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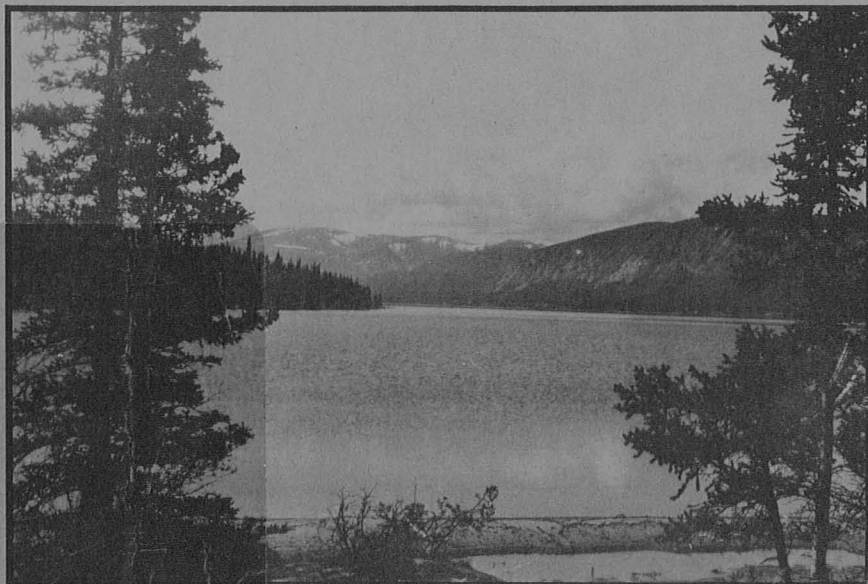
The Aishihik Hydroelectric Development

Implications for Fisheries Resource Maintenance

Summarized and edited by
W.J. Schouwenburg

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Northern Operations Branch
Pacific Region



THE AISHIHIK HYDROELECTRIC
DEVELOPMENT

IMPLICATIONS FOR FISHERIES
RESOURCE MAINTENANCE

Summarized and Edited

By

W. J. Schouwenburg

Northern Operations Branch
Pacific Region
Fisheries and Marine Service
Department of the Environment

October, 1974

F O R E W A R D

The impact of the proposed Aishihik Hydroelectric Development on local fisheries resources has been the subject of rather intensive investigations extending from the spring of 1972 to the fall of 1974. In the intervening period, several manuscript and technical reports have been prepared relating to various aspects of this development and their implications for maintenance and preservation of local fish stocks. This publication brings together, under one cover, all the information pertinent to resolution of fisheries resource maintenance problems posed by the development. Recommendations concerning the operation of the hydroelectric facility have been made so that the Yukon Territorial Water Board may take those factors into account in their deliberations of the Northern Canada Power Commission water licence application.

W. J. Schouwenburg,
Chief, Habitat Protection Unit,
Northern Operations Branch.

A C K N O W L E D G E M E N T S

I would like to thank Messrs. C. E. Walker, R. A. Robertson, B. R. Eliassen and B. C. Lawley for the assistance provided me in the interpretation of the data and reports they were instrumental in collecting and preparing and for their assistance in formulating the recommendations contained in this presentation.

I would like also to thank Messrs. L Margolis, Z. Kabata, T. Evelyn and R. Arthur for their effort in assessing the potential parasite transfer problems arising from the diversion of Stevens Lake into Aishihik Lake.

Finally, and most especially, I would like to thank Mr. Kenneth Jackson for his constructive criticism of this report as it was being prepared.

Miss Wendy Watson typed all the drafts.

W. J. Schouwenburg

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July, 1973

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INTRODUCTION:

Any proposal for a hydroelectric development presents a series of multi-faceted problems for any person or agency concerned with the management and maintenance of the fishery resources in the drainages being proposed for development.

Before the Aishihik project was proposed, the Fisheries Service was well aware that the need for electric power in the Yukon was becoming acute. Having recognized this reality, the selection of Aishihik Lake as a site for the development of comparatively low cost hydroelectric power did not come as a surprise. Furthermore, in spite of a lack of detailed information pertaining to the extent, value and particular environmental requirements of fish populations in the Aishihik System and the prospect of having precious little time to obtain the needed information, in relative terms the choice of this System was regarded as fortunate in the sense that the inevitable incompatibilities between Hydro development and fisheries resource preservation could have been much more serious.

In our first presentation to this tribunal in May, 1972 we expressed our concerns that the basic information necessary to assess the implications of the project on the local fishery resources was not available and that, consequently, a water licence should not be issued until such time as the information germane to this assessment could be obtained. At that time, we elaborated on the nature of the anticipated fisheries resource problems and outlined a program of investigation to assess the magnitude and significance of these problems and how they might be resolved. Studies were subsequently initiated to establish the effects of:

- 1) flooding or drawdown of Aishihik Lake on fish populations utilizing the streams tributary to and residing within the lake;
- 2) flow regulation on fish populations residing in the drainage basin downstream of Aishihik Lake;
- 3) diversions of water via the powerhouse canal on fish populations resident in the east Aishihik River below Canyon Lake;
- 4) alterations of the water levels of Aishihik Lake on water quality in the lake; and finally
- 5) determining the means by which detrimental effects identified could be offset or reduced to an acceptable minimum.

In addition, an attempt was made to assess the potential for parasite transfer into the Aishihik River drainage if water were diverted into the reservoir from Stevens or Long lakes. In this regard, our principal concern was the transfer of parasite laden pike into Aishihik Lake.

While some of the data collected since the spring of 1972 has already been made available to this body in the form of an Interim Report (Appendix A), other new information has subsequently been obtained. It is the purpose of this report to present a summary of all the information obtained over the past three years and, on the basis of this information, to make recommendations as to how the development can proceed with minimal impact on the fisheries

resources. Some aspects of this presentation have already been provided to the Board along with tentative recommendations to facilitate day to day decisions pertinent to the project but the Fisheries Service has not, until now, made these generally available to the public.

While this report will not re-describe the power project proposal, it should be recognized that certain portions of our investigations do not pertain to the development as it now is envisaged. This situation was brought about because the Northern Canada Power Commission development proposals have changed considerably since they were first advanced in 1972. Initially the development was to include diversion of water from Stevens and Long lakes into the Aishihik System. These possibilities are no longer being actively considered so that reference to problems brought on by these diversions are only of passing interest to all concerned.

*New
proposals*

ASSESSMENT OF THE FISHERIES RESOURCE MAINTENANCE PROBLEMS POSED BY THE AISHIHIK HYDROELECTRIC DEVELOPMENT

For ease of presentation, it is perhaps best to relate the implications of the development to the two key structures involved in the project, that is, the control dam at the outlet of Aishihik Lake and the diversion dam at the outlet of Canyon Lake.

1) Effects of Water Storage on Aishihik Lake and Its Tributaries

The control dam at the outlet of Aishihik Lake has been designed and constructed to permit water storage regulation between Elevations 2992.5 and 3007.5, a range

of fifteen feet. The maximum natural level of the lake has been estimated at Elevation 3002.5 and the minimum is estimated to have been at Elevation 2996.5, a range of six feet. It should be noted that there is only a small difference in elevation between Aishihik and Sekulmun Lakes. The maximum and minimum water levels in Sekulmun Lake are estimated to be 3006.0 and 3003.0 respectively.

15' cont'd
range.
6' original

In their assessment of the implications of issuing the Northern Canada Power Commission a water licence to operate the Aishihik Lake storage dam over the full range of its design capability, Robertson and Eliassen (Appendix B) have considered several pertinent consequences. Obviously, storage on Aishihik Lake to Elevation 3007.5 will result in the flooding of Sekulmun Lake during the late summer - early fall period and would lead to major changes of water velocity in the Sekulmun River. This alteration could result in considerable undercutting and slumping of the existing high banks along the rivers edge. This erosive process would continue for an indeterminate number of years until a state of equilibrium is reached and would release large amounts of silt into the Sekulmun River in the interval.

river bank
slumping
Sekulmun
River

channeling
during drawdown

Drawdown of Aishihik Lake below its natural low level of 2996.5 will cause the Sekulmun River, through erosive processes, to cut a much deeper channel and this would result in the elimination of the very deep pool sections which presently characterize the lower four miles of that stream. These pools are important fish rearing habitat. Robertson and Eliassen indicate there is a high probability that this scouring action would continue back to the outlet of Sekulmun Lake thereby effectively causing

a lowering of its present levels. The streambed composition is such that there are no obvious bedrock outcropping or heavy boulder sections which could prevent the erosion processes from proceeding upstream from Aishihik Lake for the full length of the stream. The scouring of a new riverbed resulting from the drawdown of Aishihik Lake would, if allowed to proceed unchecked, take many years. These observations confirm the suspicions alluded to in the Interim Report.

*Lowering of
Sekulmun
elevation due to
downcutting
outlet.*

Prolonged injections of silt into the Sekulmun River generated from bank slumpage and scouring of a new riverbed are sure to be inimical because they will continuously disturb the seasonal cycles of events which are prerequisite to the survival of fish. The sediments will blanket spawning substrates and cause, at the very least, partial losses of spawn. Similarly, there will be a reduction in the production of fish food organisms either through suffocation or loss of habitat. As a new riverbed is scoured out when the Aishihik Reservoir is being drawn down, a constant shifting of the streambed will occur and this will not be conducive to establishment of either a stable spawning substrate or to the maintenance of zones along the river bank which juvenile fishes require for rearing.

*slumpage causing
sediment blanket
of spawning
substrates.*

*reduction of food
production*

*shifting stream-
bed reducing
stable spawning habitat
or rearing areas*

Once conditions have stabilized in the Sekulmun River, which would require many years, the fish population composition can be expected to change markedly. Whitefish, pike and grayling presently make extensive use of the pools in the lower few miles of the river for rearing and, to a lesser extent, spawning. Given a history of scouring, these pools will no longer exist. Furthermore, in the

spring and early summer, the stream would be faster flowing. This would tend to favor production of stream spawning species such as grayling. Fall spawning species, such as whitefish and perhaps occasionally lake trout, would not fare so well in the long term because spawn would be deposited when the Aishihik Reservoir is near its highest level. These eggs do not hatch until the following spring at which time the reservoir would be at its lowest level. Consequently, many of the eggs deposited in the Sekulmun River will be exposed and will die during the drawdown period. It is not possible to predict whether the species affected by the drawdown would deposit sufficient spawn in portions of the streambed which will remain wetted to sustain populations at their present levels, and given survival of sufficient spawn, whether the resulting progeny will find sufficient food and protection from predators in the altered regions of the stream. In our opinion, the combined odds of sustaining present populations of pike, whitefish and grayling in Sekulmun River are poor unless preventative works are undertaken. These will be described later.

Sekulmun R.
cannot sustain
present species
of pike, w.f. & grayling

In addition to the Sekulmun River, Aishihik Lake has approximately 40 tributary streams of either a permanent or intermittent nature. In general, the combined flow of all of these tributaries exceeds the flow in the Sekulmun River. However, none of these tributaries could be classified as a large stream and none could be classified as substantial fish producers. Most of the permanent streams and some of the intermittent ones are characterized by having low gradient sections in the lower reaches adjacent to the lakeshore, followed by steep gradient sections and moderate to low gradient upper sections. Spawning and rearing takes place in the lower sections. Unfortunately, the effects of flooding or drawdown of Aishihik Lake will affect the low gradient sections at the stream mouths.

40 tribs.
tributaries of
Aishihik
flooding will
immediate tribs lower
perhaps

The lower portions of the majority of these streams have streambeds comprised of silt and sand and possess banks heavily overgrown with brush and tall grasses. Drawdown of Aishihik Lake will cause the streams to erode deeper channels in the lower reaches in the same manner as that previously described in the discussion of the Sekulmun River. Flooding of the reservoir will result in the inundation of the delta zone and a back-up of water in the streams for varying distances. Stabilization of the streams would take several years.

*erode stream
chan. etc.
> vel.
fury drawdown*

Walker and Brown (Appendix C) have established that one of the two fish producing streams - referred to as "McIndoe Creek" by Walker and Brown and "A9" in the Interim Report - appears quite productive in the lower reaches. The spawning and rearing potential in this section will undoubtedly be reduced during the late spring and early summer when the lake levels will be low but the late summer rearing potential may actually be increased because of the back-up of lake water into the stream which would normally have very low flows and a reduced wetted perimeter.

*2 fish prod.
tribs*

Neither flooding nor drawdown will impede the migration of grayling into the two fish producing tributaries.

} good

In addition to the effects of reservoir manipulation on the Aishihik Lake tributaries, there are serious implications of this manipulation for the lake itself. When a reservoir is created or the level of a lake is raised beyond its natural high levels, land slumpage, due to undercutting of steep hillsides and high banks by waves and a decrease in soil stability due to intrusion of water into the soil, are expected occurrences. According

*reservoir
slumpage*

to Robertson and Eliassen, most of the lake margin is composed of fine grained soils which would be susceptible to wave induced erosion when inundated, but the ~~extent of~~ erosion anticipated is quite limited. However, there are four miles of lake margin where massive erosion can be expected if the lake levels are raised to Elevation 3007.5.

4 miles massive erosion

The lake margins which will be highly erodible are of two types; high, steep banks comprised of a coarse sand/gravel mixture and high, steep banks comprised of a fine sand/silt/clay mixture. There are three miles of the latter extending approximately from the Aishihik Indian village east to Soldier Bay and there is a mile of the former on the western shore about 1.5 miles north of Lister Creek.

location?

Robertson and Eliassen have estimated that the foreshore would recede up to 140 feet in these areas. The height of these banks for the most part exceeds 50 feet. It is not possible to predict how many years would be required for the shoreline to stabilize. There is the potential therefore of a massive injection of silt (119 million cubic feet) from the clay deposits into the northern portion of the lake over what amounts to an instant in geologic time. The consequences of this environmental event would impact most heavily on the humpback whitefish population because juveniles of that species find very favourable habitat in the shallow northern end of the lake for rearing for the duration of the summer (Lawley, Appendix D). The significance of this area for juvenile whitefish rearing is very apparent when one considers that catches per set in the northern arm of Aishihik Lake and Soldiers Bay yielded from 300 to 7,000 humpback whitefish fry while the catches using the same gear elsewhere along the margins of the lake never exceeded 5 fry per set.

140' more recession

humpback W.F. rearing area with sand and silt

With the drawdown of Aishihik Lake to Elevation 2992.5, the resultant scouring of the Sekulmun River would

extend the rivers delta into the present lake bed at the northern end. Some indication of the extent of this scouring for a new low level channel is illustrated in the Interim Report where the results of the lake sounding program are discussed and areas having depths of less than 15 feet are shown. Lake bed substrates in this area comprise fine, easily re-suspended mud which originated through natural erosion of the high clay/silt banks in the area and from the Sekulmun River. The scouring of a new river channel will result in a very marked increase of suspended solid concentrations at the northern end of the lake which will be easily detectable both visually and chemically for a distance of perhaps several miles. This condition would not be a permanent feature if some means were applied to curtail bank slumping from the lake margin during reservoir filling.

*sedimentate
shape
+ low level
channel
erosion causing
high turbidity*

It is obvious from the foregoing that the conversion of Aishihik Lake to an artificially controlled reservoir can have varying and inter-related effects on the streams tributary to the lake and on the quality of the lake itself which are dependent upon the degree of storage and/or drawdown. The next question of importance then relates to the impact of this reservoir manipulation on the production of fish in Aishihik Lake.

Summary

Kussat (Appendix E) has considered the implications of reservoir manipulation from a limnological point of view. He concluded that the change in biological productivity brought on by the annual artificial fluctuations in the reservoir necessary to meet power generation design capacity (i.e. a six foot annual fluctuation) would not be measurable. He did, however, indicate two possible reservations with regard to that conclusion. The first was that a localized major disruption, which he was not in a

*fluct.
prod.*

position to predict, could foreseeably be detrimental to overall fish production in the lake. The second implied a concern over littoral zone biomass production deterioration which might result if the reservoir was operated principally on the drawdown concept in relation to natural lake levels. Kussat's implied concern over the effects of drawdown on the littoral zone was subjected to further investigation in 1973 by Lawley. As a result of extending the littoral zone investigation to depths beyond fifteen feet, Lawley was able to confirm Kussat's conclusion that benthic productivity was indeed confined to a narrow band around the lake. However, this band is not as narrow as previously believed. It ranges from nine to forty-five feet in depth. Consequently, Kussat's concern over loss of productive area is not as significant as previously supposed. *narrow band lit. zone*

Kussat's implied concern over the consequences of a major localized disruption of the overall fish population appears to be borne out in the light of the potential for and probable character of massive land slumpage in the north end of Aishihik Lake where the principal rearing grounds for juvenile humpback whitefish are located. Inasmuch as Kussat has determined that the lake trout diet is substantially comprised of juvenile fish, it is possible that a major decline in whitefish fry production could have detrimental second generation effects on lake trout production. *decline W.F. prod. 2nd. gen. effect on W.F.*

2) Implications of Regulation of Flow from the Aishihik Lake Reservoir

The Aishihik power generation proposal, as it is presently envisaged, entails integration with the Whitehorse

Rapids powerplant. As a result of this integration, the Aishihik powerhouse will operate in the winter months (October through April) and the aim will be to store water during the remainder of the year. During this storage period, outflow from Aishihik Lake would be substantially curtailed to permit a re-filling of the reservoir. This constitutes a total reversal of the natural discharge pattern from Aishihik Lake and this is of major significance to fisheries resource maintenance.

*reversal
natural H₂O
regime.*

The stream flowing from Aishihik Lake to Canyon Lake - referred to as Canyon River in the Interim Report and the Upper Aishihik River by Walker and Brown and Robertson and Eliassen - is a complex, short stream which is a major spawning and rearing area for Arctic grayling. The maintenance of this grayling population presents the greatest single source of concern over this hydro development proposal. Walker and Brown have undertaken extensive biological investigations in an attempt to identify those factors which are critical to the preservation of the Canyon River as a major grayling producer under artificially reduced summer flow conditions. Robertson and Eliassen conducted stream hydrology investigations to provide support data for the biological assessment. The prime objective of these investigations was to determine the minimum summer flows required and to determine the hydraulic conditions which must be produced concurrently with that minimum flow. These studies were conducted during the summers of 1973 and 1974. With the installation of the coffer dam at the outlet of Aishihik Lake in the summer of 1974, it was possible to partially assess the physical and biological conditions which would ensue from certain low flow discharges.

*d/s. outlet
R. for
control.*

Since the Canyon River is used by grayling for all three of the functions of feeding, rearing and spawning, reductions in flow can be expected to raise questions pertinent to fish food sources, reduced living space and loss of spawning area. Walker and Brown have determined that the quantity of stream drift is relatively high and that it is comprised of plankton from Aishihik Lake and from aquatic insect larvae and adult insects produced in the stream itself which are taken by the grayling. While the production of plankton in the lake is not affected by stream flow, the amount delivered as food will definitely be flow dependent. The quantity of insects produced within the stream is more dependent upon the wetted area of the streambed and water velocity. Walker and Brown have concluded that the wetted area of the Canyon River between Canyon Pond and Aishihik Lake will not be substantially reduced if the flows are not permitted to go below 50 cfs. *50 cfs min. flow.* The consequences of reduced flows are likely to be more severe in the Canyon River downstream from Canyon Pond where the stream is presently characterized by having a deeper central channel and extensive shallow shelf areas. These authors have determined that the shelf areas in this portion of the Canyon River and in the Canyon Pond itself are extremely productive zones for aquatic insects. On the basis of the 1974 flow release tests, extensive de- *as at 100 cfs extensive denuding of fls.* watering of these shelf areas will occur when flows are re-duced to approximately 100 cubic feet per second.

A second consideration with respect to reduced flows emanating from Aishihik Lake relates to changes in the behavioral patterns of resident fishes. Walker (Appendix F) observed that when flows below Canyon Pond approximated 95 cfs fingerlings abandoned the shelf areas and fry were forced to inhabit the exposed stream margins. *now also prey-pred. relations* Such compressions of habitat normally have adverse effects

upon food getting and predator - prey relationships. In addition, stream water temperatures at the water's edge were profoundly altered. Temperatures on the shelf areas reached 72°F whereas the previous maximum was in the order of 60°F . Losses of fingerlings and fry were observed and attributed to both increased susceptibility to predation and warm temperatures.

< flow
> heat

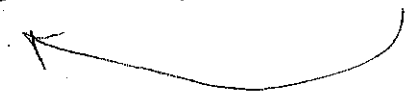
Reduced flows through Canyon Pond brought on marked changes in water temperature and fry distribution. The fry of all species, which at normal water levels inhabited the areas containing aquatic vegetation, were forced to retreat to the plantless areas on the sloping beaches which eliminated the benefits of shelter that the fry normally seek in a plant community and also reduced their food supply. Rearing areas in the Giltana Creek mouth were also reduced. Water temperatures on the Canyon Pond flats increased 8.5°F during low flow trials in comparison with normal flow situations. There was also evidence of increased predation on fry in Canyon Pond during the low flow situation.

Normal fish distribution patterns were re-established when the flows in the lower Canyon River were increased to 150 - 200 cubic feet per second.

no of
dist. pattern at $150 - 200$
cfs

Given reduced flows, and stability of flows, one can expect that, over the long term, the shelf areas would re-establish with protective aquatic vegetation cover and a new shoreline biological community. However, the end result would be that the overall living space for fish would be reduced and this in turn would result in a decline of fish populations in comparison with natural levels. The alternatives to that situation are to release enough water (150 - 200 cfs) from Aishihik Lake to maintain the shelf

release
150 - 200 cfs



areas as useable fish habitat, or to simulate the water levels obtained at that flow range through installation of level control structures. Since the release of 150 - 200 cfs during the summer months destroys the economic viability of the project, Robertson and Eliassen addressed themselves to investigating the feasibility of installing level control devices in the Canyon River between Canyon Pond and Canyon Lake. They have suggested a technique of installing rock plugs at several points in the Canyon River which would preserve the stream levels existing at 150 cfs while discharging only 100 cfs. This approach would appear to offer a reasonable solution to the problem of habitat maintenance in the Canyon River.

*rock plugs
to $>$ stream
levels*

3) Implications of Water Diversions into the
Powerhouse Intake Canal

From the outset, it has been obvious that fish stocks in the East Aishihik River between Canyon Lake and the powerhouse tailrace could not be maintained at their present natural levels after the power project becomes operational. This conclusion is based upon the knowledge that winter flows from Canyon Lake will be reduced to those accruing from uncontrollable seepage. The summer flows will also be curtailed to permit the filling of the Aishihik Lake reservoir and will never exceed the combined flows emanating from Giltana Creek and the minimum fish maintenance flows released from Aishihik Lake. While a greatly reduced fish population feeding almost exclusively on air borne insects might be sustained during the summer release period, these populations could not, with the possible exception of those residing in Otter Pond, survive the winter because the pool sections will freeze solid. With the installation of a berm at the out-

*east run
between
control & powerhouse
diverted*

let of Otter Pond to artificially maintain natural high levels, Walker (personal communication) has concluded that it may be possible to maintain a remnant of the rainbow trout populations in the pond over the winter. As has been recommended in the Interim Report, the fish losses incurred in the East Aishihik River should be compensated for by the developer.

During the summer period when reduced, but yet to be determined flow releases are made over Otter Falls, fish would naturally be attracted into the East Aishihik River upstream from the powerhouse tailrace. These fish would take up residence in the ponds between the tailrace and the back of Rainbow Falls. Unless some man-made structure such as a barrier dam is constructed across the stream immediately upstream from the tailrace to prevent migration above this point, many of the fish taking up residence in this area will become trapped and be destroyed when flows are cut off during the winter.

In the Interim Report, reference was made to the fish losses which would accrue when juveniles are drawn into the powerhouse. At that time, it was suggested that special design considerations would have to be made to offset this loss. The intake canal has now been designed and constructed in such a way that water velocities in the powerhouse canal will not exceed 1.5 feet per second. Since the powerhouse will be operated at a time when fry-of-the-year have had the opportunity to feed and grow over the summer months, it is considered that these fish should be able to avoid being drawn into the powerhouse. It should also be recognized that juvenile fish are naturally lost to Canyon Lake once they have passed over Otter Falls.

juv. retained
powerhouse redesign

In recognition of these two factors, the Fisheries Service has taken the position that screening devices to prevent fish from being drawn into the powerhouse will not be required for fisheries resource maintenance purposes.

4) Implication of Diverting Stevens Lake into
 Aishihik Lake

The diversion of Stevens Lake into the Aishihik Lake watershed has always been considered a possibility by the developers but is not a part of their present proposal. In anticipation that such a diversion proposal may eventually be made, the Pacific Biological Station was asked to undertake an investigation of the possible parasite transfer problems which such a diversion might bring about. The results of that investigation are presented in Appendix G*. You will note from this report that it has been concluded that there is a strong possibility that the tapeworm Trienophorus nodulosus present in Stevens Lake would infect salmon resident in the Alsek River System. The authors have suggested this parasite transfer could be prevented if pike were prevented from entering Stevens Lake and that pike resident in the lake were poisoned before the actual diversions were undertaken. This is a feasible and acceptable solution to that problem.

RECOMMENDATIONS:

From the foregoing presentation, it is clear that the fisheries resources of the Aishihik Lake System can be maintained albeit at reduced levels in conjunction

* Dr. L. Margolis, Dr. Z. Kabata, Dr. T. Evelyn
 and Mr. R. Arthur, authors.

with the hydro-electric development if certain remedial actions are taken and certain operating conditions are imposed on the developer.

In formulating its recommendations concerning these remedial actions and operating conditions, the Fisheries Service has taken several key factors into consideration. First, as was pointed out in the Interim Report, the Aishihik Lake drainage basin presently is a highly important recreational fishing area especially for Yukon residents. *recreate* As Kluane National Park is developed and access through north-western British Columbia is improved, tourist use of this portion of the Yukon Will undergo marked increases. The potential recreational use and value of the Aishihik system for sports fishing is therefore obvious. Consequently, the Fisheries Service considers maintenance of the sports fish stocks (i.e. grayling and lake trout) to be of prime importance. Second, since the project was not considered to be incompatible with fisheries resource maintenance, ~~construction of certain portions of the project, including fish maintenance facilities, has been completed or is underway.~~ *fish* One such facility is the installation of a fishway which will permit the continued migration of grayling from Canyon Pond to Aishihik Lake. The third and final consideration pertains to the Fisheries Service's legal obligations and responsibilities with respect to this type of development as defined in the Fisheries Act. The following recommendations are commensurate with these considerations.

- 1) In order to prevent the flooding of Sekulmun Lake and confine the effects of flooding to Aishihik Lake, it is recommended that the maximum storage level in Aishihik Lake be set at

New
Site

Cante-Perry
Lower stream
Spiga-Yukon

in 60

Elevation 3003.5.

- 2) If allowed to go unchecked, flooding of Aishihik Lake to Elevation 3003.5 will result in considerable land slumpage at the north end of the lake in an area critical to whitefish production. It is recommended, therefore, that the three miles of foreshore in that area be rip-rapped between the natural high water mark and Elevation 3003.5 to control erosive processes.
- 3) At some future time, the level of Aishihik Lake will be drawn down to possibly as low as Elevation 2992.5. Subsequent scouring of the Sekulmun River bed will occur. It is recommended that rock invert weirs be strategically placed in the bed of the Sekulmun River to prevent the bed scouring and maintain this fish producing habitat.
- 4) Inasmuch as the Canyon River grayling stocks are of considerable magnitude and recreational value, it is considered essential that a minimum flow sufficient to maintain these stocks at their present population magnitudes, be released from the Aishihik Reservoir at all times. It is recommended that this minimum flow be established at 100 cubic feet per second.
- 5) The release of 100 cfs minimum flow from Aishihik Lake will not, of itself, maintain sufficient depths of water over the margins of the Canyon River or Canyon Pond to preserve this rearing habitat for juvenile fishes. Consequently, it is

CS

recommended that permanent plugs, of a nature and number acceptable to the Fisheries Service, be placed in the Canyon River to simulate water levels normally reached when the natural flows were in the order of 150 - 200 cfs.

- 6) In order to prevent the migration of fish into that portion of the East Aishihik River above the powerhouse tailrace, it is recommended that a permanent rock weir of a height sufficient to prevent fish passage, be placed in the river immediately upstream of the powerhouse tailrace.
- 7) It is possible that a remnant of the rainbow trout population currently resident between Rainbow Falls and Otter Falls could overwinter in Otter Pond if the water levels of the pond are artificially maintained near their natural high flow levels. Inasmuch as this would entail a minor effort, it is recommended that a rock berm be installed at the outlet of Otter Pond in an attempt to salvage some portion of the rainbow trout populations.

A P P E N D I X A

FISHERIES PROBLEMS ASSOCIATED WITH THE
PROPOSED AISHIHIK RIVER POWER DEVELOPMENT

INTERIM REPORT,
FISHERIES SERVICE,
JANUARY, 1973

FISHERIES PROBLEMS ASSOCIATED
WITH THE
PROPOSED AISHIHIK RIVER POWER
DEVELOPMENT

INTERIM REPORT

NORTHERN OPERATIONS BRANCH
FISHERIES SERVICE
DEPARTMENT OF THE ENVIRONMENT
1090 WEST PENDER STREET
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I INTRODUCTION

In May of 1972 the Yukon Territorial Water Board held the first public hearings into the proposed Aishihik Hydro Power Development. At that time the Fisheries Service of the Department of the Environment presented a brief and requested that the application by the Northern Canada Power Commission for a water license be held in abeyance until the impact of the proposed project on the fisheries resources could be assessed and until guidelines for the preservation of these resources could be established. The Water Board has now decided to hold a second public hearing to review new information which has been gathered in the intervening eight months and, in the light of this new evidence, to consider the Northern Canada Power Commission's water license application.

This interim report has been prepared for use by the Water Board during the January 1973 hearing and describes the fisheries resources impact study, details the effort expended to obtain this information, discusses the nature of the anticipated fish-power problems and establishes the Fisheries Service overall position regarding the Aishihik power proposal.

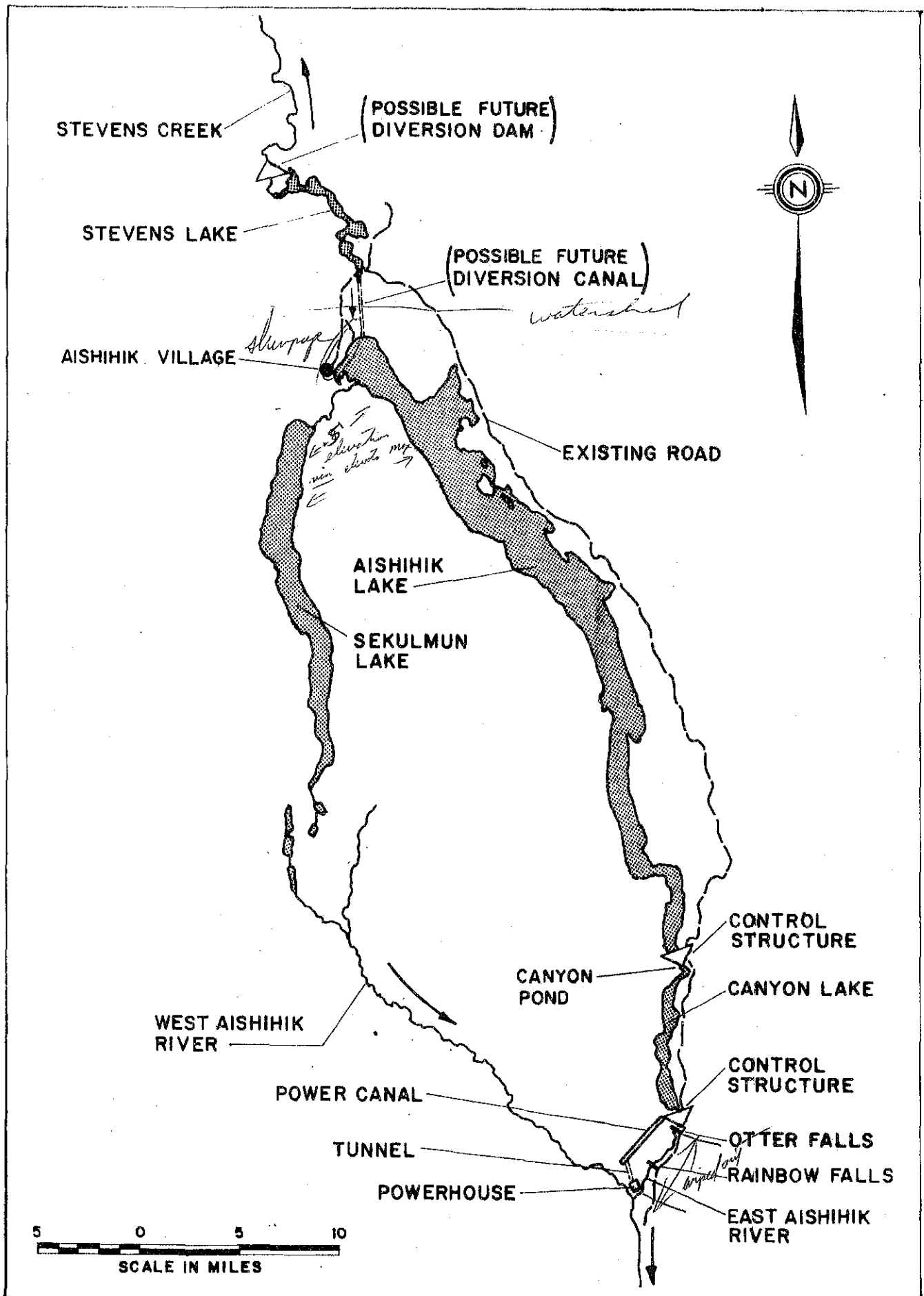
The report represents the first interpretation of rough and sometimes incomplete field data collected during the 1972 survey. A final completion of the

fisheries study is not possible until the power proposal has been finalized and total storage range and mode of operation are known. In this report the Fisheries Service has assumed that the project will be built as outlined in G.E. Crippen's Engineering Report - April 1972 and in their Interim Supplementary Report - October 1972. (The proposal is schematically illustrated in Figures 1 and 2.)

The Fisheries Service does not object to the granting of a water license to the Northern Canada Power Commission for the purpose of installing hydro-electric power generating facilities in the East Aishihik River System provided that:

1. fish protective measures are implemented as stated in this report;
2. unavoidable fisheries losses be compensated for in perpetuity;
3. a decision on the final operating levels of Aishihik Lake reservoir be deferred for another year so that further biological studies into the impacts of lake drawdown or flooding can be conducted during 1973; and
4. no consideration be given at this time to diversion of other watersheds into the Aishihik River System.

At this juncture, the Fisheries Service would like to reiterate in the strongest terms that it is not possible to complete in reasonably precise detail biological impact assessments of large scale proposals such as this in a few months. The outcome



AISHIHIK - PROPOSED POWER DEVELOPMENT

Fig. 1

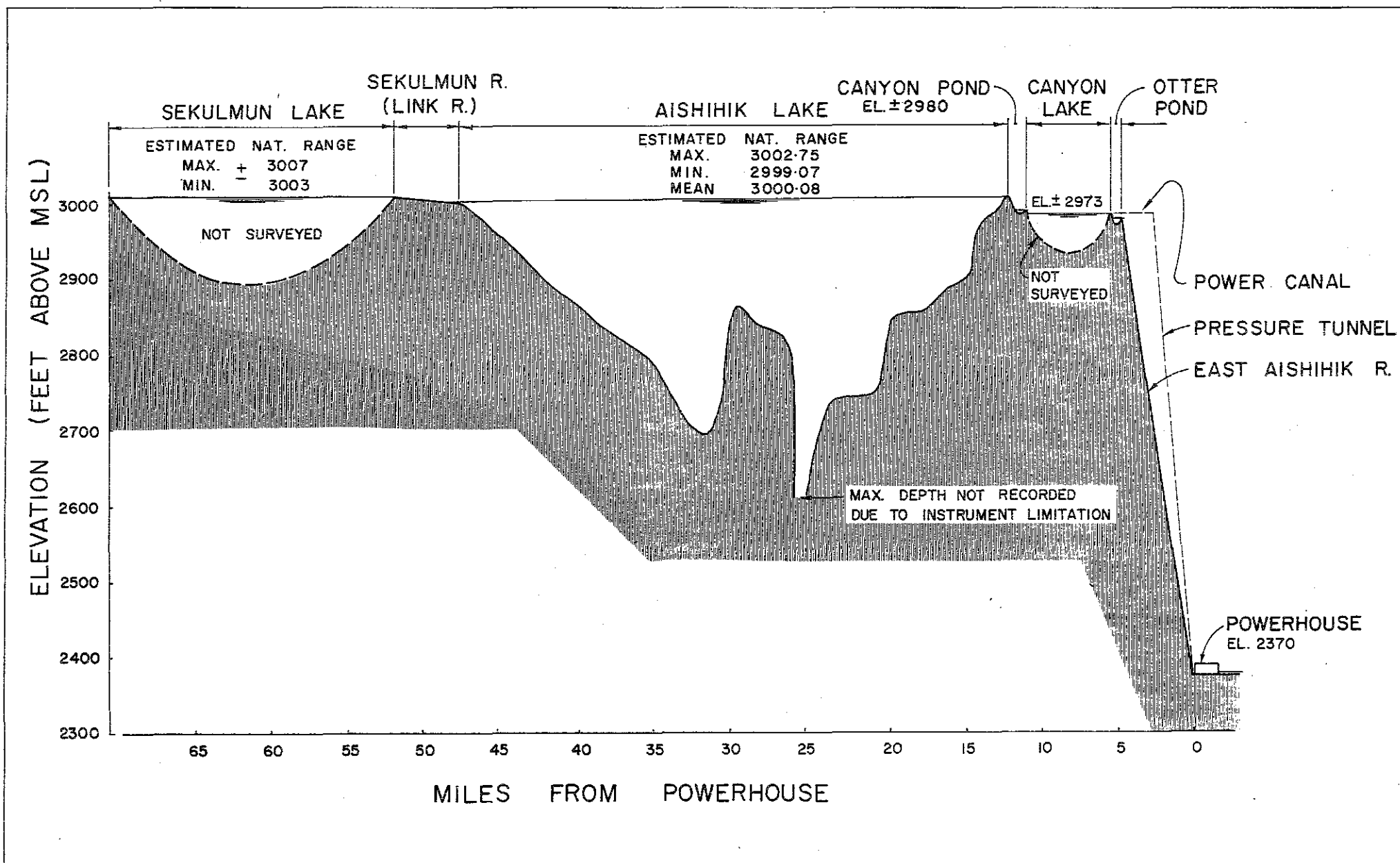


FIG. 2. AISHIHIK RIVER SYSTEM - SCHEMATIC PROFILE

of the fisheries investigation during the past season demonstrates that despite the considerable effort expended in obtaining biological information many data gaps exist thus making it impossible to make recommendations on certain aspects of the proposal. It is because of these constraints on gathering data that it is generally accepted practice to give at least three years lead time for living resource agencies to conduct environmental impact and ecological studies. It should also be further pointed out that the Aishihik power proposal was launched in a manner suggesting all the elements of single purpose resource development. A similar situation should not be allowed to recur. Power projects should be part of a general policy and strategy of long term resource planning and multiple purpose management. In future, the Fisheries Service will have to insist that more lead time is given to undertake biological and environmental studies, that project details and data be made available at an early stage of planning, and that major fish protection requirements be established during the planning stage prior to the granting of a water license. In short, the Fisheries Service must be involved in the early planning processes to assure a balanced development consistent with sound principles of aquatic environmental management.

