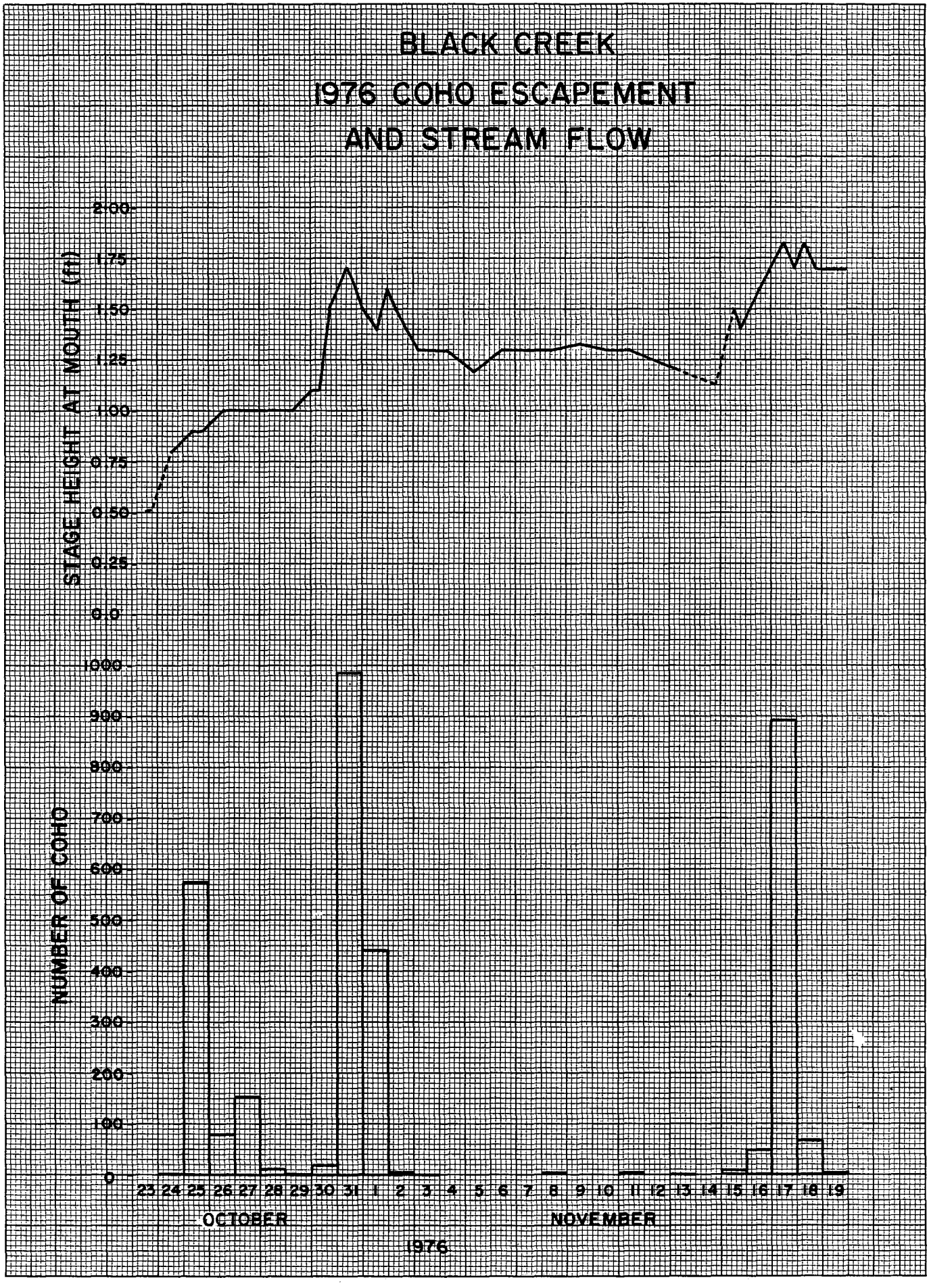
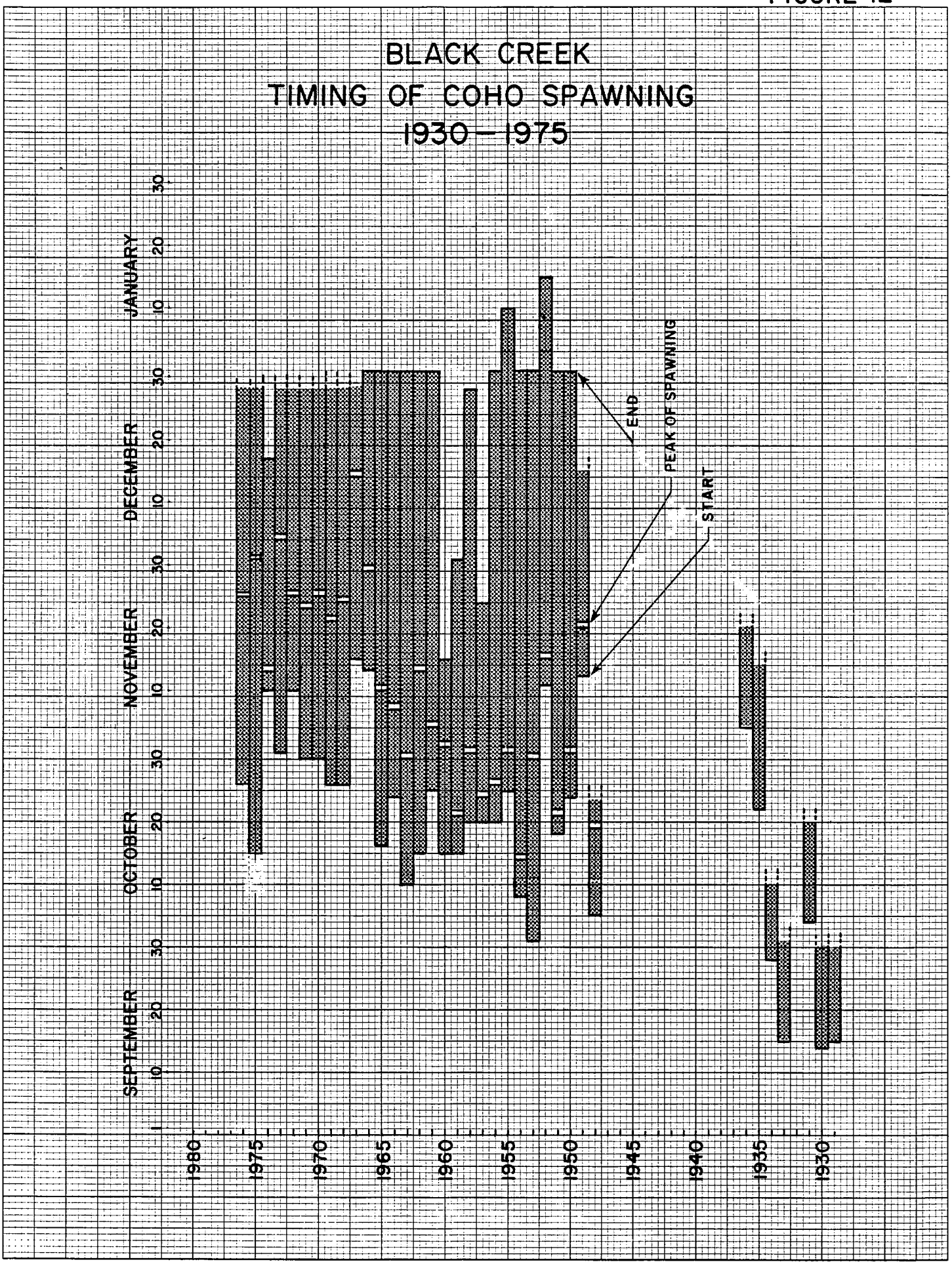

BLACK CREEK
1976 COHO ESCAPEMENT
AND STREAM FLOW
STAGE HEIGHT AT MOUTH (ft)
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.0
NUMBER OF COHO
1000
900
800
700
600
500
400
300
200
100
0
23 24 25 26 27 28 29 30 31 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
OCTOBER
NOVEMBER
1976

FIGURE 12


BLACK CREEK
TIMING OF COHO SPAWNING
1930–1975
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
1 10 20 30
1980
1975
1970
1965
1960
1955
1950
1945
1940
1935
1930
END
PEAK OF SPAWNING
START

fence. On October 10th another heavy count (2,593 coho, 322 coho jacks, and 8 trout) was made. Each days count, up to October 28th is shown in Figure 10. A total of 9,559 fish (7,539 coho, 1,953 coho jacks, and 67 trout) was counted through the fence up to October 28th.

Coho were spawning in the mainstem up to Northy Lake and in lower Millar Creek by October 18th and they were observed jumping in Northy Lake on October 31st. Peak spawning above Duncan Bay Main Road took place about November 6th. November 2nd to the 7th was the peak spawning period in Areas 3, 6, 8, 9, and 11. Mr. Westdorp,a local farmer, observed coho moving upstream towards Northy Lake on November 10th.

Figure 11 shows numbers and timing of upstream migrants for 1976. The total count was 3,510 coho and 199 trout, although some fish escaped past the fence without being counted. Coho were still being observed above Duncan Bay Main Road in Area 13 on December 31st.

Spawning Gravel Distribution

There is considerable variability in the amount of suitable substrate material in the watershed (Figure 13). The substrate was visually apparaised and rated according to the amount of "spawnable gravel" present. "Spawnable gravel" was defined as material consisting primarily of grain sizes ¼ inch to 4 inch diameter. Sieve analyses were not made; instead, gravel sizes were judged bv eye. Gravel quality was considered to be generally satisfactory because the majority of the accessible gravel beds were utilized by spawners. A 500 foot section of Drainage 66, composed of shale-like substrate, was initially thought to have poor spawning potential, but it was heavily utilized by spawning coho in 1974 and large numbers of fry were seen in the same area on May 1, 1975.

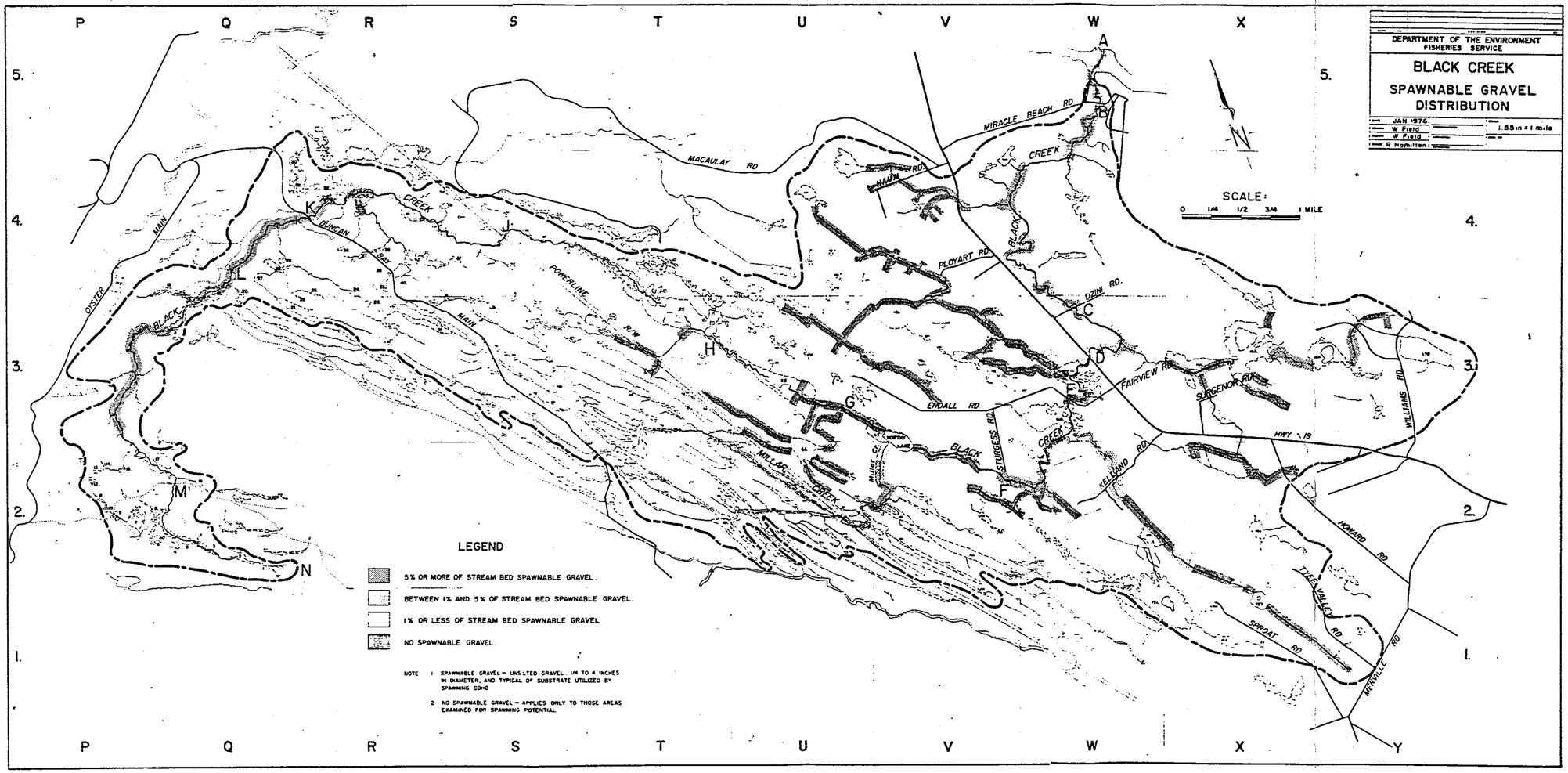
FIGURE 13

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE

BLACK CREEK
SPAWNABLE GRAVEL DISTRIBUTION

JAN 1976
W. Field
W. Field
R. Hamilton

1.55 in = 1 mile



Gravel distribution was rated as good, marginal, or poor. "Good" areas were those where over 5 percent of the streambed had spawnable gravel. "Good" areas generally had gravel bars or banks. An example is the Upper Mainstem which contained numerous gravel beds ideal for spawning. Approximately 30 percent of the bed had spawnable gravel.

"Marginal" areas had 1 percent to 5 percent spawnable gravel. The marginal sections in the Kelland Road system, with approximately 4 percent gravel, are typical.

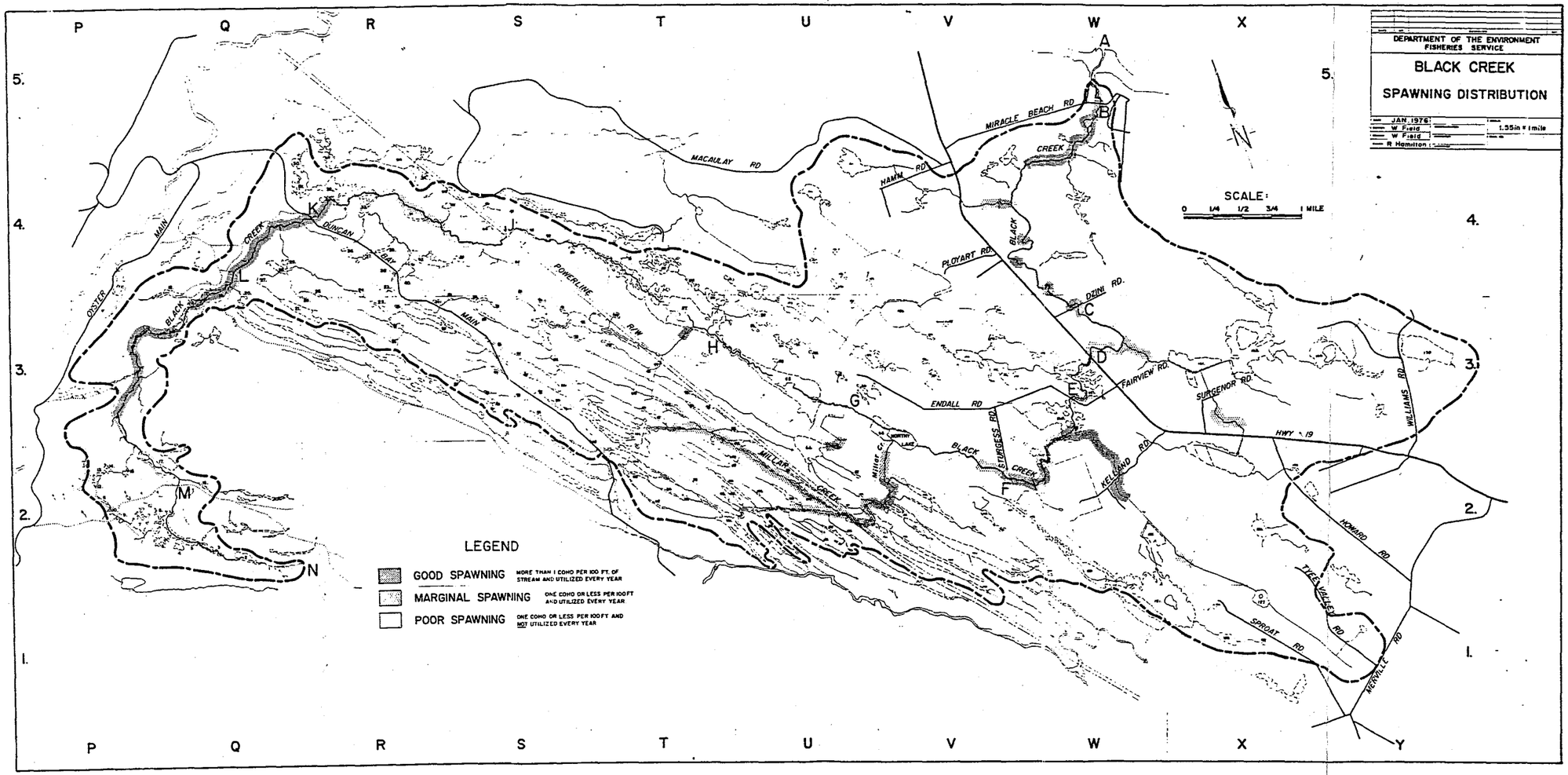
"Poor" areas had less than 1 percent spawnable gravel. Usually, the gravel was found to be in a few isolated pockets. The poor section of the Surgenor system, containing about 0.2 percent gravel, is typical of a number of small drainages and upper parts of tributaries.

Areas identified on Figure 13 as having no gravel are typically ditches, or tributaries that have been ditched. Tributaries without a rating were not examined because of inaccessibility or because they were not being utilized by spawners.

Coho Spawning Distribution

A coho spawning area (Figure 14) was rated "good" if it supported more than one spawner per 100 feet, and was utilized every year; "marginal" if it supported one coho or less per 100 feet, and utilized every year; "poor" if it supported one coho ore less per 100 feet and was not utilized every year.

FIGURE 14


DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE
BLACK CREEK
SPAWNING DISTRIBUTION
JAN. 1976
W. Field
W. Field
R. Hamilton
1.55in = 1 mile
SCALE:
0 1/4 1/2 3/4 1 MILE
N
LEGEND
GOOD SPAWNING MORE THAN 1 COHO PER 100 FT. OF STREAM AND UTILIZED EVERY YEAR
MARGINAL SPAWNING ONE COHO OR LESS PER 100FT AND UTILIZED EVERY YEAR
POOR SPAWNING ONE COHO OR LESS PER 100FT AND NOT UTILIZED EVERY YEAR
P Q R S T U V W X Y
5. 4. 3. 2. 1.
A B C D E F G H J K L M N
MACAULAY RD
MIRACLE BEACH RD
HAMM RD
CREEK
PLOVART RD
DZINI RD
FAIRVIEW RD
SURGENOR RD
WILLIAMS RD
HWY 19
ENDALL RD
BLACK CREEK
ELDRIDGE RD
KELLAND RD
HOWARD RD
TYEE VALLEY RD
SPROAT RD
KENVILLE RD
MILLAR CREEK
POWERLINE R/W
MAIN
DUNCAN BAY
OYSTER
BLACK CREEK

Over 95 percent of the spawners utilized areas rated "good"; less than 5 percent utilized marginal areas; and only a few fish were found in "poor" areas.

Approximately 38 miles of stream in the Black Creek watershed is accessible to adult coho during fall high water, but only 10 miles support spawning, of which 5½ miles were rated as "good". Mainstem Black Creek (Areas 1, 5, 13) supports 75 percent to 80 percent of the total coho spawning population (Figure 15). The tributaries above Northy Lake support 15 percent to 20 percent of the run, while those below support 4 percent to 6 percent. Approximately half the total run spawn above Northy Lake.

Areas, 2, 3, 4, 6, and 7 support only 4 percent to 6 percent of the total run although, historically, they supported a much larger proportion. Area 4, Ployart Road, with 5.7 miles of accessible stream, at one time supported a substantial run. The extensive degree of land alteration and ditching affecting 4.5 miles of stream appears to have resulted in the complete loss of spawning habitat.

The upper Mainstem (Area 13) supports high density spawning along most of its accessible length. About half of Northy Lake Mainstem (Area 5) supports high density spawning. Most of the lower mainstem supports spawning, a third of which is high density.

Obstructions to Upstream Migration

Swamp 163 on Surgenor Creek (Area 3) blocks upstream migration at the present time (Table F). There is over 2,000 feet of stream with "good" substrate above the swamp which could support an estimated 250 to 500 coho, but improvement of this system may not be practical because of the increasing pressure from land development.

FIGURE 15

BLACK CREEK
COHO SPAWNING DISTRIBUTION IN 1975

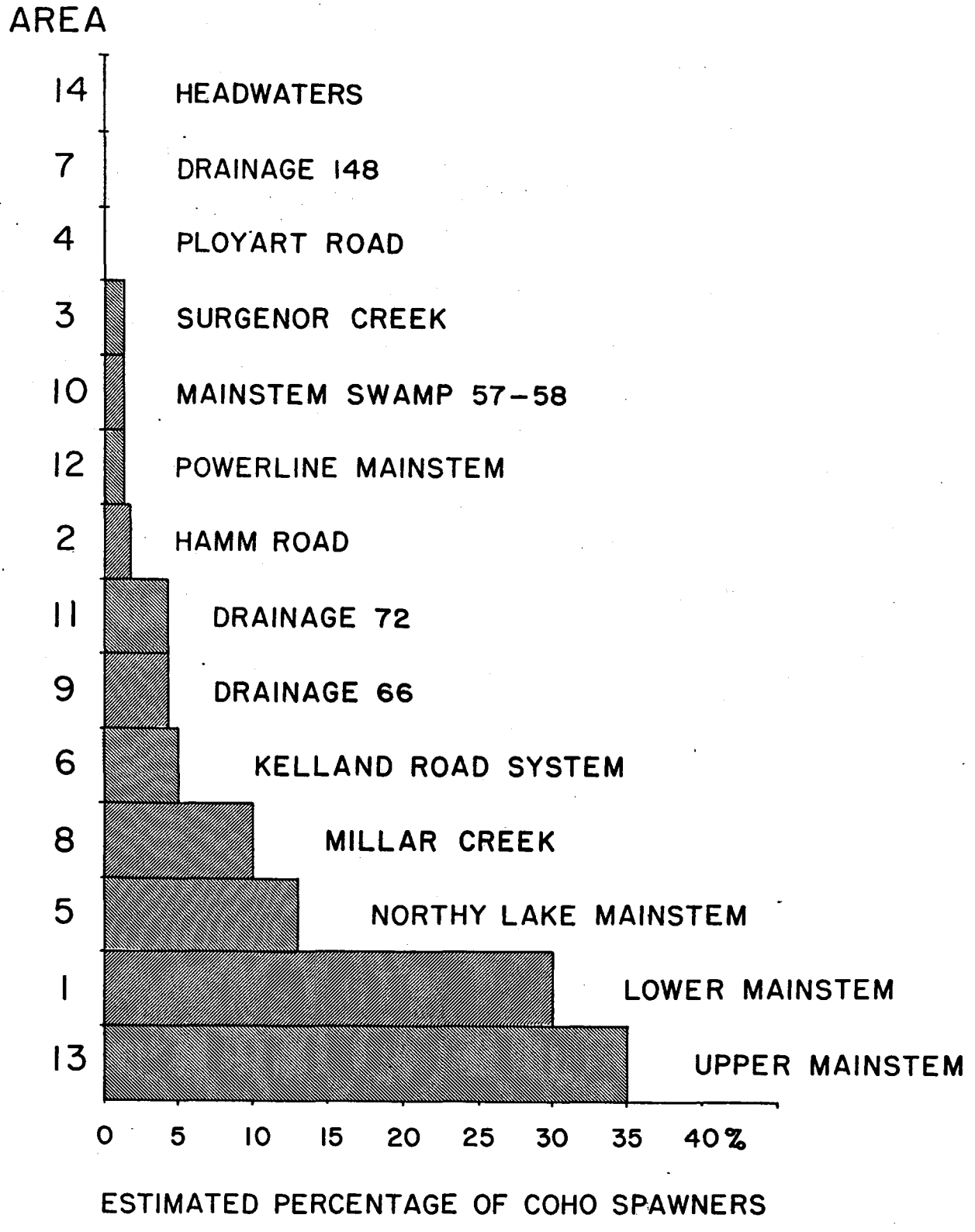


TABLE F

BLACK CREEK

MAIN OBSTRUCTIONS TO FISH MIGRATION

Area	Location	Nature of Obstruction
1	mouth drainage	Log debris from early booming activity, covers spawning beds and may have been major cause of chum salmon's decline in escapement. Log debris also traps and destroys coho which enter the mouth and are unable to leave as the tide recedes.
2	above Hy. #19	Ditch face, 4 to 5 ft. drop, creates a complete obstruction. No potential spawning areas exist above this point.
3	above Surgenor Rd.	Rock dam, partial obstruction accessible at higher flows.
3	swamp 163	Dispersed and subterranean flow, may create a complete obstruction for adults and smolts, (no spawning takes place above this point).
6	drainage 151	Dispersed and subterranean flow, creates a complete obstruction.
10	swamps 57 - 58	Numerous beaver dams, log jams, and widely dispersed flow creates a partial obstruction accessible only at high water.
13	swamp 19	Numerous inactive beaver dams produce partial obstructions accessible at high water.
14	swamp 17	A large beaver dam creates a complete obstruction, no spawning was seen above this point.

The beaver dam at the outlet of swamp 17 in Area 14 appears to be a complete obstruction to upstream migration as no coho adults or juveniles were observed above this point. Removal of the dam is not recommended as the pond above helps sustain summer flows and supports an excellent cutthroat population. It may also be a good site for development of additional, controlled storage.

Coho Rearing

Areas of good coho rearing do not correspond exactly with areas of heavy spawning, especially in the lower watershed below Northy Lake, because of the drying up of extensive reaches of the creek (Figure 5). Rearing habitat appears to be a limiting factor in coho production in this area. It is believed that survival of coho juveniles depends on the success of displacement either into the estuary or into tributaries that sustain a perennial flow. Many of them are trapped in pools where they die from desiccation, rising temperatures, predation, or other associated causes. On many occasions in the past, Fishery Officers have had to rescue coho juveniles, trapped in isolated pools, by moving them to permanent ponds or swamps (such as swamp #170).

Observation of juvenile populations in the vicinity of swamps 160 - 171 at Endall Road indicates that they are forced into this area as the mainstem dries up. Logging and land development in this sensitive area within the last few years has probably caused considerable damage to the fisheries habitat.

During the summer months there is no sustained flow in mainstem Black Creek below Northy Lake. Although this is

a natural occurrence it is aggravated by upstream irrigation diversions. The only areas in the lower watershed that maintain a sizable volume of summer water are:

1. Swamps 160 and 171 (including lower Ployart, Area 4, and lower Kelland, Area 6, drainages).
2. A few pools within the lower mainstem.
3. A few pools and a deep ditch within the Surgenor system, Area 3, below swamp 163.
4. Swamps 166 (Larkin Lake) and 170 in Area 3.
5. Swamp 157 in Area 6.

Beaver dams, ponds, and natural channels are abundant in the watershed above Northy Lake indicating that rearing habitat for coho is not a limiting factor for this part of the watershed.

LAND DEVELOPMENT

Land reclamation, ditching, logging and clearing, and urbanization, tend to cause a progressive degradation of the natural watercourse environment supporting fish life. Most development activities result in a more rapid runoff response of the watershed. Generally, peak flows are increased and recession flows are reduced. This results in an increase in erosion and incidence of flooding, coupled with reduced low flows during the dry season. Low flows and increased sediment loads resulting from erosion are particularly damaging to fish life. Operation of equipment in streams, construction of barriers and stripping of streamside vegetation are direct forms of degradation which also have severe effects on the fishery and other aquatic life. The extent of land development in the period 1968 to 1972 is shown in Figures 16 and 17, and Table G.

Some control of development is presently exercised through zoning, A.L.R. designation and tree farm licences (Figures 18 and 19), but these controls are not directly related to watershed characteristics and preservation of stream habitat so that development allowed under all these controls could result in progressive degradation of stream habitat.