The Fisheries Service also considers that it would be appropriate for the Yukon Territorial Water Board to investigate the possibility and desirability of developing mechanisms whereby various development agencies having large scale water utilization demands

would be required to submit their medium and long range development plans to the Board. This would enable the agencies represented on the Board to secure needed information before formal applications for water licenses are made, and might, in future, reduce the number of occasions when the Board had to defer decisions because of a lack of information. Most important, from our point of view, this procedure would ensure that adequate lead time is available in which to carry out essential impact studies.

II DESCRIPTION OF FISHERIES STUDY ACTIVITIES

The assessment and ultimate resolution of fisheries resource problems accruing from the installation of a hydro-electric development entails biological, engineering and socio-economic investigations.

The biological investigations within the affected watershed must be designed to measure the population size and distribution of all species of indigenous fish; to determine timing and behaviour of migratory species; to define critical rearing and spawning habitat requirements for all fish species; and to determine the food chain relationships for the indigenous species.

The engineering investigations are designed to identify and measure critical, limiting physical conditions in the watershed such as stream profiles, stream velocity barriers and unstable land forms; to determine the existing hydrological conditions; to define the altered hydrologic conditions which will prevail when the development becomes operational; to establish the need for fish protective facilities, such as intake screens and fishways; and, to prescribe design specifications for such facilities. Once the pre-development biological and engineering data has been gathered and interpreted and is compared, collated and integrated with the anticipated environmental changes brought on by the development,

assessments are made as to which fish stocks will be totally lost or partially reduced or impaired. At such time the need for remedial facilities can be determined and specified.

While the biological and engineering investigations are in progress, socio-economic studies are undertaken to assess the existing and potential utilization by man of the fisheries resources within the watershed. Such assessments include impact determination on both the recreational and commercial benefits to man before and after the development becomes a reality.

When the Aishihik hydro-electric proposal was brought to the attention of the Fisheries Service in October, 1971, the planning of fisheries studies was initiated. The actual field investigations incorporating all of the above mentioned considerations commenced in May and concluded in October, 1972. The nature of the investigations is detailed below.

1) Biological Studies

The biological investigations were conducted by two separate teams, one team examined the streams within the system and the other team conducted the lake investigations. A total of 550 man days of professional and technical personnel effort was expended in the field to gather the

biological information. This effort was equally divided between the lake and stream studies.

The stream studies entailed a combination of netting, trapping, observing and sport fishing operations on a total of nine streams including the East Aishihik River, the Canyon River and the Sekulmun (Link) River to ascertain the species composition, relative abundance and behavioral activities of fish. These stream locations are illustrated in Figure 3. Traps or nets were used to sample fish populations as conditions dictated, and, where all else failed, sport fishing gear was used. Tags were applied to fish in the Sekulmun River and Canyon pond between Aishihik and Canyon Lakes to assist in the identification of migration habits. Stream characteristics were quantified and related to the above information to gauge productivity.

The lake studies involved the gillnet sampling of fish from 29 stations in Aishihik Lake to determine species composition, age/length/weight relationships and diet through analysis of stomach contents (Figure 4a); dredge sampling of 38 stations in shallow zones of the lake to determine benthic invertebrate population and their relationship to fish diet (Figure 4b) and plankton sampling from a total of 37 stations (Figures 4a, 4c) to ascertain the productive significance of shallow bays as

compared to deeper positions of the lake. It was anticipated that the benthic and planktonic production in shallow areas of the lake might have a critical significance if the lake levels were altered from the natural state.

Traditional limnological determinations of temperature profiles, dissolved oxygen profiles, nutrient and heavy metal concentrations were obtained from 3 to 8 stations in the main lake (Figure 4c) depending on the parameter of measurement to establish which of these factors, if any, were limiting insofar as lake productivity is concerned.

2) Engineering Studies

The engineering field studies on the Aishihik River System included the following:

- (a) The Aishihik Lake shoreline study (Figure 5)
- (b) Limited stream surveys on Giltana Creek, Albert Creek, Sekulmun River and four major tributaries to Aishihik Lake. (Figures 6 and 7)
- (c) The sounding of Aishihik Lake (Figure 5)

A total of 150 man days of professional and technical personnel effort was expended on engineering surveys.

The shoreline study on Aishihik Lake established an inventory of shoreline conditions. This information will be used in connection with biological data to estimate changes in lake productivity and to establish the effect of storage and drawdown on shoreline, bays and low land.

The entire lakeshore was classified and related to twelve typical lakeshore study areas (Figure 5). These study areas were surveyed to 15 feet below and 15 feet above water surface and physical features such as sub strate composition, vegetation and soil conditions were described and catalogued.

The Aishihik Lake sounding program established underwater topography in water depths between 2 - 410 feet (Figure 5). A "Raytheon Model DE-719 Precision Survey Fathometer Depth Recorder" was used. The results of this survey allowed the selection of Lake sampling stations for the biological program.

The lower reaches of major tributary streams were surveyed and water surface profiles, cross sections and stream velocities obtained (Figure 6).

Together with biological stream survey data, the combined bio-engineering information will allow an assessment of the effect of reservoir changes on tributary streams, their habitat and fish populations.

3) Socio-Economic Studies

In addition to the Engineering and Biological studies, socio-economic studies have been completed to measure the socio-economic consequences of the Aishihik Power Development. This study makes use of data gathered in two ways. One was by the use of a mailed questionnaire and the other by shoreline enumeration. Two major reports using the above data will be published during the summer of 1973.

All data and information pertinent to the Aishihik waterways are contained in this socio-economic evaluation. From this information an estimation of the total angler days and total angler expenditures

on the Aishihik Lake area was obtained.

III RESULTS OF FISHERIES STUDIES

At this point it is appropriate to advise the Board that at the time of preparation of this report not all the biological and engineering data obtained during our surveys has been completely analyzed. We have however, subjected all data to a preliminary analysis and presented in the following paragraphs those observations which we are certain will not be substantially changed by the in-depth analysis which is now under way. We have also identified those areas where more information is necessary.

1) Stream Investigations:

Nine streams within the Aishihik River System were determined to be significantly important fish producers. These streams can be broadly classified into lake outlet streams which have a great fisheries value and lateral streams which have a much lesser importance. These streams are listed below.

Lake outlet streams:

East Aishihik River - flowing from Canyon Lake

Canyon River - flowing Aishihik Lake to Canyon Lake

Sekulmun or Link River - flowing from Sekulmun Lake to Aishihik Lake.

Lateral streams:

Giltana Creek - flowing into Canyon River

Lister Creek - flowing into Aishihik Lake

Creek A9 - flowing into Aishihik Lake

Albert Creek - flowing into Sekulmun Lake

Isaac Creek - flowing into Sekulmun Lake

Bear Creek - flowing into Sekulmun Lake.

The three lake-outlet streams are most important and contain complex ecological environments. The East Aishihik River is a 7.5 mile long high-gradient stream. Two falls preclude upstream migration of fish. Otter Falls is located at the outlet of Canyon Lake and Rainbow Falls is approximately 4 miles downstream. Chutes and cascades occur throughout and bedrock and boulder forms the stream base. A small lake measuring approximately $4\frac{1}{2}$ acres and commonly called Otter Pond, is located 2000 feet below the outlet of Canyon Lake and interrupts the rapid flow pattern of this stream. Rainbow trout is the dominant species in the 2000 feet of stream from Otter Falls (outlet of Canyon Lake) to Otter Pond. This trout population numbering perhaps 1,500 fish creates an attractive sport fishery. In Otter Pond round whitefish are most common. Longnose sucker and burbot are also present, Grayling are prevalent downstream of Otter Pond and some of this population of perhaps 3,000 fish are taken on sport gear.

Spawning populations have not been identified for any species nor have migration movements.

The Canyon River flows approximately 1.5 miles on a relatively moderate gradient. The stream bed is largely coarse gravel and small boulder. A pond slightly larger in area than Otter Pond lies approximately $\frac{1}{3}$ of the distance from Aishihik Lake to Canyon Lake. A tributary stream, Giltana Creek, quite different in some physical and chemical properties from the outlet stream of Aishihik Lake, enters the pond near the outlet and this results in a complex biological environment downstream of this point.

Grayling numbering perhaps several thousand are present throughout but are most concentrated in or adjacent to pond and pool areas. The species provides good sport fishing. Humpback and round whitefish occupy Canyon Pond. Round whitefish are found in pond and stream areas depending upon stage of sexual maturity. Longnose suckers are dominant in pond waters within

the influence of Giltana Creek in June.

Populations of sexually mature longnose suckers and round whitefish appear in June and September respectively. Precise spawning areas are unknown, however, intra-stream movements between stream and pond waters occur dependent upon feeding opportunities and stage of sexual maturity. There is no evidence of migrations to or from Canyon Lake or Aishihik Lake and Canyon River.

The Sekulmun River measures 5 miles in length and has a relatively low gradient (Figure 6). The upper 2 miles is a combination of broad and narrow riffle with coarse to fine gravel. The lower part is largely pool with a mud base. The stream is connected to adjacent ponds and small lakes. Outflows from ponds and groundwater create a complex temperature regime.

The fish species composition is diverse. Grayling are seen most commonly in the riffle area and round whitefish frequent the areas intermediate of pool and riffle. Humpback whitefish appear to prefer the pool areas. Lake trout, pike and burbot are also present. The size composition of fish ranges from the very young to large adults. One grayling tagged in Sekulmun River was recovered in Albert Creek suggesting migratory activity. The natives report that fish move through the stream seasonally. Spawning areas are not identified but the sampling of sexually mature individuals and of newly emerged juveniles indicate that spawning does occur. The high abundance of young demonstrates that Sekulmun River serves as a nursery area.

The lateral streams are all similar in that the lower part flows on a delta where gradient and velocity are low (Figures 6 and 7), sand and fines predominate

and grass banks exist. The delta areas serve as feeding areas for immature fish and possibly as spawning areas for grayling and round whitefish. Above the delta, the gradient is steep; "white" water rapids, cascades and shutes prevail. The bottom is usually boulder or coarse material at the best. The productive value of this type of habitat is believed to be low. The upper parts of the stream are situated in alpine meadow where gradients and velocities are low to moderate, and pools and broad riffle prevail. Grayling are more frequently observed here than in the delta and high velocity areas. Some spawning occurs here and feeding is a principal activity. Spawning areas are not identified.

It is clear from the above information that the size of fish populations in the Sekulmun River and the lateral streams has yet to be determined by further study. The same can be said for size and distribution of spawning populations in these streams.

2) Aishihik Lake Investigations:

Aishihik Lake is the largest of the three lakes in the Aishihik River System, has an area of 58 sq. miles and is approximately 36.6 miles long. It is a narrow, deep lake throughout (mean depth 108 feet) with the exception of the extreme northern and southern ends and some of the lateral bays which are quite shallow. The depth contours as determined from engineering investigations are illustrated in Figure 5.

The gill netting program conducted on the lake was highly successful and has provided valuable information on fish species, diet and rate of fish growth. (Figure 4a)

The humpback whitefish, Coregonus clupeaformis, were by far the most abundant fish species in the lake and were taken at all stations throughout the summer. The gill nets appeared selective for the six to eight year classes. The weight of 90 fish sampled randomly within these age classes, ranged from $1\frac{1}{4}$ to $1\frac{1}{2}$ pounds; lengths varied from 14 to 15 inches. Adult whitefish are primarily bottom feeders. Stomach analyses indicated that these fish consume a variety of organisms including snails, clams, fish, plankton, and adult and juvenile insects. Juvenile whitefish feed initially on zoo-plankton, then change to benthic organisms.

Lake trout, Salvelinus namaycush, were also caught at most net stations. The majority of those captured belonged to the 7, 8 and 9 year classes. The fish ranged from $1\frac{3}{4}$ to $2\frac{1}{2}$ lb. in weight and from $16\frac{1}{2}$ to $18\frac{1}{2}$ inches in length. The sample size in this case was 55. Adult trout fed primarily on other fish and adult insects, however, snails, plankton and terrestrial rodents also formed a large part of their diet. Immature lake trout remain in shallow water along the lake shores for several years before moving to deeper water. As juveniles they depend on aerial insects and benthic organisms for their energy supply.

Round whitefish, Prosopium cylindraceum, were caught throughout the lake in small numbers. These fish are thought to prefer shallow water lake zones and streams, where they feed largely on benthic organisms.

Only a small number of Arctic grayling, Thymallus arcticus, were captured in the gill nets. This is probably due to the fact that grayling are less numerous and the gill nets were not set in shallow water near stream mouths where grayling are more prevalent. These fish feed primarily on insect drift but some stomachs

contained a few snails and zoo-plankton.

Other miscellaneous fish captured in the nets were burbot, Lota lota, northern pike, Esox lucius, longnose sucker, Catostomus catostomus. These presented only incidental catches.

Bottom samples were collected from 38 stations during the summer. Collections at twelve main sites were from depths of 2, 5, 10 and 15 feet. (Figure 4b) The data indicates that the abundance of benthos increases with depth within the sample range. Numbers of organisms for the two and five foot samples ranged from 0 to 42. The ten and fifteen foot sample numbers ranged from 2 to 130. Limited dredging at thirty feet showed a decline in numbers suggesting that with present lake levels the maximum numbers of bottom organisms occur at depths of 5 to 25 feet. As discussed previously, the benthos forms a significant part of the diet of Aishihik Lake fish.

Lake productivity was studied throughout the summer by recording the abundance of phyto- and zoo-plankton. (Figures 4a, c) Primary production in the lake appears to be extremely low as witnessed by the limited numbers of algae collected. Zoo-plankters were also relatively few in number and appeared uniformly distributed throughout the trophogenic zone of the lake. The wind action, cool temperatures and resulting mixing of the lake waters appear to have prevented the establishment of localized areas of high primary and secondary plankton production.

The lake is usually ice covered from October to early June and, if 1972 was typical, is subject to almost constant wind action either from a northerly or southerly direction. These two factors in combination with the relatively cool summer temperatures prevalent in the

area impair the warming of the surface waters. Average summer temperature readings for the top twenty feet from the two extreme northern stations was 51.3°F , 47.5°F for the three central stations and 47.1°F for the three southern stations (Figure 4c). At this point in time we can only speculate on the reasons for the significantly warmer temperatures in the northern stations. There was no evidence of the presence of the classic lake stratification situation.

The 1972 water quality measurements reflected pristine conditions prevalent in an undisturbed environment. Dissolved oxygen was copious throughout the water columns. Average saturation levels on June 21, 1971 ranged from 99.9% at the surface to 86.2% at a depth of 98.4 feet. The pH of the lake was slightly on the alkaline side with average surface readings of 8.5 which is not unexpected in a moderately dry climate.

Nutrient analyses of lake water in June and August revealed total phosphate and nitrate values of less than 0.01 and 0.10 mg/l respectively. Solids and mineral content of waters were also studied. The filterable residue of water from three lake stations ranged from 50.3 to 99.1 mg/l. Specific conductivity ranged from 85.3 to 94.2 micro mhos. These low measurements of dissolved matter are indicative of a low level of productivity.

Lake transparency was measured with a secchi disc on three occasions. Stations at the northern and southern extremities of the lake were too shallow to obtain a reading as the bottom was clearly visible from the boat. Average secchi disc readings for main lake stations two to six ranged from 19.7 feet to 29.5 feet. These values are indicative of very clear water.

It is apparent from our netting experience that humpback whitefish are very abundant in Aishihik Lake. This may be a reflection on the fact that no commercial fishing has taken place since 1968.

It is also very clear that Aishihik Lake is a very unproductive oligotrophic lake and that snails and insects present in the margins of the lake form the largest part of the diet of whitefish and lake trout. Contrary to first impressions, the relationships between this food supply and the upper fifteen feet of these shoreline zones are not clearly understood. As a result, it is not possible to deduce which operating levels for the Aishihik Reservoir are most desirable. The 1973 lake investigations will concentrate solely on the biological significance of the shoreline areas to fish production so that we can indicate to the Board which operating levels are optimum.

3) Economic and Social Assessment

From a fisheries management point of view there are three primary factors to be considered when evaluating the social and economic consequences of the Aishihik power development. These are, in turn:

1. The losses associated with a dissipation or total elimination of the Aishihik sport fishery,
2. The social and economic costs associated with dissipation or elimination of the fishery as it pertains to Indian subsistence fisheries and,
3. The loss of commercial fishing potential in the Aishihik waterways.

The Sport Fishery

A true measure of the negative socio-economic impact of the Aishihik power development depends upon (1) the extent to which the number of visitors to the Yukon declines or their length of stay is reduced because of a partial or complete loss of the sport fishery and (2) the degree to which the development reduces the fishing enjoyment of the resident sport fisherman. Since precise measurement of these two factors depends significantly on data which are not available and would take considerable time to obtain, reasonable assumptions have to be made on the basis of existing knowledge. This is possible because of a recent study carried out by the Fisheries Service on sport fishing in the Yukon and because supplementary information on the Aishihik Lake area was gathered during the summer of 1972.

Turning first to the problem of estimating the development's effect on visiting fishermen, Table I provides the reader with the number of angler-days on each of nine major sport fishery locations for the period May 23 to August 15 in 1972. According to Table I, Canyon Lake and Otter Falls ranked fourth in terms of total fishing effort during the summer of 1972. Aishihik Lake proper ranked sixth. When Canyon Lake and Otter Falls, Aishihik Lake and Aishihik River are added together, then their ranking becomes second in terms of total fishing effort. These data are however, subject to considerable sampling error. The data gathered for the Aishihik Lake area was obtained by Fisheries personnel working on biological surveys during the summer of 1972. Personnel were present at the Aishihik Lake area 24 hours a day throughout the entire summer period. The information presented on the other areas was gathered sporadically throughout the summer and therefore, it cannot be considered as accurate as the information on the

TABLE 1
NUMBER OF ANGLER-DAYS AT SURVEYED YUKON LAKES
MAY 23 - AUGUST 15, 1972*

	<u>Angler-Days</u>			<u>Rank</u>
	<u>Week-Days</u>	<u>Week-end Days</u>	<u>Total Days</u>	
Teslin Lake	793	144	937	1
Tagish Lake	427	400	827	2
Kathleen Lake	468	240	708	3
Aishihik River, Canyon Lake & Otter Falls	336	208	544	4
Little Atlin Lake	244	120	364	5
Aishihik Lake	223	137	360	6
Marsh Lake	195	120	315	7
Fox Lake	278	24	302	8
Lake Laberge	195	-- ¹	195	9
Dezadeash Lake	71	0	71	10
TOTAL	<u>3,230</u>	<u>1,393</u>	<u>4,623</u>	

1. Not surveyed.

* These data are based on shoreline surveys conducted during the summer of 1972.

Aishihik Lake area. Thus, the Aishihik Lake area data, of all the data presented in Table 1, are likely to be most accurate.

Table 2 provides the estimated number of angler-days for the nine major fishing locations shown in Table 1 by licence category for 1971.¹ The data presented in Table 2 are based on a five percent sample of fishermen purchasing fishing licences during the 1970-71 fiscal year. Thus, these data are more likely to be accurate than the data presented in Table 1. It is therefore significant that the data presented for the Aishihik Lake area in Table 2 compares favourably with the data presented in Table 1. However, for all other waterways there is considerable discrepancy in the estimated fishing effort. The data collected by random sample differs in both magnitude and direction from the data collected in the less accurate shoreline survey method. It does therefore seem reasonable to accept the data presented in Table 2 as an accurate indication of the total fishing effort on each of the waterways shown. Moreover, it points to the fallacy of only concentrating on one waterway when attempting to determine the relative importance of a particular sport fishery. According to Table 2, the Aishihik sport fishery ranks 8, but unlike the other major sport fishing locations it caters to all categories of sport fishermen, resident and non-resident alike.

In addition to information on total fishing effort expended by sport fishermen on each major Yukon waterway, data were also collected on the average expenditure by sport fishermen visiting the Yukon from the five percent sample survey. It was determined that non-Canadian short-term sport fishermen spent \$52.60 per day

1. A Socio-Economic Study of Sport Fishing in the Yukon, a report to be published by the Economics Unit, Northern Operations Branch, Fisheries Service, Spring, 1973.

TABLE 2

ESTIMATED NUMBER OF ANGLER-DAYS ON POPULAR WATERWAYS

BY LICENCE CATEGORY, YUKON TERRITORY, 1971³

	<u>Resident</u>	<u>Non-Resident Canadian</u>	<u>Non-Canadian Short-Term</u>	<u>Non-Canadian Full-Term</u>	<u>Total</u>	<u>Rank</u>
Teslin Lake	480	140	499	619	1,738	5
Tagish Lake	2,020	160	540	340	3,060	2
Kathleen Lake ¹	1,940	80	440	320	2,780	3
Aishihik Lake ²	480	20	360	220	1,080	8
Little Atlin Lake	2,280	40	-	-	2,320	4
Marsh Lake	2,880	100	140	-	3,120	1
Fox Lake	1,320	80	120	100	1,620	6
Lake Laberge	1,040	-	350	-	1,390	7
Dezadeash Lake	480	40	-	-	520	9

1. Includes Kathleen River.

2. Includes Aishihik River, Otter Falls and Canyon Lake.

3. This information is based on A Socio-Economic Study of Sport Fishing in the Yukon, a report to be published by the Economics Unit, Northern Operations Branch, Fisheries Service, Spring, 1973.

while visiting the Yukon. Non-Canadian full-term sport fishermen spent \$67.18 each day while in the Yukon Territory.² From this information and the knowledge that it would take at least one additional day in the Yukon to participate in a sport fishery which is removed from the main highway and considerable distance from the populated centres, the total non-resident expenditures attributable to the Aishihik Lake area fishery can be estimated.

Table 3 provides a breakdown of expenditure by fishing licence category for the year 1971. This table shows that a total of \$41,000 was expended by fishermen fishing Aishihik Lake area during 1971. Of this total only \$28,900 can be said to represent a net contribution to the Yukon economy as a result of the Aishihik Lake area sport fishery. It has to be assumed that the \$12,200 spent by resident fishermen would have been spent elsewhere in the Territory even if the Aishihik Lake area sport fishery did not exist.

Although it is impossible to determine the precise amount of expenditures by resident sport fishermen as a result of the Aishihik Lake area sport fishery, the possible loss to resident sport fishermen as a result of the Aishihik power development cannot be ignored. The Aishihik Lake area sport fishery is highly regarded by resident sport fishermen. The area's proximity to the populated centres of the Yukon makes it ideally suited for outdoor recreational excursions during the summer months. The scenic beauty of the area together with the notoriety of Otter Falls has created a situation whereby residents of the Yukon

2. A Socio-Economic Study of Sport Fishing in the Yukon
(noted above).

TABLE 3

ESTIMATED EXPENDITURE¹ BY ANGLERS ACCORDING TO LICENCE CATEGORYAISHIHIK, 1971

	<u>Resident</u>	<u>Non-Resident Canadian</u>	<u>Non-Canadian Short-Term</u>	<u>Non-Canadian Full-Term</u>	<u>Total</u>
	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>	<u>\$</u>
Aishihik Lake, Canyon Lake	4,600	-	-	6,300	10,900
Aishihik River	3,500	1,300	2,100	-	6,900
Otter Falls	4,100	-	16,800	2,400	23,300
TOTAL AISHIHIK	<u>12,200</u>	<u>1,300</u>	<u>18,900</u>	<u>8,700</u>	<u>41,100</u>

1. Expenditure estimates based on data presented in A Socio-Economic Study of Sport Fishing in The Yukon, a report to be published by the Economics Unit, Northern Operations Branch, Fisheries Service, in the spring of 1973.

point to this area with considerable pride. Therefore, even if the scenic beauty of the area is not altered significantly because of the power development, the psychological impact of the development itself would also probably detract from the quality of the outdoor recreational experience especially among those residents who are familiar with the area's natural condition today. Therefore, even though it is difficult to determine the magnitude of the loss, Yukon residents will incur some fishery related losses because of the power development. Moreover, these losses probably will be greater and more difficult to offset than the losses which will occur because of decreased non-resident fishing activity in the area.

Thus, it can be seen from the foregoing discussion that the Aishihik Lake and associated waterways provide a relatively important sport fishery for residents and non-residents alike. The net economic loss potential to the Yukon economy because of elimination of the Aishihik River System non-resident sport fishery would amount to approximately \$30,000 per annum. It is impossible to provide a precise estimate on the losses which would occur because of a demise in the resident sport fishery in the same area. However, as suggested above, the possible loss would probably be more than the \$30,000 per annum estimate developed for the non-resident sport fishery.

To put this in perspective, it should be remembered that tourism is the fastest growing sector of the territorial economy, and promises to rival the mining industry by the end of the decade.³ Good quality

3. Stated at a presentation made by Rod H. Thompson, Assistant General Manager, Travel Industry Association of Canada, at Northern Resources Conference held in Whitehorse, Yukon in April, 1972.

fishing is one of the factors which attracts many visitors to the Yukon each year. A recent survey of sport fishermen indicates that of the \$10 million provided by tourism to the Yukon in 1971, one-tenth (\$1 million) of this amount was spent by visitors who fished at least on one or more days during their stay.⁴ Since there is no reason to believe that the growth in tourism and in fishing effort will not continue at its present rate, it may be assumed that sport fishing's contribution to the economy of the Territory will continue to grow, and its value increase, in future. The data presented above show that the Aishihik River System sport fishery is a significant part of the total Yukon sport fishery which in turn helps to maintain and enhance the territorial tourist industry.

It is important to note that despite the undeniable fact that the power development may in itself attract some visitors to the area on sight-seeing excursions, social and economic losses will occur nonetheless. Dams are not unique to the Yukon as certain species of fish are to the north and it cannot be assumed that expenditures of the same magnitude will be made either by residents or by non-residents merely to view a power development. The act of fishing requires certain expenditure commitments such as a licence purchase or fishing equipment. It would be extremely difficult to argue that expenditures of this sort are made to visit a power development or some such related developments. Maintenance of existing fish stocks would seem particularly important in locations around the Aishihik River System. Kluane National Park will attract many thousands of visitors all of whom will be interested in the natural setting of the area and presumably in its wildlife habitants. The Aishihik River System in terms of ease of access and convenience is one of a few locations ideally suited to

4. A Socio-Economic Study of Sport Fishing in the Yukon
(noted above)

provide quality fishing for the sport fishermen visiting Kluane National Park.

The Subsistence Fishery

In addition to the contribution made by the Aishihik River System fishery to the sport fishing and tourist industry of the Yukon economy, the fishery also provides social and economic benefits to the Indians living in the general area. For instance, the Aishihik village, located in the area, is isolated from the main highway system and from the more populated centre of Whitehorse because there is no suitable road connecting the village to the outside world. Thus, to residents of the Aishihik village, the fish population of the Aishihik area waterways provides a year-round readily available food supply. Thus, fish to the people of the village is extremely important particularly in the winter when their only means of transportation to the outside world is by dog team or when other sources of income such as animal trapping is poor.

In addition to supplementing the local Indians' diet, fish caught by them are also used to feed their dogs. Since the only economic means of transportation during the winter is, in many cases by dog team, it would seem that fish used for this purpose is essential to the welfare of the Indian people.

To fully appreciate the importance of fishing to the people of the Aishihik village and surrounding area, it is essential to remember that fishing, particularly to the Indians of the north, has always been an important food source and supplement to their incomes. Indians living in the area, like Indians living

ing elsewhere in Canada, are tied to the wildlife resources in the areas where they reside. In the isolated areas of the north this is still true today and from our investigations this summer, it would appear to be true for Indians living in the Aishihik area. Moreover, it may be the case that the resource and its concomitant activities such as sport fishing and tourism may provide opportunities to improve the living and economic condition of the Indian population in future.

Existing economic theory does not permit proper quantification of the importance of the subsistence fishery to the people of the Aishihik village. However, it is apparent that there have existed strong historical links between village residents and the Aishihik fishery. So, even though their dependence upon the fishery perhaps is not as strong as it was historically, this resource still contributes to the villagers' economic and social well-being. This should be taken into account before embarking on any development which might detract from the quality of the fishery as it exists today.

The Commercial Fishery

From a commercial fish point of view, fish populations in the Aishihik River System have very little value at the present time. No commercial fishing has taken place on Aishihik Lake or its surrounding waterways since 1968.

The commercial quota was eliminated at that time because it was deemed desirable at the local level to reserve the area for recreational fishing. This decision has since been recinded. Rising meat prices in the market-place and a world shortage in protein products suggest that the Aishihik River System

and other areas where fish are available in similar abundance may have considerable commercial value in future. This is one other factor which makes it important that proper provision be made for existing fish populations of the area.

IV EFFECT OF POWER PROJECT ON FISHERIES

1) Tributary Streams and River

(a) Tributary Streams (Figures 3, 6 and 7)

Preliminary study of water surface profiles and cross sections in the summer of 1972 indicates that drawdown of Aishihik Lake would result in stream bank sloughing, riverbed scouring and hydraulic changes in the lower reaches of tributary stream channels. These changes may result in unfavourable fish passage or spawning conditions. Furthermore, it is highly likely that delta areas would lose their value in stock maintenance.

Raising the water level in Aishihik Lake will result in inundation of whole or part of the tributary stream deltas. This action will result in the loss of some potential spawning area but feeding opportunities may remain to some degree and lake delta spawning areas should remain intact. In other words, at this stage of knowledge, flooding appears to be less deleterious than drawdown.

Studies should be undertaken in 1973 to determine to what degree tributary stream erosion will occur under various conditions of lake drawdown and, if required, to develop the type of stream channel stabilization needed to protect important fish producing streams.

(b) Sekulmun River (Figures 3 and 6)

The Sekulmun River is the most important stream in the Aishihik River System insofar as fish are concerned. In addition to being a migrational route between Aishihik and Sekulmun Lakes, the river contains the widest variety of fish species, with size composition ranging from very young to mature adults. In terms of populations density and variety, as well as in respect to dependency throughout life cycles, the Sekulmun River is considered to be a very sensitive and critical area.

The Sekulmun River traverses a terminal moraine created by the last glacial advance. The moraine is composed of unconsolidated material such as clay, silt, sand and a few boulders, all of which are quite susceptible to erosion by the action of water. The river drops approximately 3 feet in its overall length of 5 miles, with most of this occurring in the upper one mile. The riverbed in this section is composed of relatively fine gravel. In the lower 4 miles the river changes to a meandering, gently sloping stream, controlled to a large extent by the level of Aishihik Lake. The riverbed in this section is characterized by fine sand and silt and has an established growth of aquatic vegetation over much of its length. Under the present flow regime, erosion of the riverbed is probably quite limited in the lower reaches.

With the loss of supporting backwater in the lower reaches of Sekulmun River in the event of drawdown of Aishihik Lake, increased river gradient and water velocity would occur. Since the maximum annual drawdown of Aishihik Lake

would almost coincide with the peak annual discharge in Sekulmun River, severe scouring and degradation of the entire river channel could be expected. Over the long term, substantial lowering of Sekulmun Lake could also be anticipated.

Furthermore, it can be expected that lowering Aishihik Lake will decrease pool volume and increase riffle area in the Sekulmun River. These conditions, providing they are not too extreme, will favour some species such as grayling. On the other hand, raising the water level will favour the production of lake and pool preferring species such as pike and lake whitefish. In other words, the present stock composition in the stream can be expected to change very significantly under prolonged drawdown or flooding regimes.

Assuming that the Sekulmun River channel will not be stable under conditions of drawdown, measures will be required to artificially stabilize the channel in such a way that:

1. fish access from Aishihik Lake to Sekulmun Lake can be maintained,
2. fish spawning and rearing habitats are not destroyed.

The Fisheries Service will continue fish composition and distribution studies in Sekulmun River in 1973 in order to obtain a better understanding of the requirements of each species.

Field tests should be initiated in 1973 to determine the degree to which erosion may be expected to occur in the Sekulmun River at times of drawdown in Aishihik Lake and to develop the type of

treatment required to protect the fish habitats of Sekulmun Lake and River.

(c) Canyon River and Canyon Pond

The second important stream in the Aishihik River System is Canyon River and Canyon Pond connecting Aishihik Lake and Canyon Lake.

The cessation of flows at any time from Aishihik Lake would make Canyon Pond and the stream below dependent upon Giltana Creek as the only source of supply. Giltana Creek lacks the discharge to compensate for the loss of Aishihik Lake flow and, therefore, a decrease in water level throughout the pond and stream area will occur. Also, because there are considerable differences in chemical properties between Aishihik and Giltana outflows, the whole ecology of the area will change. Furthermore, spawning areas which may lie upstream of Canyon Pond will be inaccessible. Food and oxygen supplies will be eliminated or significantly reduced to pool residents with serious effect. Shutting off water from Aishihik Lake could be expected to result in severe adverse effects on those populations of grayling, whitefish and suckers which are dependent upon Canyon River and Canyon Pond for completion of their life cycles. Therefore, continuous discharge from Aishihik Lake is prerequisite to the preservation of fish stocks in this area. Although migrations between Aishihik Lake and Canyon Lake have not been determined, it is possible that some provision for such movement may be required in the storage dam.

(d) Otter Pond and East Aishihik River (Figure 9)

The discontinuance of flow from Canyon Lake at any time will destroy populations of rainbow trout, grayling and whitefish in Otter Pond and the East Aishihik River. Releases of summer flows to satisfy aesthetic needs in respect to Otter Falls will not ensure the maintenance of viable fish populations in Otter Pond and the East Aishihik River.

The East Aishihik River below the powerhouse will be in a vulnerable position during powerhouse shutdowns when some sections of the river are liable to become completely dried up unless compensatory flow is released from the reservoir. When shutdown of powerhouse or control structures is planned, the cutback to compensatory flow must be made in stages in order to allow adequate time for fish to move into deeper water if necessary.

2) Lakes

(a) Aishihik Lake (Figure 1, 2 and 5)

One of the major requirements for economic power production on the Aishihik River System is the storage of peak flows in the Aishihik Lake reservoir for use during periods of low flow. Under these conditions the magnitude of annual lake fluctuations would increase and the timing of these fluctuations would differ from those occurring naturally. These changes could have a significant impact on lake productivity, fish species composition and survival, and fisheries habitat in the affected lower reaches of tributary streams. A brief discussion of the expected cause-effect relationship follows.

Lake productivity is the result of many factors which in turn are linked together in a complex way. In general terms these factors can be considered in three groups:

- Morphometric factors - size and shape of the lake basin.
- Edaphic factors - the bio-chemical aspects of water and nutrient supply.
- Climatic factors.

It has been found in many lake studies that the shallow submerged lake shoreline and shallow river deltas are the most productive areas within a lake and are most influenced by morphometric, edaphic and climatic conditions. These shallow areas lie within the photic zone (the zone of light penetration and biological production) and receive a high supply of nutrients. It is here that plant growth and benthic animal communities are found; both are vital links in the aquatic food web.

Aishihik Lake is a deep lake with steep slopes and a narrow shoreline (littoral zone). Loss of submerged shoreline or the temporary exposure of part of it during the winter months would render this area sterile and unproductive, thus curtailing overall lake productivity and reducing those fish stocks that depend on the littoral zone for their food supply.

Preliminary analysis of the 1972 Aishihik Lake survey data indicates that the problem may not be as critical as initially assumed, in which case some limited drawdown could be tolerated. It appears now that maximum production of organisms found in the submerged shoreline of

Aishihik Lake occurs at depths of up to 25 feet and is somewhat deeper than originally assumed. However, further field studies and a computer analysis of collected data will be required before any firm conclusions can be drawn.

Spawning, egg incubation and fry emergence are critical phases in the life cycles of fishes. Each species has become adapted over a long time period to certain characteristics of its environment. Adverse environmental changes brought about by hydro-electric development could virtually eliminate certain species. This is particularly true if rate and timing of lake drawdown coincide with the spawning and incubation periods resulting in the loss of spawning grounds or in the exposure and consequent loss of spawn.

An attempt was made to relate lake variations with fish spawning and incubation by superimposing natural and projected lake levels on the time and depth of whitefish spawning (Figure 8a, 8b, 8c). These illustrations are based on textbook information and observations in other watersheds and should be considered as hypothetical until further studies on Aishihik Lake confirm the location, depth and timing of spawning. Figures 8a, 8b and 8c assume that whitefish spawn and their eggs incubate on the bottom, 1.5 to 5 feet below the water surface, from September to March.

Based on these assumptions, it is indicated that under regulated reservoir conditions, a significant loss of spawn and subsequent reduction of fish productivity could be expected. It should be noted that not all species would be affected in the same way since timing and locations of spawn-

ing varies among species.

(b) Canyon Lake and Power Canal

The same arguments presented in connection with Aishihik Lake also apply to Canyon Lake, except that the lack of tributary streams and delta areas makes Canyon Lake somewhat less vulnerable to drawdown conditions.

The most important fish producing area within the Canyon Lake basin is Canyon River and Canyon Pond which is dealt with in Section (1c) and where it is concluded that the preservation of Canyon Pond and its environment is important from a fisheries point of view. Future storage on Canyon Lake should be kept in a range below Canyon Pond elevation so that Canyon Pond is not flooded out at any time of the operating cycle.