Land development is discussed below under the separate subject headings of: land reclamation, ditching, logging and land clearing, and urbanization. Many developments, of course, involve more than one of these activities.

Land Reclamation

The original swamp area in the Black Creek watershed is estimated to have been approximately 3,186 acres (5 sq. miles).

FIGURE 16

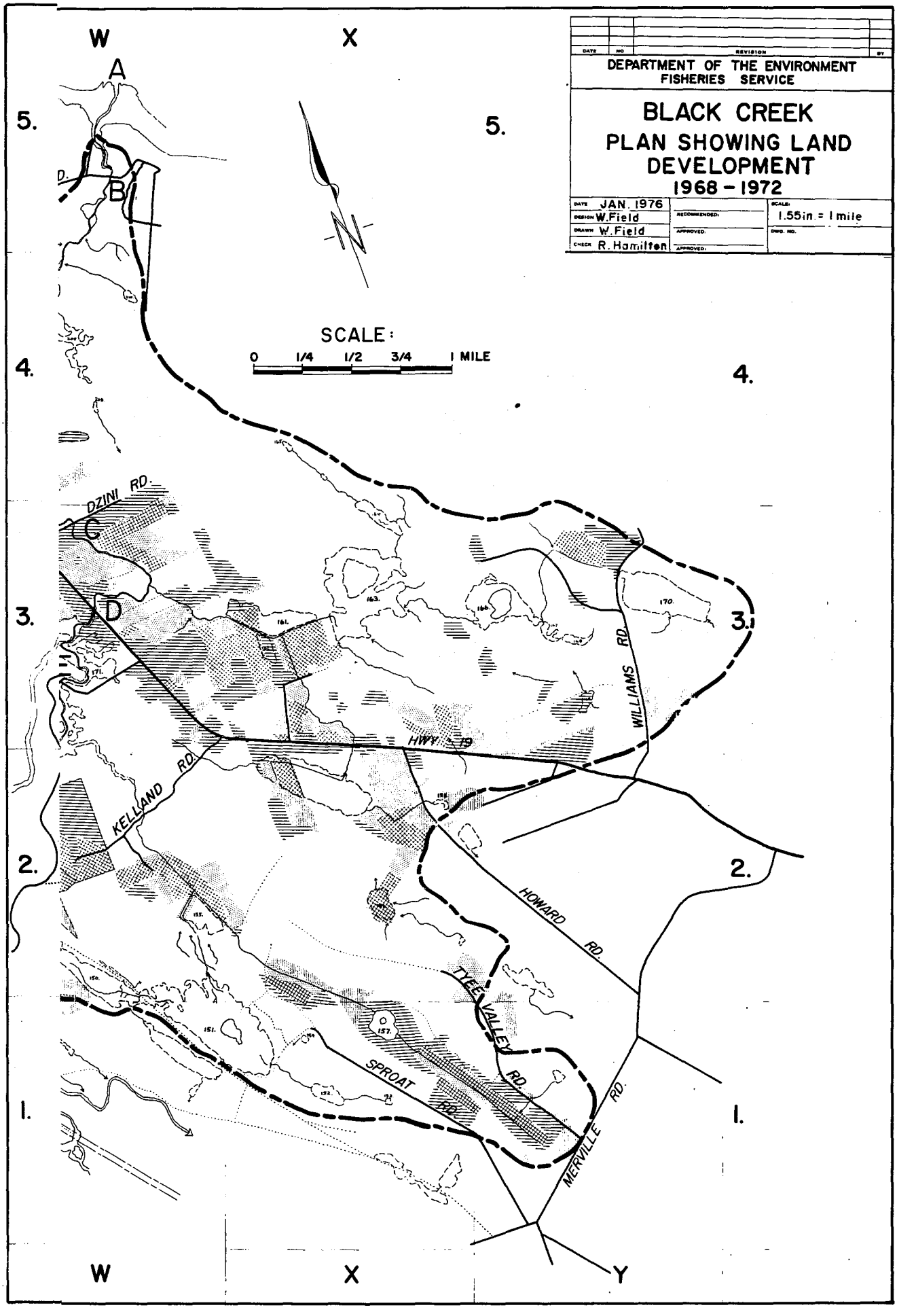
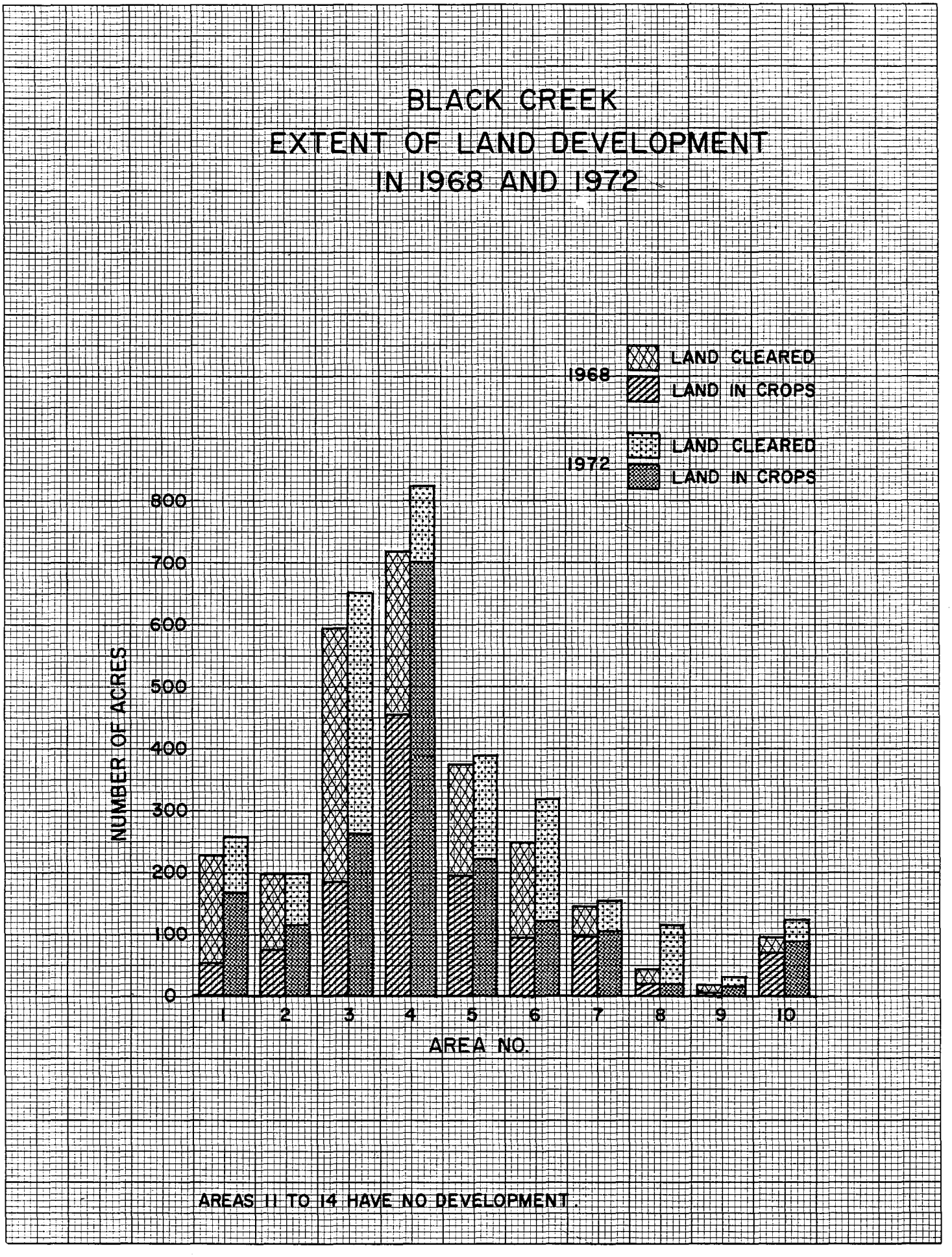

W
X
Y
A
B
C
D
5.
4.
3.
2.
1.
SCALE:
0 1/4 1/2 3/4 1 MILE
DZINI RD.
KELLAND RD.
HWY 19
WILLIAMS RD.
HOWARD RD.
TYEE VALLEY RD.
SPROAT RD.
MERVILLE RD.
DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE
BLACK CREEK
PLAN SHOWING LAND DEVELOPMENT
1968 - 1972
DATE JAN. 1976
DESIGN W. Field
DRAWN W. Field
CHECK R. Hamilton
RECOMMENDED:
APPROVED:
APPROVED:
SCALE: 1.55in. = 1 mile
DWG. NO.

FIGURE 17


BLACK CREEK
EXTENT OF LAND DEVELOPMENT
IN 1968 AND 1972
1968
LAND CLEARED
LAND IN CROPS
1972
LAND CLEARED
LAND IN CROPS
NUMBER OF ACRES
800
700
600
500
400
300
200
100
0
1
2
3
4
5
6
7
8
9
10
AREA NO.
AREAS 11 TO 14 HAVE NO DEVELOPMENT.

BLACK CREEK

WATERSHED DATA BY AREA

PART 1

TABLE G

AREA NO.	WATERSHED ACREAGE	SWAMP ACREAGE	ACREAGE CLEARED 1968	ACREAGE CLEARED 1972	ACREAGE CLEARED PERCENT INCREASE	ACREAGE IN CROPS 1968	ACREAGE IN CROPS 1972	ACREAGE IN CROPS PERCENT INCREASE	PERCENT SPAWNING SUPPORTED
1.	1446	35	230	259	13	56	167	198	30
2.	549	23	200	200	0	76	114	50	1.3
3.	3004	253	595	653	10	183	262	43	0.5
4.	2145	162	720	830	15	454	702	55	0
5.	881	112	373	393	5	192	222	16	12.5
6.	1644	175	248	321	29	94	121	29	3.8
7.	348	16	147	154	5	95	107	13	0
8.	2835	465	46	118	156	20	20	0	10
9.	396	22	20	32	60	3	16	433	3
10.	1231	292	92	126	37	60	96	60	0.3
11.	598	55	-	-	-	-	-	-	3
12.	1235	93	-	-	-	-	-	-	0.6
13.	1336	83	-	-	-	-	-	-	35
14.	686	77	-	-	-	-	-	-	0
TOTAL:	18,334	1,863	2,671	3,086		1,233	1,827		100

Percentage of watershed cleared: 1968 - 14.6 1972 - 16.8
Percentage of watershed in crop: 1968 - 6.7 1972 - 10.0

FIGURE 18

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE

BLACK CREEK
LAND MANAGEMENT ZONES

DRAWN:	DATE: JAN. 1976
CHECK: R. HAMILTON	SCALE: 1:50,000
APPROVE:	DRAWING NO.

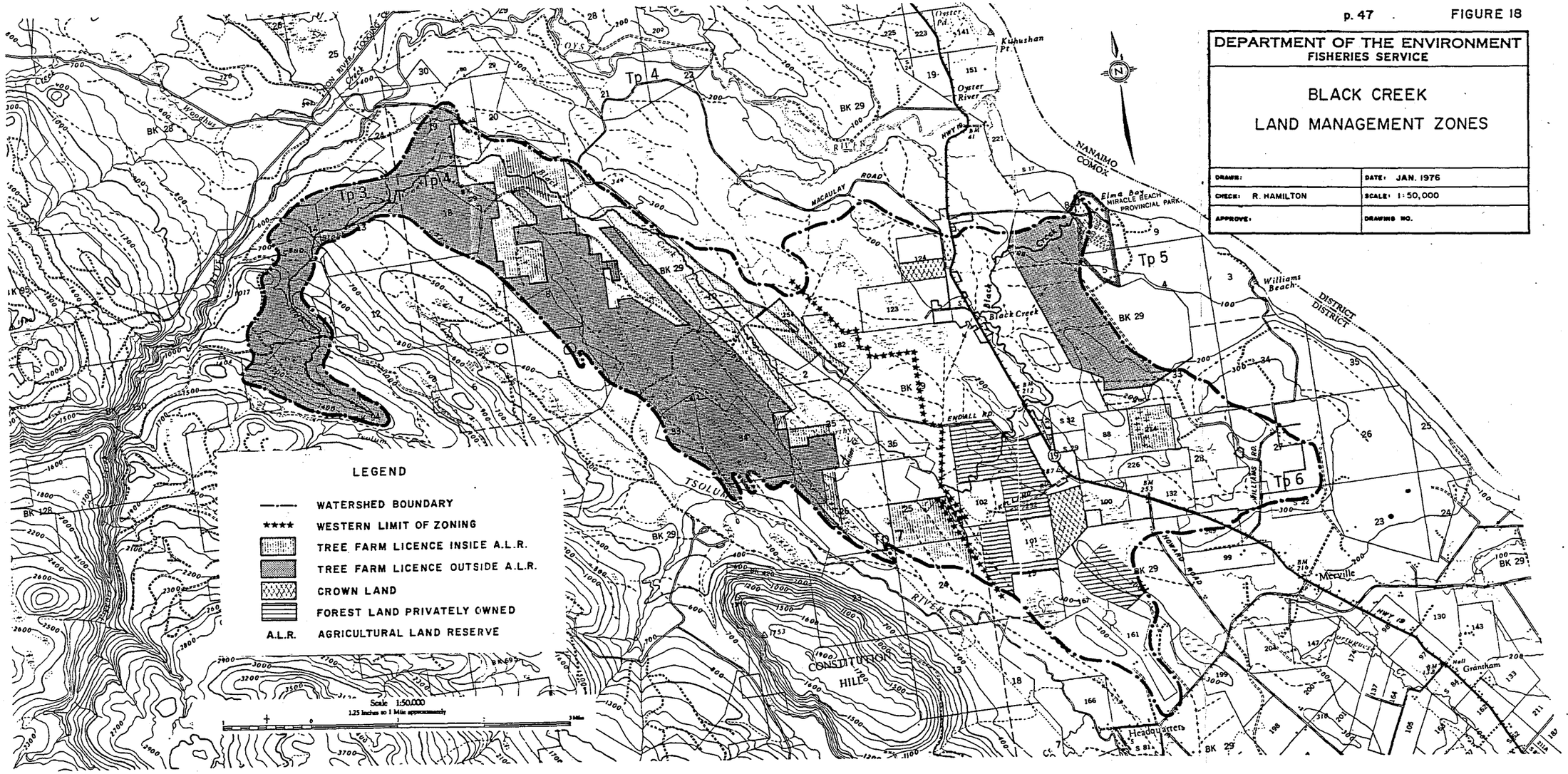
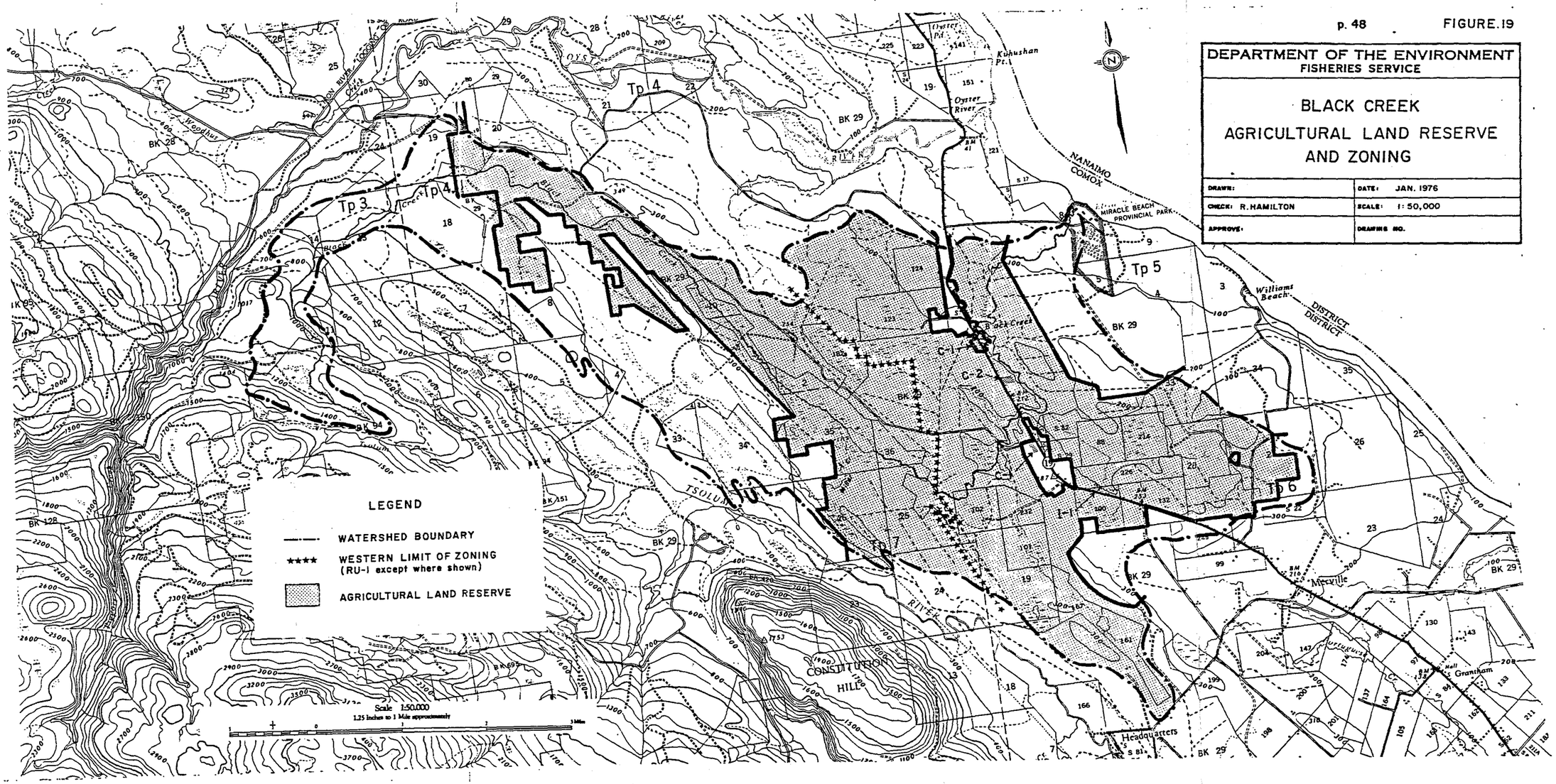


FIGURE.19

DEPARTMENT OF THE ENVIRONMENT
FISHERIES SERVICE

BLACK CREEK AGRICULTURAL LAND RESERVE AND ZONING

DRAWN:	DATE: JAN. 1976
CHECK: R. HAMILTON	SCALE: 1: 50,000
APPROVE:	DRAWING NO.



The swamp area remaining in 1975 was about 1,863 acres (2.9 sq. miles). Reclamation, then, has accounted for 1,323 acres or 42 percent of the original swamp area, up to 1975.

The main purpose of land reclmation has been for agricultural development. Most of the reclamation has been taking place in the southeastern half of the watershed for vegetable and hay crops. As yet, land fills have not become a factor; reclamation has been accomplished by land clearing, removal of stream obstructions, and ditching. Approximately 56 percent of land bordering the accessible mainstem and tributaries of lower Black Creek (from swamp 57 to mouth, including Hendrick's ditch and 1,000 feet of lower Millar Creek) has been cleared on at least one side.

Swamps act as reservoirs to delay storm runoff so that downstream flow decreases more slowly and persists for a longer period. The beaver population has played an important part in the hydrology of the watershed by building many substantial dams which have increased the total storage capacity in the system considerably. Reclamation in the lower watershed has virtually eliminated the beaver habitat in that area, but in the more remote upper watershed active beaver dams regulate the flows sufficiently to maintain small but important flows through the summer low flow period.

The nature of discharge at the mouth, higher peaks and faster recessions than the flow at recorder #1 (Figure 10), reflects the effects of ditching, swamp reclamation, and clearing in the lower watershed. As development proceeds, higher peak flows, more erosion and lower low flows, or more extended dry periods may be expected, especially along the lower mainstem of Black Creek below Highway 19.

Slaymaker and McPherson (1973) have reviewed the work of a number of investigators showing that land clearing for agricultural use inevitably results in an increase of sediment yield. Bullard (1966) reports that, on the average, 0.25 mm of sediment (3 tons per acre) reaches the major streams of the American Northwest wheat belt directly as a result of agricultural activity. Jacobsen, Olafson and Roberts (1970) in a study of soil erosion in New Brunswick showed that erosion was slight under pasture, increased when corn was grown, and was a serious problem where potatoes or other vegetables were grown. Ursic and Dendy (1965) reported a range of annual sediment yield of from 3.5 mm (.42 tons per acre) from corn-fields to less than 0.0003 mm (0.0036 tons per acre) from pine plantations.

Ditching

Approximately 70,000 feet (13.3 miles) of ditch (Table H) associated with agricultural development and land reclamation have been constructed in the lower part of the watershed.

Ditch construction usually results in the removal of streamside vegetation and the disturbance or destruction of natural gravel beds. Ditches in the Black Creek watershed are characterized by their muddy substrate. They are often constructed in existing sluggish natural channels resulting in faster runoff and a shorter runoff period. This is because:

1. Tne cross sectional area of the channel is enlarged and "improved" in shape.
2. The frictional resistance of the channel is reduced.
3. The slope of the channel is increased by straightening.

BLACK CREEK

WATERSHED DATA BY AREA
PART 2

TABLE H

AREA	TOTAL LENGTH (ft.)	CLEARED LENGTH (ft.)	DITCHED LENGTH (ft.)	ACCESSIBLE[1] LENGTH (ft.)	SPAWNABLE[2] LENGTH (ft.)	COHO IN 1974
1. Lower Mainstem:	23000	1000	-	23000	21300	2400
i) Mouth Drainage.	(600)	-	-	(400)[3]	(100)	(4)
ii) Drainage #209.	(1800)	-	-	(1500)	(1500)	(4)
2. Hamm Road.	11400	3780	3300	5280	1900	100
3. Surgenor Creek.	22100	6000	7000	12540	5280	25
4. Ployart Road.	35000	23750	23000	30000	100	-
5. Northy Lake Mainstem.	14200	6900	7250	14000	5600	1000
6. Kelland Road.	16700	10750	11100	16700	6150	300
7. Drainage from:						
i) Swamp #147.	4000	3125	2975	4000	0	0
ii) Swamp #148.	4600	4600	4600	4600	0	0
8. Millar Creek.	206000	1000	1000	24000	23000	800
9. Drainage #66.	4000	3675	3675	4000	650	250
10. Mainstem Swamp.	19450	4300	6650	19450	100	25
11. Powerline Drainage.	34000	0	0	3300	1300	250
12. Powerline Mainstem:	11700	0	0	11700	9250	50
i) Drainage Swamp #42.	(8000)	-	-	(4600)	(4600)	(4)
13. Upper Mainstem.	20100	0	0	20100	20100	2800
14. Headwaters.	24000	0	0	0	0	0
TOTALS:	450,250	67,980	70,550	192,670	94,730	8,000

1. Accessible to migrating fish.
2. Present length suitable for spawning.
3. Values in brackets refer to tributaries and are included in total for each area.

Besides affecting the hydrology, ditches tend to cause more erosion and transport greater quantities of sediment because of the higher velocities produced.

Ditches, particularly new ditches, are poor fisheries habitat for the following reasons:

1. Lack of shade, and resulting increased water temperature.
2. Unsuitable substrate, muddy or silted.
3. Lack of cover (overhanging trees, other streamside vegetation, coarse gravel and boulders in the stream).

An example of the effect of ditching is shown in Figures 14 and 16 where a short reach of stream between swamps 155 and 157 has not been developed (because of different ownership) and thus retains a natural stream still supporting spawning. Fortunately, some ditches rehabilitate in time, providing the owner is not too diligent in their maintenance. Coho may use ditches for spawning and rearing once gravel beds and streamside vegetation become re-established. Some ditches have been constructed with sudden drops or other obstructions which hinder or prevent migration.

Logging and Land Clearing

Large scale clear-cut logging of the watershed took place during the early 1900's and virtually all of the extensive stands of coastal fir, western hemlock, and cedar were removed by the late 1930's. Land clearing and settlement followed in the wake of the logging operations, particularly in the lower part of the watershed. The nature of the terrain made it especially suited to locomotive methods of logging,

and today old railroad grades can be found in all parts of the watershed. In many instances, the network of old grades has influenced the drainage pattern of storm runoff from tributaries to Black Creek. In the upper watershed they have become fire access roads and trails into reforested areas. A few are used for present day log hauling operations. In the lower populated areas of the watershed, the old grades form the basis for the local road system.

Approximately 15.4 square miles, or 52 percent of the watershed is presently covered by some form of forest land tenure (Figure 18). Crown Zellerback own and control 11.5 square miles of forest land in the upper watershed, along and mainly above the B.C. Hydro powerline, under Tree Farm Licence No. 2, dated January 24, 1949. Logging within a T.F.L. is controlled to some extent by the B.C. Forest Service. The original T.F.L. 2 permitted thinning only of timber under 100 years old, up to 1984, and after 1984 only mature timber may be logged. On March 19, 1979 Crown Zellerback revalidated their licence for 21 years, up to 1991. Most of T.F.L. 2 (8.2 square miles) is outside the A.L.R. (Figure 18).

Other Tree Farm Licences in the lower, more populated part of the watershed account for 2.4 square miles of forest land and the remainder, 1.5 square miles, is privately owned. The B.C. Forest Service has no control over logging practices on private land not included in a T.F.L.

A piece of private land lying between Kelland Road and Endall Road (Figure 18) was logged in 1975. The area of watershed affected supported 400 to 1,000 coho spawners yearly and was an excellent rearing area with a year-round water supply from "Kelland Creek". Another area immediately east of the intersection of Highway 19 and Howard Road was cleared in 1975.

Clear-cut logging and land clearing, such as the 1975 activities, have a number of adverse effects on watercourses and the fish. The removal of forest cover, destruction of undergrowth and forest litter, and disturbance of the soil results in more flashy runoff. Large amounts of soil and debris produced by logging operations are washed into the stream, spoiling the spawning beds and disrupting the aquatic organisms and insect fauna supporting rearing fish. Soil disturbance and higher peak runoff causes further soil erosion, turbidity, and siltation. Low summer flows may be affected by changed draingage patterns; and summer water temperatures, which may be very critical to rearing fish, will be increased because of loss of stream bank shading. Loss of stream bank cover also means loss of shelter from predators and loss of desirable rearing habitat. Operation of logging equipment in and across streams and road building operations may cause problems. For example, an equipment crossing over a spawning bed could destroy eggs incubating in the gravel, and a road closely paralleling the stream may contribute destructive quantities of silt and debris.

Urbanization

Urban development affects both water quality and the hydrology. Natural cover is destroyed and the soil structure disturbed during clearing and construction. Often, there is excessive erosion during development resulting in downstream siltation of spawning gravels and degradation of water quality. Removal of forest cover, and replacement with buildings, pavement and ditches or storm drains results in faster runoff. Peak flows will be higher, increasing erosion and the probability of flooding. Low flows may be further reduced. Runoff from urban areas may be very toxic, particularly during a heavy rainfall after a long dry period.

Higher population densities associated with urban development results in more human interference with the physical environment of streams, the spawning grounds and the spawning fish.

Prior to 1974, the lower Black Creek watershed was essentially a rural community with some minor building activity taking place along Highway 19. Since then, several developments have been started. An 88 acre area between Surgenor Road and the extension of Howard Road north of Highway 19 (in Area 3) has been cleared and sold in 5 acre lots. Most of the area between Kelland and Endall Roads on both sides of swamp #160 and Black Creek has been cleared. It is understood that this land will be subdivided. Landowners in Area 7 at the end of Kelland Road are contemplating building an access road to their property near swamp #145.

There has also been some recent subdivision development immediately to the north of the watershed at the end of Macauley Road. It is probable that with the high growth rate of the east side of Vancouver Island that urbanization will soon become a more serious consideration.

SUMMARY AND RECOMMENDATIONS

A large proportion of the good spawning area in the lower mainstem of Black Creek corresponds with seasonally dry areas (Figures 5 and 14) that develop by the gradual dry weather depression of the water table. This is a natural occurrence, undoubtedly aggravated by irrigation withdrawals, ditching, and swamp reclamation activities. It is not known what flows would have to be released from upstream storage to maintain a suitable spawning flow because the water table would have to be raised before surface flow in the stream becomes stabilized. Once the ground water was replenished by fall rains, storage could be used to augment natural surface flows.

As the lower mainstem goes dry in the summer months some of the juvenile fish may disperse into adjacent tributaries or the estuary but many of them become trapped in isolated pools as the surface flow diminishes. Attempts have been made over the years to save the trapped juveniles by capturing them and transporting them to more suitable habitats in the system. Again, it would be difficult to maintain suitable rearing flows through the sections of the lower mainstem that perennially dry out. Neither the storage required nor the flows that would have to be released can be readily calculated. Fortunately, certain "areas" or tributaries can be treated separately; for example, Areas 13 and 14 (Figure 1). These two contiguous areas are in an undeveloped portion of the watershed. Storage in Area 14 could be developed to provide guaranteed flows in Black Creek through Area 13 which contains important spawning and rearing habitat. A more detailed study of storage feasibility for this and the other potential sites (pp 19) is necessary to determine the

economic balance between developable storage and suitable fisheries flows. Releases from storage in the upper watershed would, of course, tend to improve conditions down through the lower mainstem.