The power canal and intake structure on the southern end of Canyon Lake will present fisheries problems but their exact nature and magnitude can not be predicted with certainty at this time. The power canal will attract fish and those passing through the powerhouse will be lost. Fish entering the power canal may be prevented from returning to Canyon Lake by the hydraulic conditions in the canal intake structure and these will also be lost. In designing the structure consideration must be given to fish passage. Other remedial measures may have to be developed in the future when the project is in operation and fisheries problems can be identified.

V CONCLUSIONS AND RECOMMENDATIONS

The recreational fishery of the Aishihik River System contributes significantly to the total recreational fishery in the Yukon Territory. With the development of Kluane National Park and the attendant influx of tourists that can be anticipated, the value of this fishery can be expected to increase substantially. The Yukon Territorial Water Board in its adjudication of the water licence application by the Northern Canada Power Commission should recognize the potentially large recreational demands which will be placed on this and other watersheds in the near future. Recognition of this demand should ensure that the ultimate decisions of the Board will not detract from this potential and that the options open to developing this fishery are not restricted by these decisions. It follows that protection of the recreational fishery will also benefit the subsistence and commercial fisheries.

In recognition of the large fishery values that this watershed affords, the Fisheries Service has the following recommendations to offer to the Board concerning the maintenance of a productive aquatic environment while at the same time enabling the hydroelectric development to proceed.

1) Drawdown of Aishihik Lake could lead to major stream bed erosion and river deterioration with extremely serious consequences to the fishery resource in the Sekulmun River and other tributaries to Aishihik Lake and Sekulmun Lake. It is requested that this problem be fully examined by soil consultants and engineers. Fish producing streams which may become unstable under a drawdown regime should be stabilized in such a way that:

- (a) fish access is maintained at all times and at all lake elevations;

- (b) fish spawning habitats and rearing habitats are not destroyed or lost.

No drawdown of Aishihik Lake should be permitted until the above conditions are met.

2) The grayling population residing in Canyon River and Canyon Pond between Aishihik Lake and Canyon Lake is considered to be very valuable. This population would be destroyed if a cessation of flows were to occur. The magnitude and uniqueness of this population is such that direct compensation for such a loss is not possible. Consequently, the Fisheries Service recommends that, in the event of a powerhouse shutdown and resultant shutdown of the proposed Aishihik Lake control structure for any period of time, fisheries flow releases be made into Canyon River which would equal minimum computed or recorded natural outflows for the same time of year.

3) It is evident that fish populations resident in the East Aishihik River between Otter Falls and the powerhouse tailrace will ultimately be destroyed if the power proposal becomes a reality. Compensation for these fish losses for the life of the project by the Northern Canada Power Commission is acceptable to the Fisheries Service. The optimum form of this compensation is yet to be determined but it could include the provision and maintenance of hatchery facilities, the planting of fish in alternate watersheds or the permanent establishment of similar fish stocks in alternative watersheds. Without the provision of such compensation, the basic fisheries resource would, in effect, be used to subsidize the power development.

4) The final storage range selected for the Aishihik Lake reservoir must be compatible with preservation of the aquatic environment and maintenance of the fisheries resource. The 1972 studies indicate that the 8 - 10

foot storage range required under the original power proposal would not be overly harmful to the fisheries, provided that the combination of drawdown and storage around the present mean lake level is carefully selected. From a fisheries point of view, a storage range in excess of 10 feet is very undesirable, and one in excess of 12 feet is not acceptable.

At the present stage of studies, the Fisheries Service cannot recommend how this storage range should be manipulated. It is evident, however, that a disproportionally large drawdown would cause excessive scouring in delta areas, destroy Sekulmun River as a fish producing habitat and possibly substantially lower the level of Sekulmun Lake, impair productivity in the lakes of the system, interfere with fish migration between lakes and streams and probably affect spawning adversely. It is because of these impacts that the Fisheries Service favours storage rather than drawdown. However, before the optimum operating levels around the mean lake level can be determined, more information must be obtained.

5) The Fisheries Service requests that construction of the proposed Aishihik Lake control structure be postponed for one year so that studies can be continued in 1973 under natural lake conditions. If, however, the Board considers that such a deferment is not desirable, the Fisheries Service recommends that approval for storage on Aishihik Lake be confined to the first stage of the development for the present time. The required storage for the first stage of the proposal is estimated to be 5 - 6 feet. The Fisheries Service further recommends that within this 5 or 6 foot range the bulk of this should be top storage so that stream

erosion and delta scouring can be studied and necessary remedial work can be determined. Remedial work would of necessity have to be undertaken prior to any drawdown of Aishihik Lake.

It is also recommended that operating rule curves for all phases of the development be subject to the approval and surveillance of the Board.

6) Fisheries problems associated with the diversion of water from Stevens Creek and Long Creek have not been investigated by the Fisheries Service in 1972. It is recommended that any portion of a water licence dealing with the diversion of water from other watersheds be held in abeyance until necessary investigations have been completed. It is anticipated that appropriate studies will be initiated by the Fisheries Service.

7) The Fisheries Service does not object to the commencement of construction of the powerhouse, the water intake structure including the power canal and the control structure at the outlet of Canyon Lake providing, of course, that the Northern Canada Power Commission is committed to the provision of compensation for the loss of fish stocks below Otter Falls. However, construction activities must be controlled in a manner which will assure that:

- (a) sand and gravel used in construction are not obtained from water courses without prior approval of the Fisheries Service,
- (b) spoil is not placed in water courses or located in such a manner that it will be eroded or slough into water courses.

- (c) sediments from gravel washing operations or other construction activities are collected in settling ponds before wash water is discharged back to source,
- (d) stream channel relocations are not made without the prior approval of the Fisheries Service,
- (e) waste construction material, land clearing debris and camp garbage are not deposited in water courses,
- (f) water intake screens for domestic and construction water supplies are provided in accordance with specifications provided in the Fisheries Service brief of May, 1972; and
- (g) stream crossings for haul roads are culverted and bridged in accordance with Fisheries Service requirements. Fording areas must be reinforced with rock and gravel to prevent the breakdown of streambanks and associated stream siltations.

8) Construction and operation of control structures should be such that downstream fisheries flows are maintained during construction of these structures and once completed, that all future operational flow changes are made in gradual stages allowing adequate time for fish to move into deeper water.

9) It is recommended that the developer and his consultant be directed by the Board to collaborate with the Fisheries Service when designing those structures which affect fisheries, i.e. power canal, intake structure, lake control structures, stabilization of tributaries and stabilization of the Sekulmun River.

It is apparent from the preceding discussions that the lack of certain information prevents the Fisheries Service from making more specific recommendations. These information gaps are:

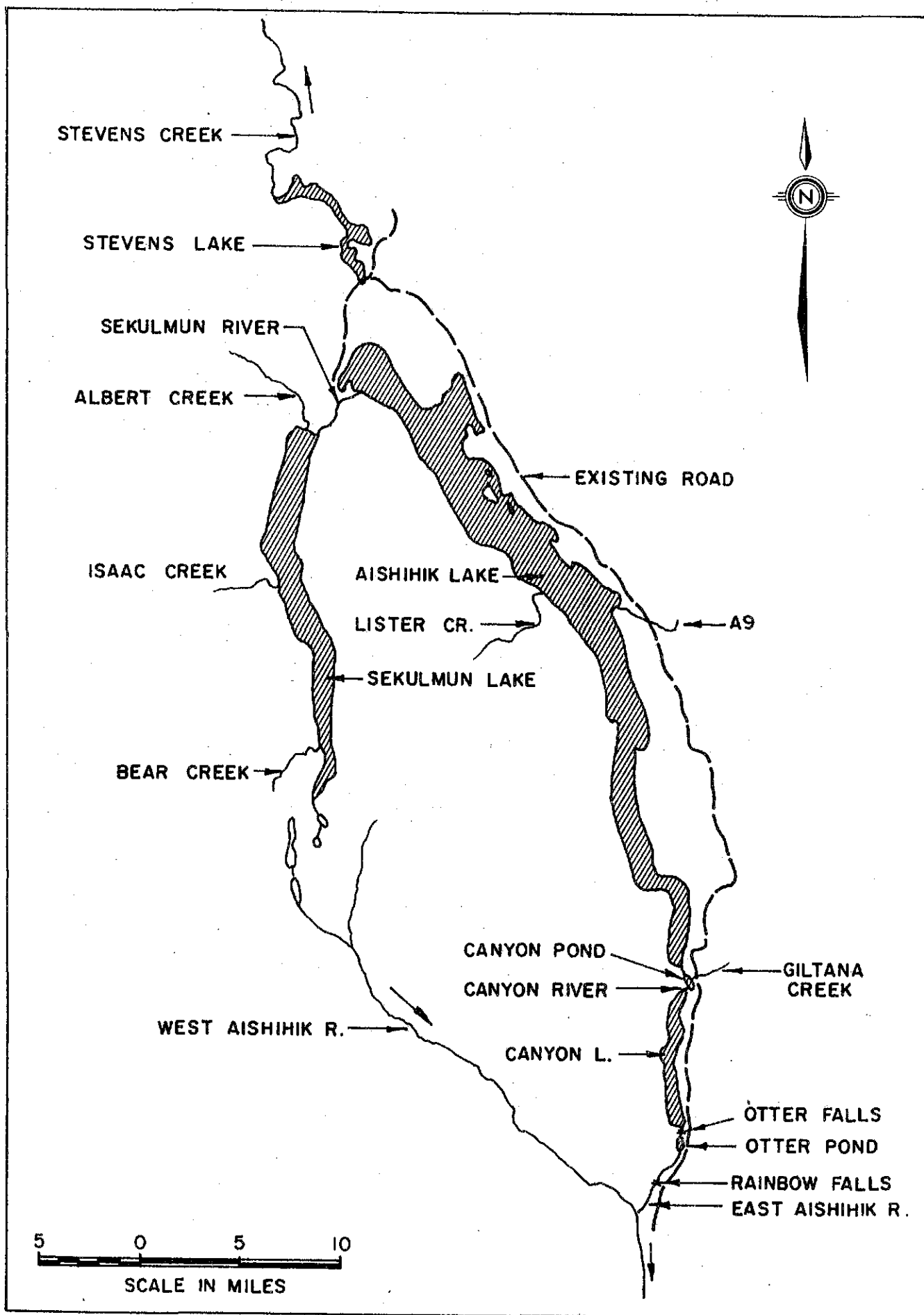
- (a) Size and distribution of spawning and rearing populations in tributary streams and the Sekulmun River.
- (b) Specification of the type of treatment required, if any, to stabilize the lower reaches of fish producing tributaries and the Sekulmun River.
- (c) Better definition of migrational patterns between the various lakes and between lakes and tributary streams.
- (d) Relationship of flow to food supply in Canyon River and Canyon Pond.
- (e) Spawning and rearing distribution in the littoral zones of Aishihik and Sekulmun Lakes.
- (f) Better definition of the significance of the littoral zones of Aishihik Lake to fish food production.

Field studies will be continued by the Fisheries Service throughout the summer and fall of 1973. However, upon completion of field activities, considerable time is required to adequately analyze the data collected. Therefore, a final report on the fisheries problems relating to the proposed power development cannot be expected before the spring of 1974.

In conclusion, the Fisheries Service very strongly recommends to the Board that no approval be granted to any phase of development or operation of such development that would irrevocably alter the ecology of the Aishihik River System until such time as the implications and consequences of such change are understood.

APPENDIX I

FIGURES 3 to 9



AISHIHIK LAKE — STREAM SURVEYS

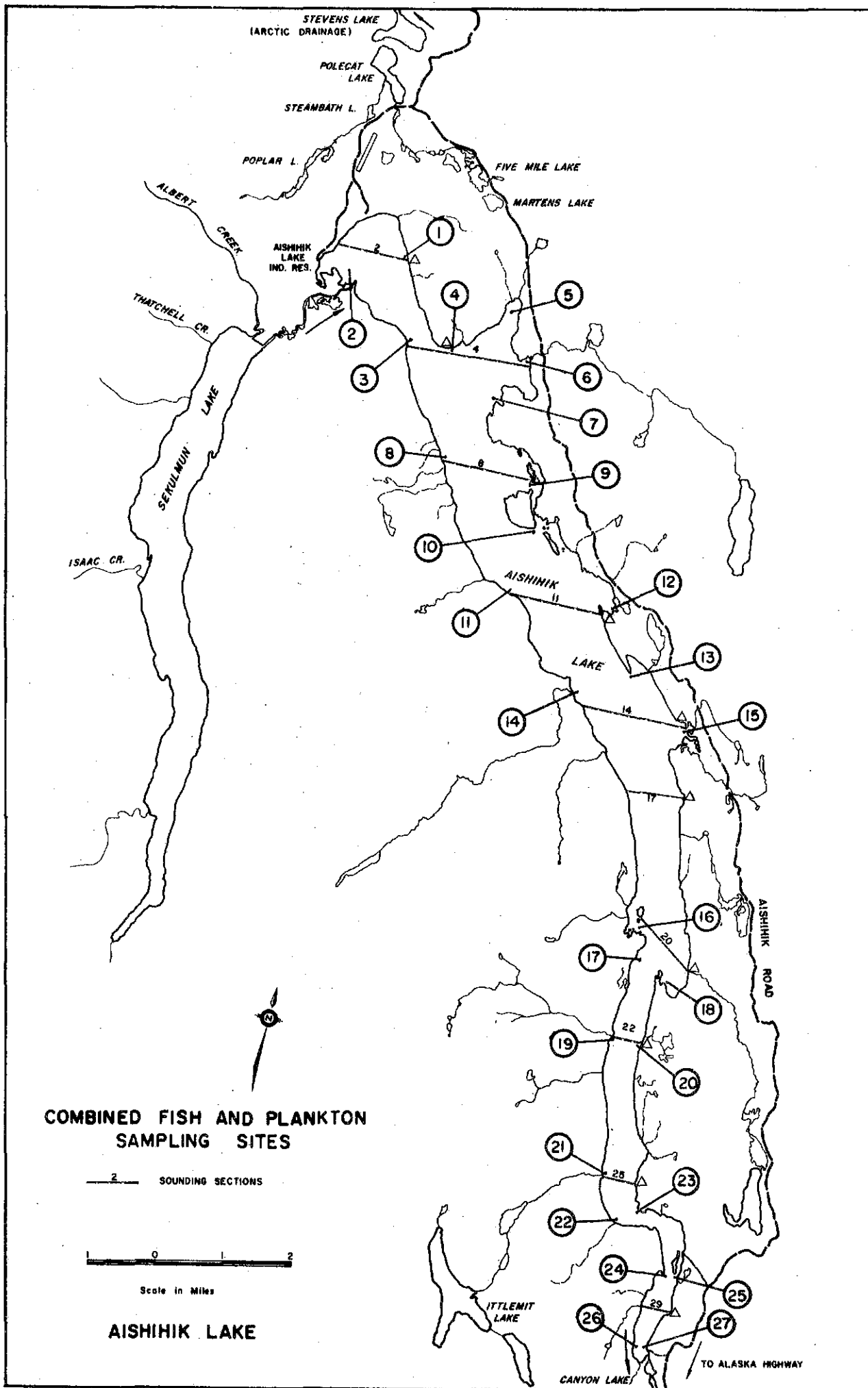
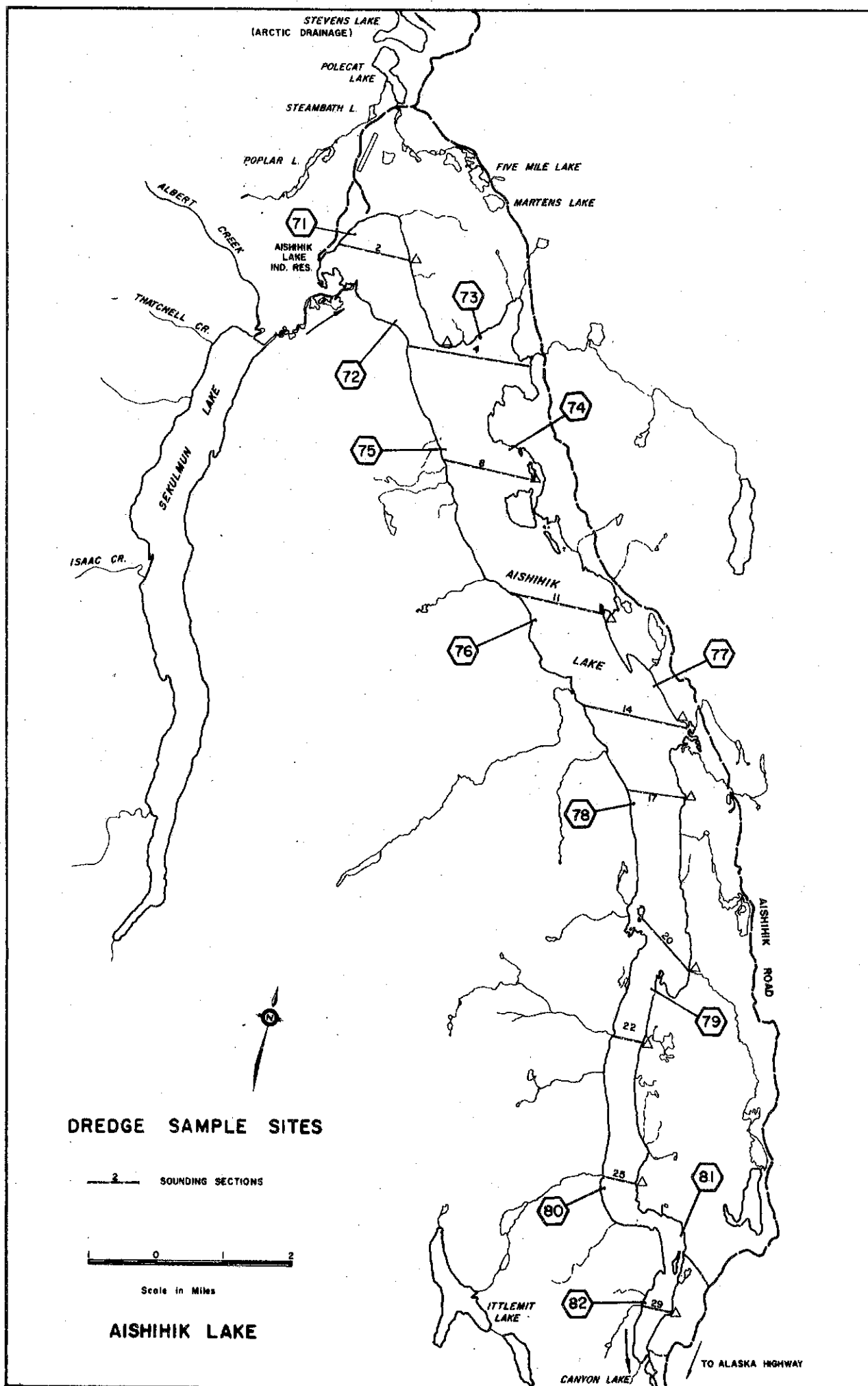
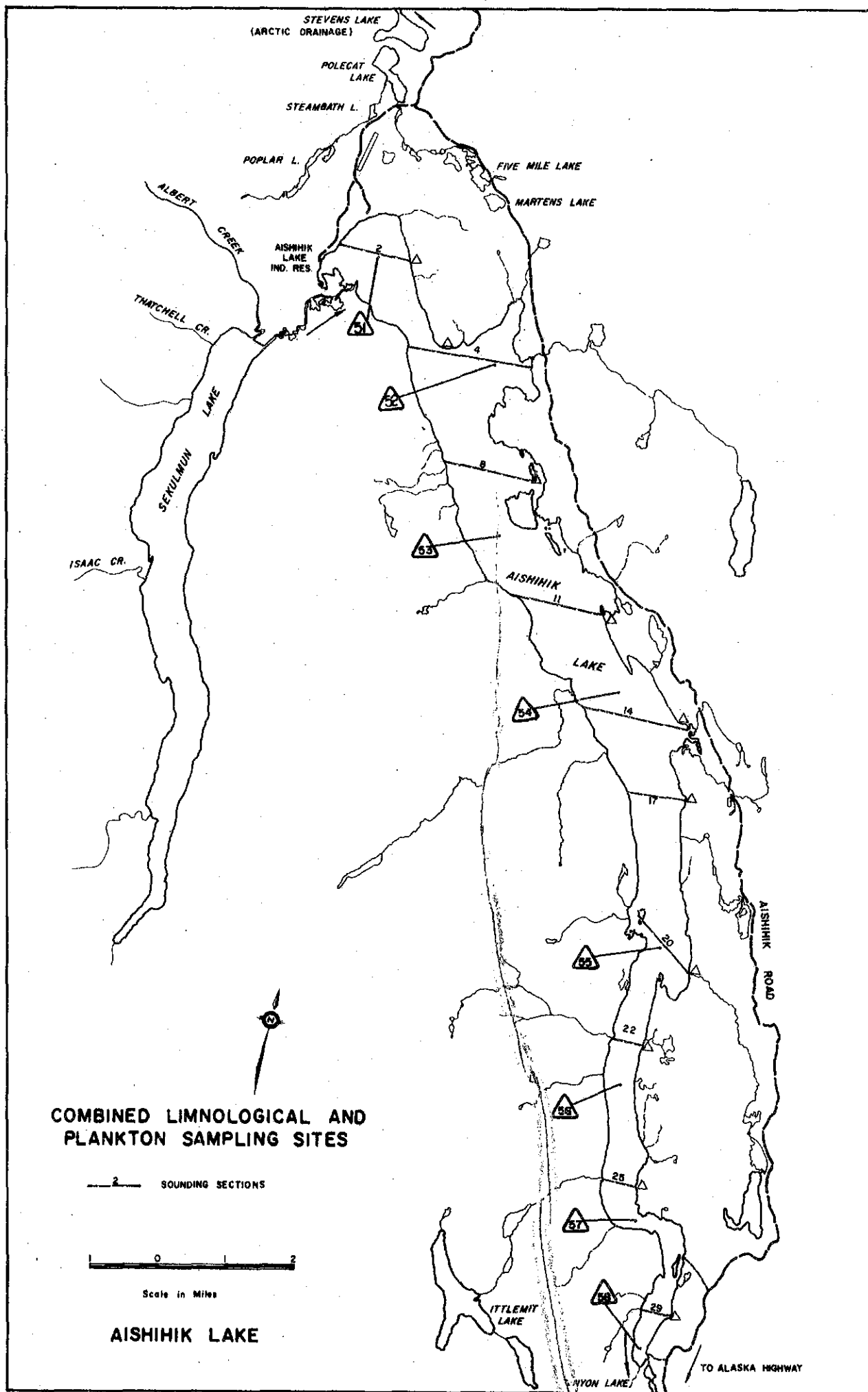
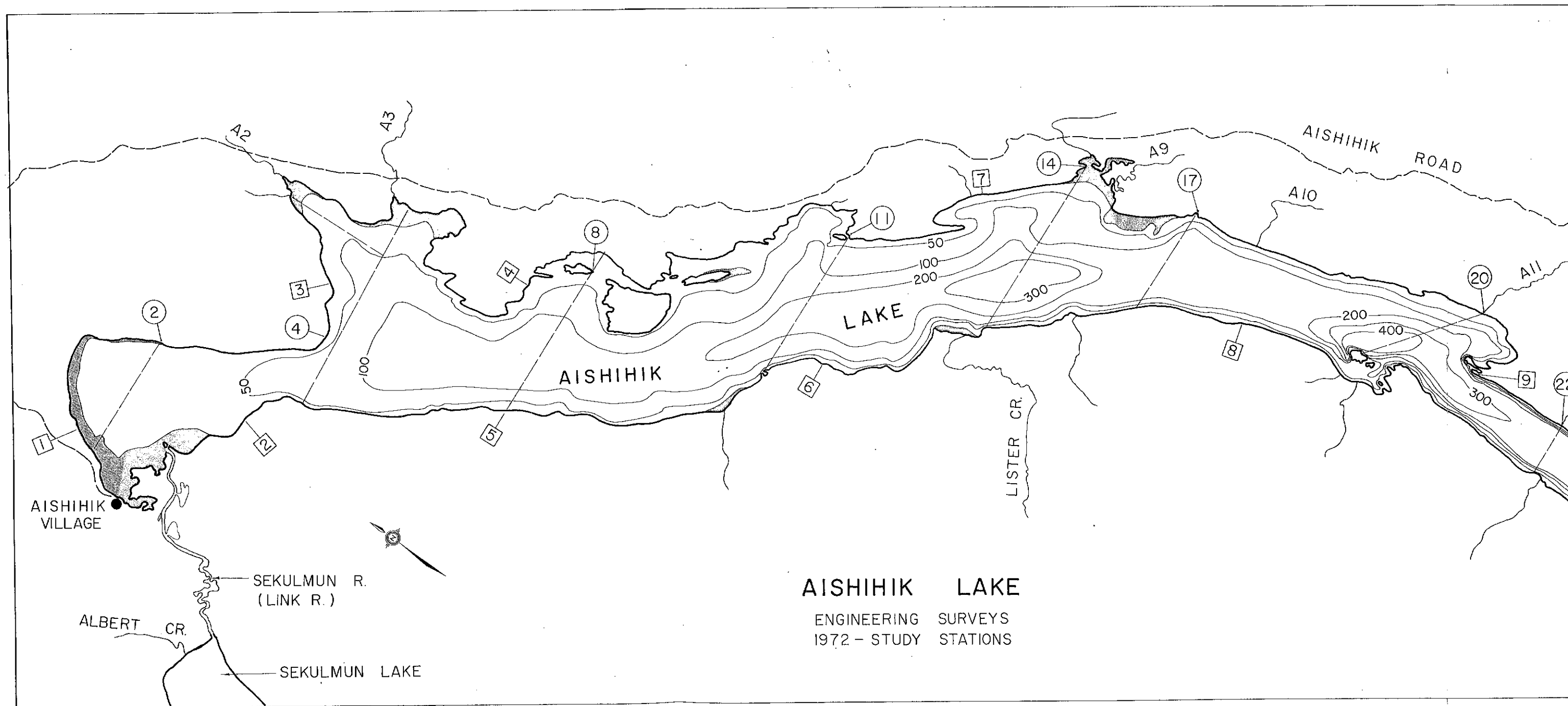


Fig. 4a







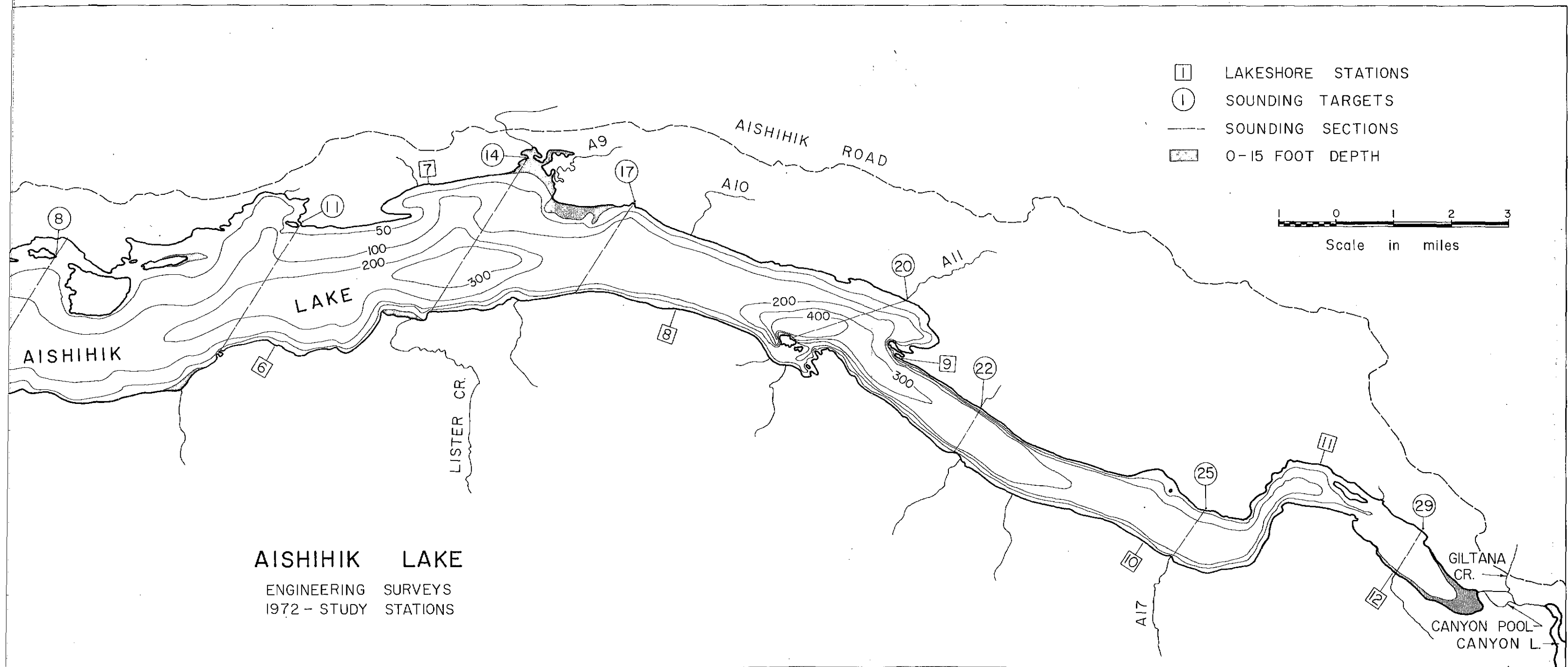


Fig. 5

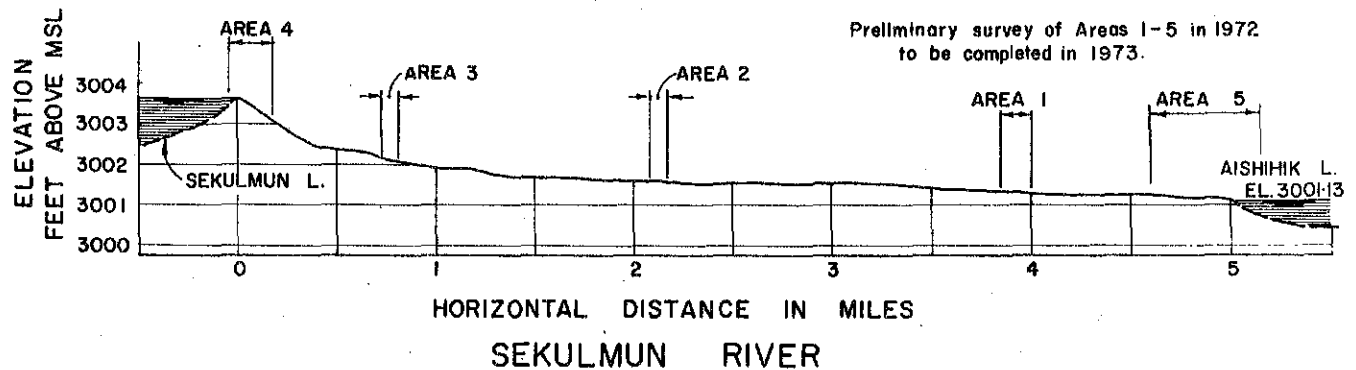
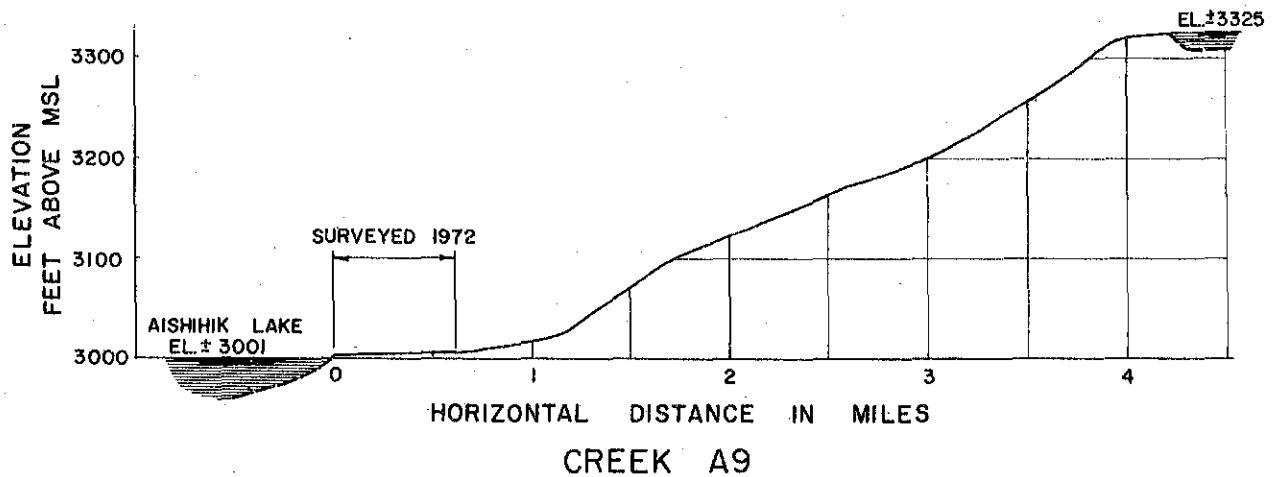
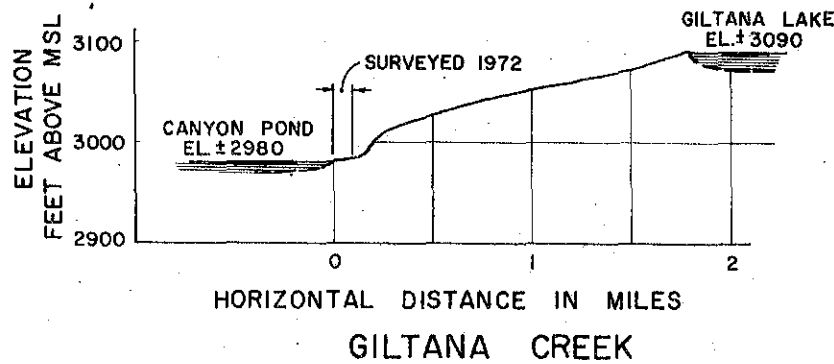
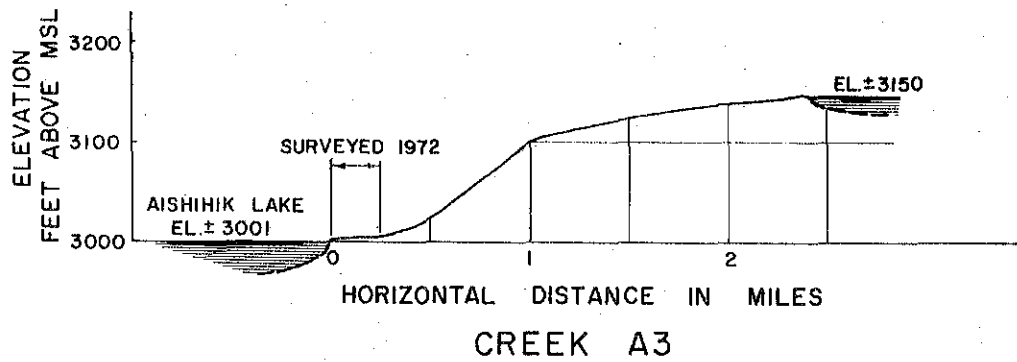
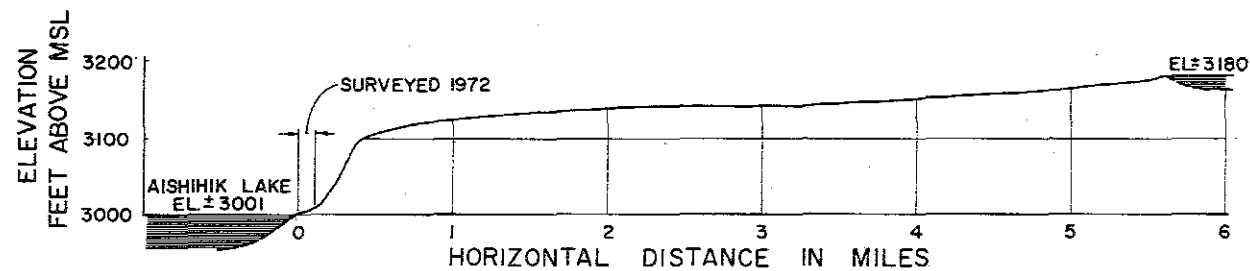
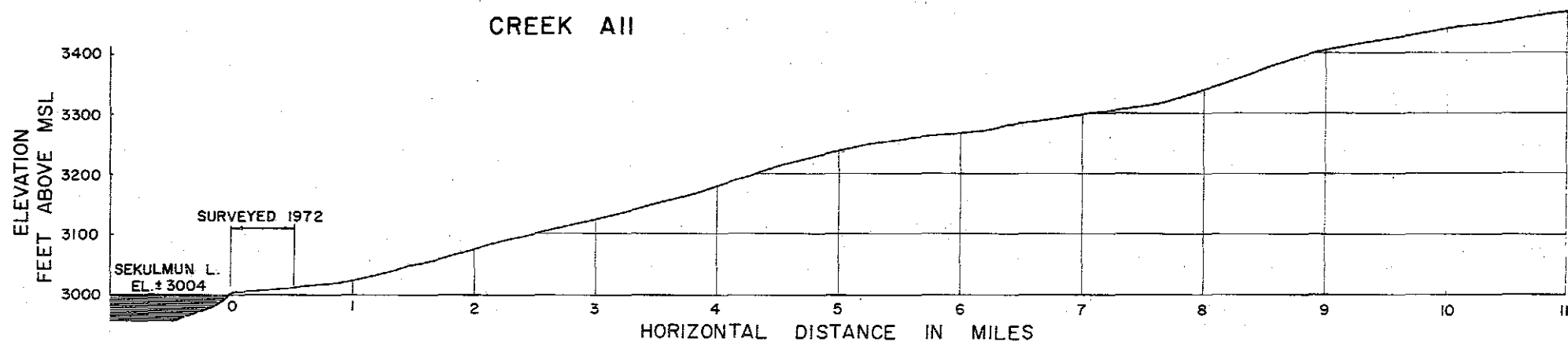