As flows in the lower mainstem have always been critical, and are likely to remain so, it is inadvisable to allow new water diversion licences unless they are to be supported by storage. Swamps and depressions should be reserved for this purpose.

Specific recommendations arising from this general watershed study follow:

1. A study of storage potential of swamps and lakes for fisheries and agricultural uses should be undertaken. Preferably, storage for fisheries use should be in the less developed, non-agricultural upper "areas" of the watershed.

2. Suitable storage sites should be protected by zoning, land acquisition, or other means.

3. Future water licences should be term licenses or permanently cancellable (after a suitable period of notice) by the Water Comptroller. They should also contain clauses restricting diversion to specific non-critical periods of the year, if this is feasible, and providing for temporary suspension of the licence if necessary for the preservation of fish life.

4. All future water licences issued for purposes commonly served by a municipal distribution system should contain a clause to the effect that they are cancellable when such a system becomes available.

5. Low level water storage in swampy areas should be encouraged, providing suitable fish passage and downstream flows can be maintained. Water licences for storage should be for only the high runoff period.

6. A green strip reserve should be placed on all watercourses and swamps within the watershed which are significant producers of trout and salmon. This might be done by zoning or bylaw. The green strip reserve should be defined by linear boundaries, chosen during the legal survey to enclose the meander belt wherever possible and yet maximize the use of arable upland.

7. Modfifications to green strips, such as removal of tall trees shading farm lands, should be permitted. Fencing of green strips should only be necessary in those areas where concentrations of livestock could significantly damage the stream and fish habitat.

8. Zoning or rezoning for land uses associated with concentrations of people, traffic, or pollution should be located well away from important fish producing waterways.

9. Guidelines should be developed for drainage, ditching and land reclamation and a joint arrangement made by the concerned agencies to:

   a) Monitor drainage, ditching and land reclamation work.

   b) Check compliance with terms of water licences.

   c) Check operation of dams and other water control works.

   d) Read and maintain water level recorders.

   e) Monitor logging and land clearing.

   f) Monitor pollution sources.

A local resident guardian could perform these duties with consultive help from the appropriate agencies.

10. The present Sturgess Road water recorder and some of the critical lake or swamp staff gauges should continue to be maintained and read.

REFERENCES

Associated Engineering Services Ltd., "Regional Water Study, School District 71 for Regional District of Comox - Strathcona", 1975.

B.C. Water Investigations Branch. "Tsolum River Flooding, Erosion and Irrigation Investigation", April, 1968.

Bullard,W.E. 1966. "Effects of Land Use on Water Resources". J. Water Pollution Control Fed. 645-659.

Calver, G.L., "Flooding Report". B.C. Department of Agriculture, 1963.

Chow, Ven Te, "Hydrologic design of culverts". J. Hyd. Div. ASCE March, 1962 p. 39.

Jacobson, P., Olafson, E.A. and Roberts, I.A. 1970. "Erosion Control in New Brunswick". Trans. Amer. Soc. Agric. Eng., 459-461.

Slaymaker, H.O., and McPherson, H.J., "Effects of Land Use on Sediment Production". In: Fluvial Processes and Sedimentation, Proc. of Hydrology Sym. U. of A. May 8 and 9, 1973. pp. 159-183.

Ursic, S.J. and Dendy, F.E. 1965. "Sediment Yields from Small Watersheds under Various Land Uses and Forest Covers". U.S. Department Agric., Misc. Pub. 970, 47-52.

Van Ryswyk, A.L., and Bawtree, A.H. 1971. "Management and improvement of meadows on organic soils of interior B.C.". B.C. Dept. of Agriculture.

APPENDIX A

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1969
C.F.S.

Day	Jan	Feb	Mar	Apr	May		Jun	Jul	Aug	Sept	Oct	Nov	Dec
1							15	5.5	0	0.2	25	55	46
2							25	5.5	0	0.4	32	49	42
3							23	7	0	0.4	28	44.5	48.5
4							17	8	0	0.3	24.5	60.5	69
5							11	8	0	0.1	20.5	110	70
6							9.5	7.5	0	0	18.5	181	64
7							8.5	6.5	0	0	21.5	366	57
8							8	5.5	0	0	56	496	67
9							6.5	4.5	0	0	63	351	74
10							6	4	0	0	58	203	90
11							5	3.5	0	0	48.5	136	232
12							4.5	4	0	0	40	105	540
13							4	4	0	0	34.5	84	466
14							3.5	3	0	0	29	67	432
15							2.8	3	0	0	24	57	318
16							2.2	2.5	0	0	21	50	192
17							1.6	2.2	0	1.3	19	45	149
18							1.2	2	0	1.4	17	43	172
19							0.7	1.4	0	1.2	16.5	52	191
20							0.5	0.9	0	2.8	20	86	169
21							0.3	0.7	0	6.5	44.5	106	199
22							0.2	0.5	0	13.5	54	104	318
23							0.2	0.3	0	36.5	50	127	598
24							0.5	0.1	0	40	44.5	138	450
25							0.5	0	0	50	40	123	274
26							1.5	0	0	46	35	102	162
27							2.7	0	0	38	44	82	122
28						8	4	0	0.8	32	58	67	100
29						12	5.5	0	0.6	25	61	58	88
30						16	5.5	0	0.6	23	62	51	79
31						17		0	0.5		60		71
						M	176.4	90.1	2.5	318.6	1169.5	3599	5949.5

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1970
C.F.S.

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	64	82	34.5	21.5	19.5	11.5	0.2	0.6	0	0	30	42
2	58	76.5	32	19.5	18.5	11	0.2	0.4	0	0	25	44
3	54	101	29	18.5	17	9	0.1	0.4	0	0	22.5	43
4	50	104	27	17.5	14	8	0.1	0.4	0	0	20	73
5	48	95	25	20	13	7	0	0.3	0	0	19	42
6	45	90	29	24	12	6	0	0.3	0	0	20	43
7	44	89	52.5	25	11.5	5.5	0	0.3	0	0	27	71
8	43	86	54	30	13	5.5	0	0.3	0	0	53	123
9	56.5	73	47	74	16	5	0	0.3	0	0	99	192
10	54	69	41	95	16	4.5	0	0.3	0	0	125	208
11	48.5	62	37	79	15	4.5	0	0.2	0	0.1	252	240
12	44.5	56.5	71.5	65.5	14	4.5	0	0.2	0	0	334	459
13	42.5	51	175	53	14	4	0	0.1	0	0	229	297
14	44	48	224	44.5	13	3	0	0	0	0	156	237
15	42.5	60	218	38	12.5	2.5	0	0	0	0	149	368
16	39	115	175	34	12	2	0	0	0	0.1	112	525
17	33.5	186	130	30.5	11.5	1.4	0	0	0	0.2	106	502
18	30	177	99.5	28	11	0.9	0	0	0	1.5	101	366
19	52	141	78	27	10	0.5	0	0	0	2.9	90	234
20	104	132	64	27	9	0.3	0	0	0	7.5	78	172
21	129	87	54	27	9	0.2	0	0	0	20	66	136
22	163	71.5	47	26.5	9	0.1	0	0	0	54	54	110
23	220	62	43	25	11	0	0	0	0	123	45	90
24	217	56	39.5	26	11	0	0	0	0	168	41	74
25	165	49	34.5	25	10	0	0	0	0	141	51	65.5
26	130	44.5	33.5	23.5	9.5	0.1	0	0	0	104	54	66
27	108	41	29.5	22	9	0.4	0	0	0	78	50	86
28	89	37	27.5	20	9	0.2	0.2	0	0	60.5	49	163
29	75		26	19.5	10.5	0.2	2.3	0	0	47	47	247
30	65		23.5	19.5	12.5	0.1	1.1	0	0	39	44	230
31	76		22		13		0.8	0	0	34.5		194
Total	2434	2342	2023	1005.5	386	97.9	5.0	4.1	0	881.3	2548.5	5742.5

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1971
C.F.S.

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	149	275	62	131	56.5	10.5	20.5	1	0	0.5	30.5	132
2	116	198	60	115	59	10	17.5	0.9	0	0.5	29.5	136
3	91	154	60	100	54	9.5	15.5	0.9	0	0.5	39.5	145
4	74	130	58	88	49	9.5	14	0.8	0	0.6	42.5	138
5	65.5	107	56	78	47	9.5	13.5	0.7	0	0.6	38.5	138
6	60.5	86	68	74	44.5	9.5	13	0.7	0.1	0.6	37	127
7	60	75	185	72	41	12	12.5	0.5	0.3	0.5	35	106
8	65.5	65.5	310	109	36.5	17.5	12	0.4	0.4	1	101	93
9	79	61	303	201	33.5	22	12	0.3	0.5	1.9	483	86
10	91	76.5	348	210	30.5	26.5	13.5	0.2	0.7	2.1	720	79
11	87	91	380	169	29	27.5	16	0.1	1	2.1	515	69
12	77	106	519	134	26.5	26	23	0	0.8	2.1	311	69
13	69	127	486	108	24.5	23	23.5	0	0.7	2.1	201	65.5
14	62	178	354	93	23.5	21	21	0	0.7	2.1	191	62
15	60.5	264	314	82	24	19.5	17	0	0.6	2.1	176	59
16	103	218	237	75	37	18	15	0	0.6	2	141	56.5
17	140	163	163	68	48	16.5	13.5	0	0.5	2	115	59
18	201	132	127	62	46	15	12	0	0.5	2.5	93	60.5
19	273	117	105	58	43	13.5	10	0	0.4	9.5	97	61
20	251	103	88	57	39.5	12.5	9	0	0.4	19.5	113	60
21	181	92	76	58	34	12.5	8	0	0.3	26	121	58
22	135	91	72	61	29.5	12.5	7.5	0	0.3	53	112	57
23	110	91	101	69	26.5	12.5	7	0	0.2	73	113	56.5
24	97	92	125	69	22.5	15.5	6.5	0	0.2	69	176	56
25	85.5	90	122	61	20	34.5	5.5	0	0.1	59	198	53
26	79	84	108	60.5	19	42.5	5	0	0.1	50	268	51
27	85.5	78	96	64	18	40	4.5	0	0.1	42	278	48
28	92	71.5	101	68	16	34	3.5	0	0.1	35	237	47
29	111		126	69	14	30	2	0	0.4	31	217	45
30	201		152	61	12	23.5	1.5	0	0.5	30.5	170	45
31	320		147		12		1	0		30.5		48.5
Total	3672	3416.5	5509	2724.5	1016	586.5	356	6.5	10.5	553.8	5399.5	2366.5

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1972
C.F.S.

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	53	44	158	77	M	11.5	9.5	0.6	0	6	2.8	26.5
2	55	39.5	142	M	M	11	8.5	0.5	0	6.5	3	23.5
3	53	36.5	123	M	M	10.5	8.5	0.4	0	8	4	19.5
4	53	34.5	109	M	M	9.5	7.5	0.3	0	7.5	6.5	15.5
5	52	34.5	118	M	M	9	7	0.2	0	7	8.5	13.5
6	51	38	141	M	M	7.5	6.5	0	0	6	26	11.5
7	51	54	146	M	M	7	5.5	0	0	6	73	9.5
8	51	72	132	M	M	6	5.5	0	0	6.5	122	8
9	52	76.5	130	M	M	6	5.5	0	0	6.5	154	7.5
10	52	76	205	M	M	7	5.5	0	0	6.5	228	6.5
11	52	75	298	M	M	19	7	0	0	6	M	6
12	50	85	392	M	34.5	31	8.5	0	0	6	M	6
13	47	114	486	M	34.5	33	10	0	0	6	M	6
14	45	124	402	M	33.5	29	10.5	0	0	6	M	5.5
15	48	129	328	M	32	26	10.5	0	0	6	M	6
16	61	162	296	M	32	24	10	0.1	0	6	M	20
17	70	196	269	M	33	22.5	9	0.4	0	6	M	99
18	68	210	278	M	31	21.5	8	0.3	0	6	M	196
19	66	216	269	M	29.5	19.5	7	0.3	0	5.5	M	400
20	69	284	226	M	27	18	5.5	0.2	1.7	5.5	M	350
21	79	304	182	M	25	16	5	0.2	3.5	6	M	221
22	79	269	180	M	24.5	15	3.5	0.1	2.5	6.5	M	143
23	77	236	179	M	23	15	3	0.1	2.4	M	M	119
24	81	198	191	M	21	14	2.4	0	2.2	M	M	101
25	64	162	211	M	19.5	13.5	1.9	0	2.2	M	M	137
26	57	142	182	M	17.5	13	1.7	0	2.1	M	M	174
27	52.5	137	150	M	15.5	12	1.5	0	2	M	M	179
28	49	156	126	M	14.5	11.5	1.3	0	3	M	M	148
29	47	168	108	M	14	11	1.1	0	4	M	M	108
30	45		95	M	13.5	10	0.9	0	5.5	M		96
31	45		85		12		0.7	0		M		90
Total	1774.5	3872.5	6337.0	-	(487)	459.5	178.5	3.7	31.1	(138)	-	2752

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1973
C.F.S.

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	M	143	84	19.5	4	7	2.2	0	0	0	32	107
2	M	204	86	22	4	6	1.9	0	0	0	24.5	116
3	M	172	85.5	24.5	4	5.5	1.6	0	0	0	19.5	240
4	M	117	101	26.5	4.5	4.5	1.5	0	0	0	17	262
5	M	87	97	22.5	5.5	4.5	1.1	0	0	0	15	165
6	M	66	87	19.5	5	4	1.1	0	0	0	14	226
7	M	50	75	17	4.5	3.5	1.3	0	0	0	15	296
8	M	40	63	15.5	5	3.5	1.3	0	0	0	15.5	212
9	M	33.5	51	14	5	4	1.5	0	0	0	15.5	130
10	M	30	47	13.5	5	4	1.7	0	0	0	18.5	95
11	M	27	40	12	5	4	1.4	0	0	0	77	128
12	M	24	35	11.5	4	5	1.2	0	0	0	180	262
13	M	21.5	31	10.5	3.5	6	1.2	0	0	0	179	384
14	M	20.5	27	9	3	6	1.1	0	0	0	131	324
15	M	21	28	8.5	2.7	6	0.9	0	0	0	109	308
16	M	22	73	8	2.3	6	0.7	0	0	0	147	478
17	M	22.5	93	8	2	6	0.6	0	0	0	156	378
18	M	21.5	129	7.5	1.8	6	0.5	0	0	0	118	198
19	M	20.5	262	7.5	1.8	5.5	0.4	0	0	1.2	82	114
20	M	19	218	7	1.8	5	0.3	0	0	6	73	180
21	M	18	138	6.5	1.9	4.5	0.2	0	0	12	97	295
22	M	17	94	6.5	2.1	4	0.3	0	0	12	100	237
23	M	15.5	71	6	8.5	3.5	0.2	0	0	10	81	150
24	M	15.5	55	5.5	52.5	3	0.1	0	0	17	67	129
25	M	15.5	43	5	59	3.5	0.1	0	0	26.5	60.5	127
26	M	28	35	5.5	42.5	3.5	0.1	0	0	25	56	102
27	M	57	29	5.5	28	3.5	0.3	0	0	30.5	79	79
28	M	71	24	5	19.5	3	0.2	0	0	55	112	65
29	M		21	4.5	15.5	2.8	0.1	0	0	60.5	115	56.5
30	124		19.5	4	11.5	2.4	0.1	0	0	51	107	46
31	129		19.5		9		0	0	0	42		38
Total	-	1399.5	2261.5	338	324.4	135.7	25.2	0	0	348.7	2313	5727.5

BLACK CREEK
SURFACE FLOW AT RECORDER #1
1974
C.F.S.