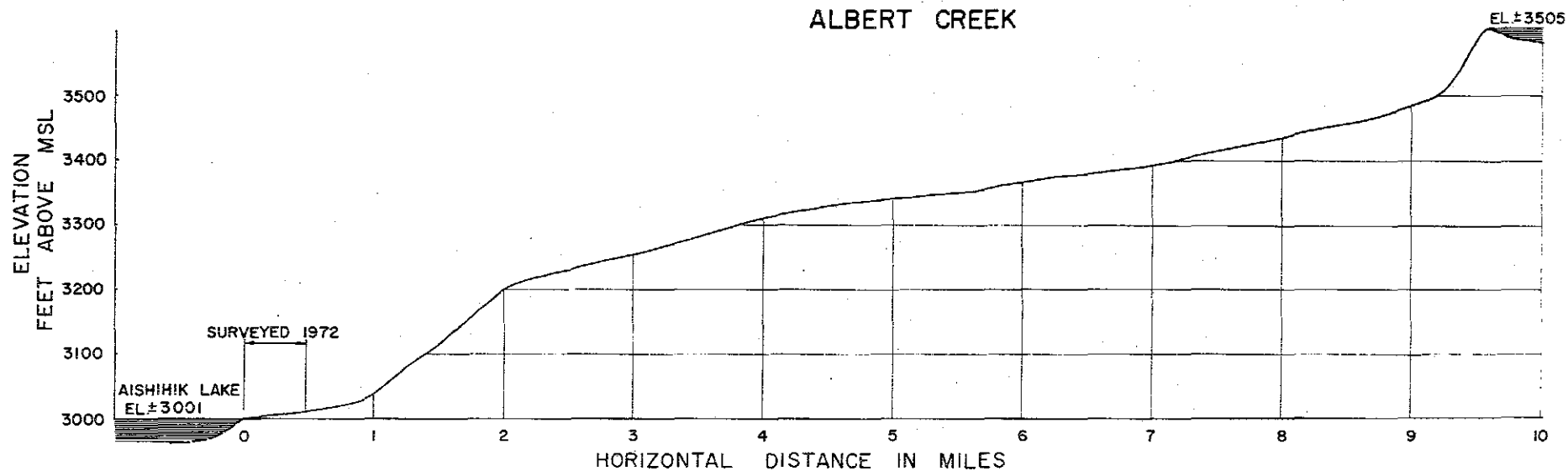
Fig. 6



CREEK AII



ALBERT CREEK



LISTER CREEK

Fig. 7

AISHIHIK LAKE NATURAL LAKE HYDROGRAPH AND WHITEFISH REPRODUCTION

NOTE: LAKE HYDROGRAPH FROM "AISHIHIK RIVER
POWER DEVELOPMENT" — G.E. CRIPPEN OCT-23/72

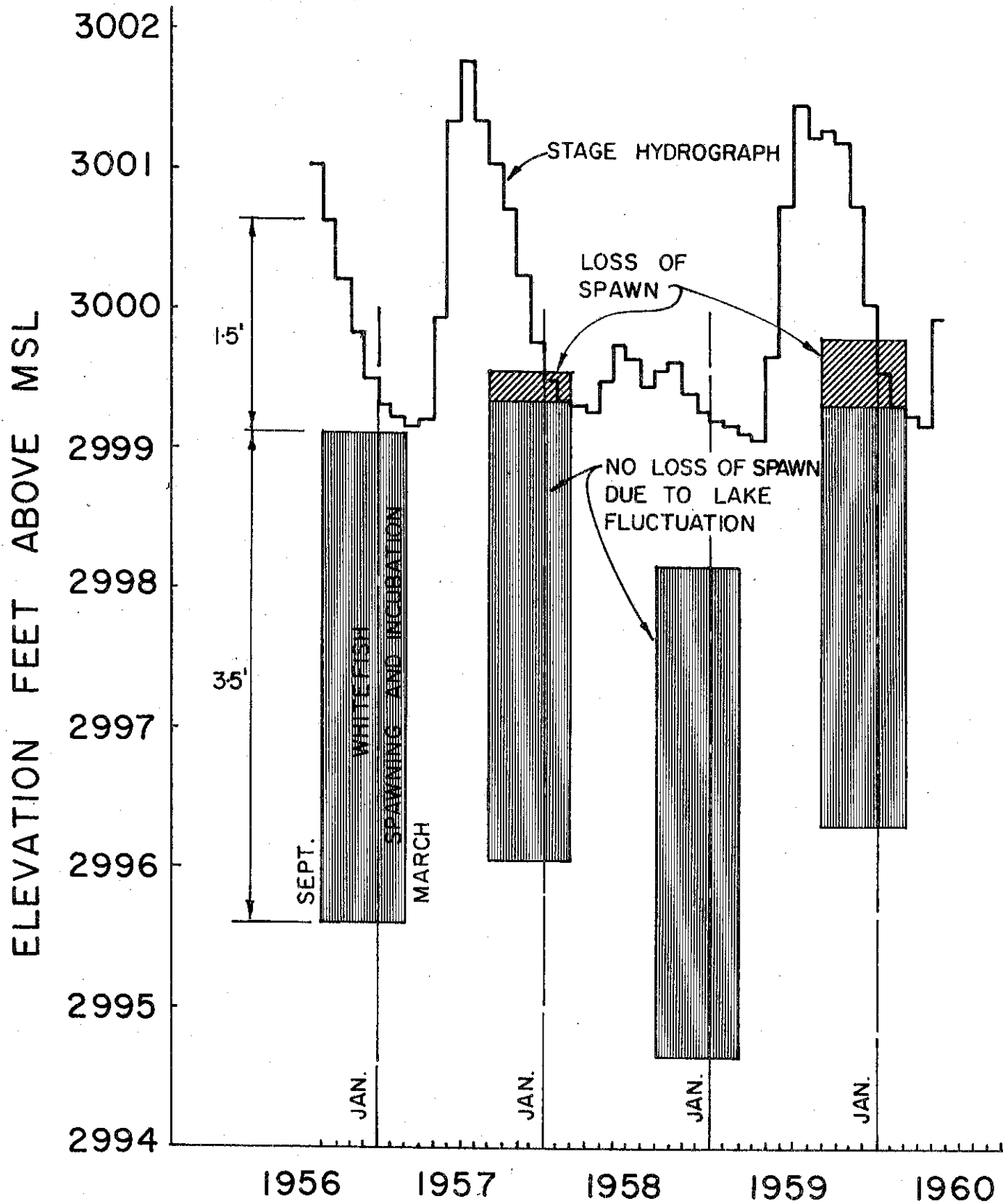
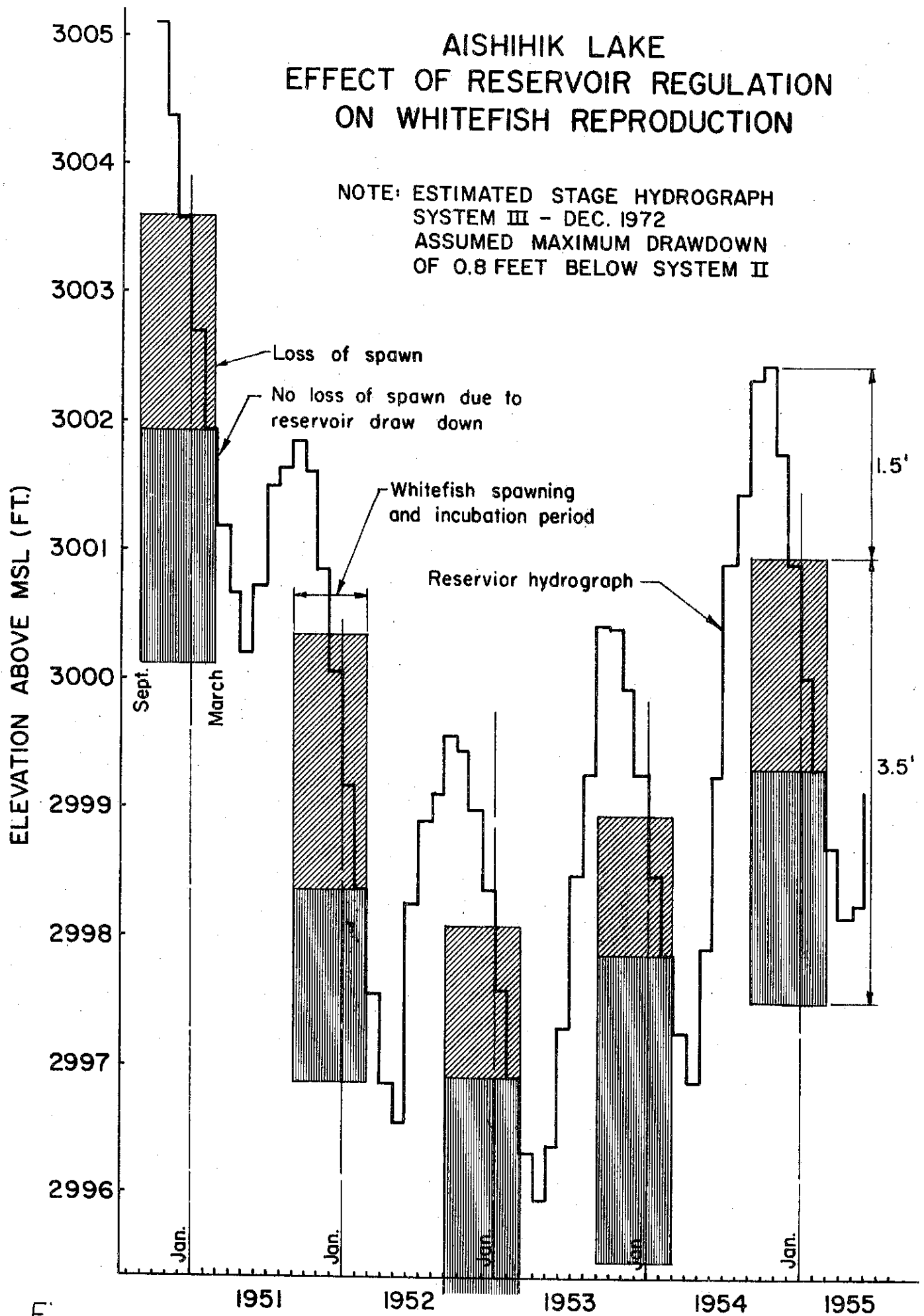


Fig. 8a

AISHIHIK LAKE EFFECT OF RESERVOIR REGULATION ON WHITEFISH REPRODUCTION

NOTE: ESTIMATED STAGE HYDROGRAPH
SYSTEM III - DEC. 1972
ASSUMED MAXIMUM DRAWDOWN
OF 0.8 FEET BELOW SYSTEM II



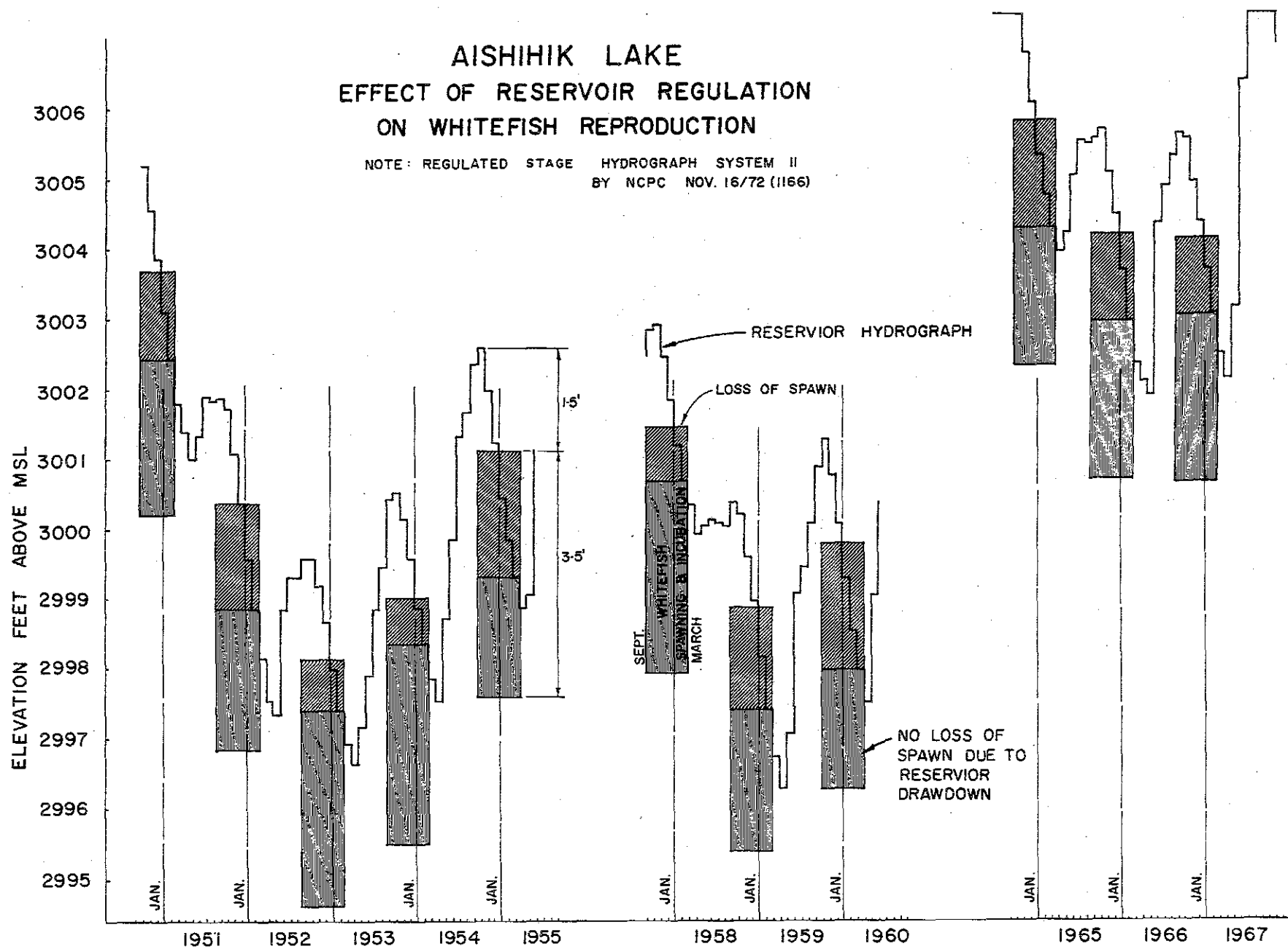


Fig. 8c

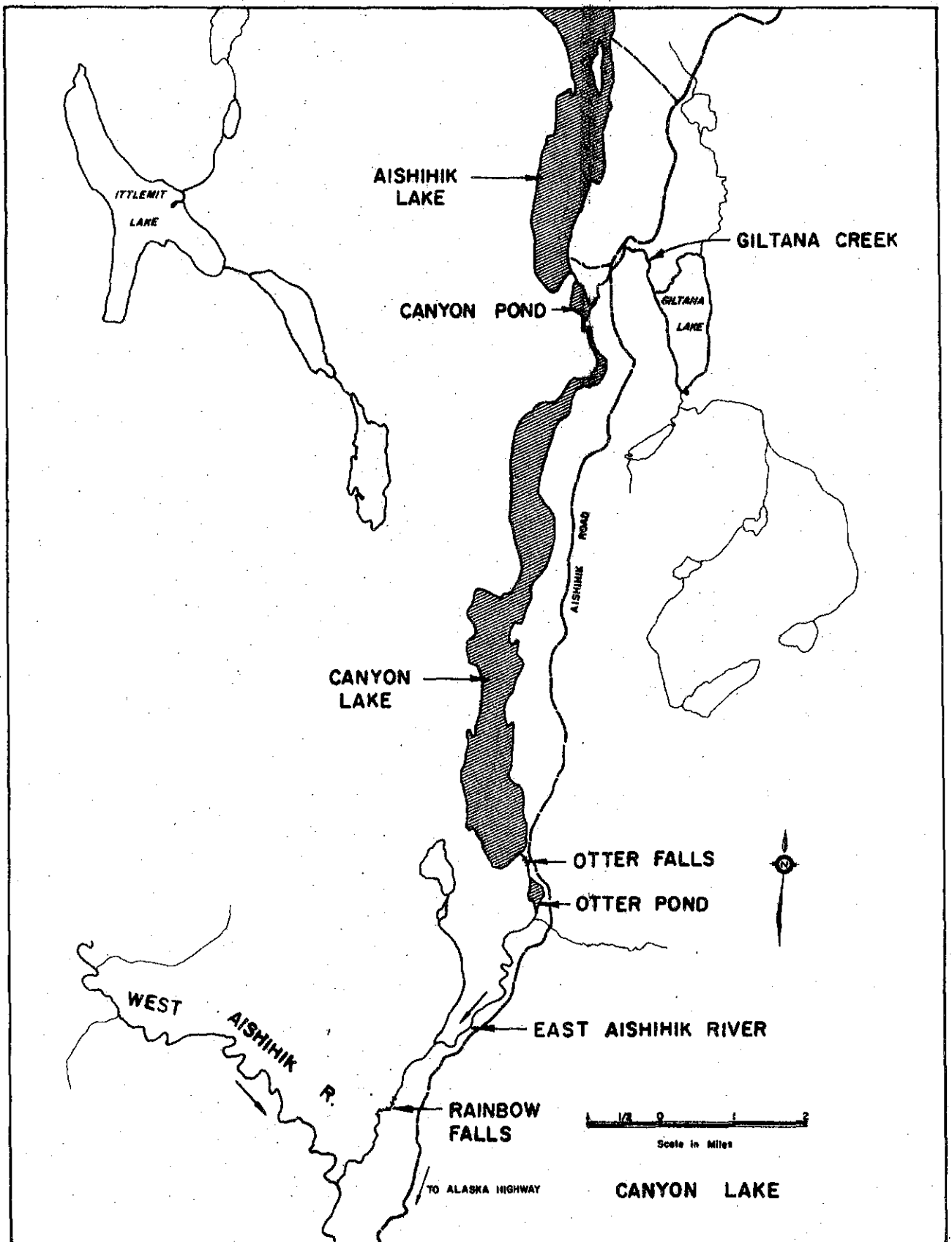
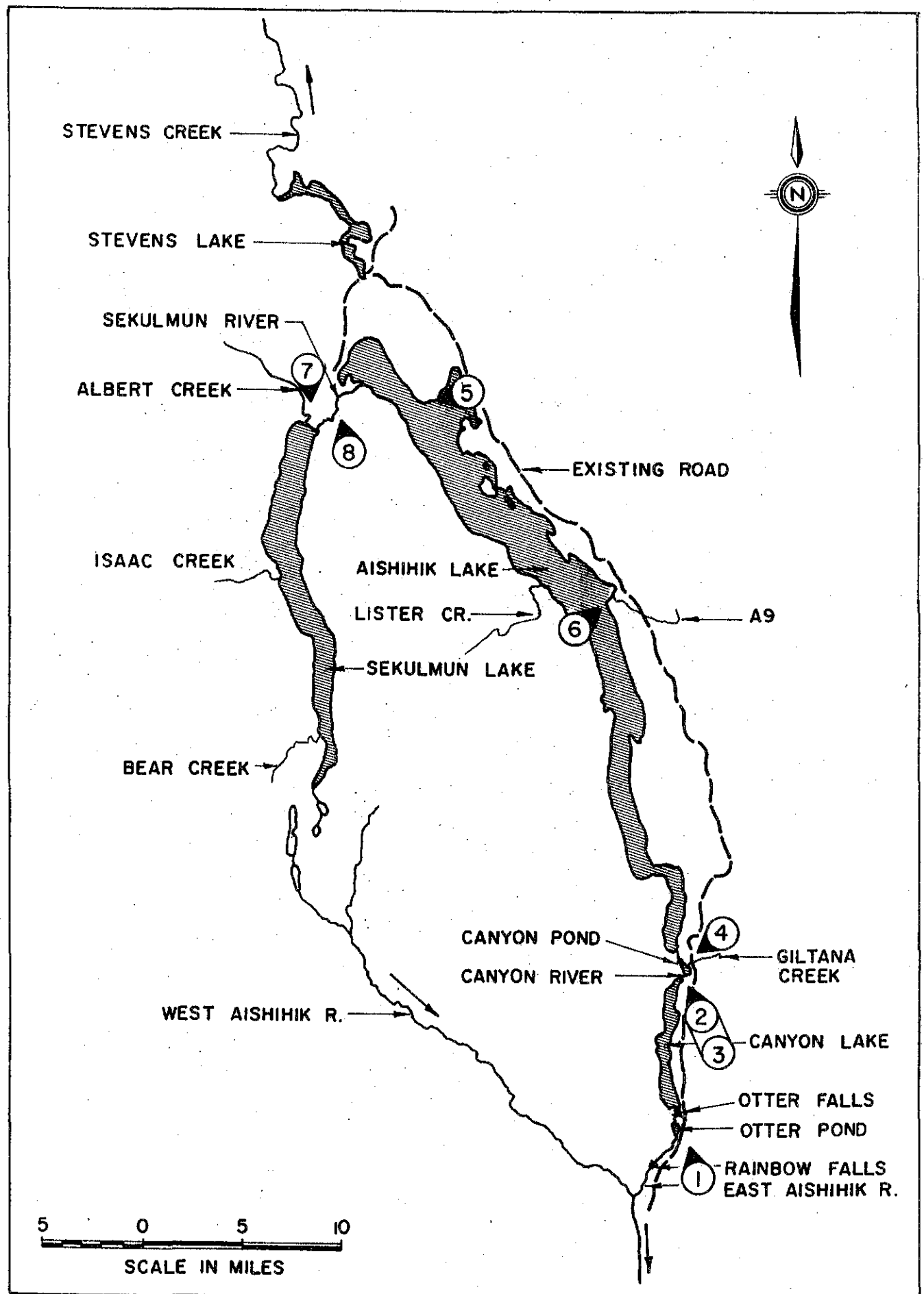


FIG. 9. CANYON LAKE AND EAST AISHIHIK RIVER

APPENDIX II

PHOTOGRAPHS



AISHIHIK RIVER SYSTEM - PHOTOGRAPH KEY MAP

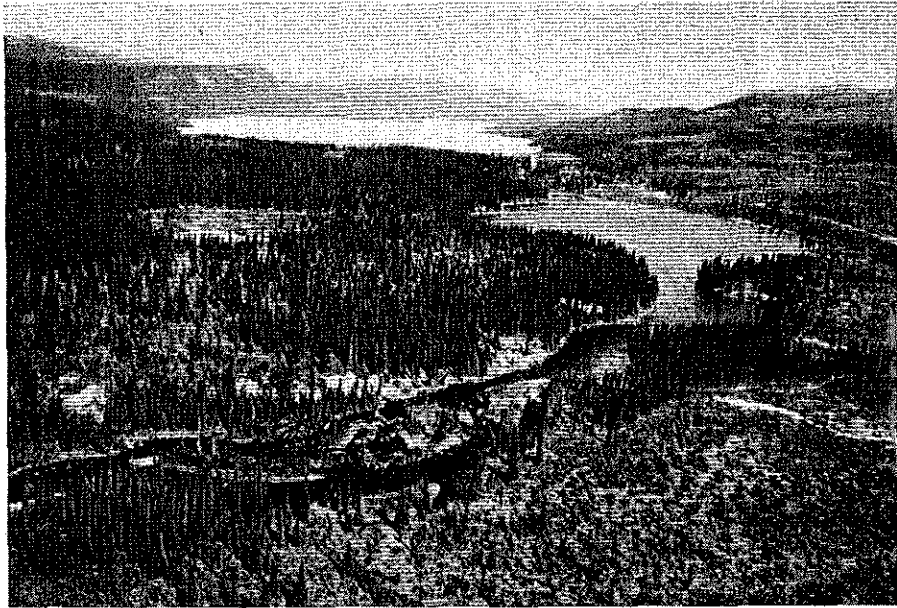


PLATE 1. From top to bottom: CANYON LAKE (with ice cover), OTTER POND and EAST AISHIHIK RIVER.

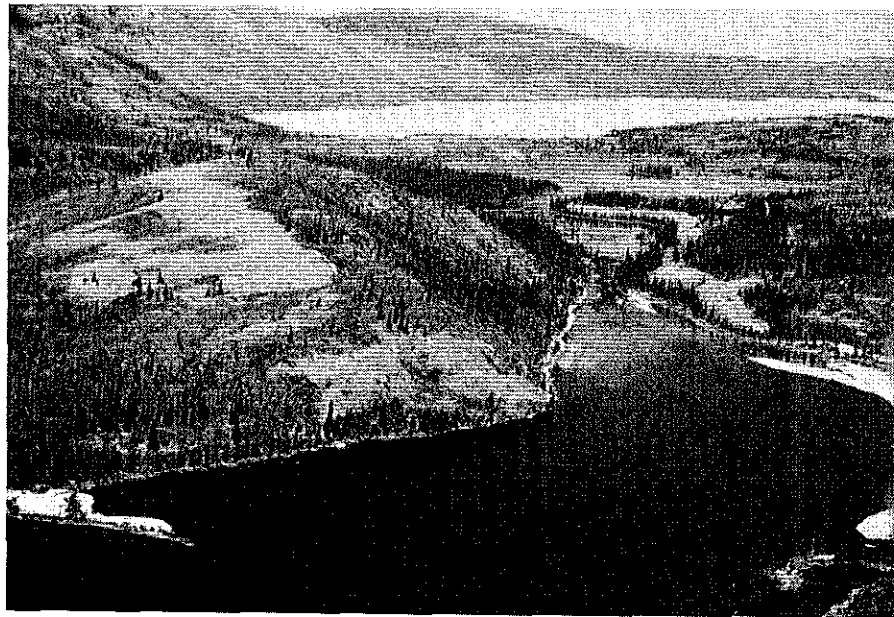


PLATE 2. From top to bottom: AISHIHIK LAKE (with ice cover), CANYON POND, CANYON RIVER and CANYON LAKE.

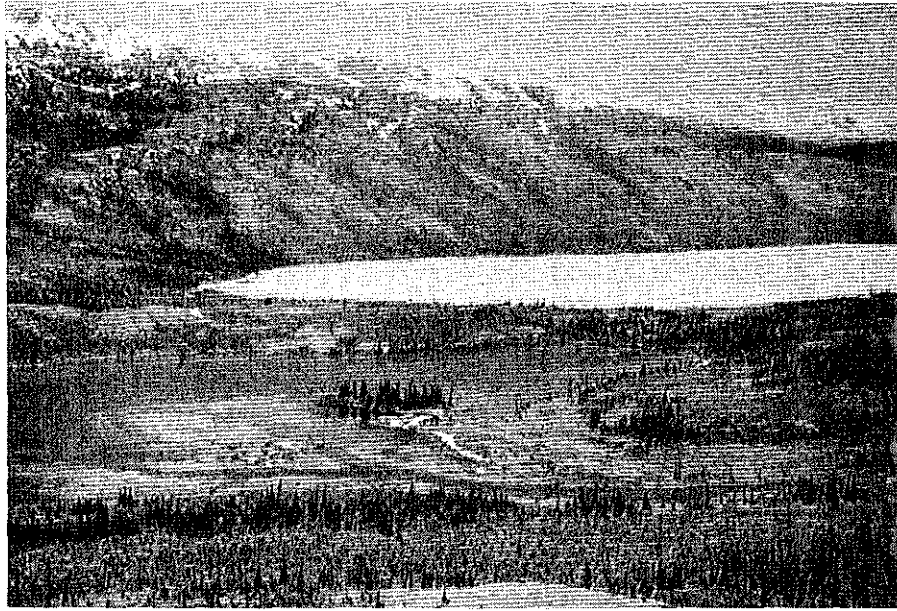


PLATE 3. CANYON POND with AISHIHIK LAKE (top) and GILTANA CREEK (bottom). Canyon Pond is considered to be the second most important fish producing area in the Aishihik Lake System. Adequate flow releases will be required from the future Aishihik Lake reservoir to protect and maintain valuable fish stocks in Canyon Pond.



PLATE 4. CANYON POND. Excellent fishing opportunity, easy access and magnificent scenery contribute to a unique sport fishing experience.

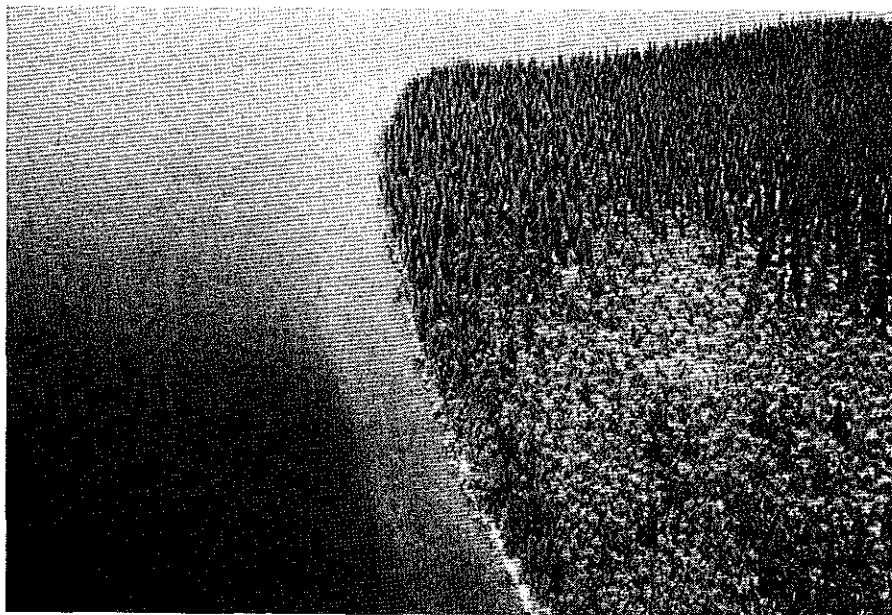


PLATE 5. AISHIHIK LAKE is a deep lake with steep slopes and a narrow submerged shoreline or littoral zone. The littoral zone is the submerged biologically productive area which lies within the photic zone (zone of light penetration). It is here that plant growth and benthic animal communities are found; both vital links in the aquatic food web. Disproportionate drawdown of Aishihik Lake would result in loss of productive shoreline and loss of spawning grounds.



PLATE 6. Delta region of CREEK A-9. In the event of substantial drawdown the few stream deltas in Aishihik Lake would cease to be fish producing, fish rearing and fish feeding areas.

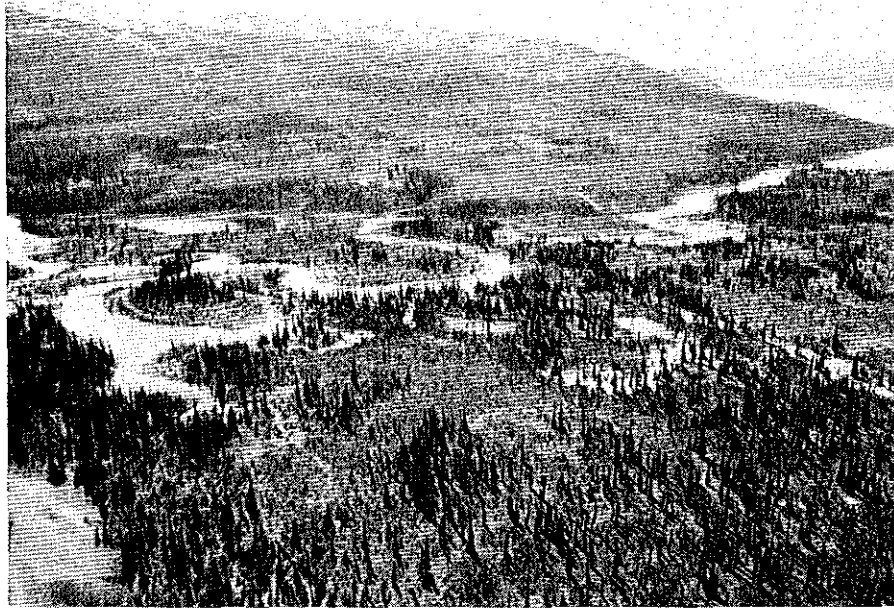


PLATE 7. SEKULMUN LAKE OUTLET with SEKULMUN RIVER. Sekulmun River is the most important fish producing water in the Aishihik Lake System, with the widest variety of species. Sekulmun River lies on the terminal moraine left by the last glacial advance. The moraine is composed of uncompacted loose materials such as clay, silt, sand and boulders. Under the proposed hydro power requirements high run-off in Sekulmun River would coincide with low reservoir levels in Aishihik Lake. Rapid erosion and lowering of Sekulmun River and Sekulmun Lake can be expected. Sekulmun Lake and Aishihik Lake could become one body of water (except when maximum drawdown occurs). A substantial loss to the fishery can be expected unless remedial works are provided prior to any drawdown.



PLATE 8. SEKULMUN RIVER and a school of unidentified fish.



PLATES 9 & 10. In 1972, the Fisheries Service of the Department of the Environment spent 700 man-days of professional and technical effort in the field to conduct biological, engineering and socio-economic studies in lakes and tributary streams of the Aishihik River System. Further studies will be undertaken in 1973.

A P P E N D I X B

ENVIRONMENTAL ENGINEERING STUDIES ASSOCIATED WITH
THE AISHIHIK RIVER HYDROELECTRIC DEVELOPMENT

R. A. ROBERTSON AND B. R. ELIASSEN,
FISHERIES AND MARINE SERVICE,
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Environmental Engineering Studies
Associated with the Aishihik River
Hydroelectric Development

By

R. A. Robertson and B. R. Eliassen

Department of the Environment
Fisheries and Marine Service
Northern Operations Branch
Habitat Protection Unit
Pacific Region

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ENVIRONMENTAL ENGINEERING STUDIES ASSOCIATED WITH
THE AISHIHIK RIVER HYDROELECTRIC DEVELOPMENT

1. INTRODUCTION

As part of the overall assessment of the effects of hydroelectric development on the fisheries resource of the Aishihik River system, various engineering surveys have been conducted in the area over the past two years by the Habitat Protection Unit, Northern Operations Branch. The nature and location of these surveys were as follows:

- Summer of 1972 - water surface profile between Sekulmun and Aishihik lakes.
 - Depth soundings of Aishihik Lake, Canyon Pond and Otter Pond.
 - Terrestrial and aquatic terrain classification of the Aishihik Lake shoreline.
 - Water surface profiles of the lower reaches of Giltana Creek and major tributary streams of Aishihik Lake.
 - Water surface profile of the upper Aishihik River between Aishihik Lake and Canyon Pond.
- Summer of 1973 - controlled stadia survey of Sekulmun River between Sekulmun and Aishihik lakes.
 - Aquatic terrain classification of the Aishihik Lake shoreline (sections extended from 15 foot depth to 30 foot depth).
 - Controlled stadia survey of the upper Aishihik River between Canyon Pond and Canyon Lake at a discharge of 570 cfs.
- Summer of 1974 - controlled stadia survey of the upper

Aishihik River between Canyon Pond and Canyon Lake at a discharge of 70 cfs. Staff gauges were erected to aid biological staff in establishing water surface profiles at intermediate discharges.

This report deals with the surveys of the Sekulmun and upper Aishihik rivers and the terrestrial and aquatic terrain classification of the Aishihik Lake shoreline. Other surveys indicated above were discussed in the Fisheries Service interim report of January 1973 entitled "Fisheries Problems Associated with the Proposed Aishihik River Power Development."

2. SEKULMUN RIVER

2.1 General:

The Northern Canada Power Commission has been granted a licence to regulate water levels in Aishihik Lake between the natural historic low and high lake levels. These levels have been computed to be at elevations 2996.5 and 3002.5, respectively.¹ However, for greater optimization of powerplant flows the Commission has applied for increased storage on Aishihik Lake. A decision has not yet been made on the ultimate storage range but the Water Board has stipulated that the lake will not be regulated below elevation 2992.5 or above elevation 3007.5

Biological studies conducted during 1972 concluded that Sekulmun River acts as a rearing area and migrational route for several species of fish. Concern was therefore expressed that regulation of

1. Personal communication with Dr. A. B. Hollingshead.

Aishihik Lake beyond its natural storage levels may lead to degradation of the aquatic environment of the Sekulmun River with a resultant adverse effect on these fish stocks. Engineering surveys were then conducted to determine the physical changes that may ensue as a result of either a drawdown of 4 feet below the natural historic low level of Aishihik Lake or an increase in storage to 5 feet above the natural historic high. These were conducted during the summer of 1973 and were comprised of the following:

- a) a control traverse from Sekulmun to Aishihik Lake providing vertical and horizontal control over the entire length of river;
- b) a detailed topographical survey of 4 representative study areas over the length of the river;
- c) water surface and river bed profiles between Sekulmun and Aishihik lakes;
- d) measurement of river discharge;
- e) random sampling of riverbed material within each study area; and
- f) identification of marginal vegetation.

Round steel pins were set at intervals of 300 to 600 feet along the riverbanks and tree benchmarks were established at convenient locations for

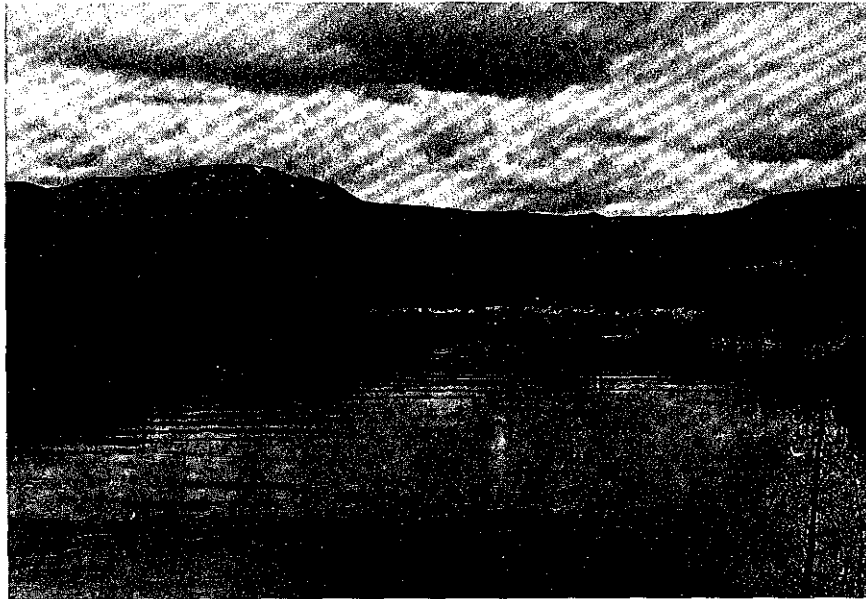
future reference. All levels during the survey were based on the NCPC bench-mark at Sekulmun Lake, BM.2, geodetic elevation 3006.94.

2.2 River Morphology:

The Sekulmun River is a 5 mile long stream meandering through a flat to undulating area between Sekulmun and Aishihik lakes (Figure 1). The river has a low gradient over most of its length with practically all of the head differential between the lakes occurring in the upper one mile (Figure 2). Depth of flow varies from quite shallow below the outlet of Sekulmun Lake to as much as 14 feet at the outside of bends and in deep pools throughout the lower 4 miles of river. The river becomes very shallow as it enters Aishihik Lake (Figure 3).

The composition of the riverbed changes from fine gravel and sand in the area above P13 to fine sediments of sand, silt or clay in the lower reaches of the river. A relatively heavy growth of aquatic vegetation occurs throughout the lower third of the river. Grain size compositions of the samples obtained in each study area are shown on Figure 4.

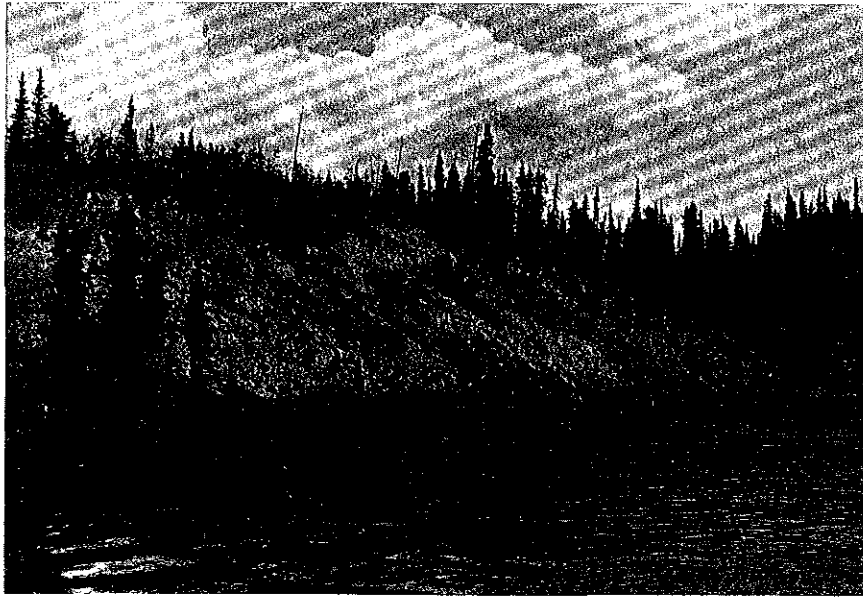
Riverbanks vary substantially over the length of the river. In the lower reaches the banks rise steeply and are often more than 10 feet above water level. The banks are composed of clay or silty material and the higher ones are generally devoid of vegetation and subject to erosion in the



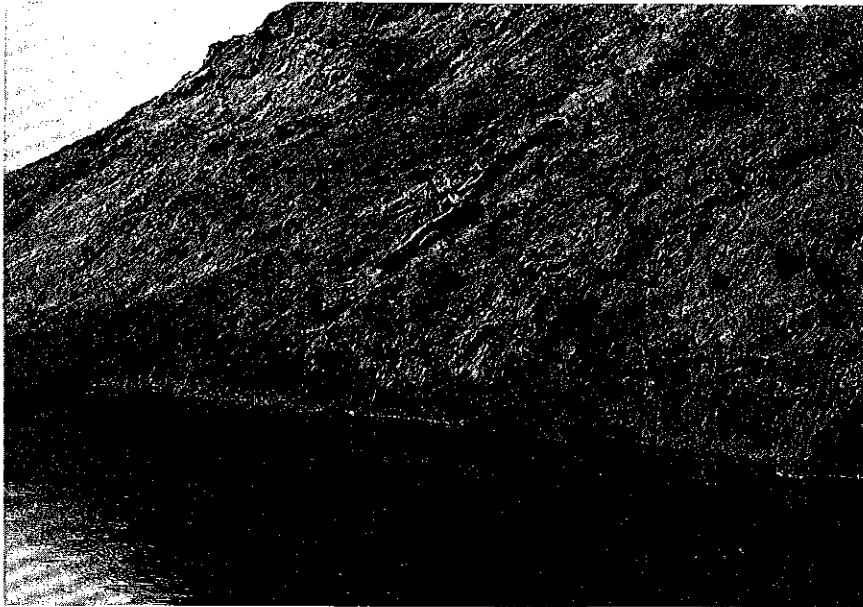
Sekulmun River looking upstream from hub P6. Banks are low and the surrounding terrain is generally quite flat. For location of hubs refer to Figure 1.



Left bank of Sekulmun River between hubs P10 and P11. Note block slumping which is believed to be caused by frost melt.



Left bank of Sekulmun River near hub P23. Clay cut banks sometimes rising to more than 80 feet in height are common to the central reaches of the river.



Active erosion occurring at the base of the left bank of the Sekulmun River near hub P23.

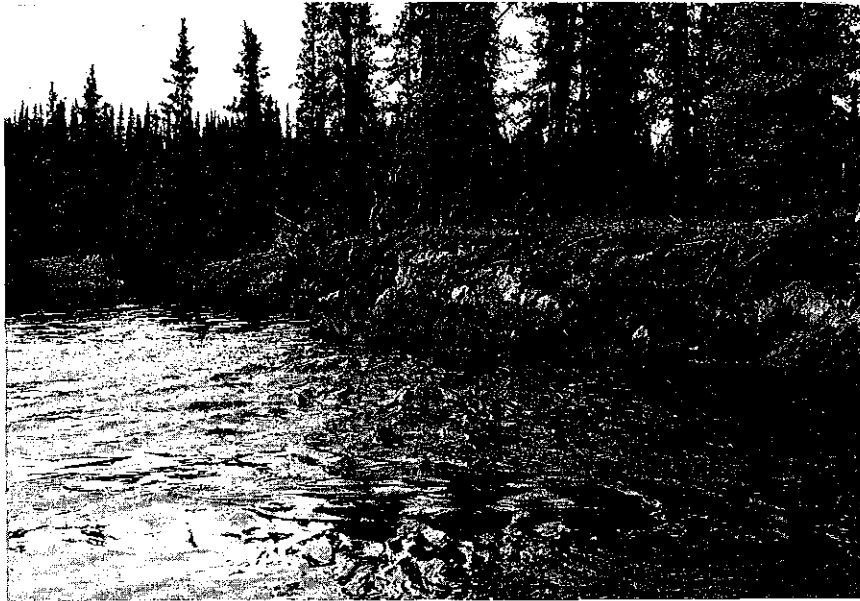
form of sloughing or block slumping. Willow, white spruce and grasses provide some bank stability in certain areas over the lower reaches of the river. In the upper reaches the banks are generally quite low and are occasionally overtopped by high flows. Banks are composed of granular material in the upper 1/4 mile of river and this appears to be the only source of gravel recruitment for the entire river. Extensive erosion was occurring at several points along the low banks between hubs P1 and P20. This is believed to be a slow but continuing process brought on by the combined action of water scour and frost melt.

Several large ponds drain into the river over the lower two miles. These are flat-bottomed, shallow ponds generally not more than 6 feet in depth.

2.3 Hydrology:

The Sekulmun River water surface gradient changes naturally as Sekulmun and Aishihik Lakes fluctuate. Level profiles run between these lakes indicates that the drop varies between 3 and 5 feet. Approximately 50 percent of this difference occurs in the upper mile.

Discharges recorded by NCPC in the Sekulmun River between 1971 and 1973 show a variation between 66 cfs and approximately 800 cfs. However, discharges were never recorded between November and May and it is likely that the minimum discharge falls well below 66 cfs. The discharge measured while the topographical surveys were being conducted



Block slumping occurring along left bank of the Sekulmun River approximately 400 feet upstream of hub P30.



Sloughing of left bank of the Sekulmun River near hub P37.



Sloughing of left bank of the Sekulmun River near hub P40.



Sekulmun River looking downstream from hub P50. This is typical of the lower reaches of the river. A dense growth of grasses, stunted willow and mature white spruce occur to the rivers edge. The river is deep with a very low gradient.

was 566 cfs.

River velocities are in the order of 2 fps near the outlet of Sekulmun Lake. The flow is much more sluggish in the lower four miles with velocities seldom above 1 fps.

In their Supplementary Report of December 20, 1972, G. E. Crippen and Associates indicate a total drainage area of 1080 sq. miles above the outlet of Aishihik Lake. The drainage area above the outlet of Sekulmun Lake makes up 485 sq. miles (45%) of this total. The surface areas of Aishihik and Sekulmun lakes are 57.0 and 19.3 sq. miles, respectively. The respective ratios of surface area to drainage areas for each of the lakes are therefore .096 and .040, which indicates that Sekulmun Lake is filled more quickly during spring run-off than Aishihik Lake. Thus, it is reasonable to believe that at some time during the spring run-off, Sekulmun Lake would be at its highest level, while Aishihik Lake is still at a low stage, a condition which would control the erosional processes in the Sekulmun River.

2.4 Implications of Power Development

a) Raising Aishihik Lake to elevation 3007.5:

The level of Sekulmun Lake normally ranges between elevations 3003 and 3006. Therefore, increasing the level of Aishihik Lake to 3007.5 would flood the entire length of the Sekulmun River and its adjacent low-lying terrain. Velocities within



Sekulmun River looking upstream
from hub 1C



Sekulmun River looking downstream
from Sekulmun Lake

STUDY AREA NO. 1

This area lies in very flat terrain. Banks are low and the river is generally quite shallow. The stream is approximately twice as wide and has a steeper gradient than the remainder of the river. The riverbed is composed of fine, clean gravel due to the higher velocity throughout this area. Stunted willow, white spruce, shrubs, and grasses tend to stabilize the fine soil composition of the banks.



Sekulmun River looking at right bank from opposite hub P19

STUDY AREA NO. 2

Riverbanks are low and the surrounding terrain is generally quite flat between this point and Sekulmun Lake. Steep clay banks begin to occur a short distance downstream. The stream is narrower than in study area No. 1 and the gradient is much flatter. The riverbed is composed of sandy clay material and velocities are low.



Sekulmun River looking downstream
adjacent to hub P32

STUDY AREA NO. 3

This area has banks rising 8 - 12 feet from the water surface and an undulating terrain. Dense stands of mature white spruce and stunted willow crowd the riverbanks. Gradient and velocity is low, resulting in a sandy, clay river bottom. Signs of bank sloughing is very common throughout this area.



Sekulmun River looking at right bank from above hub 3A

STUDY AREA NO. 4

This area is typical of only a short section of the river. Although more open than Study Area No. 3, it contains a similar dense growth of vegetation to the river edge. The riverbed is composed of a sandy clay material with patches of aquatic vegetation. The river is up to 16 feet in depth and the water surface gradient and velocity are extremely low.

the present river channel would be substantially reduced or even eliminated.

It is understood that operation of the Aishihik powerplant will be integrated with the Whitehorse Rapids plant. This will require that flows from the outlet of Aishihik Lake be reduced during the summer to allow as much storage as possible for winter operation of the Aishihik powerplant. Therefore, water levels within the Aishihik and Sekulmun lakes will be increasing throughout the summer months, reaching their peak in October when operation of the powerplant is expected to commence.

Extensive erosion and slumping of high riverbanks would undoubtedly occur in the Sekulmun River following flooding to elevation 3007.5. It is expected that most of this erosion would take place within the first few years after reaching the upper lake levels and would continue over a number of years on a reducing scale until a new equilibrium was reached. Projected water levels on typical cross sections of each study area are shown on Figure 5. In estimating the water levels at each section with Aishihik Lake raised to elevation 3002.5, a constant gradient was assumed between Sekulmun and Aishihik lakes. It was assumed that the water surface would remain level over the entire length of river when Aishihik Lake is at elevation 3007.5

b) Lowering Aishihik Lake to elevation 2992.5:

Since glaciation, the Sekulmun River has undergone an adjustment of its riverbed profile

to conform to its peak discharges and the level of Aishihik Lake. The very low water surface gradient which presently exists over the lower four miles is controlled to a large extent by the level of Aishihik Lake. Velocities are quite low in this section of river and bed degradation is probably quite limited. It is believed that further erosion would rarely occur and only when a major flood through the Sekulmun River coincides with a low Aishihik Lake level.

The immediate and temporary effect of lowering Aishihik Lake to elevation 2992.5 would be to steepen the water surface gradient within the Sekulmun River so that it becomes controlled by the bank and bed resistance within the river. The fine sediments in the lower reaches of the river could not remain stable under the increased velocities accompanying this increase in gradient and bed degradation would occur until a new equilibrium was reached at a lower level. Bedrock outcroppings or heavy boulders are not present in the river to prevent this from happening. The river would also have a tendency to adjust to its present width and it is therefore expected that extensive bank erosion would also occur.

The estimated water levels at typical cross-sections of each study area are shown on Figure 4. These represent the levels which would prevail under the discharge measured during the surveys with Aishihik Lake drawn down to elevation 2996.5 and 2992.5. In estimating these levels it was assumed that the water surface over the entire length of river would eventually stabilize at its present gradient.

It is unknown how long it might take to reach this new equilibrium, but erosion would probably continue for several years.

It is unlikely that the coarser material in the upper one mile of the river could remain stable under these conditions and bed degradation would probably continue through to Sekulmun Lake. This would lower Sekulmun Lake and initiate erosion in the lower reaches of each of its tributary streams.

Widespread erosion above the outlet of the Sekulmun River could be prevented by placing a layer of coarse granular material or a series of underwater weirs near the outlet of the Sekulmun River. These would have to be designed in a manner to ensure that fish could easily migrate upstream from Aishihik Lake under any condition of discharge and lake level.

3. UPPER AISHIHIK RIVER

3.1 General:

The Whitehorse Rapids powerplant can be operated at full capacity during the summer months when flow in the Yukon River is relatively high. However, sufficient storage is not available in the system for maximum power production throughout the winter. On the other hand, the Aishihik River development has ample storage, but limited discharge. Present plans are therefore to operate the Aishihik powerplant for base loads

during the winter months and the Whitehorse Rapids powerplant during the summer months. The Aishihik powerplant will not normally be operated during the summer so as to allow maximum storage for the winter.

To optimize power production from the Aishihik system, NCPC are therefore interested in storing as much water as possible during the summer on Aishihik Lake. However, a complete cessation of flows below the outlet of Aishihik would destroy fish populations which utilize the pool and river environment between Aishihik and Canyon Lakes. Details of these fish populations are contained in reports prepared by the Northern B. C. and Yukon Division, (Walker, Brown, 1974).

Studies were conducted by the Fisheries and Marine Service during 1973 and 1974 to determine the minimum summer flows required below Aishihik Lake to sustain fish populations. Hydraulic studies were conducted by the Habitat Protection Unit to provide support data for the biological assessment. These consisted primarily of topographical surveys and water surface profiles between Canyon Pond and Canyon Lake for a range of flow releases from Aishihik Lake of 70 to 570 cfs.

3.2 Canyon Pond:

The small pool area a short distance below Aishihik Lake has been designated as Canyon Pond for purposes of this study. The pond has been found to be an important rearing area for several

species and sizes of fish. Some of these depend upon the aquatic vegetation which grows in the marshy area along the east side of the pond. This area is normally wetted during the summer, but is dewatered during low winter flows.

Water levels within Canyon Pond are controlled by its outlet into the upper Aishihik River. A stage discharge curve for this outlet is shown on Figure 7. In using this curve, it is to be noted that the discharge includes flow from Giltana Creek.

3.3 Upper Aishihik River Below Canyon Pond:

Biological studies carried out during 1973 concluded that the upper Aishihik River between Canyon Pond and Canyon Lake was extensively utilized by several species and sizes of fish. Since most of the water in this river originates from Aishihik Lake, cessation of summer flows following the construction of the Aishihik Lake dam could have a serious impact on these fish populations. Further studies were therefore undertaken during 1974 with controlled flow releases from Aishihik Lake to determine the minimum flow necessary to sustain fish stocks in this river. The controlled flows were provided after closure of the cofferdam at the outlet of Aishihik Lake early in July, 1974.

It was originally planned to study the river with outflows of 25, 50 and 100 cfs from Aishihik



Canyon Pond looking upstream towards Aishihik Lake.



Upper Aishihik River immediately below Canyon Pond.

Lake. However, during the course of the study it became obvious that a discharge of 70 cfs below Canyon Pond (58 cfs from Aishihik Lake and 12 cfs from Giltana Creek) would not be ample to meet the basic hydraulic requirements of depth and velocity needed to sustain fish populations. All subsequent studies were therefore conducted at discharges of 70 to 220 cfs below Canyon Pond.

A topographical survey was carried out to provide a detailed contour map of the area (Figure 6). Eleven cross-sections were established over the length of the river and water levels were monitored at each section at discharges of 70, 220 and 570 cfs. This information was then used to determine a discharge rating curve and a theoretical velocity distribution for each section. Individual cross-sections, rating curves and velocity distributions are shown on Figure 7 to 11. The velocity distributions were computed at approximately 10 foot increments across the width of the river using the Mannings equation,

$$v = \frac{1.486}{n} R^{\frac{2}{3}} S^{\frac{1}{2}} \quad \text{where}$$

n = Mannings coefficient, which was computed for each discharge at each section.

R = hydraulic radius, which is approximately equal to the depth of flow for wide, shallow channels such as the Aishihik River.

S = slope of the water surface, which was determined for each section from actual field measurements.



Upper Aishihik River looking downstream towards Canyon Lake.



Upper Aishihik River - Pool 1 in background, Pool 2 in foreground.

(See Figure 7)

Although the theoretical velocities do not account for minor irregularities due to protruding cobbles or boulders, they were found to be very representative of the velocity distributions measured in the field at Section 6.

Biological studies carried out during 1974 have tentatively concluded that the most productive area within the river occurs between Sections 1 and 7. This area is comprised of a relatively deep trench near mid-channel bounded on either side by a wide, shallow shelf area. The larger species of fish were observed in and adjacent to the trench where water was deeper and of higher velocity, while juvenile fish were found to rear along the shelf areas where they have an abundant food supply and are less vulnerable to predation by the larger fish.

The productivity of a stream is related largely to the depth and velocity of flow. As a basis for assessing the effect of discharge on depth and velocity on the wetted area between Sections 2 and 6, distribution curves were plotted for each of these parameters for various discharges. These were plotted for the individual sections and then combined to produce depth and velocity composites for the entire area (Figure 12). As an example of how these curves are interpreted it can be seen that at least 93% of the area is covered to a depth of 1 foot at a normal summer discharge of 570 cfs, whereas only 18% of the area is covered to this depth when the discharge is reduced to 70 cfs. Similarly, the area subject to a velocity

of 1 fps is reduced from 93% to 6% with a reduction in discharge from 570 cfs to 70 cfs.

Observations carried out by the biologists during 1974 found that a flow of 100 cfs would not provide a sufficient depth of water over the shelf area between Sections 1 and 7 to sustain fish populations (Memorandum of August 22, 1974 by C. E. Walker). It was concluded that depths would have to be increased to be more representative of those occurring at 150 cfs. However, it is considered that corrective measures could be adopted to increase the depth of flow at 100 cfs. These should be in the form of small weirs placed across the trench at the locations and to the crest elevations shown on Figure 13. Installation of these weirs would also result in a slight increase in velocity throughout the shelf area.

4. AISHIHIK LAKE SHORELINE STUDY

4.1 General:

The shoreline study was undertaken to provide an inventory of shoreline characteristics on Aishihik Lake and some insight into the possible consequences of lake storage or drawdown on shallow bays and low land areas around the lake. A primary purpose of the study was also to provide support data for the biological assessment of the effects of storage or drawdown on lake productivity.

The entire lakeshore was classified and related to twelve typical lakeshore sections.

During 1972, these sections were surveyed to 15 feet below and at least 10 feet above water surface. Physical features, such as substrate composition, vegetation and soil conditions were described and catalogued. One or two test pits were hand excavated at each section to a depth of 2.5 feet for visual identification of surficial soil composition. The height, location and type of vegetation was documented. Underwater substrate was initially identified to a depth of 15 feet using dredge samples and photographed by the use of a periscope. Other photographs documented the terrestrial vegetation and the condition of the bank and beach area.

Limnological surveys carried out during 1972 indicated that productive substrate areas generally extend beyond a 15 foot depth. It was therefore decided to extend the soundings and identify the substrate composition to a depth of 30 feet at each section. This was done during the summer of 1973.

4.2 1972 Survey:

A reconnaissance survey of the entire shoreline was carried out and 12 sections were selected to represent all existing shoreline conditions. The location of these sections are shown on Figure 14. Sketches of the shoreline profiles together with the pertinent information and photographs obtained at each section are shown on Figure 16 to 27. The various symbols and soil classifications used in these sketches are shown on Figure 15. It is to be noted that the shore-

line profiles are extended only to a maximum of 15 feet below water level and pertain only to the surveys conducted during 1972. The information obtained during 1973 is discussed later in this report.

Similarities exist in the physical features of several of the shoreline sections. Therefore the 12 sections were grouped into 6 distinct shoreline classifications on the basis of the following physical characteristics:

- Class A - Very steep, unstable foreshore with shallow, flat littoral zone.
- Class B - Steep, stable foreshore with shallow, flat littoral zone.
- Class C - Very steep, exposed bedrock foreshore with steep, rocky littoral zone.
- Class D - Steep, stable foreshore with steep gravel littoral zone.
- Class E - Low, stable foreshore with moderately flat littoral zone.
- Class F - Very flat foreshore with moderately flat littoral zone.

The proportion of the total shoreline perimeter represented by each of the above classifications and the sections assigned to each classification are as follows:

<u>CLASS</u>	<u>SECTION</u>	<u>SHORELINE LENGTH IN MILES</u>	<u>PERCENT OF TOTAL SHORELINE LENGTH</u>
A	1, 6	4.0	4.2
B	2	10.8	11.3
C	9	5.7	5.9
D	11, 12	8.2	8.5
E	3, 4, 7, 8, 10	66.9	69.7
F	5	0.4	0.4
<u>TOTAL</u>		<u>96.0</u>	<u>100.0%</u>

Except in the case of Class A shoreline, flooding of Aishihik Lake to elevation 3007.5 should not have a major impact on the shallow littoral zone. Increased turbidity can be expected adjacent to soil based slopes, but the beaches should quickly adjust to the increased water levels. Some of the fine grained soil common to most of the shoreline will accumulate on the lake bottom within the littoral zone, but most of it will likely be taken into suspension and distributed by wave action throughout the lake.

Extensive erosion will, however, occur along the Class A shoreline with flooding to elevation 3007.5. This includes the 3 miles of steep clay banks along the north end of the lake, as represented by Section 1, and the 1 mile of steep gravel banks at Section 6. The instability of the clay banks is apparent by the large cracks and slumping occurring near Section 1. Wide beaches have formed at the toe of the banks but a certain amount of erosion probably occurs

naturally with high water levels and intense wave action. Raising the lake to elevation 3007.5 would inundate these beaches, leaving the banks vulnerable to severe wave attack.

In attempting to quantify the probable extent of erosion along these steep banks with the lake raised to elevation 3007.5, it has been assumed that the banks are now in equilibrium with the historic high water level of 3002.5 and that they will recede with increased water level until the beaches and littoral zone reach their present profile relative to the water level. On the basis of this premise, a recession of 140 feet and 150 feet has been estimated for Sections 1 and 6, respectively (Figure 28). It is expected that the recession would progress rapidly during the initial stages of flooding and would continue for many years before stabilizing.

Drawdown of Aishihik Lake to elevation 2992.5 would dewater some of the substrate areas which may be important for the production of benthic organisms. The areas which would be particularly affected by drawdown are the shallow regions around the north end of the lake; the deltas of the Sekulmun River, Creeks A2, A3 and A9; and the shallow substrate below the gravel banks at Section 6. An approximation of the area that would be dewatered below elevation 3002.5 for each of the shoreline classifications is indicated below:

<u>SHORELINE CLASSIFICATION</u>	<u>AVERAGE WIDTH OF SUBSTRATE DEWATERED BELOW ELEV. 3002.5, FEET</u>	<u>LENGTH OF SHORELINE, MILES</u>	<u>AREA DEWATERED BELOW ELEV. 3002.5, ACRES</u>
A	230	4.0	112
B	210	10.8	275
C	30	5.7	21
D	50	8.2	50
E	100	66.9	811
F	120	0.4	6
<u>TOTAL</u>			<u>1275</u>

The actual area dewatered will be somewhat greater than 1275 acres since the shoreline classifications do not account for all of the shallow bays and delta areas around the lake.

4.3 1973 Survey:

The biological investigations during 1972 found that benthic organisms often originated at depths well below 15 feet (Kussat, 1973). Therefore, during 1973 it was decided to continue the soundings and identify the substrate composition at each section to a depth of 30 feet. A standard Ponar dredge was used in identifying the substrate. The information obtained in this survey is summarized below:

Section 1: The substrate continues at a constant gradient beyond the 15 foot depth, reaching a depth of 30 feet approximately 1400 feet from

shore (Station 0). Between 15 and 30 feet in depth the substrate is comprised of sand and silt.

Section 2: The substrate continues at a constant gradient beyond the 15 foot depth, reaching a depth of 30 feet approximately 1300 feet from shore (Station 0). Substrate is again comprised of sand and silt in the area between 15 and 30 feet in depth.

Section 3: The substrate gradient remains reasonably constant to a depth of 30 feet, which occurs approximately 300 feet from shore. Sand and silt occur at the 30 foot depth but it is unknown where the transition from rock occurs, as shown on Figure 18.

Section 4: The substrate gradient remains constant beyond 15 feet, reaching a depth of 23 feet at 330 feet from shore and then flattens out to the 30 foot depth at 700 feet from shore. Sand and silt occurs at a depth of 30 feet.

Section 5: The substrate continues at a constant gradient for 200 feet from shore, levels off at an 18 foot depth for a further 55 feet and then drops steeply to a 30 foot depth at 310 feet from shore. The substrate is composed of sand and silt at 30 feet.

Section 6: The substrate gradient remains relatively constant beyond 15 feet, reaching a

depth of 30 feet at 770 feet from shore. Sand and silt was found at the 30 foot depth.

Section 7: The substrate gradient remains constant beyond 15 feet, reaching a depth of 30 feet at 260 feet from shore. Fine silt occurs at this depth.

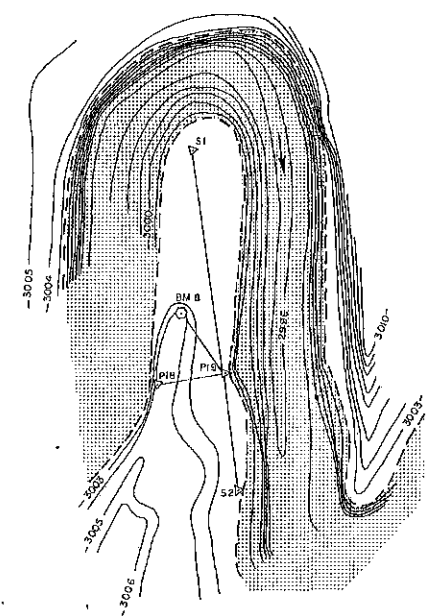
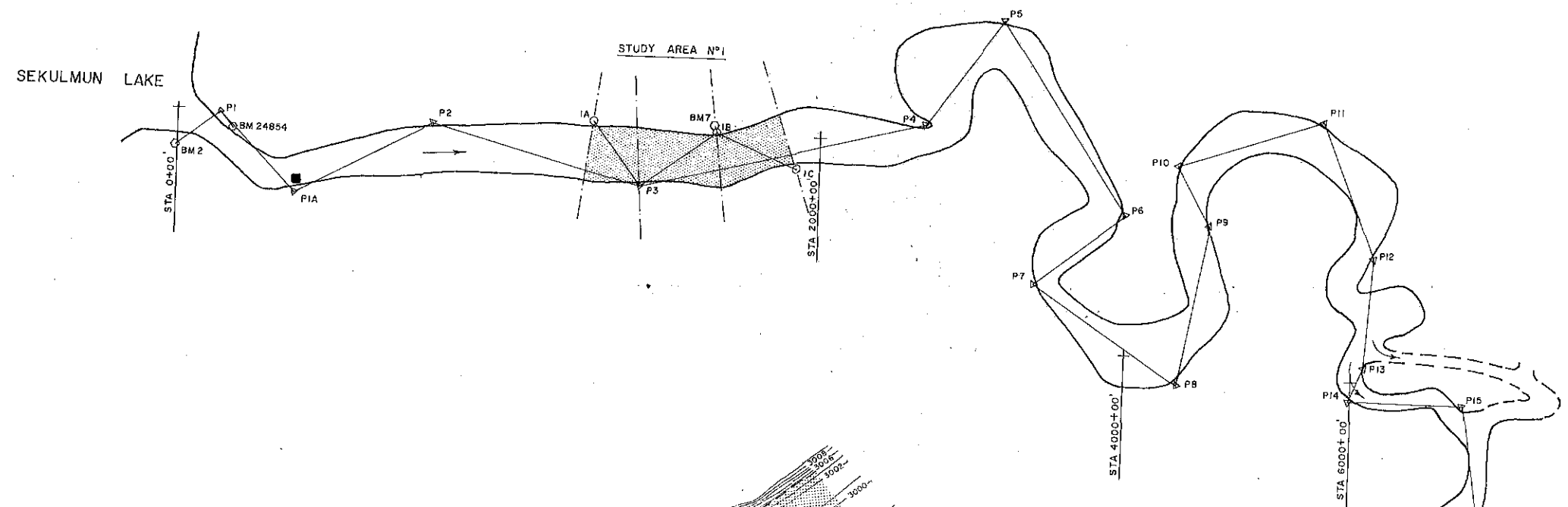
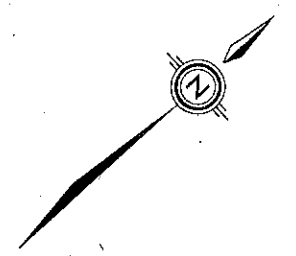
Section 8: The substrate gradient remains constant beyond 15 feet, reaching a depth of 30 feet at 340 feet from shore. A mixture of sand and silt was found at the 30 foot depth.

Section 9: The substrate gradient remains relatively constant to a depth of 17 feet and then flattens out slightly, reaching a depth of 30 feet at 125 feet from shore. Silt was found at the 30 foot depth.

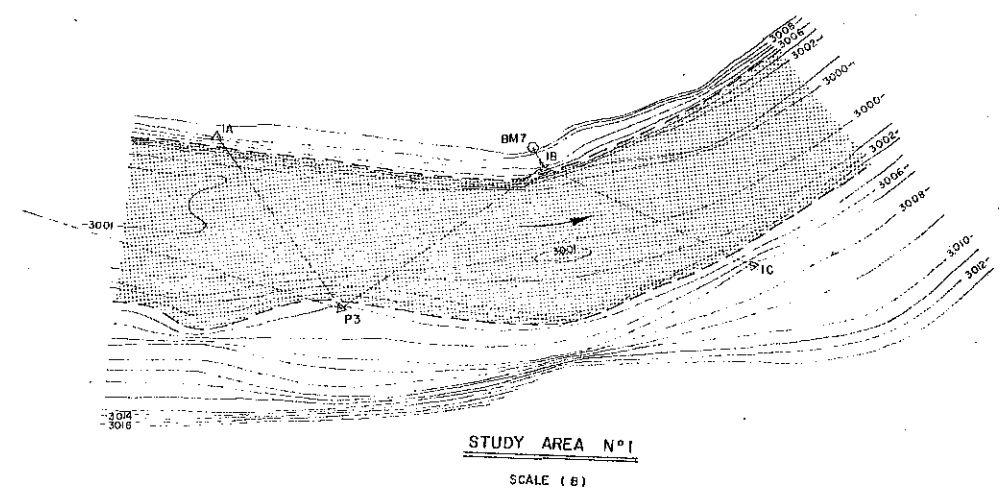
Section 10: The substrate gradient remains constant beyond 15 feet, reaching a depth of 30 feet at 140 feet from shore. The substrate at 30 feet is comprised of silt.

Section 11: The substrate gradient remains constant to a depth of 17 feet at 85 feet from shore and then flattens considerably, reaching a depth of 30 feet at 750 feet from shore. Silt was found at the 30 foot depth.

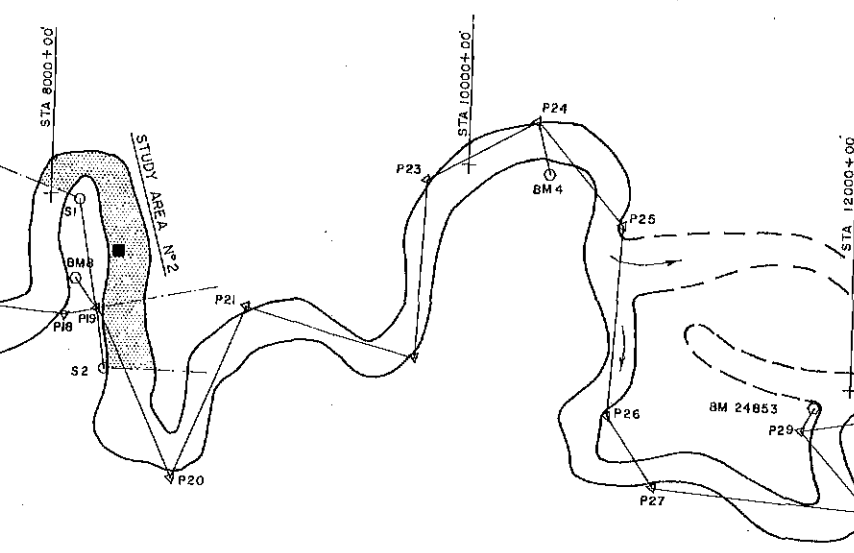
Section 12: The substrate gradient remains constant to a depth of 19 feet at 83 feet from shore and then flattens considerably, reaching a depth of 30 feet at 640 feet from shore. Silt was found at the 30 foot depth.