Day	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
1	29.5	57	235	132	10.5	2.5	0	0.8	0	0	0	42
2	23	61	195	122	10	2.5	0	0.8	0	0	0	63
3	19	74	120	102	9	2.5	0	0.7	0	0	0	101
4	16	83	86	81	8.5	2.5	0	0.6	0	0	0	140
5	14	80	72	109	8	2.5	0	0.5	0	0	0	122
6	12	71	55	185	7.5	2.5	0	0.3	0	0	0	105
7	10.5	55	52	168	7.5	2.4	0	0.2	0	0	0	101
8	9.5	48	36	126	7	2.3	0	0.1	0	0	0.3	89
9	8.5	42.5	53	95	6.5	2.2	0	0	0	0	2.5	81
10	8.2	39	212	74	5.8	2.1	0	0	0	0	5	84
11	8	36	222	71	6	2	0	0	0	0	12.5	113
12	8	38	162	56	6.5	1.8	0	0	0	0	37	119
13	8	90	127	44	6	1.6	0	0	0	0	36	141
14	42	204	101	35	6.5	1.4	0	0	0	0	28	142
15	179	203	100	31	8	1.4	0	0	0	0	21	127
16	304	214	140	27	7.5	1.2	0	0	0	0	16	142
17	208	186	153	23	6.5	1.1	2.5	0	0	0	24	195
18	159	179	122	22	5.8	0.9	4	0	0	0	42	211
19	201	142	90	19	5	0.8	4	0	0	0	47	179
20	154	103	74	17	4.5	0.6	3.5	0	0	0	56	130
21	104	130	53	16	4	0.5	3	0	0	0	67	113
22	80	140	43	16	4	0.4	2.8	0	0	0	70	92
23	83	121	36	15	4	0.1	2.4	0	0	0	77	74
24	120	210	32	14	4.5	0	2.1	0	0	0	205	61
25	136	268	30	13	5.5	0	1.8	0	0	0	407	61
26	115	200	97	17.5	5.8	0	1.6	0	0	0	284	69
27	99	124	296	18.5	5.5	0	1.4	0	0	0	150	71
28	83	152	318	17	4.5	0	1.3	0	0	0	92	60
29	71		245	14	4	0	1.2	0	0	0	65	53
30	57		204	12.5	3.5	0	1	0	0	0	49	49
31	48		144		3		1	0		0		43
	2417.2	3350.5	3905	1692.5	190.9	37.8	33.6	4.0	0	0	1793.3	3173

BLACK CREEK
SURFACE FLOW AT RECORDER #2
1969
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1						2	0.6	0.5	0.6	M	M	M
2						1.8	0.9	0.5	0.6			
3						1.6	1.1	0.5	0.6			
4						1.4	1	0.6	0.6			
5						1.3	0.8	0.5	0.6			
6						1.2	0.7	0.5	0.5			
7						1	0.6	0.5	0.6			
8						1	0.6	0.5	M			
9						1	0.6	0.4	M			
10						1	0.6	0.4	M			
11						1	0.6	0.5	M			
12						1	0.6	0.5	M			
13						0.8	0.6	0.4	M			
14						0.8	0.6	0.4	M			
15						1	0.6	0.4	M			
16						0.9	0.6	0.4	M			
17						0.7	0.6	0.5	M			
18						0.9	0.5	0.5	M			
19						0.9	0.6	0.5	M			
20						0.6	0.6	0.4	M			
21						0.6	0.6	0.4	M			
22						0.7	0.5	0.4	M			
23						0.9	0.5	0.4	M			
24						0.8	0.4	0.4	M			
25						0.9	0.5	0.4	M			
26						0.9	0.5	0.5	M			
27						0.7	0.5	0.7	M			
28						0.7	0.4	0.7	M			
29					3.8	0.7	0.4	0.6	M			
30					2.8	0.6	0.4	0.6	M			
31					2.2		0.5	0.6	M			
TOTAL						29.4	18.6	15.1				

BLACK CREEK
SURFACE FLOW AT RECORDER #2
1972
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	M	M	M	M	5	0.6	1	0.6	1	4	1	10
2					7	0.6	1	0.6	1	3.6	0.9	8
3					6.5	0.6	0.9	0.5	1	0.5	1.3	6.5
4					6	0.5	0.9	0.5	1	0.4	3.6	5.5
5					5	0.4	0.8	0.5	1.5	0.4	4	5
6					4.5	0.4	0.7	0.4	1.7	0.4	20.5	4.5
7					4	0.5	0.6	0.4	1.7	0.4	50	4
8					3.7	0.5	0.6	0.6	2.5	0.4	59	3.5
9					3.1	0.5	0.6	0.6	2.3	0.4	76	3
10					2.9	0.9	0.7	0.6	2	0.3	128	3
11					2.8	2.6	1	0.7	1.9	0.4	58	3
12					2.6	3.2	1.7	0.7	1.9	0.4	30	2.5
13					2.4	2.8	1.6	0.6	1.9	0.4	18.5	3
14					2.3	2.5	1.4	0.7	1.9	0.4	13	2.5
15					2.2	2.3	1.3	0.8	1.8	0.3	10.5	8
16					2.3	2.4	1	1.3	1.8	0.4	8	50
17					2.1	2.3	0.9	1.1	1.8	0.4	7	54
18					1.9	2.1	0.8	1	2.2	0.4	6	181
19					1.7	1.8	0.6	1	2.3	0.4	6	218
20					1.6	1.6	0.6	0.9	3.6	0.4	5.5	68
21					1.5	1.3	0.5	1.1	4	0.5	5	43
22					1.5	1.5	0.5	1.2	3.9	0.5	5	31
23					1.4	1.5	0.5	1.2	3.9	0.6	8	29.5
24					1.3	1.4	0.6	1.1	3.8	0.6	8	27
25					1.2	1.5	0.6	1	3.6	0.6	9	62
26					1	1.4	0.6	1	3.6	0.6	9	56
27				4.5	1	1.3	0.6	1	3.5	0.6	8.5	51
28				5	0.9	1.3	0.6	1	3.8	0.7	11	35
29				5.5	0.7	1.3	0.5	1	3.8	0.6	11	27
30				5	0.6	1.2	0.6	1	3.9	0.6	10.5	27
31					0.7		0.6	1		0.6		27
TOTAL					81.4	42.8	24.9	25.7	74.6	21.2	591.8	1058.5

BLACK CREEK
SURFACE FLOW AT RECORDER #2
1973
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	31	55	25	4.5	1.4	3.4	1.1	0.4	0.3	0.3	11	33
2	39	79	21.5	6	1.3	2.9	1	0.4	0.3	0.3	9.5	39
3	27	48	24	6.5	1.9	2.6	0.9	0.3	0.3	0.3	8	163
4	20	29.5	25	7	2	2.3	0.9	0.4	0.2	0.3	8	68
5	14	20	24	6.5	2	2.1	0.7	0.4	0.3	0.4	7	48
6	11.5	14.5	21	6	1.8	2.2	0.9	0.2	0.3	0.4	6.5	130
7	10	11	16.5	5	1.8	2.2	1.3	0.3	0.2	0.4	7.5	130
8	11	10	14.5	5	2.2	2.2	1.2	0.2	0.2	0.6	7	55
9	7.5	9.5	12.5	5	2.2	2	1	0.2	0.2	0.7	7	33
10	5	8	M	4.5	2.1	2.2	1	0.2	0.1	0.7	10.5	27
11	5.5	7		4	1.9	2.2	0.8	0.2	0.1	0.7	52	55
12	10	6.5		3.9	1.8	3.9	0.7	0.2	0.1	0.8	63	148
13	16.5	6		3.8	1.6	4	0.6	0.2	0.1	0.7	42	187
14	66	6		3.5	1.5	3.9	0.5	0.1	0.1	0.7	29	79
15	233	5.5		3.3	1.3	3.5	0.5	0.1	0	0.6	29.5	160
16	250	6		3.1	1.3	3.5	0.5	0.4	0	0.6	54	309
17	95	6		2.9	1.2	3.4	0.4	0.5	0.1	0.6	43	85
18	47	5		2.8	1.1	3.1	0.3	0.5	0.1	0.9	29	39
19	44	5		2.4	1	2.6	0.3	0.4	0.2	1.8	20	24.5
20	181	4.5		2.2	1.1	2.3	0.3	0.3	0.6	4.5	21.5	95
21	178	4.5		2.2	1	2.2	0.3	0.3	0.5	7	29.5	148
22	85	4		2.2	1	1.9	0.7	0.3	0.4	6	24.5	66
23	115	3.9		2.1	6	1.6	0.9	0.3	0.4	5	21.5	39
24	122	3.8		2	27	2.4	0.7	0.3	0.3	11	18	39
25	71	4		1.9	18.5	3.4	0.8	0.2	0.3	15.5	17	39
26	41	10		1.8	13	2.6	0.7	0.3	0.3	11.5	16	30
27	27	14		1.7	10	2.1	0.6	0.3	0.3	14	24	22
28	21	16		1.6	7	1.6	0.5	0.3	0.3	31	33	17
29	26			1.5	6	1.3	0.5	0.3	0.2	22.5	32	14
30	41			1.4	5	1.2	0.4	0.3	0.3	16.5	30	11.5
31	40				4		0.4	0.4		14		10.5
TOTAL	1891	402.2		106.3	131	76.8	21.4	9.2	7.1	170.3	710.5	2343.5

BLACK CREEK
SURFALCE FLOW AT RECORDER #2
1974
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	9	15.5	113	35	3.5	1.4	0.2	0.2	0	0.2	0.1	11
2	8	16	52	29	3.1	1.3	0.1	0.2	0	0.1	0.1	13
3	6	20	29	21	2.9	1.4	0.2	0.2	0	0.1	0.1	32
4	5	24.5	21.5	16.5	2.4	1.6	0.1	0.2	0	0.1	0.2	44
5	4	21.5	16.5	38	2.4	1.5	0.1	0.1	0	0	0.5	M
6	3.8	19	13	71	2.5	1.3	0.1	0.1	0	0	0.8	M
7	3.1	15.5	11.5	46	2.3	1.3	0.1	0.1	0	0	0.7	M
8	2.9	14	10	31	2.2	1.2	0.1	0.1	0.1	0	1.5	M
9	2.4	12.5	21	21	2.2	1.1	0.2	0.1	0.2	0	1.8	M
10	2.3	11.5	10.5	16.5	2.4	1	0.3	0.1	0.1	0.1	1.6	M
11	2.3	11.5	62	15.5	2.5	0.9	0.6	0.1	0	0.1	5	M
12	2.3	12	48	11.5	2.3	0.7	0.5	0.1	0	0.1	18	M
13	4.5	52	36	10.5	3.8	0.7	0.3	0	0	0.1	13	M
14	22	118	27	9.5	3.9	0.6	0.2	0	0	0.1	9.5	M
15	181	71	32	8.5	3.9	0.6	0.2	0	0	0	7	M
16	102	82	46	7.5	3.3	0.6	0.6	0	0	0	5.5	M
17	49	56	45	6.5	2.8	0.5	1.3	0	0	0	10.5	M
18	98	62	29	6	2.3	0.3	1.2	0	0	0	19	M
19	75	45	20	5.5	2	0.3	1.2	0	0	0.1	18	M
20	40	34	14.5	5	2	0.2	1	0	0	0.2	21	M
21	24.5	51	11.5	5	1.8	0.3	0.8	0	0	0.1	21.5	M
22	20	48	10.5	5	1.8	0.2	0.7	0	0	0	22	M
23	24	49	9	5	2	0.2	0.7	0	0	0	26	M
24	36	144	8	4.5	2.4	0.2	0.6	0	0	0	169	M
25	41	120	8	4.5	3.4	0.2	0.6	0	0	0	264	M
26	30	51	29	6	2.8	0.2	0.6	0	0	0	63	M
27	24	36	172	5	2.3	0.2	0.6	0	0	0.4	33	M
28	21	79	102	4.5	2	0.2	0.5	0	0	0.2	20	M
29	17		64	4	1.7	0.2	0.5	0	0	0.1	14	M
30	14		66	4	1.6	0.2	0.3	0	0	0.1	11.5	M
31	14.5		38		1.5		0.3	0		0.1		M
TOTAL	888.6	1291.5	1175.5	458.5	78.0	20.6	14.8	1.6	0.4	2.3	777.9	