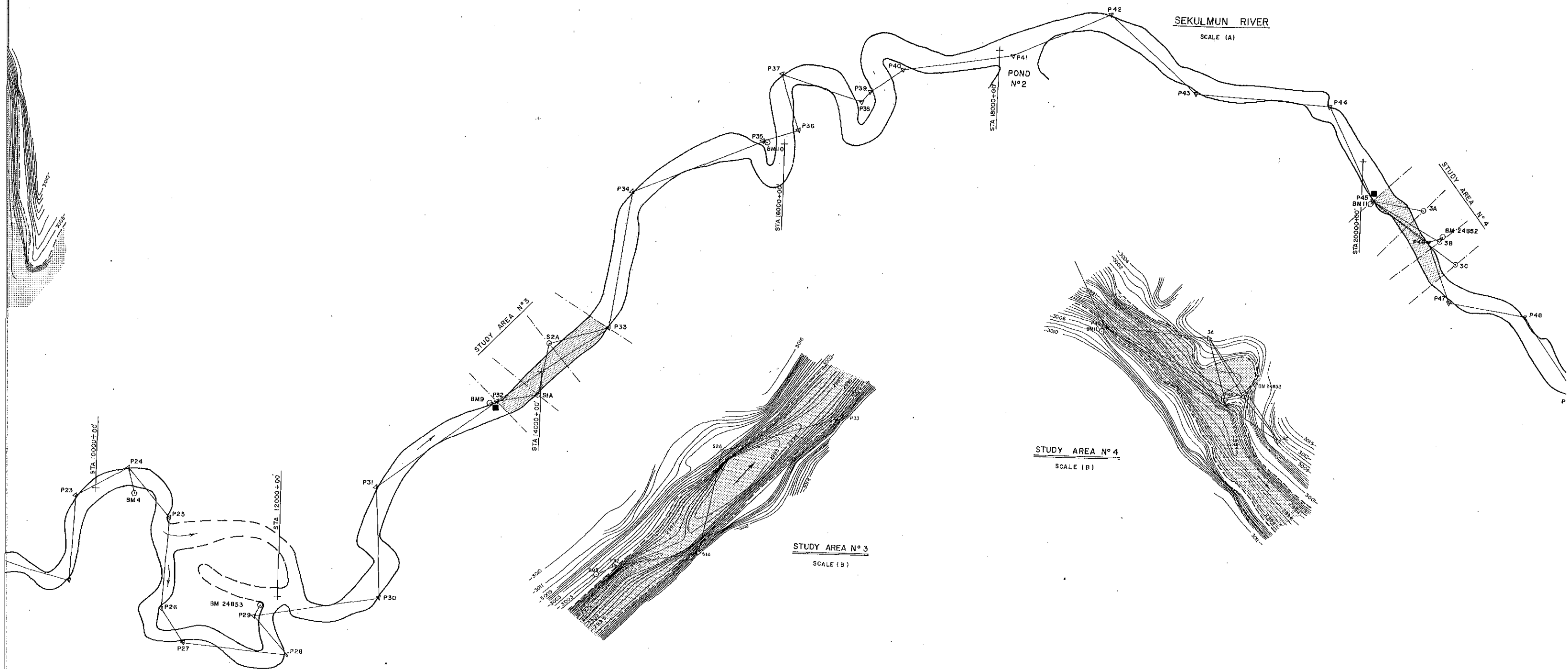


STUDY AREA N°2
SCALE (B)



STUDY AREA N°1
SCALE (B)

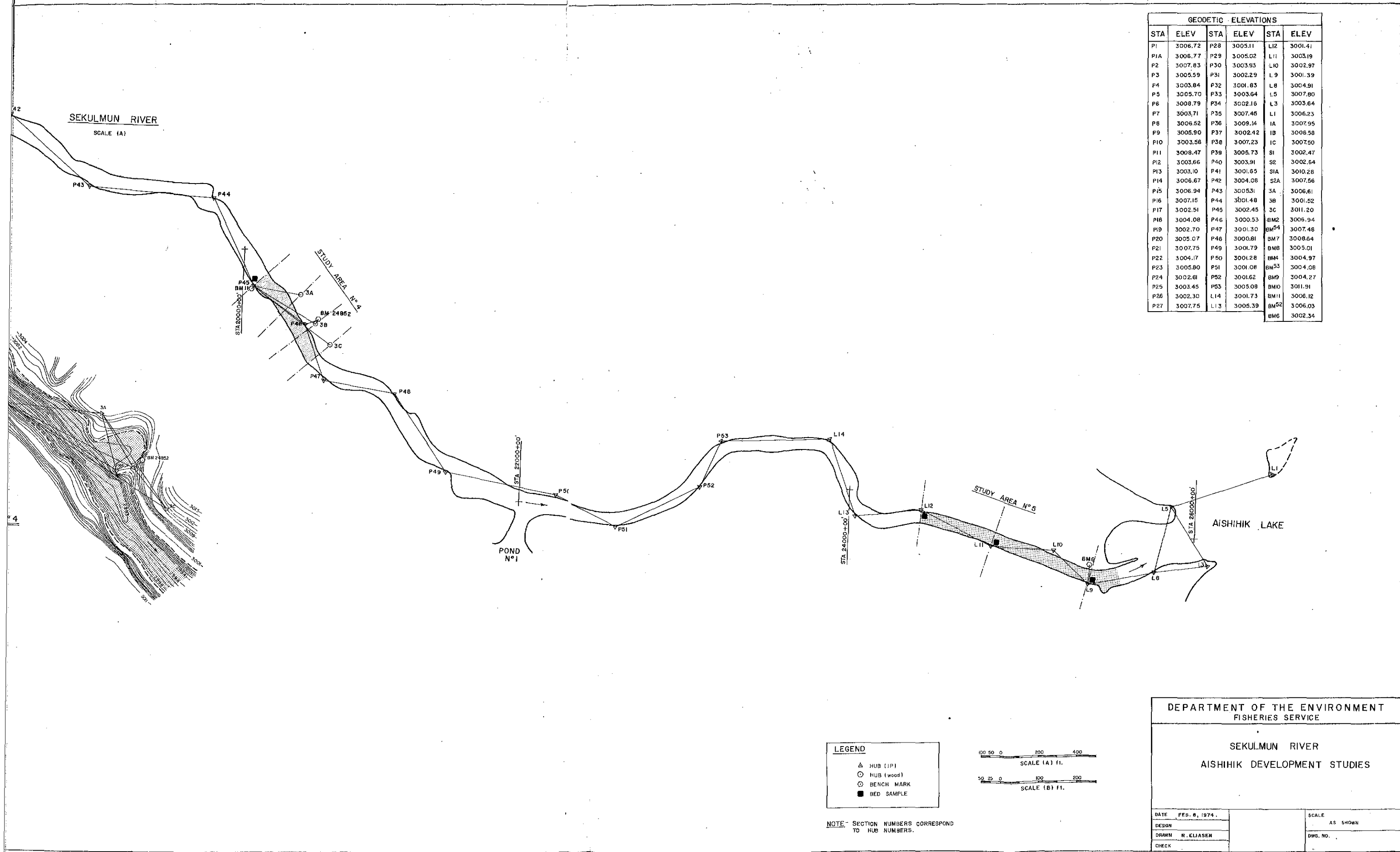


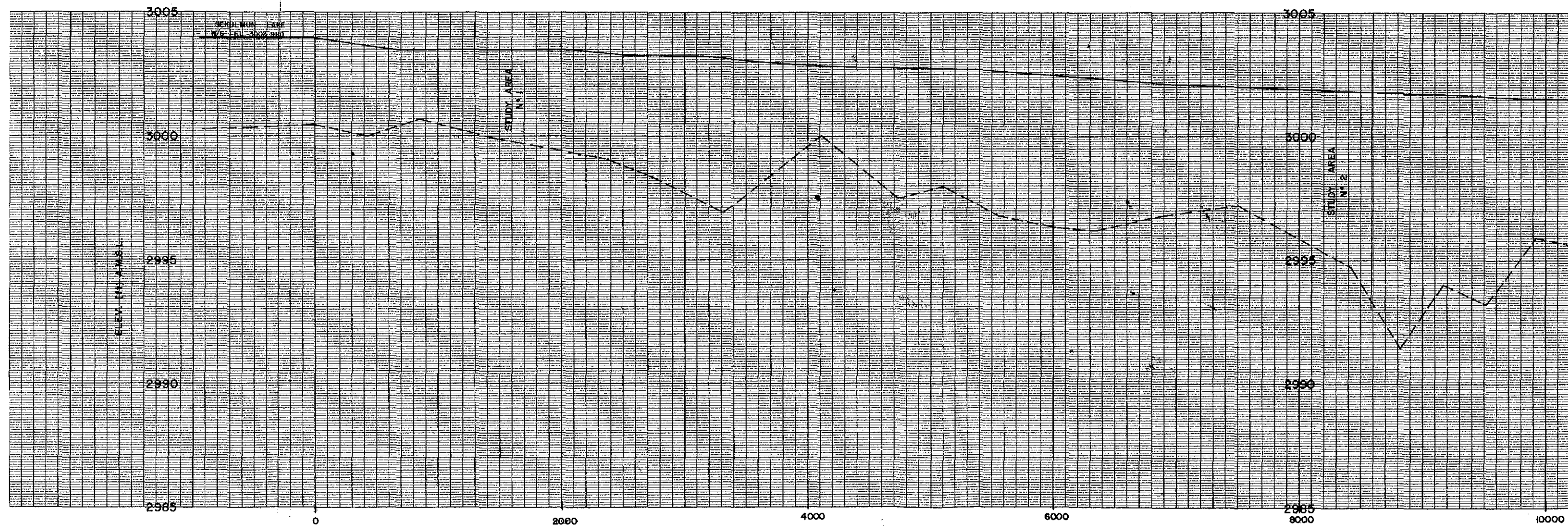


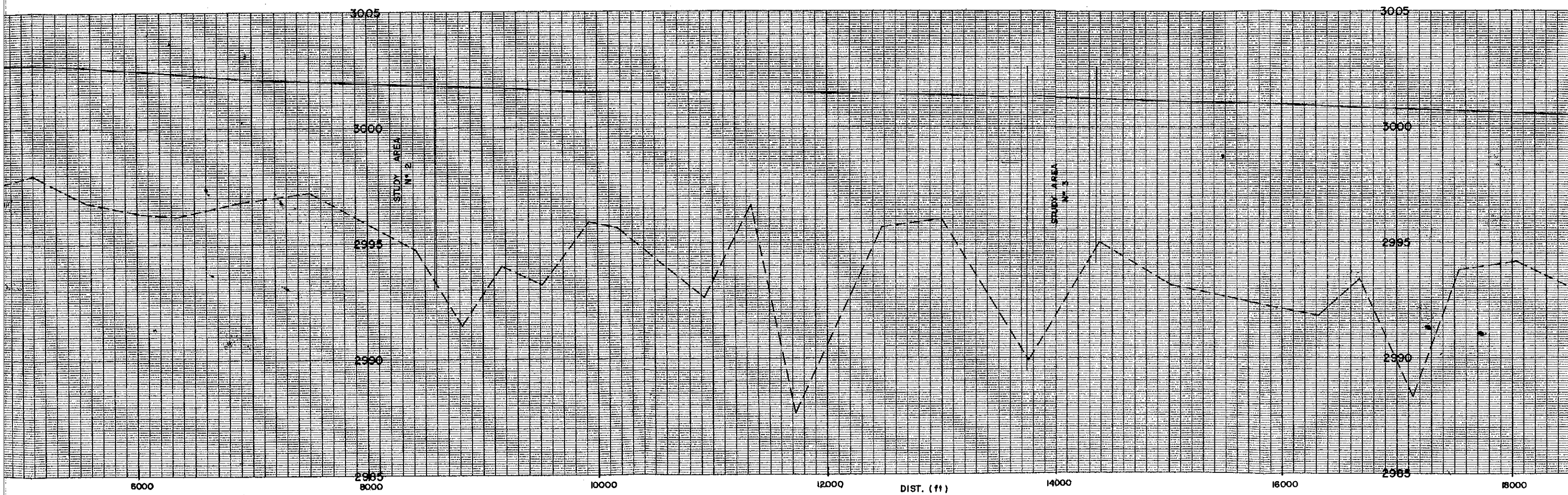
SEKULMUN RIVER
SCALE (A)

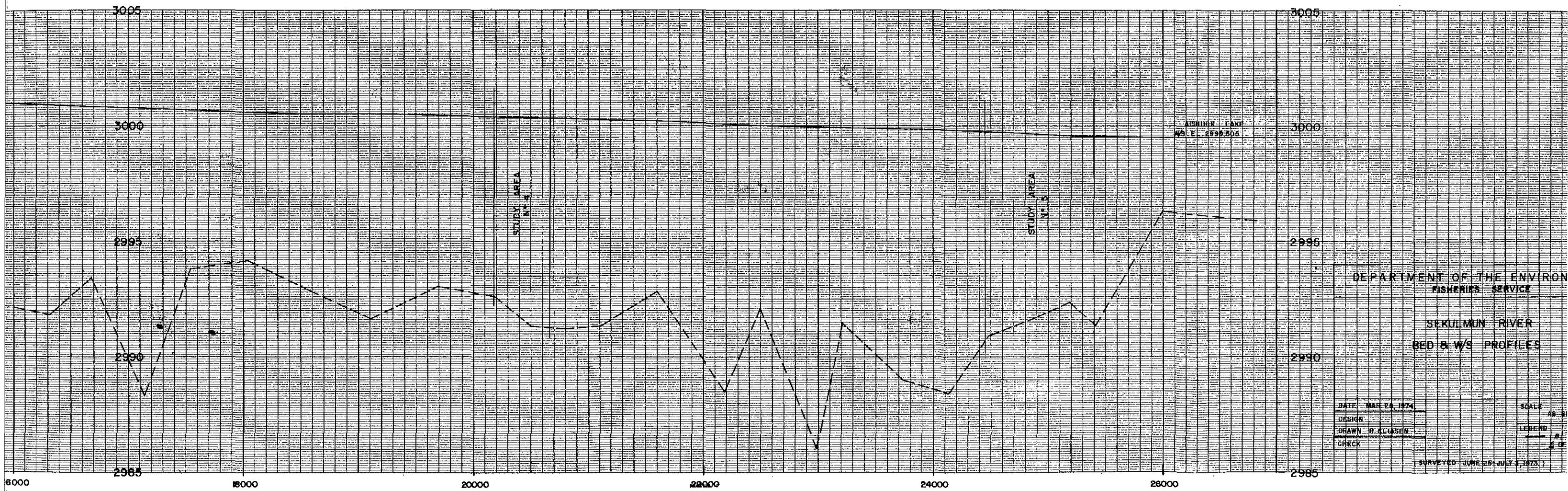
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SCALE (B)

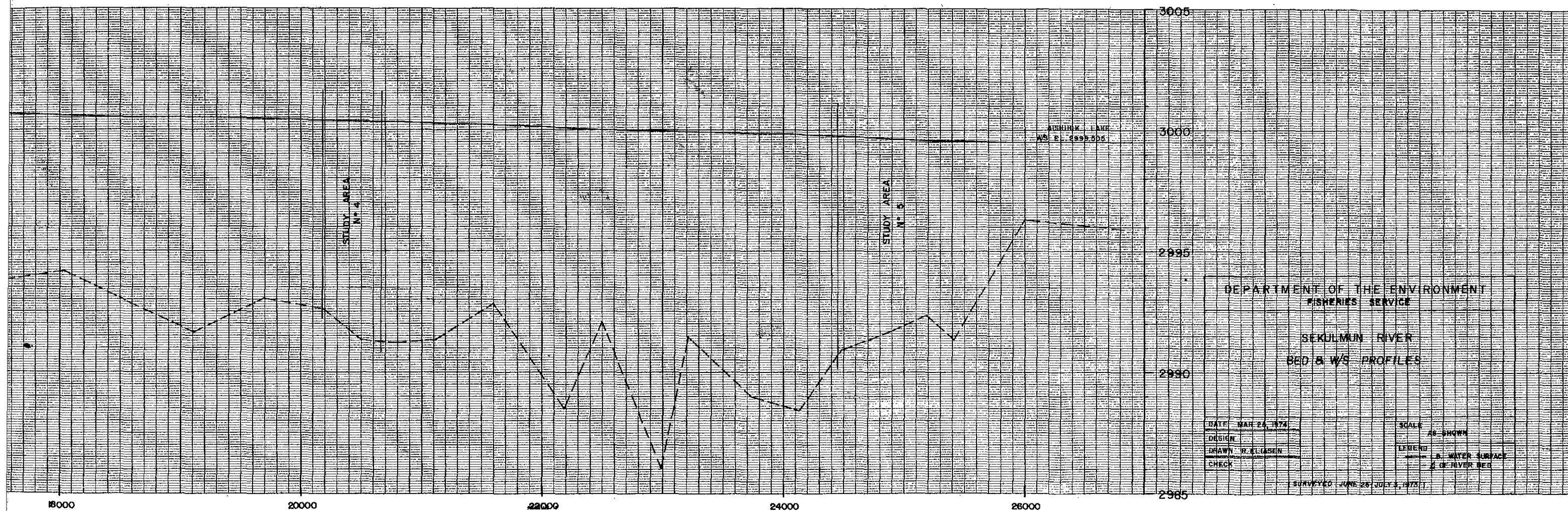
STUDY AREA N°3
SCALE (B)



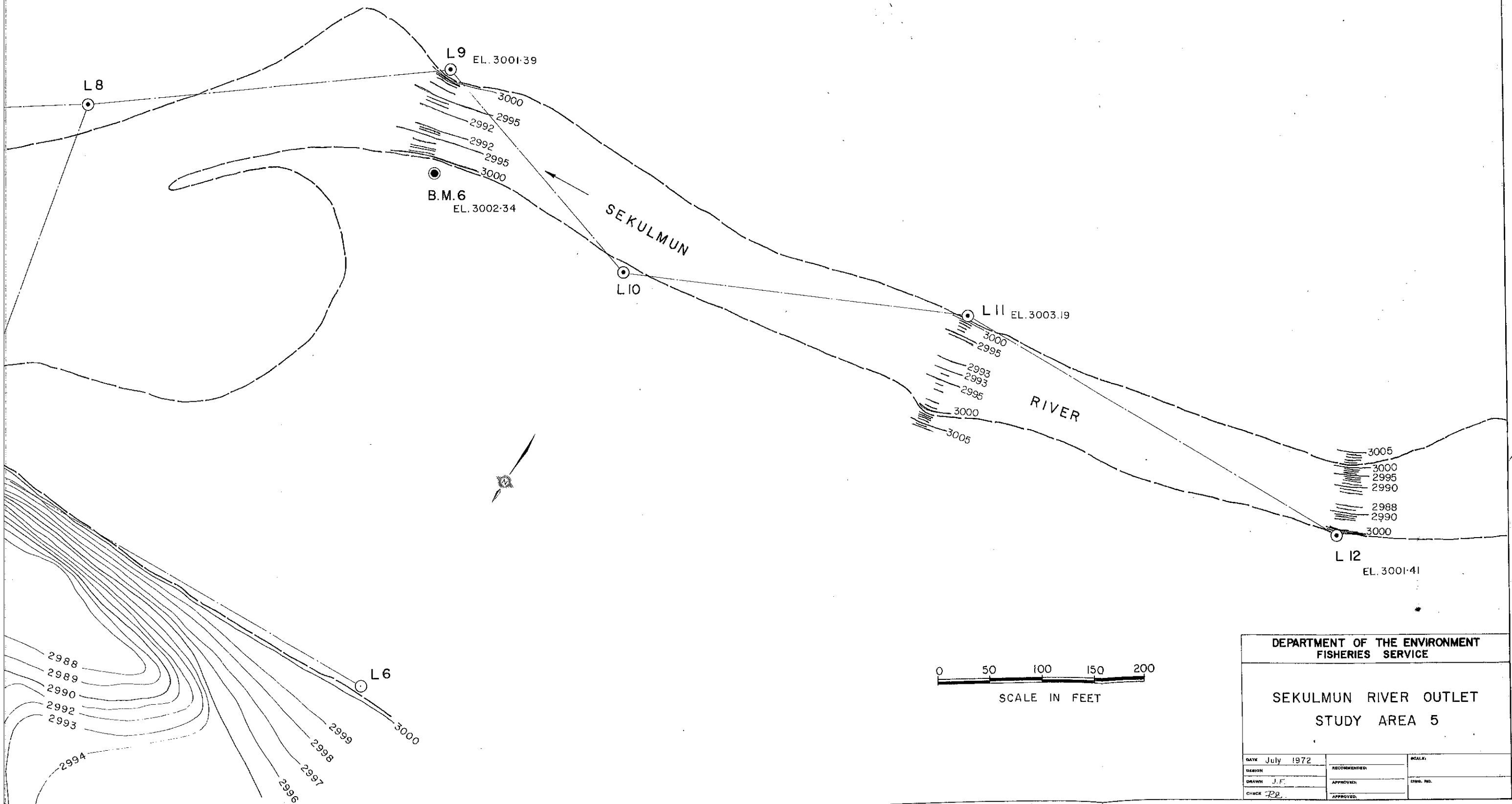






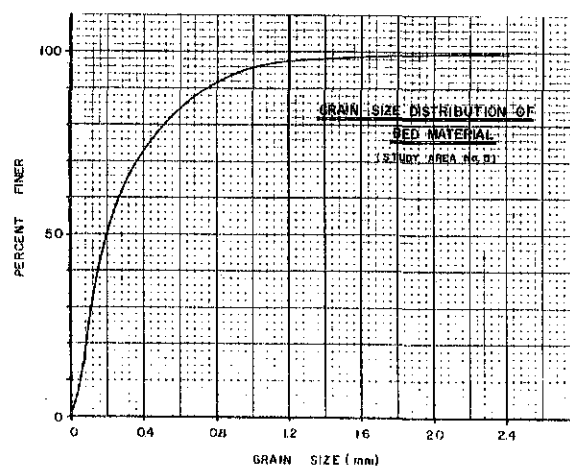
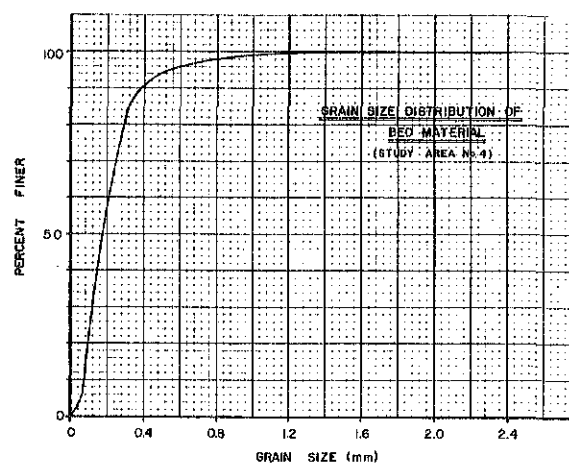
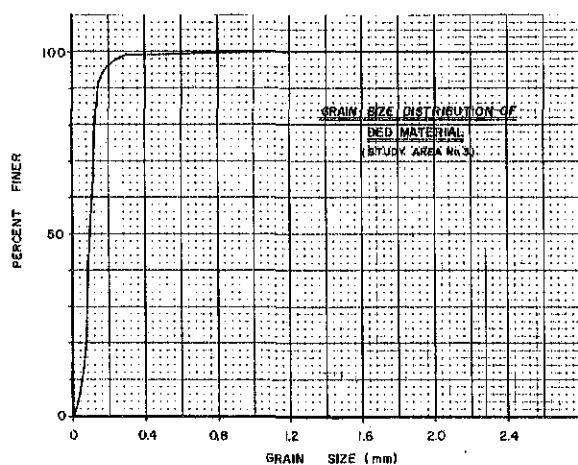
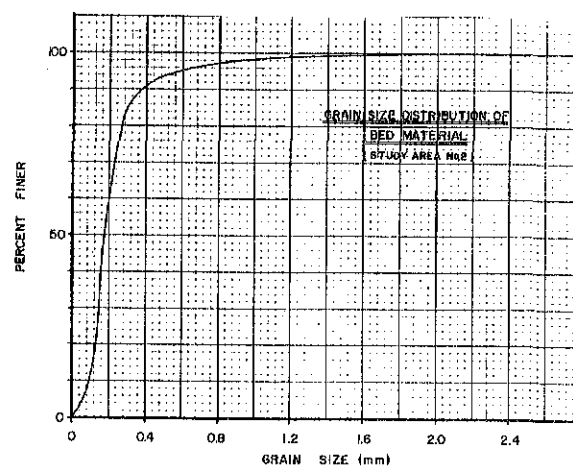
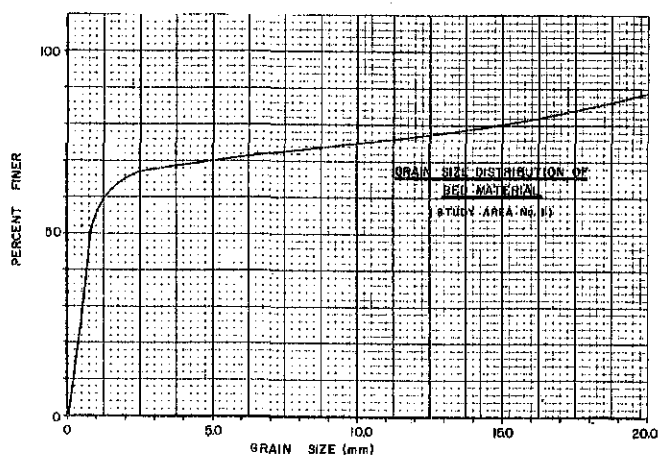




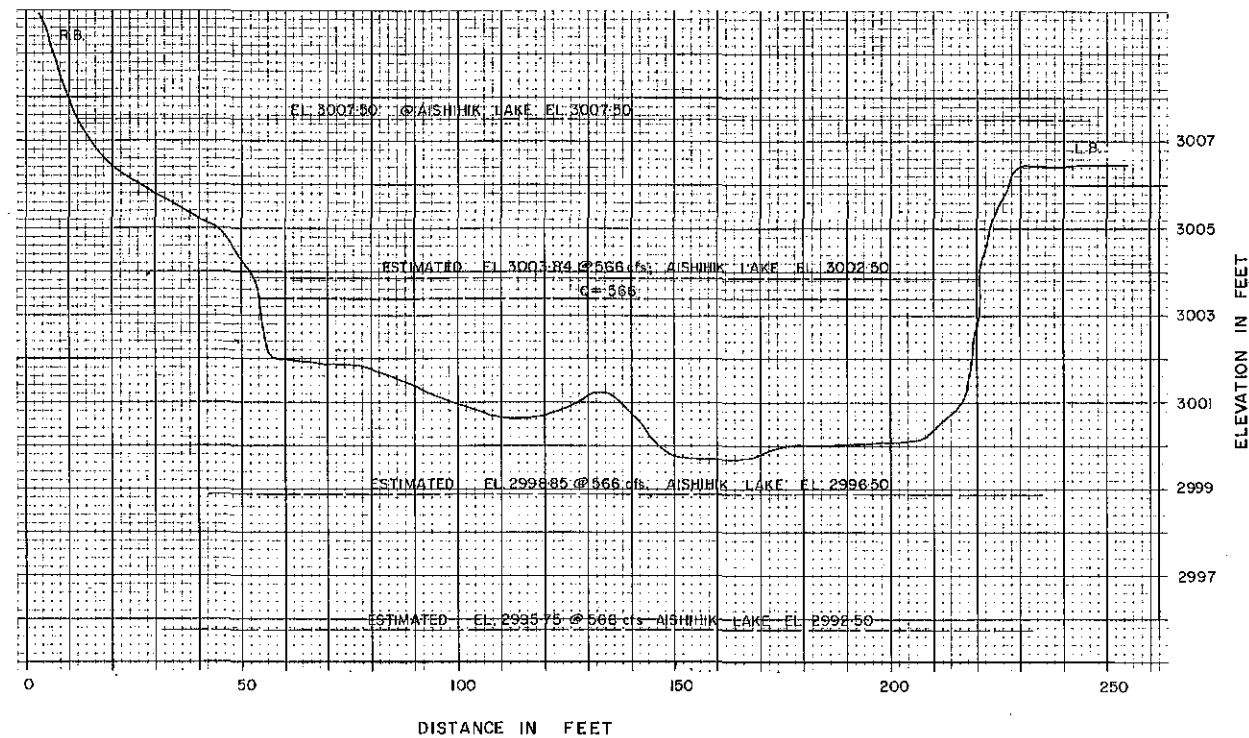


DEPARTMENT OF THE ENVIRONMENT FISHERIES SERVICE		
SEKULMUN RIVER OUTLET STUDY AREA 5		
DATE July 1972	RECOMMENDED:	SCALE:
DRAWN J.F.	APPROVED:	DWG. NO.
CHECK R.R.	APPROVED:	

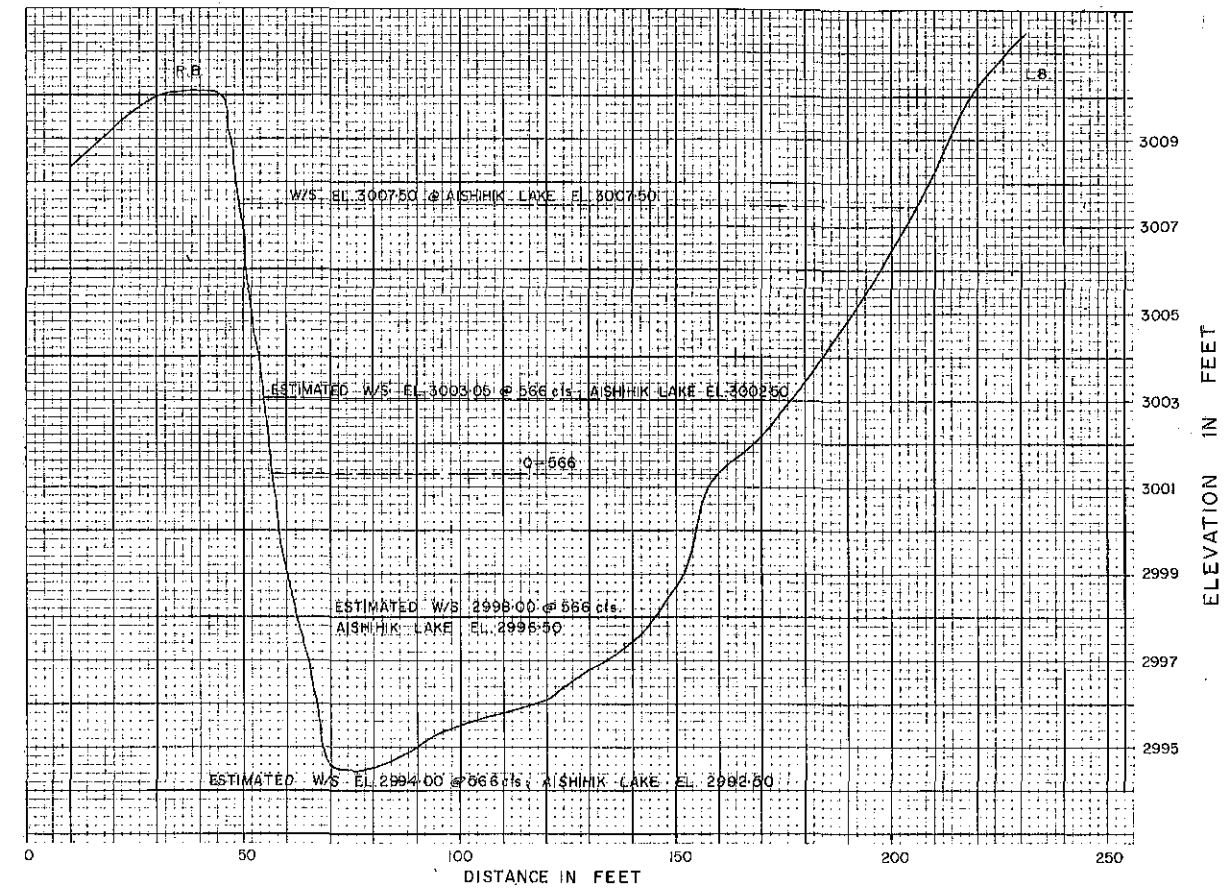
SEKULMUN RIVER GRADATION CURVES STUDY AREA 1-5.



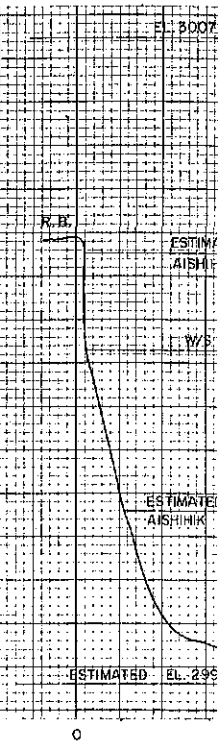
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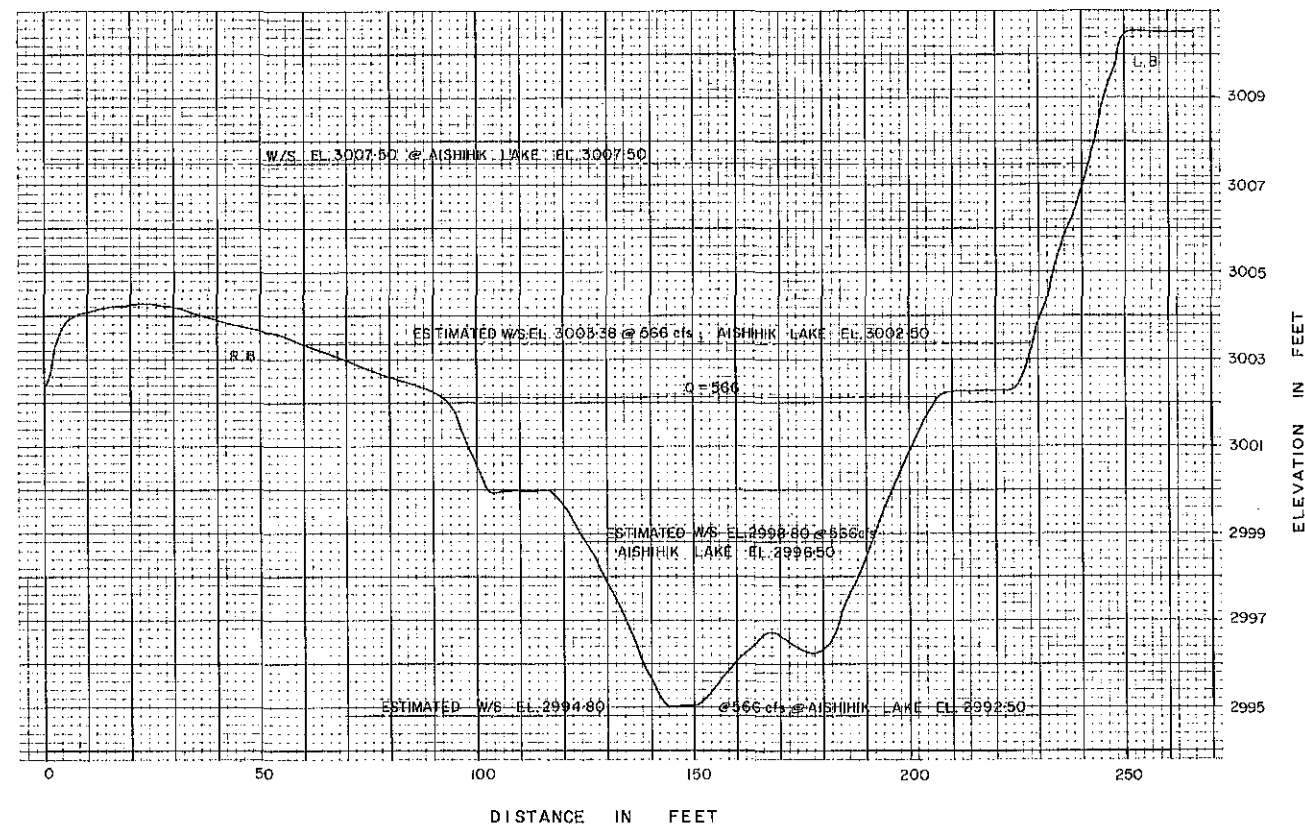
SECTION SI-A; STUDY AREA NO.3, SEKULMUN RIVER



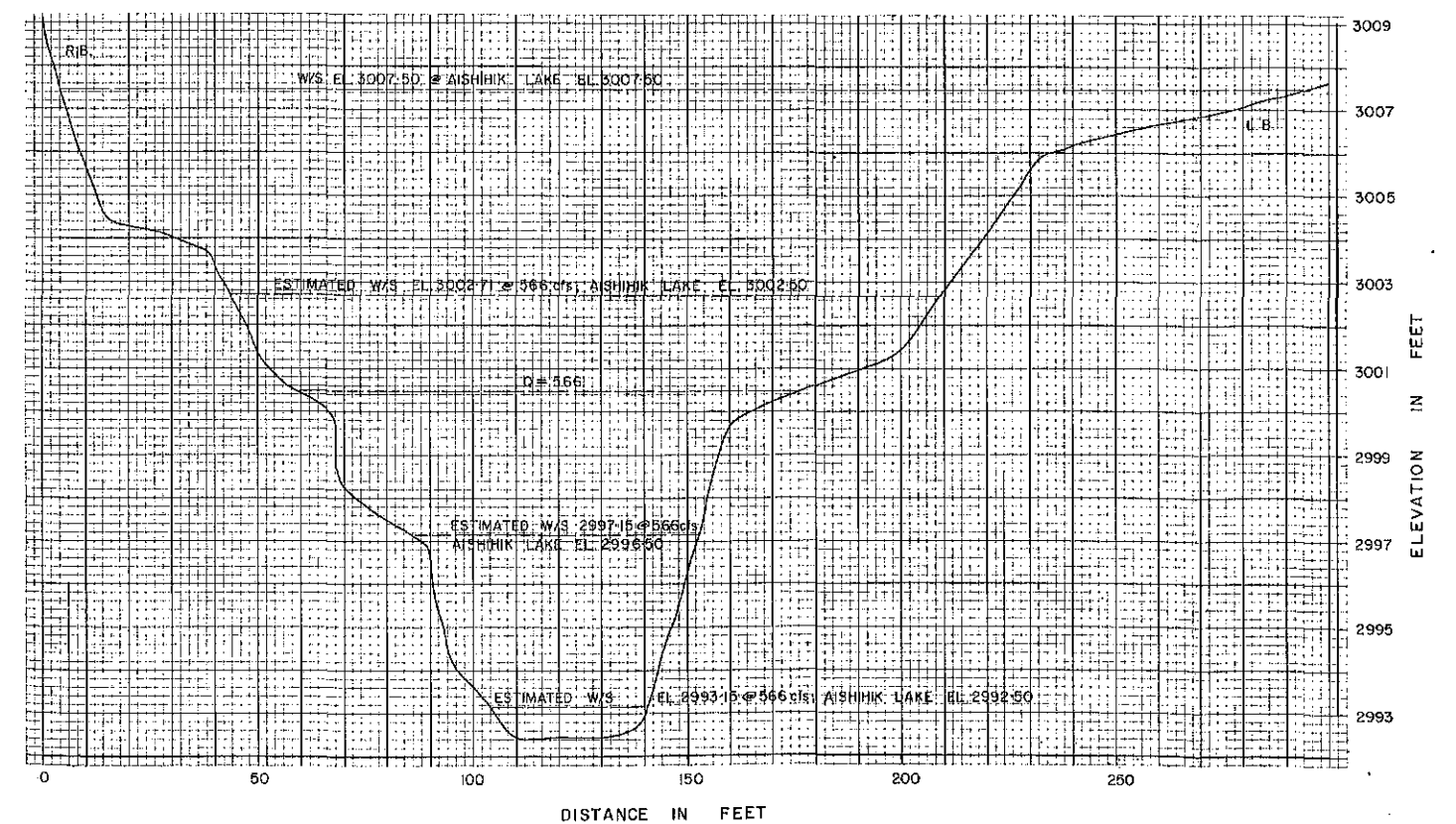
SECTION L-II;



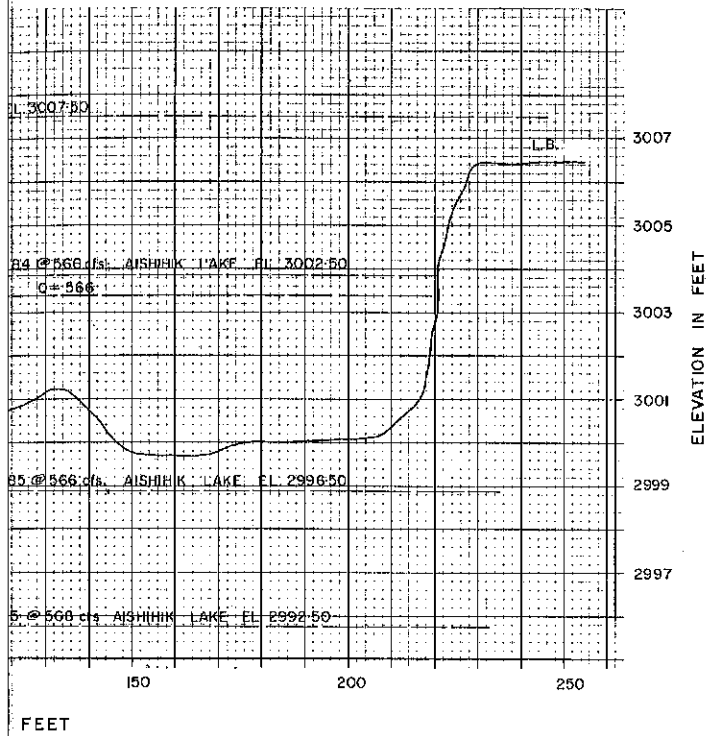
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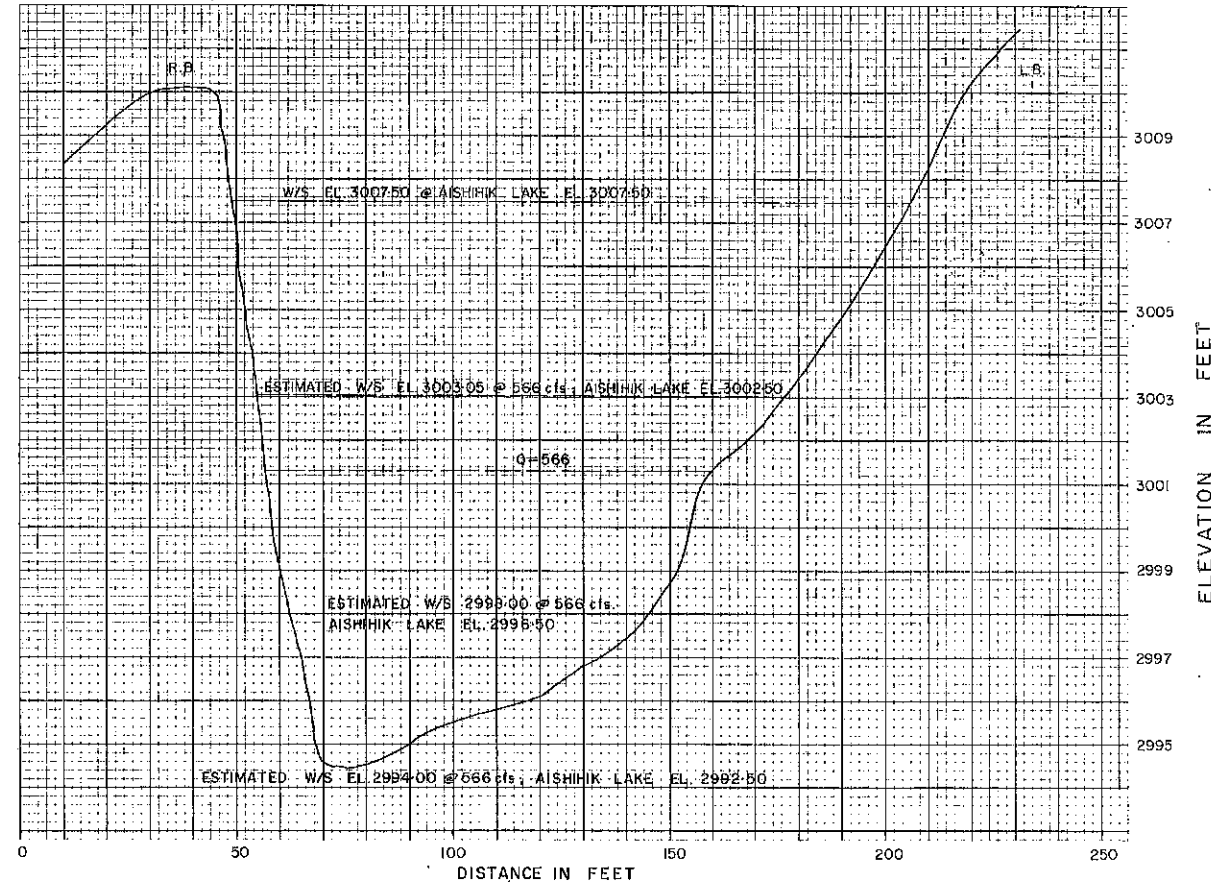
SECTION 3B; STUDY AREA NO.4, SEKULMUN RIVER