BLACK CREEK
SURFACE FLOW AT RECORDER #2
1975
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	14	10	76	12	2.3	1.3	0.9	0.1	0.7	0.2		
2	16.5	9	113	11.5	3	1.3	0.6	0.1	0.6	0.2		
3	34	8	92	12	17	1.2	0.6	0.2	0.5			
4	32	8	50	15	29	1.2	0.5	0.1	0.5			
5	42	9.5	32	15	21.5	1.1	0.5	0.1	0.4			
6	46	6.5	24	14	14	1	0.5	0.1	0.4			
7	31	6	18	12	11	0.9	0.4	0.2	0.4			
8	23	6	15.5	11	9	0.8	0.4	0.1	0.4			
9	16.5	6	14	10	7	0.8	0.4	0.1	0.3			
10	13	5.5	14	9	6	0.7	0.3	0.1	0.3			
11	11	6	13.5	8	7	0.7	0.3	0.1	0.3			
12	12	10	14.5	7	5.5	0.7	0.3	0.1	0.3			
13	12	5.5	16.5	6	4.5	0.6	0.3	0.1	0.3			
14	8	6	17.5	5.5	4	0.6	0.3	0.1	0.3			
15	7	6	35	5	4	0.6	0.4	0.1	0.3			
16	7	6.5	48	4.5	3.7	0.6	0.3	0.1	0.3			
17	10	7	52	4	3.1	0.5	0,3	0.1	0.3			
18	12	8	56	4	2.9	0.5	0.3	0.1	0.2			
19	14	14.5	41	4	2.6	0.5	0.3	0	0.2			
20	14.5	17	28	4	2.3	0.4	0.3	0	0.3			
21	14.5	14.5	34	3.7	2.4	0.4	0.2	0.1	0.3			
22	16	14	82	3.9	2.9	0.5	0.2	0.1	0.3			
23	28	27	58	4.5	3.2	0.6	0.2	0.2	0.3			
24	28	30	34	5	2.9	0.6	0.2	0.1	0.3			
25	22	24.5	21.5	4	2.6	0.6	0.2	0.1	0.2			
26	17.5	24	16.5	3.8	2.3	1.3	0.2	0.6	0.3			
27	13	23	13	3.3	2.1	1.2	0.1	0.6	0.3			
28	11	31	11	2.9	1.9	1.3	0.1	0.7	0.3			
29	10		10.5	2.4	1.7	1.3	0.1	1.0	0.2			
30	8		10.5	3	2.1	1	0.1	1.0	0.2			
31	8		10		1.6		0.1	0.7				
TOTAL	551.5	349	1071.5	210	185.1	24.8	9.9	7.2	10.0			

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1969
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1						4.4	3.5	1.8	2.3	4.8	13	10
2						4.3	5.2	1.8	2.4	5.4	12	10
3						4	6	1.8	2.4	4	11	12.5
4						3.8	5	1.9	2.3	3.5	20.5	17.5
5						3.4	3.8	2.5	2.1	3.4	60	14.5
6						3.4	3.3	2.7	2.1	3.1	262	13.5
7						3.4	3.1	2.4	2.1	4.4	505	12
8						3.4	3	2.4	2	10	181	14.5
9						3.1	2.7	2.3	1.9	10	38	15
10						3	2.6	2.2	1.9	9.5	25.5	20.5
11						2.9	2.7	2.2	1.9	7.6	20	372
12						3	3.1	2.3	2	5.9	17	286
13						3	2.9	2.5	2.1	4.9	14.5	194
14						3	3.1	2.4	2.1	4.4	13.5	170
15						2.7	2.7	2.4	2.1	4.1	12.5	35.5
16						2.6	2.5	2.3	2.4	3.9	11.5	25
17						2.6	2.4	2.1	4.6	3.7	10.5	28
18						2.4	2.3	2.3	6	3.4	10	66
19						2.3	2.2	2.4	5.2	3.9	11	38
20						2.4	2	2.4	5.3	10.5	19	31
21						2.5	2	2.4	4.1	15.5	22	76
22						2.6	2	2.3	5.1	14	19	366
23						3.5	1.9	2.1	9	12	29	344
24						5.1	1.8	2	6.5	10.5	28	51
25						4.1	1.7	2.4	7.7	9	21	31
26						4.1	1.6	2.6	5.4	8.5	17	25
27						3.9	1.7	3.3	4.2	14.5	14.5	21
28					6.1	4.7	1.8	3.3	3.4	17	13	20
29					9	4.5	1.8	2.8	3.2	16	12	19.5
30					5.9	4.1	2	2.7	3.9	15.5	11	18
31					4.7		1.9	2.5		14.5		17
TOTAL						102.2	84.3	73.5	107.7	257.4	1454	1374

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1970
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	15.5	14	9	7	6	3.8	3	3.3	1.7	2.8	8	16
2	15	15	8.5	6.8	5.8	3.4	3.2	3	1.7	2.8	8	13.5
3	14	18	8	6.6	5.4	3.2	3.3	2.7	1.9	2.8	7.5	13.5
4	13.5	16	8	6.5	5.4	3.1	3	2.6	2	2.9	7	13
5	13	15	8	7.7	5.1	3	2.6	2.5	2.1	2.8	7	17.5
6	12	15.5	10	8	4.7	3	2.3	2.5	2.6	2.6	7.5	28
7	12	16	12	7.6	4.6	2.8	2.3	2.4	2.8	2.6	10.5	120
8	12	15	11	10	6.1	2.7	2.2	2.5	3.1	3.2	17	116
9	14	14	9.5	18	6	2.8	2.1	2.6	3.2	6	31	37
10	12	13	9	14	5.7	2.9	1.9	2.4	4.1	4.8	42	192
11	12	12	8	12	5.2	3	1.9	2.2	4	4.5	64	308
12	10.5	11	20	10.5	5	2.8	1.8	2.3	3.8	4.2	68	43.5
13	10.5	11	42	9	5	2.7	1.7	2.4	3.6	3.7	31	34
14	11	11	47	8	4.7	2.6	1.6	2.2	3.5	3.4	23	118
15	10	14	31	7.6	4.9	2.6	1.5	2.1	3.5	3.4	23	270
16	9	37	22	7.1	4.7	2.6	1.5	2	3.8	3.2	30	386
17	8.5	37	16.5	7	4.5	2.6	1.4	1.9	3.3	3.5	25.5	148
18	9	24	14	7	4.2	2.5	1.4	1.9	3.1	8.5	21	50
19	19.5	18.5	12.5	7.8	3.9	2.4	1.4	1.9	3.2	11	17.5	34
20	21	16	11	7.4	3.7	2.3	1.5	1.7	3	18	15.5	31
21	34	14	10.5	7.1	3.9	2.2	1.5	1.7	3.3	25.5	13	25
22	38	13	10	6.9	5.1	2.2	1.4	1.7	5.4	152	11	22.5
23	47	12	9.5	6.6	4.8	2.1	1.2	1.6	4.3	204	13	19
24	29	11	9	7.1	4.1	2	1.1	1.6	3.5	47	15.5	16.5
25	22	11	8.5	6.6	4	2.3	1.2	1.6	3.3	24	14	15.5
26	19	10.5	8	6.6	3.7	3.4	1.9	1.7	3.1	17	14	16
27	17	10	8	6.1	3.5	5	3.8	1.9	3	13.5	15	24.5
28	15	9.5	8	5.9	4.1	3.3	6	2	3	11	13.5	56
29	14		7.5	6.1	5.8	3.1	12	2	2.9	10	13	52
30	13		7.5	6.2	5.4	2.9	7	1.9	2.8	9	13.5	41
31	15		7		4.4		4.4	1.8		9		30
TOTAL	517	434	410.5	240.8	149.4	85.3	83.1	66.6	94.6	618.7	599.5	2307

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1971
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	24	40	15	20.5	17.5	5.5	8.5	8	6	7.2	11	22.5
2	20	30.5	17.5	19.5	16	7.1	8	8	6.2	7.2	11	37.5
3	19.5	25	16.5	18	15.5	8.5	8	8	6.5	7.4	13	32
4	16	23.5	14.5	17.5	15.5	9	8	8.5	6.9	8	13	28
5	15	20	13	18.5	15.5	9	8.5	8	8	8	13	27
6	14.5	20	18	19	13	9	9	8	8	7.9	12	22
7	14	17.5	116	20	12	14	9	7.9	7.5	7.7	12	18
8	15.5	15.5	37	62	11	14	9	7.6	8.5	7.5	32	28
9	19.5	14	56	56	10.5	13	9.5	7.3	8	7.4	720	22
10	20	19.5	63	35	10	13	9.5	7	8.5	7.4	370	18
11	20	21	142	26	9	12	10	6.6	8.5	7.7	56	18
12	18	28	330	22	8.5	11	9.5	6.7	8	8	30	24
13	16.5	31.5	60	19.5	8	10	9	6.2	7.7	8	36.5	20
14	15	76	64	19	8	9.5	9	7.1	7.3	8	47.5	18
15	23.5	58	43	19.5	10	9.5	9	7.2	7.1	8.5	31	15.5
16	44.5	32	29	18.5	18	9	9	7	6.7	8	23	15
17	61	24	23.5	17	15	9	9	6.9	6.6	8	18.5	15.5
18	61	23	20	16.5	12	9	9	6.9	6.6	8	16	16
19	61	21	18.5	16.5	11	9	8.5	6.9	6.6	21	23	16
20	34	18.5	17.5	18	9	8	8.5	6.9	6.5	14	30	15
21	25	18	16	18.5	8	8.5	8.5	7.1	6.3	12	26	15
22	22	19.5	17	19.5	7.3	9	8.5	7.1	6.1	43	21	14.5
23	19.5	19.5	24	22	6.6	9	8	6.9	6.5	29	28	15
24	19	21	25.5	19	6.1	11	8	6.8	6.6	18.5	66	15
25	17	19.5	22.5	19	5.9	14	8	6.6	6.6	15	42	14.5
26	17.5	19	19.5	23	5.5	11	8.5	6.6	6.5	13	190	14
27	20	18	19	23	5.1	10	8.5	6.3	6.1	11.5	44.5	13.5
28	20	16	23.5	19.5	4.6	9	8	6	6	10.5	62	13.5
29	29		33	17.5	4.3	9	8	5.8	7	10	41	13
30	190		30	17.5	4.5	8	8	5.9	7.2	11	27	13
31	90		25		4.5		8	5.7		11		13
TOTAL	1001.5	709	1369	677	307.4	296.6	267.5	217.5	210.6	359.4	2066	582

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1972
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	13	M	M	17	14	2.6	2.3	0.6	0.3	2	1.6	13.5
2	13			17	13	2.5	2.4	0.5	0.3	1.7	3.6	12
3	13			16.5	12	2.3	2.4	0.5	0.3	1.7	6.2	10
4	13			16.5	12	2.2	2.3	0.5	0.3	1.3	10	8.5
5	12.5			16	11.5	2.4	2.2	0.5	0.3	1.2	8.5	7.4
6	12.5			17	10.5	2.3	2.1	0.5	0.3	1.1	36	6.6
7	12.5			24	10	2.2	2	0.4	0.3	1.2	172	5.3
8	13			38	9	2.1	2.3	0.4	0.8	1.2	108	4.6
9	12.5			46	8.5	2.1	2.2	0.4	2.3	1.3	258	4.7
10	12			43.5	8	5.2	2.5	0.4	1.3	1.3	250	4.2
11	12			36	8	12	3.2	0.4	0.8	1.2	56	4.3
12	12			29	7.2	6.6	4.3	0.4	0.7	1.1	29	4.1
13	12			25	6.8	4.4	3.5	0.5	0.6	1.1	20	3.8
14	12			22	6.5	3.6	3.1	0.5	0.5	1.1	15	3.7
15	12	23.5	61	20	6.6	3.5	2.6	0.4	0.5	1	12	4.2
16	12	68	70	19	7.3	3.6	2.2	1.2	0.5	1	9	22
17	16.5	39	69	20.5	6.5	3.3	1.9	1.6	0.6	1	8	132
18	16	29	136	19	6	3.2	1.6	1	0.7	1.1	7.1	226
19	15	41	74	17	5.2	2.7	1.3	0.8	1.4	1.1	7.3	354
20	15	76	42	16	4.7	2.3	1	0.7	2.4	1.2	6.6	90
21	17.5	41	34	15.5	4.2	2.2	0.8	0.6	8.5	1.5	6.1	49
22	M	41	47	15	4.6	2.3	0.7	0.7	5.9	1.7	6	36
23		33	43.5	14	4.1	2.6	0.8	0.7	5.5	1.8	9	34
24		M	68	13	3.6	2.2	0.9	0.6	3.2	1.6	9.5	29
25			46.5	13	3.4	2.1	1.1	0.6	2.2	1.8	11.5	39
26			30	13	3.3	1.9	1.3	0.5	1.9	1.9	11	66
27			25	13	3.1	2.2	1	0.4	1.6	1.9	10	78
28			22.5	16	3	2.3	0.9	0.4	2	1.9	16	38
29			20.5	16	2.8	2.2	0.8	0.4	2.3	1.9	14	28
30			20.5	14	2.8	1.9	0.7	0.4	2.1	1.9	12	29
31			17.5		2.6		0.6	0.4		1.8		23
TOTAL	(279)	(391.5)	(827)	617.5	211.8	93	57	17.9	50.4	44.6	1130	1369.9

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1973
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	31	47	29.5	19	M	M	M	M	M	M	M	M
2	39	82	26	M								
3	28	40	34									
4	22	28.5	39									
5	18	23	28									
6	14	19.5	27									
7	13	19	23.5									
8	10.5	15.5	19									
9	9	14.5	17									
10	9	14	16									
11	11.5	13	15.5									
12	19	12	15									
13	25	11.5	14									
14	106	11	12.5									
15	368	12	13									
16	282	12	22									
17	59	12.5	21									
18	38	12	56									
19	39	12	135									
20	220	11	39									
21	106	11	26									
22	59	10	20.5									
23	110	10	18									
24	184	10	16									
25	54	10	14.5									
26	33	19.5	13.5									
27	27	29.5	13									
28	27	23.5	12									
29	38		11.5									
30	36		12									
31	34		19									
TOTAL	2069	545.5	778									

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1974
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	M	M	124	50	6.9	2.3	0.9	0.3	0.1	0.6	4.1	14
2			39	37	6.5	2.3	0.8	0.2	0.1	1.6	4	32
3			27	29	6.1	2.4	0.8	0.2	0.1	0.8	4.1	59
4			24	24	5.5	2.6	0.8	0.2	0.1	0.6	4.3	49.5
5			22	54	5.4	2.3	0.8	0.2	0.1	0.6	5.6	29
6			18.5	82	5.5	2.2	0.6	0.2	0.1	1.2	8	33
7			16.5	30	6	2.1	0.6	0.2	0.1	1.9	6.5	29
8			15.5	25.5	5.2	1.9	0.6	0.1	0.2	2.3	8	24.5
9			37	22	4.4	1.7	0.7	0.1	1.4	2.3	10	25
10			86	19.5	4.4	1.6	2.7	0.1	0.8	2.5	7.5	30
11			38	19	5.1	1.6	3.7	0.1	0.5	2.9	16	39
12			32	17	4.7	1.5	2.8	0.1	0.4	3.1	25	37.5
13			29.5	15	4.2	1.4	2.6	0.1	0.3	3	16.5	42.5
14		69	26.5	13.5	5.1	1.3	1.5	0.1	0.3	3	13	40
15		49.5	36	13	5.3	1.2	1.1	0.2	0.3	3	11	34
16		148	70	12	4.4	1.2	2.1	0.2	0.3	3.1	9	102
17		44.5	44.5	12	3.9	1	8.5	0.2	0.3	3.3	16	84
18		48	30	11	3.7	0.9	3.2	0.2	0.2	3.3	24	80
19		33	25	10.5	3.6	0.8	1.7	0.2	0.2	3.4	21	39
20		28	22	10	3.8	0.8	1.2	0.2	0.2	4.3	29.5	33
21		69	20	9.5	3.3	0.8	1	0.2	0.2	3.9	32	34
22		37.5	18.5	10	3.6	0.9	1.3	0.2	0.2	3.8	26	25
23		32	17	9.5	3.7	0.8	1.1	0.2	0.2	3.7	27	20.5
24		102	16	9	4.2	0.8	0.9	0.3	0.1	3.8	364	19.5
25		80	15.5	9.5	4.3	0.7	0.7	0.3	0.1	3.9	244	23
26		35	42	12	3.4	0.7	0.6	0.3	0.1	3.9	42	27
27		29	280	10	3.1	0.9	0.6	0.2	0.1	4.8	28.5	22
28		48	170	8.5	2.7	0.9	0.5	0.3	0.1	5.1	21	18
29			69	8	2.5	1.1	0.4	0.2	0.1	4.3	16.5	17.5
30			55	7.4	2.3	1.1	0.4	0.2	0.1	4.1	14	16.5
31			33		2.3		0.4	0.1		4.1		16.5
TOTAL		(852.5)	1499	599.4	135.1	41.8	45.6	5.9	7.4	92.2	1058.1	1095.5

BLACK CREEK
SURFACE FLOW AT RECORDER #3
1975
C.F.S.