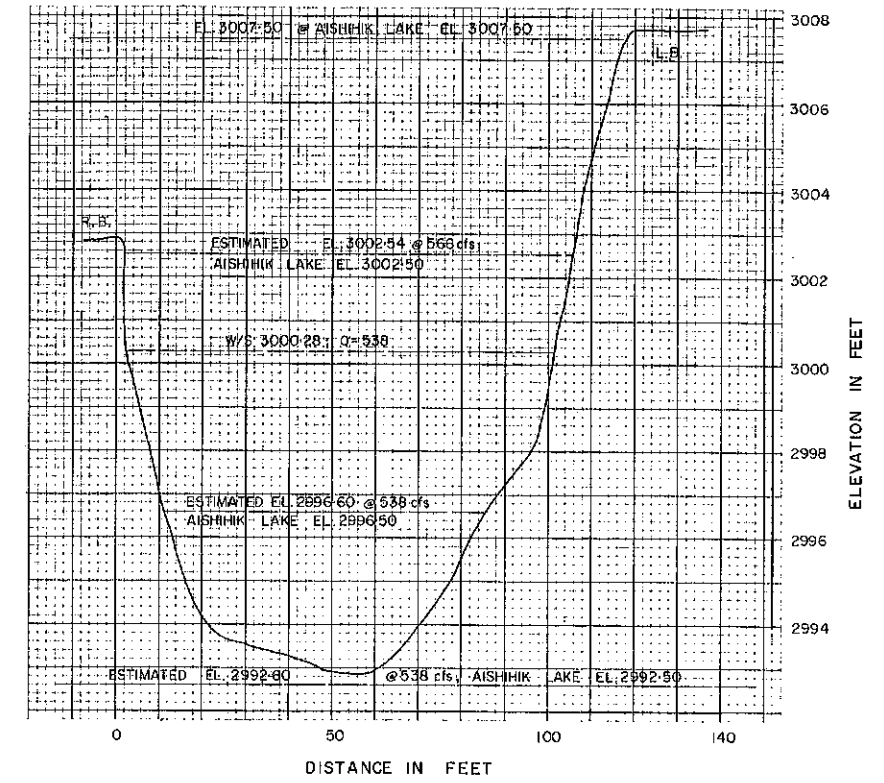
Y AREA NO. 1, SEKULMUN RIVER



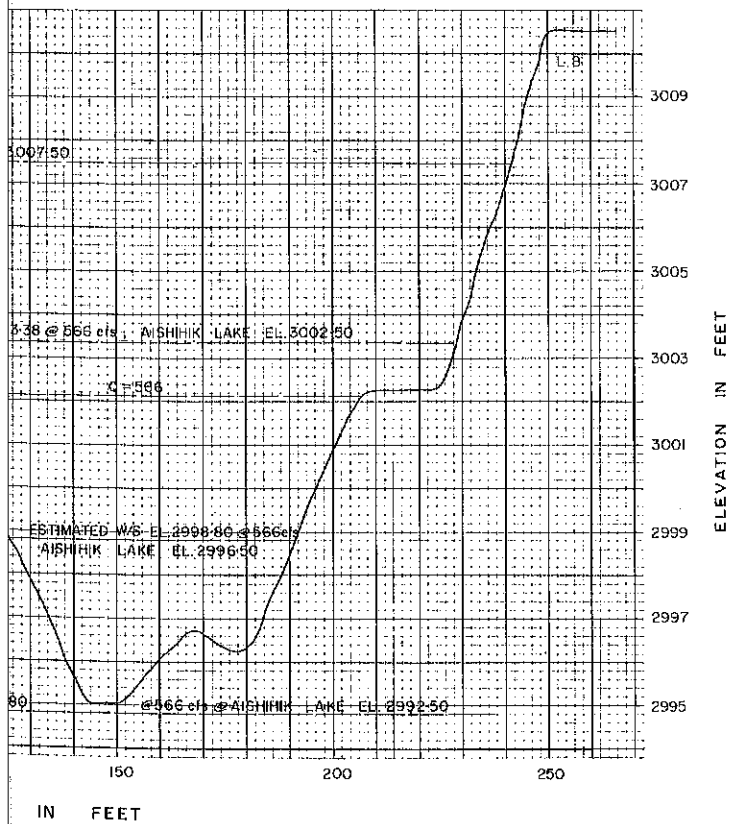
SECTION SI-A; STUDY AREA NO. 3, SEKULMUN RIVER



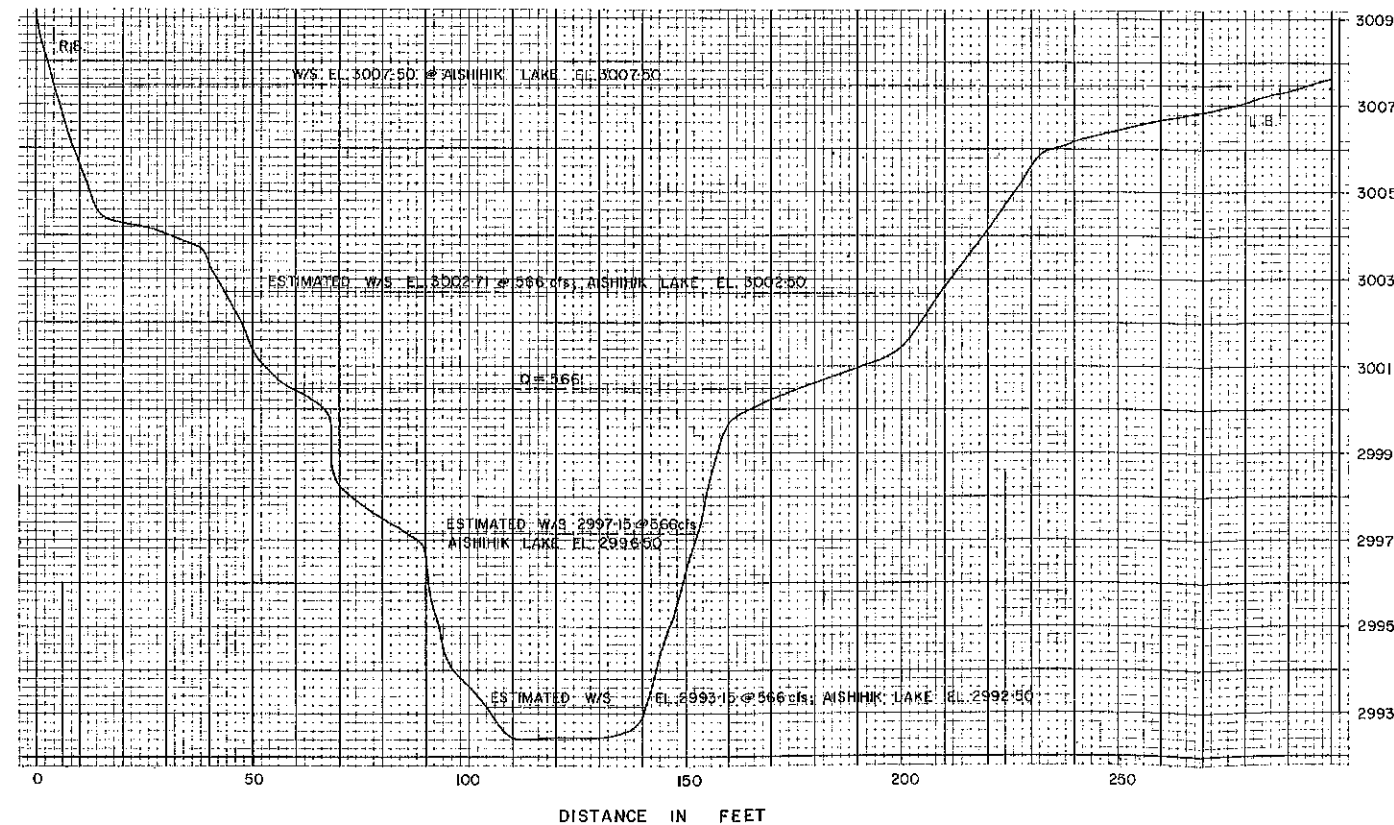
SECTION L-II; STUDY AREA NO. 5, SEKULMUN RIVER



REA NO. 2, SEKULMUN RIVER



SECTION 3B; STUDY AREA NO. 4, SEKULMUN RIVER



DATE		NO.		REVISION		BY	
DEPARTMENT OF THE ENVIRONMENT FISHERIES SERVICE							
SEKULMUN RIVER TYPICAL STUDY AREA SECTIONS							
DATE		AUG. 1974		RECOMMENDED:		SCALE:	
DESIGN		JF		APPROVED:		AS SHOWN	
DRAWN		JF		APPROVED:		DWG. NO.	
CHECK		R2		APPROVED:			

CANYON
POND

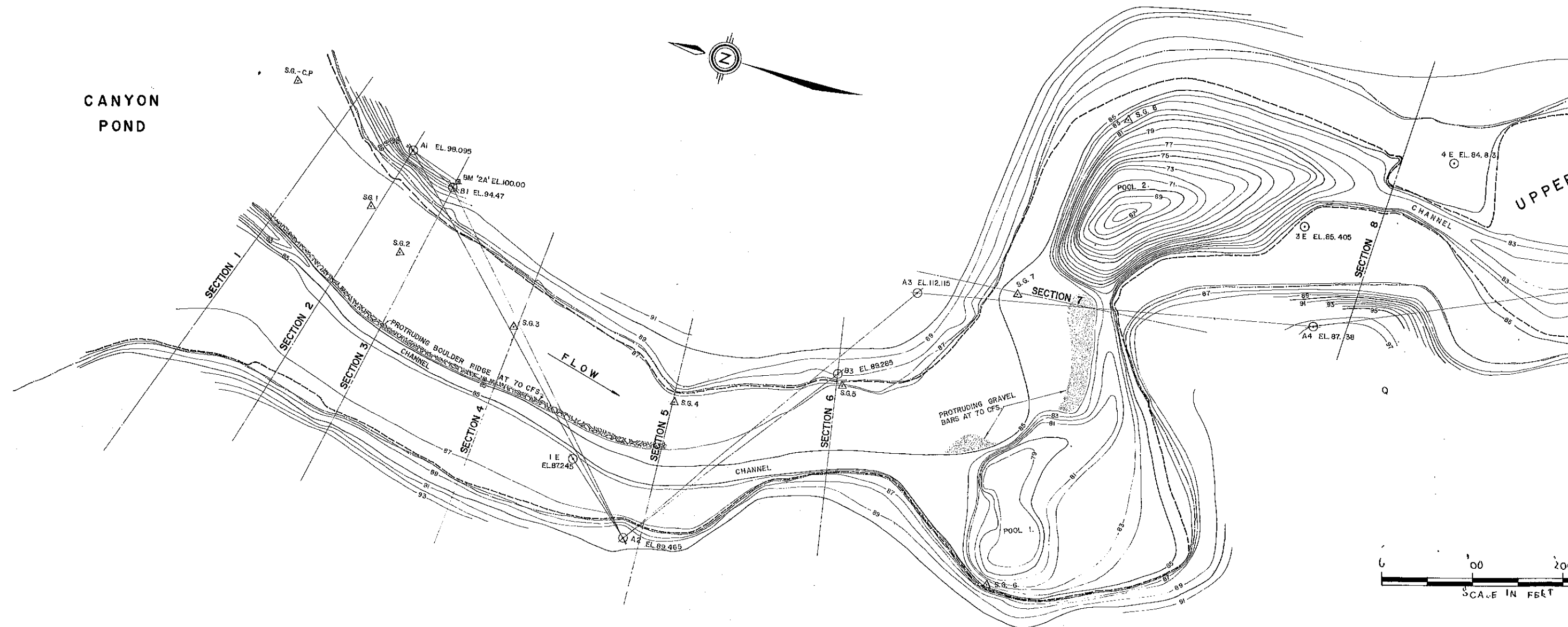
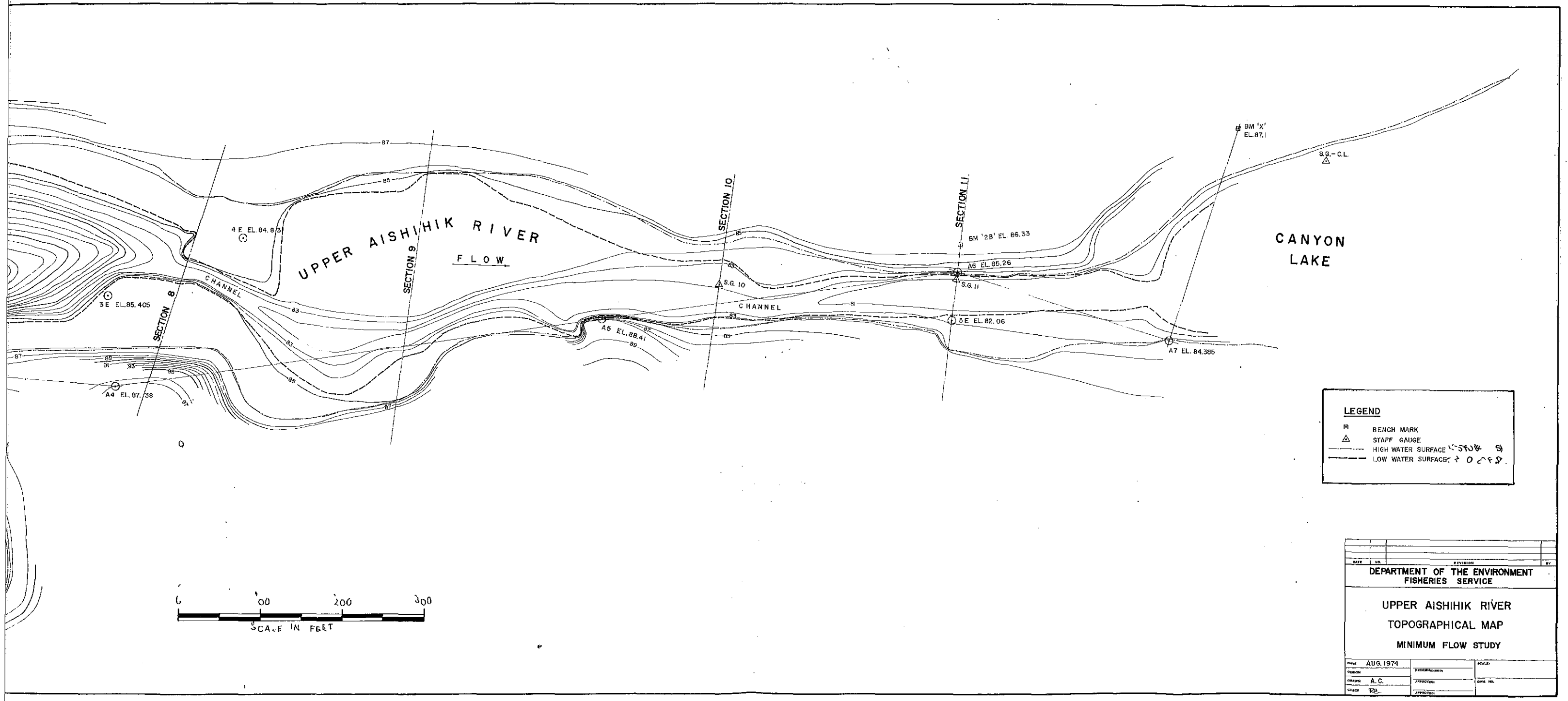
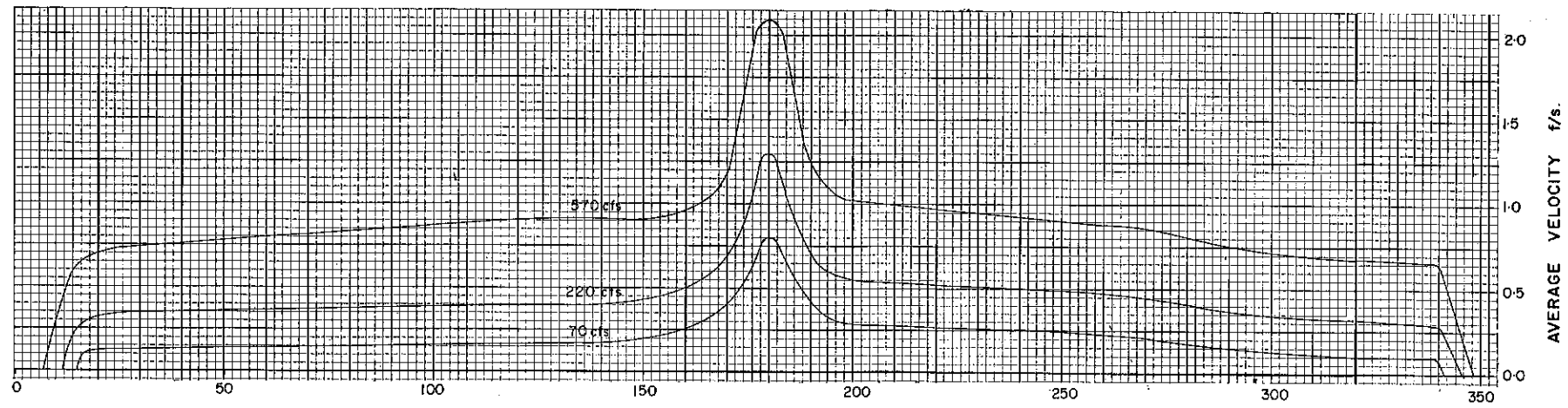
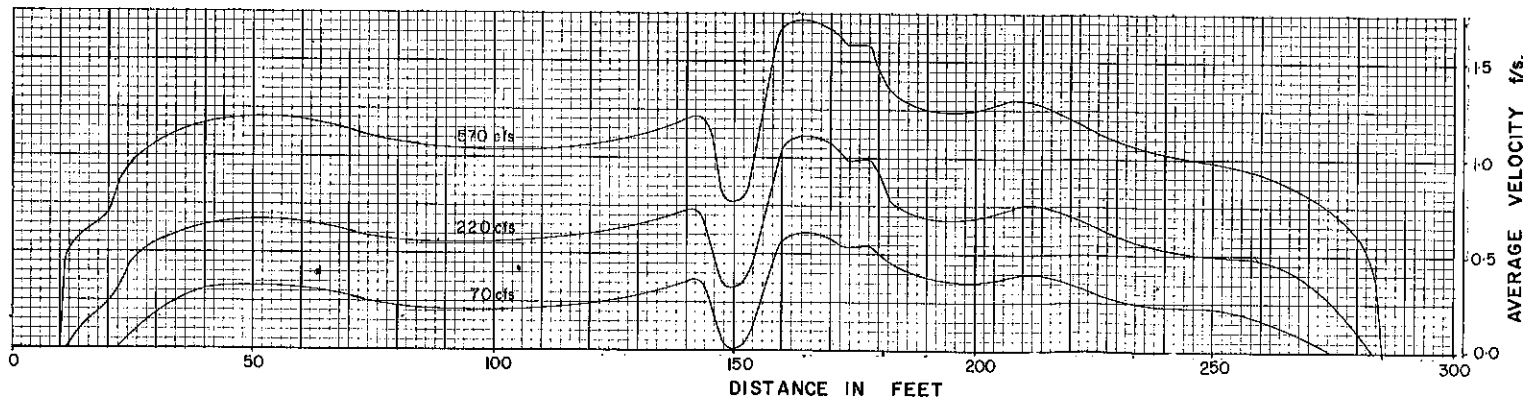
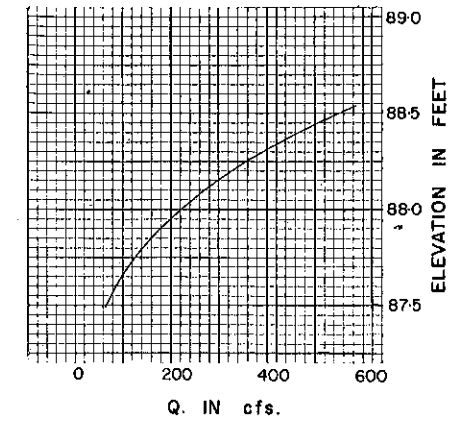
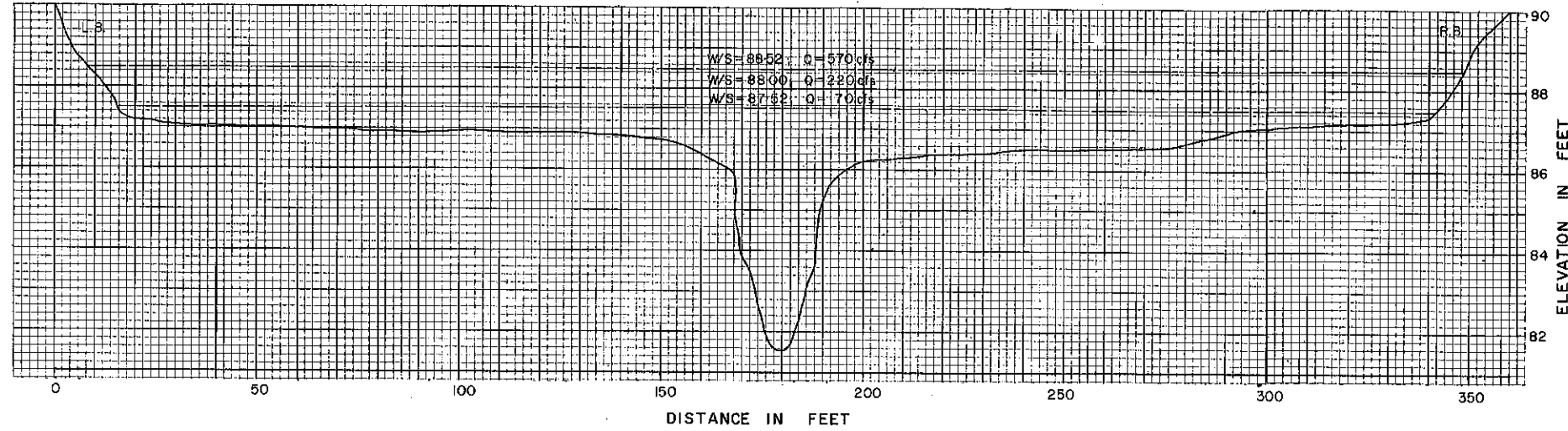


FIGURE 6

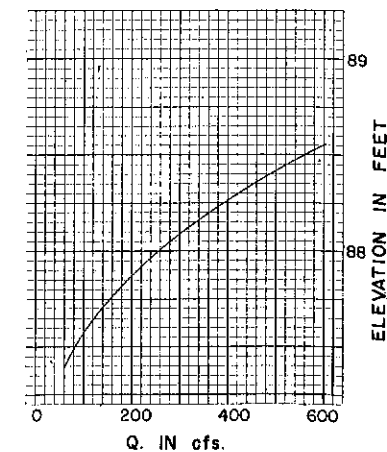
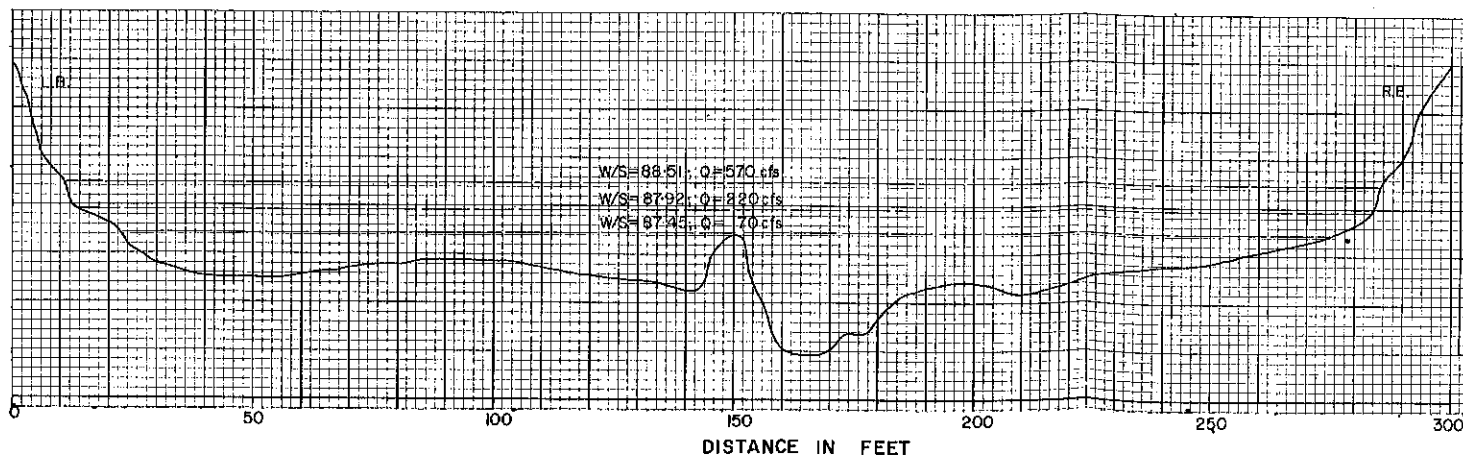


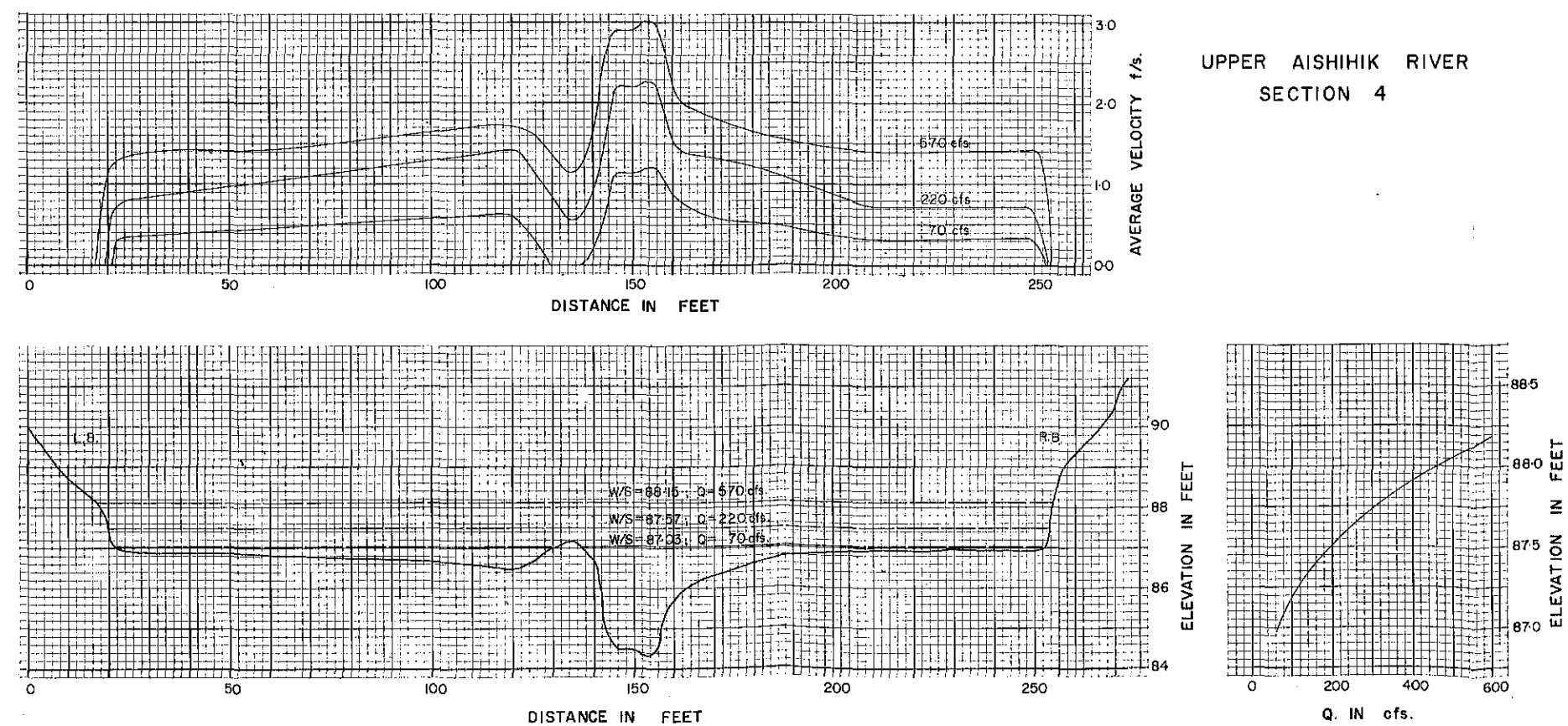
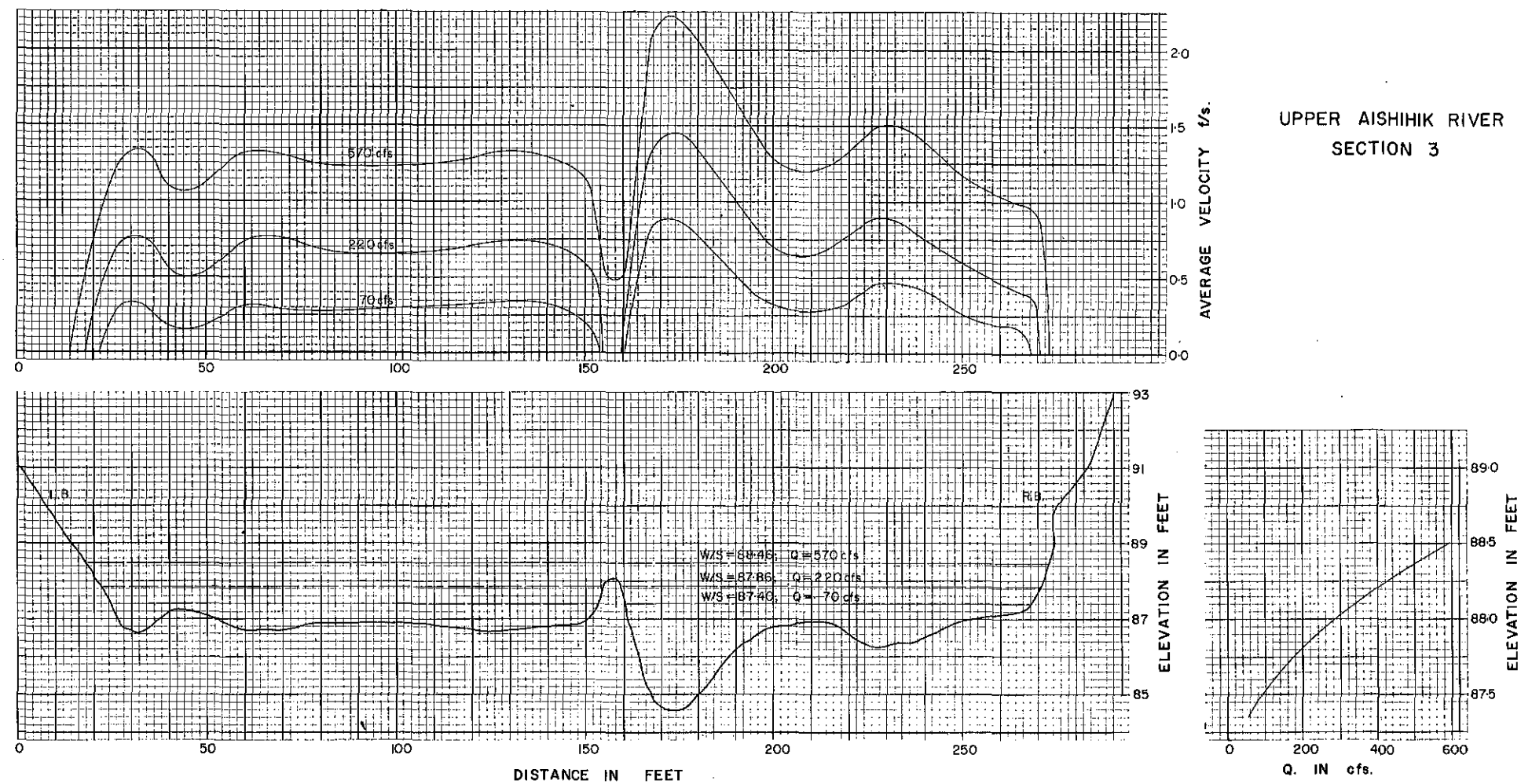


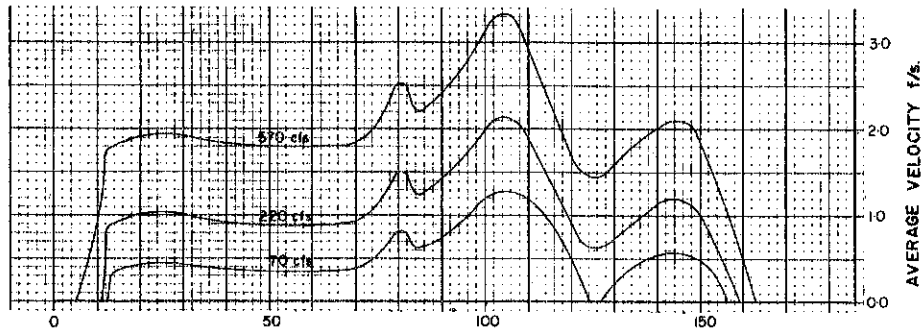
UPPER AISHIHIK RIVER
SECTION 1



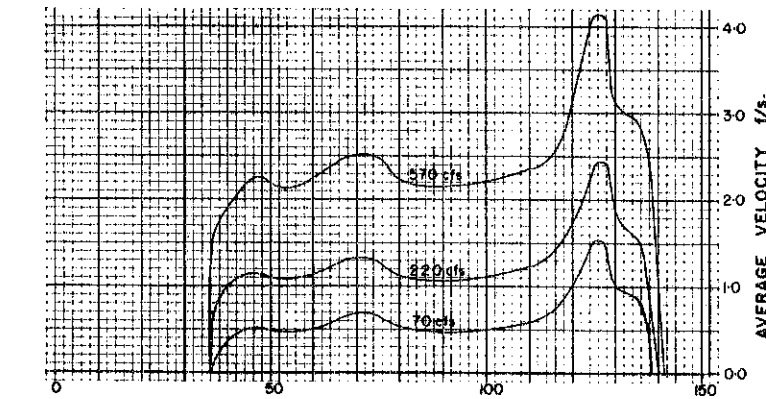
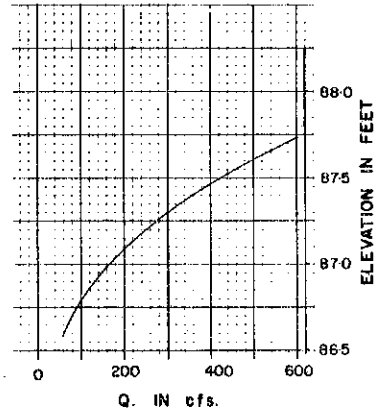
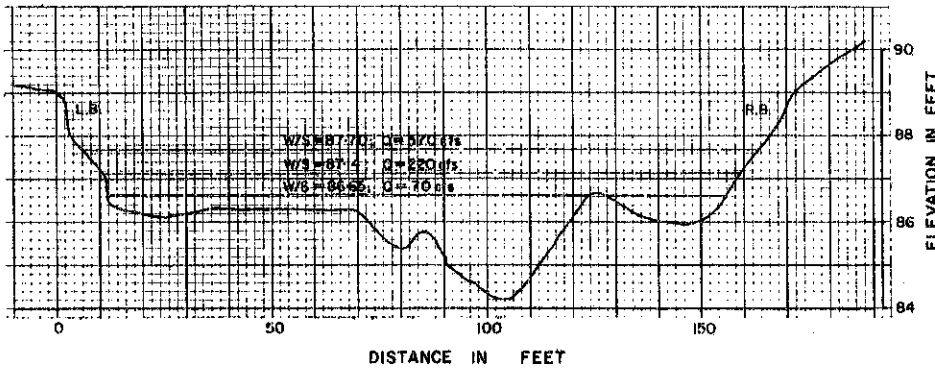
UPPER AISHIHIK RIVER
SECTION 2