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	21.5	19	50	17.5	11.5	3.1	1.7	0.2	1.5	0.3		
2	26.5	16.5	114	19.5	13	2.9	1.4	0.4	1.5	0.3		
3	29.5	15	65	22	72	2.9	1.3	1.2	1.1			
4	26	14	34	25	43.5	3.2	1.1	0.6	0.8			
5	42	13	26.5	23	24.5	3.2	0.9	0.3	0.6			
6	32	13.5	22.5	20	18	3	0.8	0.3	0.5			
7	25.5	14	19.5	19	15	2.6	0.8	0.4	0.4			
8	23	13.5	18	18	13	2.4	0.8	0.6	0.4			
9	18.5	13	17	19	11.5	2.3	0.8	0.5	0.3			
10	16	14	17	19	11	2.2	0.7	0.5	0.3			
11	15.5	13	17	20	14	2.1	0.6	0.4	0.3			
12	19	14.5	19.5	22	11	1.9	0.5	0.3	0.3			
13	15.5	15	21	22	9.5	1.9	0.5	0.3	0.2			
14	14	13	20	19.5	8.5	2.1	0.6	0.2	0.3			
15	14	14	34	18.5	8.5	2.3	1.4	0.2	0.5			
16	13	15	40	20.5	10	1.9	0.9	0.2	0.3			
17	18	13.5	52	20	8	1.8	0.8	0.5	0.3			
18	27	14	44	19	7.3	1.7	0.8	0.5	0.2			
19	28	23	33	23.5	6.7	1.5	0.7	0.3	0.2			
20	26.5	21	27	19.5	6	1.4	0.6	0.3	0.2			
21	24	17.5	41	16.5	6.3	1.4	0.5	0.3	0.2			
22	24	16.5	106	16	7.2	1.3	0.5	0.3	0.2			
23	37	28	43	18	7.2	2	0.4	2.4	0.2			
24	33	28	30	19	6.6	1.6	0.4	1.1	0.2			
25	27	24.5	24.5	19	5.9	3.3	0.4	0.7	0.2			
26	22.5	22	21.5	17	5.3	4.2	0.4	3.2	0.3			
27	20	23	19	15.5	5.1	3.7	0.3	5.1	0.2			
28	17	33	18	14	4.6	3.6	0.4	3.1	0.3			
29	16.5		18.5	12.5	4.3	3.3	0.3	5.3	0.3			
30	16		20	12	3.7	2.3	0.3	3.9	0.3			
31	19		19.5		3.4		0.2	2.3				
TOTAL	707	494	1052	566	382.1	73.1	21.8	35.9	12.6			

APPENDIX B

BLACK CREEK
DESCRIPTION AND LOCATION OF GAUGES

(See Figure 5)

Staff Gauge #4 - Drainage area, 8,484 ac.

An existing gauge located in Black Creek at the point of outflow of Northy Lake. A second gauge with identical readings was installed on April 18, 1975 in a drainage ditch near Jensen's farm buildings to facilitate reading high water levels. At very low waters levels, this ditch is probably dry so that it is necessary to walk out to Black Creek's channel to read the original gauge. Even at low water the original gauge is in a deep pool of probably 3-4 ft. of water. The long board that this gauge is attached to should be replaced by a long (18 ft. ?) 2' x 4' very soon. The gauge is vulnerable to floating debris and ice. The lake is frozen over during the winter months - usually January to early March. The gauge is usually read when recorders #1 and #2 are serviced or checked. The high readings are similar to recorder #1. For example - on November 13, 1974 recorder #1 read 6.64' and gauge #4 read 6.79'. On November 10, 1971 recorder #1 reached an extreme high of 10.96' (approx. 700 cfs) and it is assumed that gauge #4 would read approximately 11 feet. This would mean that Northy Lake was flooded to a level that was close to Jensen's barn.

Staff Gauge #5 - Drainage area, 11,066 ac.

Installed September 9, 1974, at a reading of 0.40', on a bridge piling under the Endall Road bridge crossing of Black Creek. The gauge is located in a pool beneath the bridge so that a reading can be taken even in extremely dry weather conditions. Lowest reading was 0.36' on September 23, 1974 and October 7, 1974 during drought conditions. Highest reading was 6.75' on November 25, 1974. Metering was not attempted here because of thick vegetation. Extreme high water level in this location corresponds to a reading of about 9 feet.

Staff Gauge #6 - Entire watershed area of 18,334 ac. above gauge.

Installed several years ago but was destroyed by stream debris during high water during the winter of 1973-74. A replacement gauge was installed on a tree at the same point

upstream and under Miracle Beach bridge on August 21, 1975 with a reading of 0.34. Old and new gauge readings should be fairly close. At extremely low water levels and no surface flow the end of this gauge sits in a shallow pool of water. This gauge is read most frequently because it is easily accessible and passed most often. The highest recorded gauge reading was 3.88' on November 24, 1974. Extreme readings probably range close to 6 to 7'. Frequent meterings were carried out on the downstream side of this bridge so that a "rough" discharge curve can be determined for this location. Water discharge here is roughly double the discharge at recorder #1.

Staff Gauge #7 - Drainage area, 1,984 ac.

Installed September 10, 1974 with an initial reading of 1.79'. The gauge was attached to the bridge log cribbing and set in a fairly deep pool of flowing water. The lowest reading of the gauge was 1.75' on September 23, 1974 and the highest was 2.43' on April 17 and 18, 1975. At extremely low flows the stream was metered immediately upstream of this bridge. At higher flows the metering was carried out about 40 feet upstream. The gauge is easily accessible and easy to read. It was not read during the winter months because the logging road to the site was closed by heavy snow.

Staff Gauge #8 - Drainage area, 140 ac.

Installed September 23, 1974 in a 6 acre swamp (#18) approximately ½ mile upstream from point "L". The initial gauge reading was 0.59', the lowest reading was 0.52' on October 2, 1974, and the highest was 1.85' on November 13, 1974. In the spring of 1975, the reading on April 17 was 1.43'. Water marks indicate that the water level was 3 inches higher or approximately 1.68' following snow melt. This swamp had a very small trickle flow when the gauge was installed. At the higher reading of 1.85' the flow was quite distinct since the gauge is located at the narrowing of the swampy area upstream. This gauge is remote and seldom visited.

Staff Gauge #9 - Drainage area, 455 ac.

Installed September 10, 1974 in a large, 1.4 ac., beaver pond located at the northern end of 13.2 ac. swamp #17. The initial gauge reading was 2.39'. The lowest reading was 2.30' on September 23, 1974 and a high reading of 2.88' was made on November 7, 1974. The beaver dam controlling the pond level up to 2.88' is very large (6 ft. wide and 300 ft. long) and well maintained by the beavers. On November 7 a large hole was

made in the centre of the dam to allow extra water to escape and within 10 minutes the pond level dropped from 2.88' to 2.85'. Two weeks later on November 23, the beavers had repaired the dam and the gauge read 2.87'.

Staff Gauge #11 - Drainage area, 330 ac.

Installed in a small pond beside the Duncan Main road about 2¼ miles south from Black Creek. The initial reading on September 10, 1974 was 1.83'. The lowest reading was 1.51' on September 23, 1974 and the highest was 3.18' on November 23, 1974. On April 17, 1975 the gauge read 2.85' and water was passing through a culvert pipe at approximately 0.75 cfs (metered) into swamp #95. Water in the pipe was 0.3' deep and flowing at approximately 1.47 ft/sec. The drainage area of this gauge is doubtful now because the flow of 1 cfs through a culvert pipe, that drains swamp #39 into swamp #41, indicates that part of the high water in swamp #85 may drain both ways - past gauge #11 and through swamp #39. There would be no flow past gauge #11 at a reading of 2.55' or less.

Staff Gauge #12 - Drainage area, 109 ac.

Installed in a large 6.2 acre pond - swamp #103 - alongside Duncan Main about 3½ miles south from Black Creek. On September 10, 1974 the gauge was attached to a stump in deep water with an initial reading of 2.44'. The lowest reading was 2.24' on October 24, 1974 and the highest was 4.18' on December 12, 1974. Ordinarily, the water in this pond would drain out at the south end through an old wooden culvert beneath an abandoned logging railroad grade. However, a small but well-built beaver dam across the mouth of the culvert prevents drainage to the point where there is little or no seepage through the beaver dam at relatively low water levels. At the reading of 4.18' the water was at the top of this dam but not flowing across it. Swamp #103 drains into #104 and thence into #121. On May 11, 1975, when gauge #12 was 3.99' only a very small, narrow, trickle flow could be found in the middle of swamp #121. The drainage area for swamp #103 is fairly small but the steep side hills surrounding this pond make it a possible water storage site for Millar Creek.

Staff Gauge #13 - Drainage area, 2,148 ac.

Installed September 10, 1974 in a deep pool under a small bridge at the point where the powerline road crosses Millar Creek. The initial reading was 1.78'. The lowest reading

was 1.75' on October 6, 1974 and the highest reading was 5.13' on November, 24, 1974 after two weeks of periodically moderate to heavy rain. On April 1, 1975 the reading was 3.08'. The stream gradient is low and large pools of water are located both upstream and downstream from the gauge, even in dry weather. During high water flows, this gauge acts as a stream gauge, and during low water levels in late summer it acts as a gauge for swamp #130. The gauge is fairly remote (it requires several miles of travelling) so it was not read as frequently as gauges near recorders.

Staff Gauge #14 - Drainage area, 184 ac.

Installed September 22, 1974 in a small pool of water at one end of swamp #140 beside an old logging access road. The initial reading was 0.60'. The gauge is very remote and difficult to approach within a half mile in wet weather due to poor road conditions. There is the distinct possibility that during high water the 38 acre swamp #140 drains into the Tsolum River. The lowest reading was 0.60' on September 22, October 7, and October 25, 1974. The highest reading was 1.73' on November 24, 1974. The gauge was not read during the winter and seldom read during the spring and summer of 1975.

Staff Gauge #15 - Drainage area, 370 ac.

This gauge was installed September 10, 1975 on the eastern edge of swamp #151, known locally as Cranberry Lake. The initial gauge reading was 1.68'. The gauge is reasonably accessible, but in wet weather the end portion of the road into the site is covered by fairly deep pools of water. Most of this 97 acre swamp is covered by grasses and herbaceous vegetation that is thick enough to walk on. Near the centre there is a 5 acre open area of water. A depth of 13 feet and temperature of 65.9^{o}F were measured at the edge of this open water while near the edge of the swamp at gauge #15, the water depth was 1.68' and the temperature was 53.7^{o}F. The lowest reading at this gauge was 1.53' on September 22, 1974 and the highest reading was 2.75' on November 24, 1974 after a period of heavy rain. A small but active beaver dam blocking an old logging railroad culvert prevents the flow of water from 37 acre swamp #150 into swamp #151. On April 19, 1975 there was only a small flow from swamp #150 into #151 at a high water level of 2.37' at gauge #15.

Staff Gauge #16 - Drainage area, 164 ac.

Installed August 22, 1974 at an initial reading of 2.00' in a 42 acre sawmp known locally as Halsteads pond. This swamp contains water during long dry summers. The level of this pond is controlled by a long 300 ft. active beaver dam. Two more beaver dams control the outflow from the first beaver dam. This pond has been used for salvaging coho fry removed from isolated pools along mainstem Black Creek. A 9 lb. coho was caught in this pond in November, 1974. The lowest gauge reading was 1.74' on October 6, 1974 and the highest reading was 2.76' on January 23, 1975.

Staff Gauge #17 - Drainage area, 484 ac.

Located beside an active beaver dam at the outlet of 39 acre swamp #166. An 8 acre open area of water, known locally as Larkin Lake occupies the centre of this swamp area. The gauge was installed August 22, 1974 at an initial reading of 2.00'. The lowest reading was 1.74' on October 6, 1974 and the highest reading was 2.72' on April 16, 1975. Larkin Lake is a natural reservoir area with rising ground on all sides except at its outlet.

Staff Gauge #18 - Drainage area, 4,520 ac.

Located beneath an old logging railroad bridge across Black Creek approximately 1 3/4 miles upstream from Northy Lake. The gauge was installed September 24, 1974 with a reading of 0.43'. The lowest reading was 0.43' and the highest reading was 4.05' on November 25, 1974. The gauge is fairly remote requiring a 30 minute return walk to the vehicle. At low water levels this gauge indicates water levels in swamp #57 immediately upstream. At high levels the gauge measures stage height of the stream. Swamp 57 is one of the largest swamps in the Black Creek watershed and has the greatest water level variation.

Staff Gauge #19 - Drainage area, 114 ac.

This gauge monitors 13 acre swamp #54 located beside an old railroad grade about ¼ mile directly north of gauge #18. The gauge was installed October 25, 1974 at reading of 2.06'. The lowest reading was 2.06' and the highest reading was 4.00' on December 18, 1974. Water marks on the gauge indicate a level of 4.70' between November 13, 1974 and November 25, 1974. It is possible that water from this swamp drains northward into the Oyster River at high stage heights. A large overgrown beaver dam separates swamp 54 from swamp 57 along Black Creek.