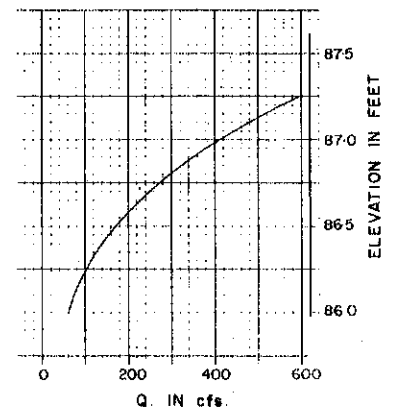
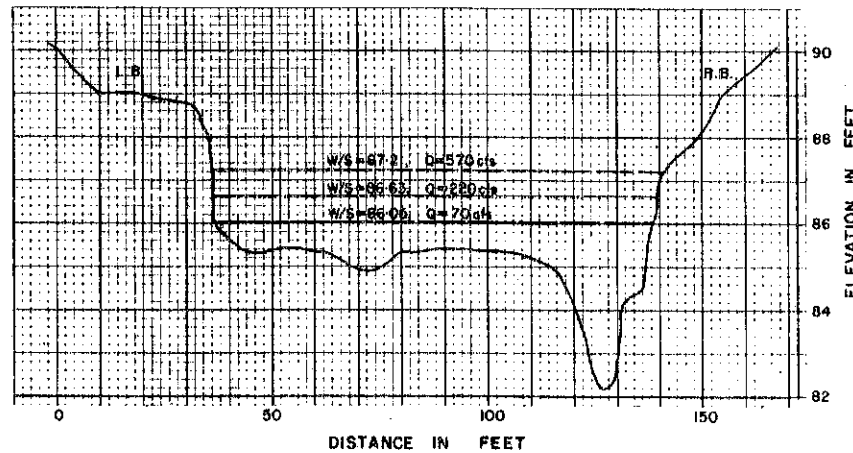


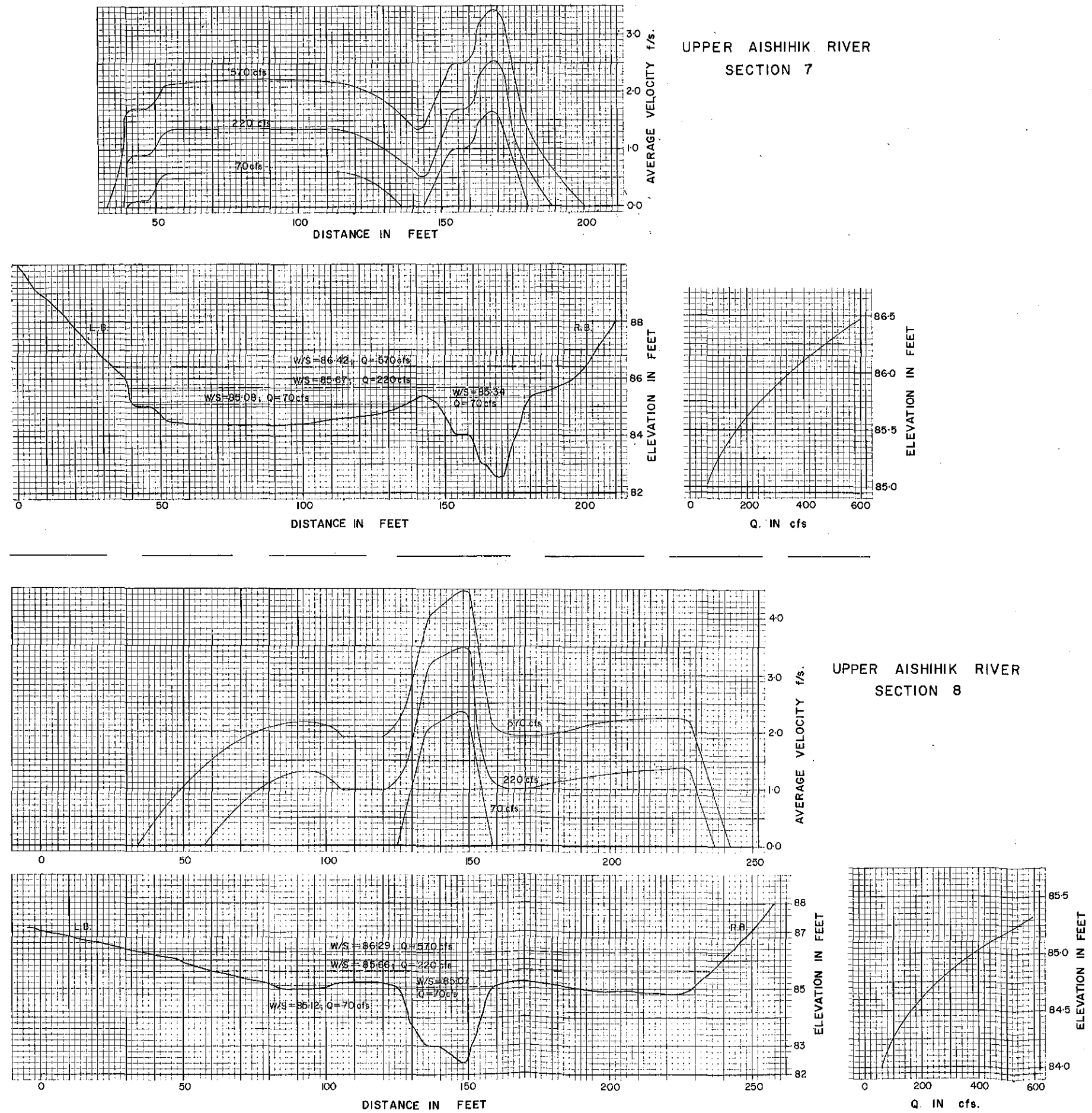


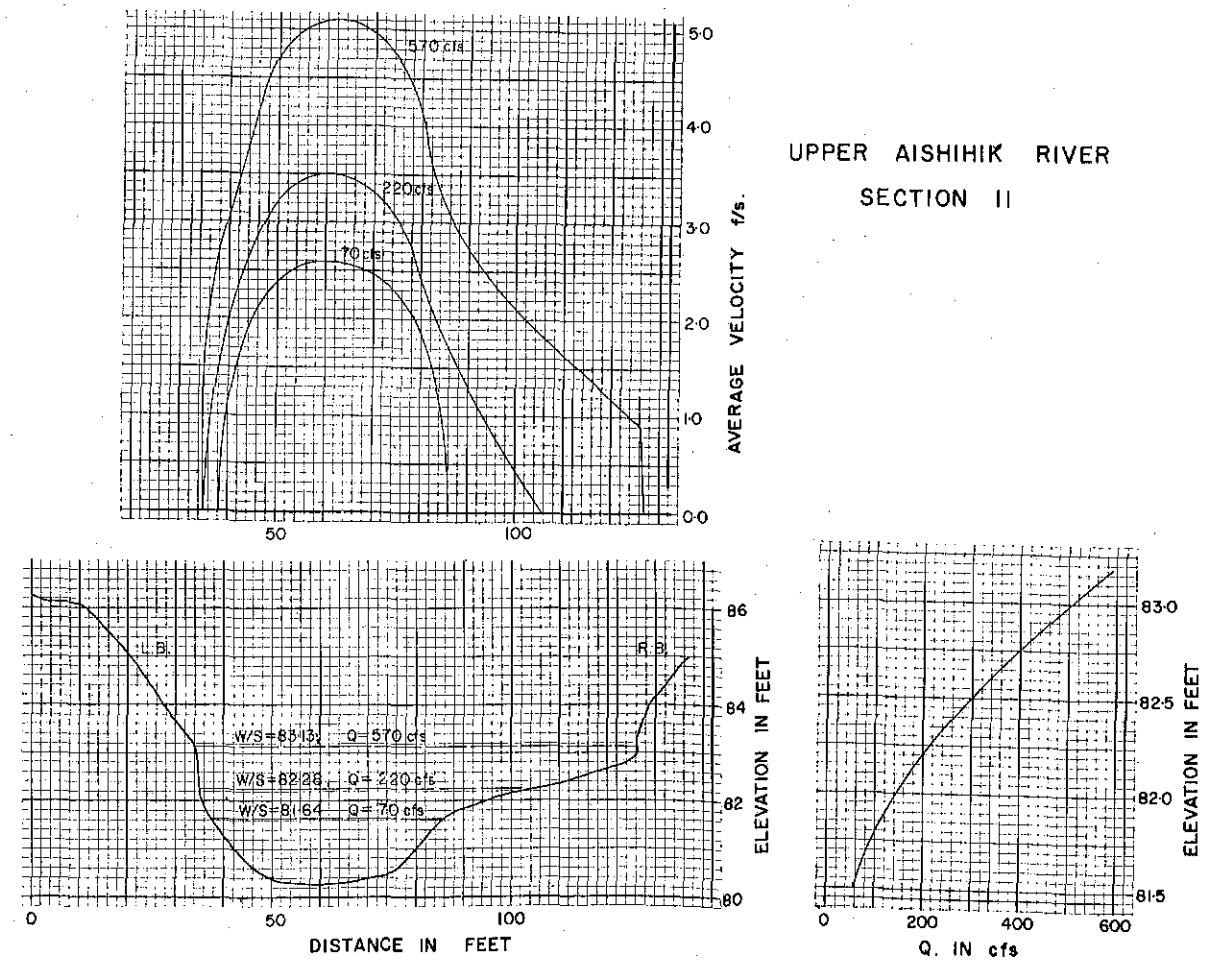
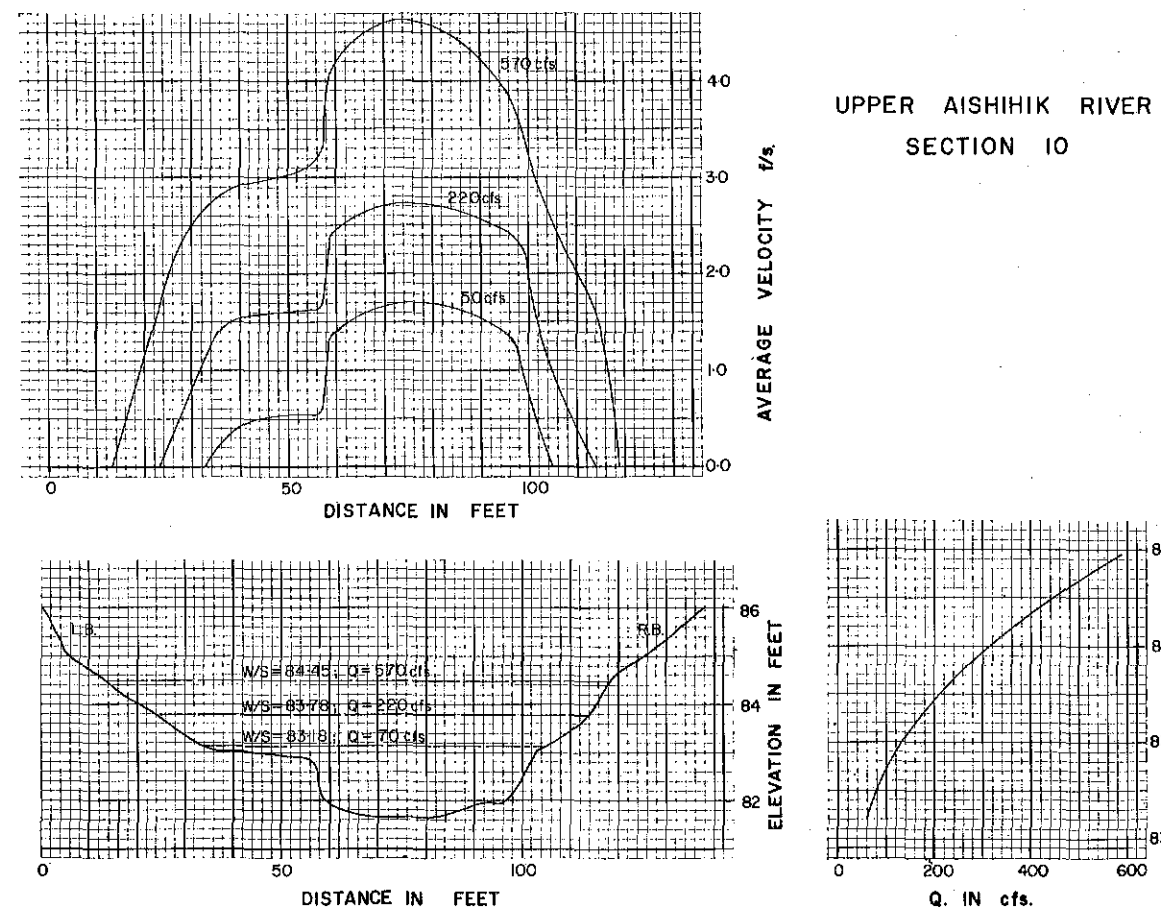
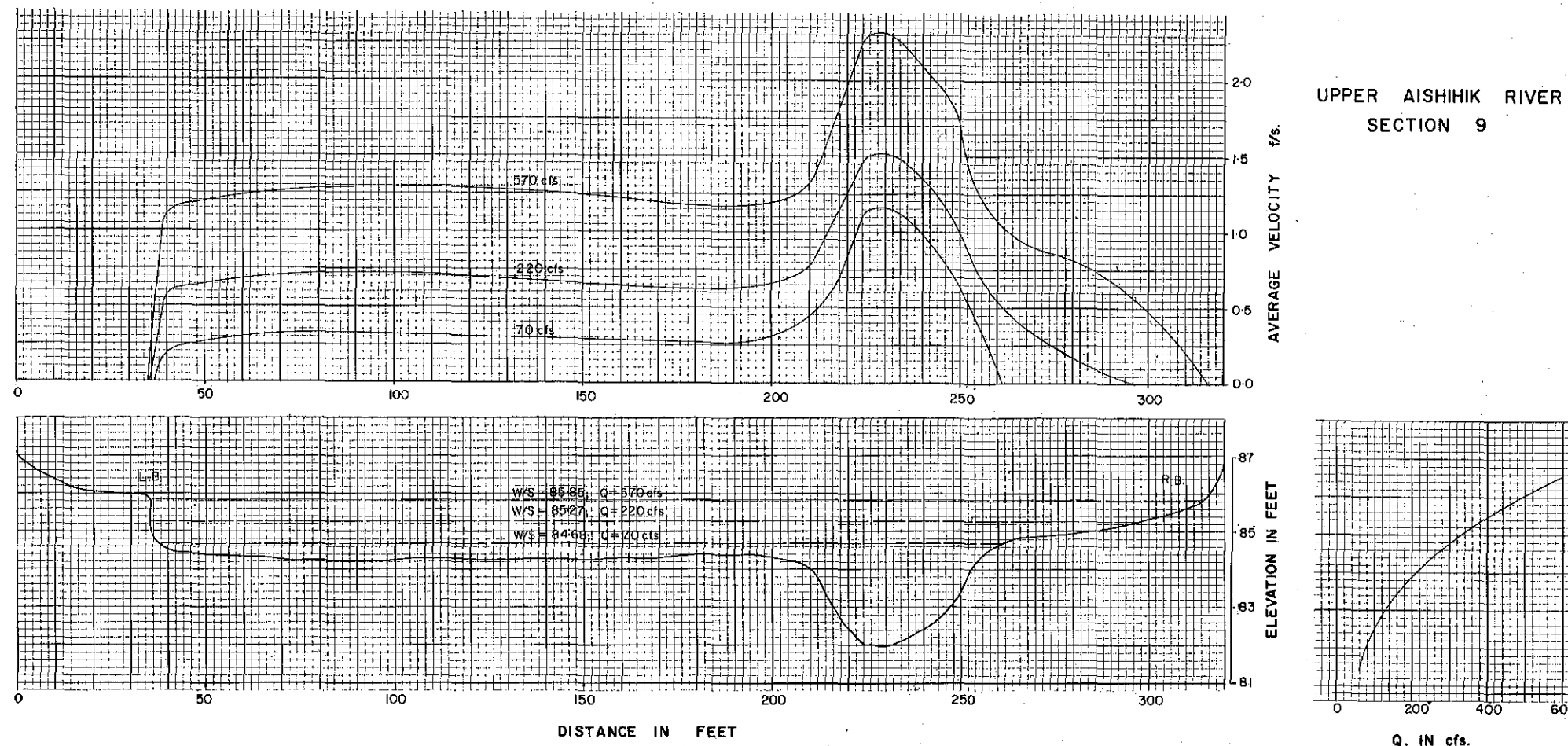
UPPER AISHIHIK RIVER
SECTION 5



UPPER AISHIHIK RIVER
SECTION 6







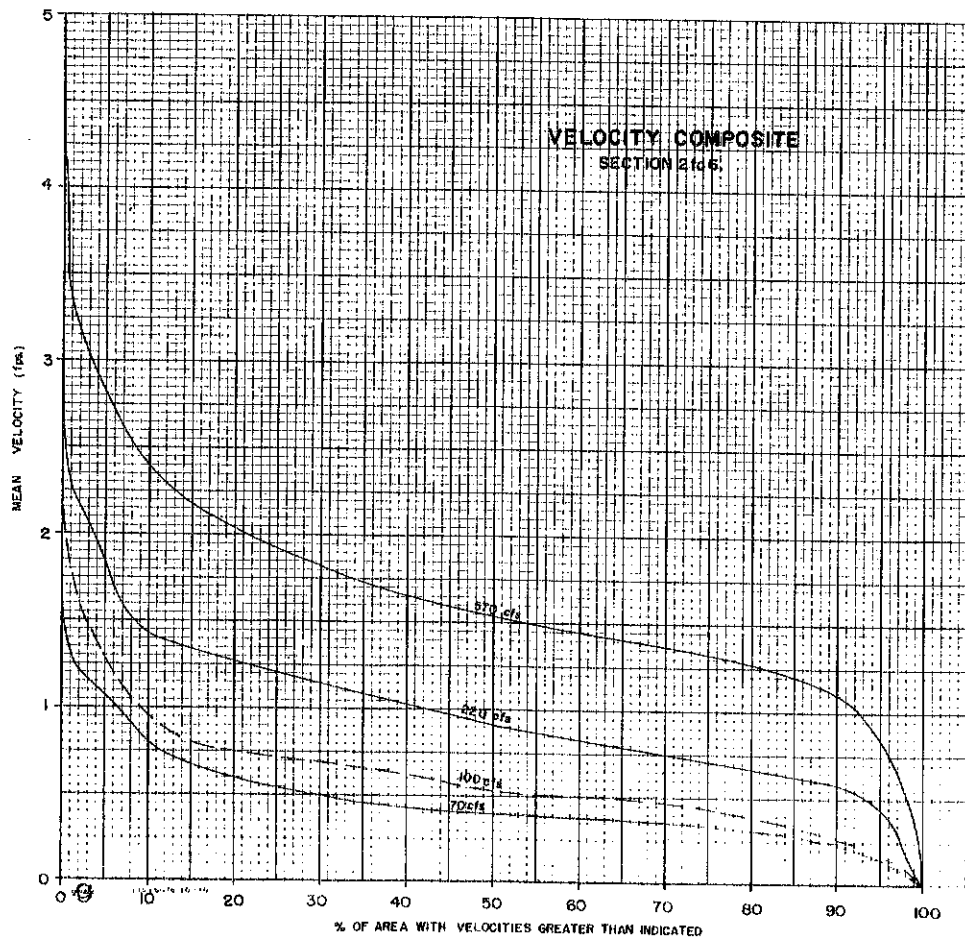
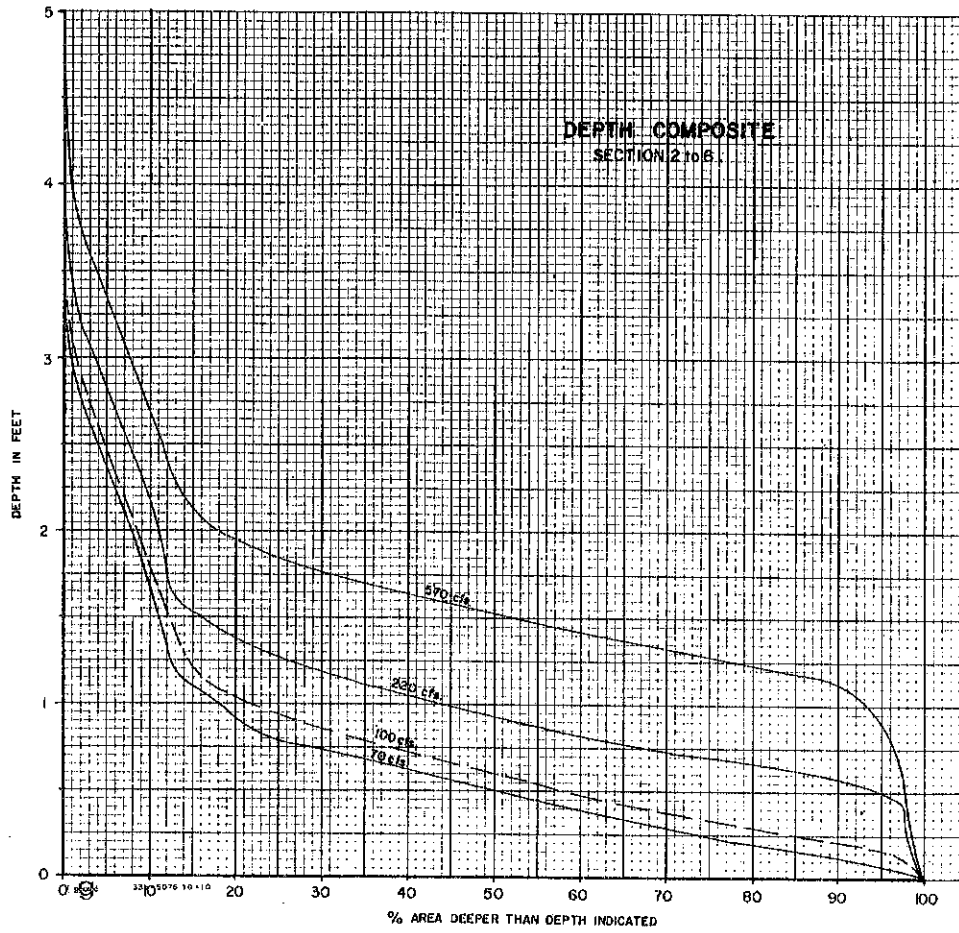
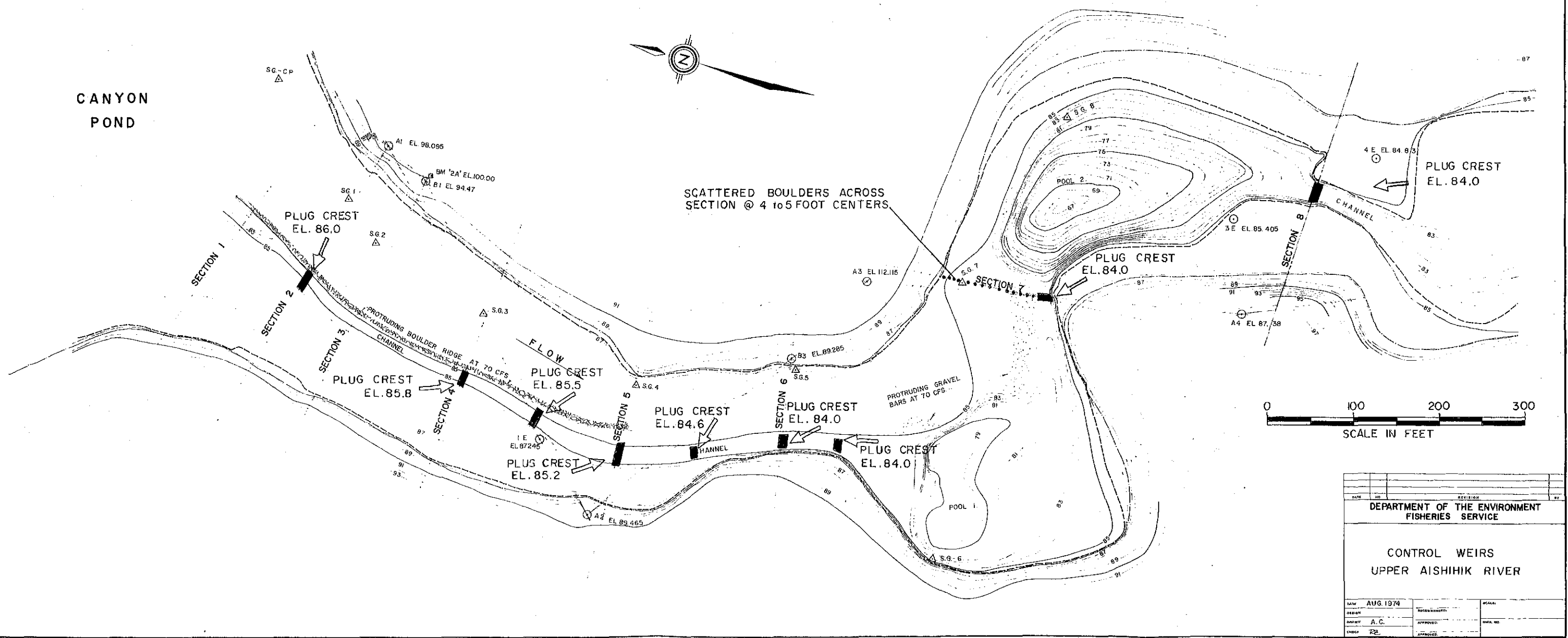
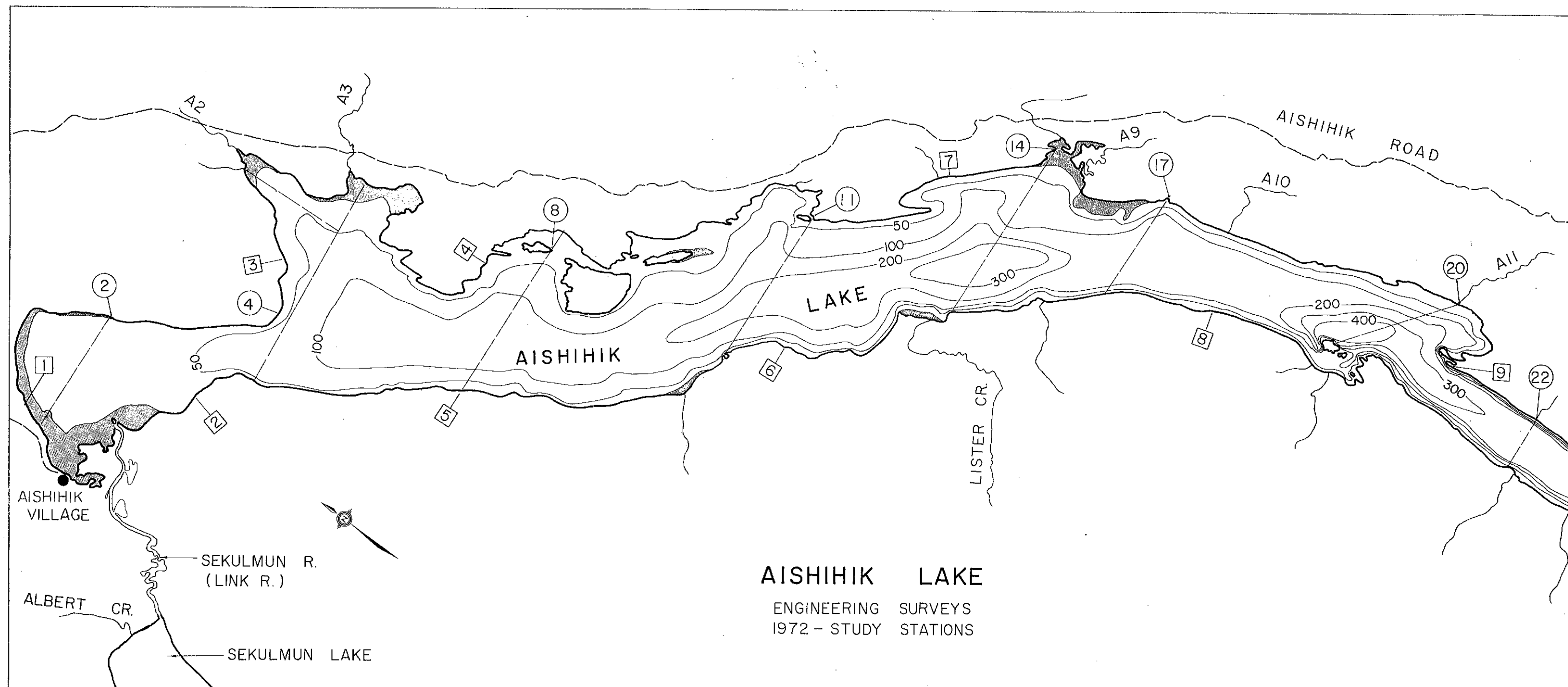


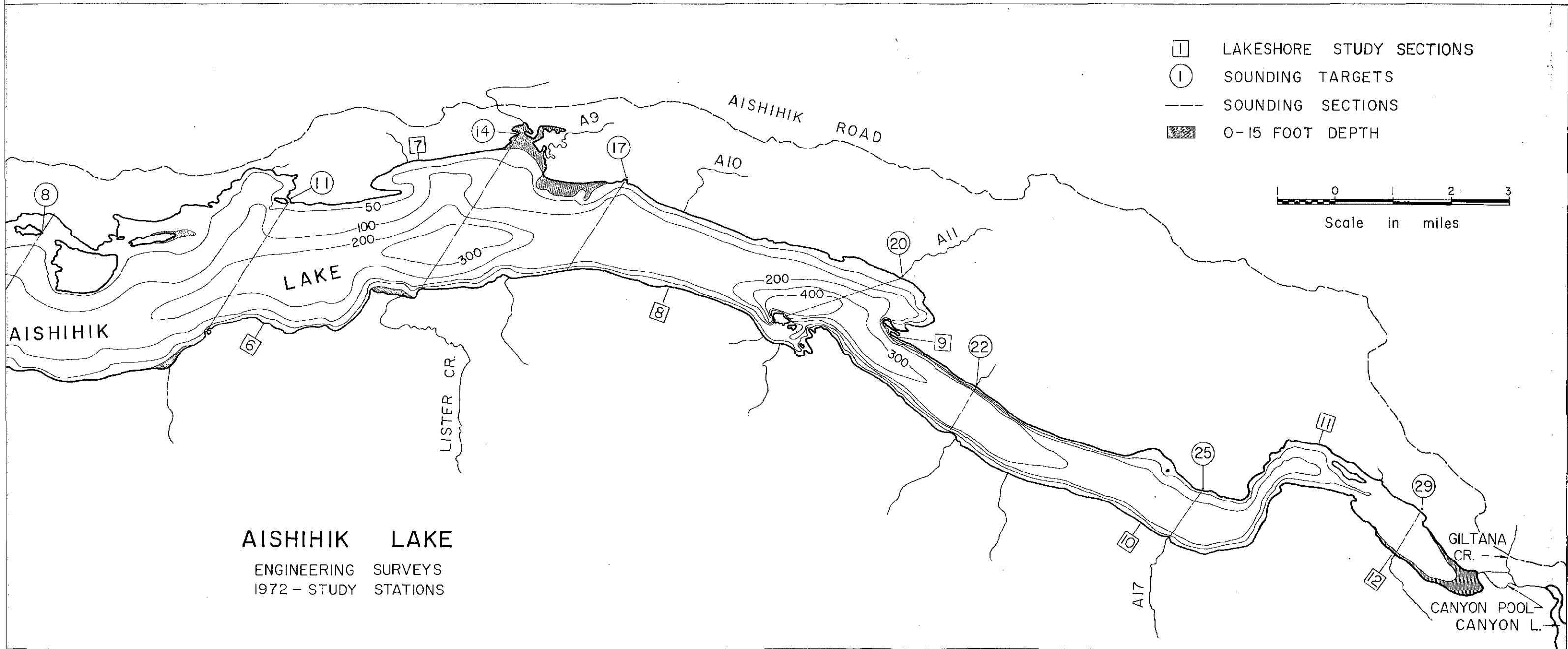
FIGURE 13





AISHIHIK LAKE
ENGINEERING SURVEYS
1972 - STUDY STATIONS

FIGURE 14

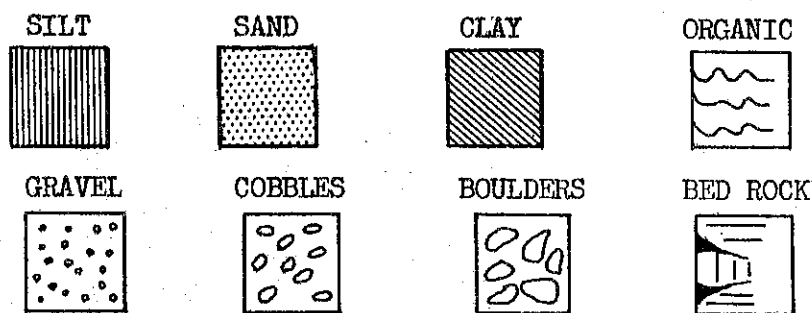


SHORELINE STUDY REFERENCE PAGEPHOTOGRAPHS:

- (A) Shoreline from 100 feet
- (B) Shoreline close up
- (C) Shoreline perpendicular to section
- (D) Submerged shoreline substrate using periscope.

SURVEY:

- (1) Lake sounded to -15 feet, except
Section 2 sounded only to -10.5 feet
- (2) Survey identification target (4' x 4').

SYMBOLS AND TERMS USED FOR SOILS.CLASSIFICATION BY PARTICLE SIZE:-

BOULDERS	-	larger than 8 inches	SAND	-	# 200 sieve to # 4 sieve
COBBLES	-	3 inches to 8 inches	SILT	-	0.002mm to # 200 sieve
GRAVEL	-	# 4 sieve to 3 inches	CLAY	-	finer than 0.002 mm.



Clay bank at north end of
Aishihik Lake from 100'

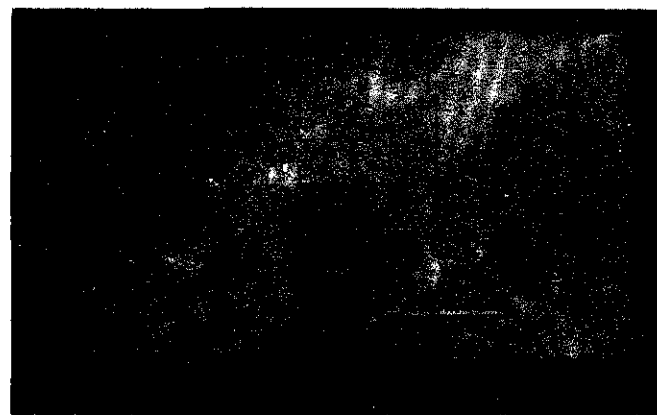
SECTION 1



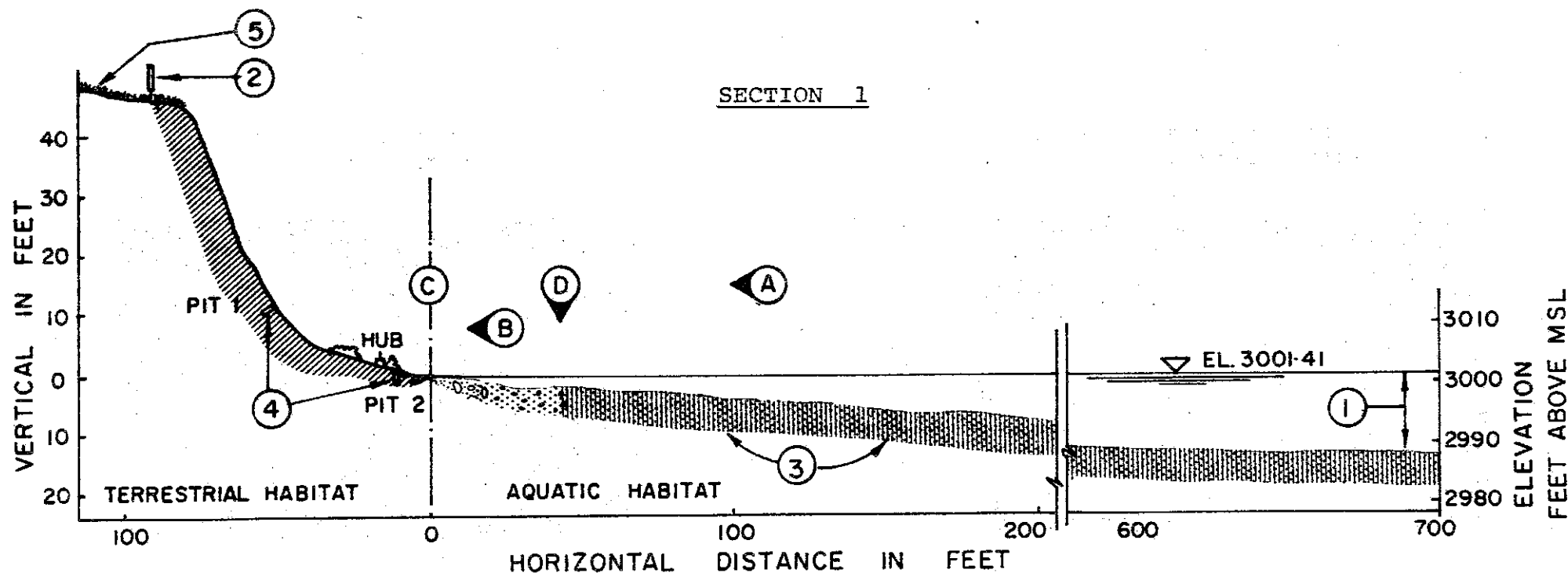
Shoreline perpendicular to section.



Close-up view of clay bank
and beach area.



Sandy bottom Photographed through
periscope 40' from shoreline.



③ UNDERWATER SUBSTRATE:-

- first 15' mainly gravel, cobbles, boulders.
- next 25' mainly sand with some gravel.
- remainder to 15' depth - sand and silt.

④ TEST PIT COMPOSITION:-

- 2.5' depth - mainly grey clay with small amounts of fine sand (both pits similar in composition)

⑤ VEGETATION:-

- intermittent low shrubs terminating 30' - 40' from water surface at base of bank.
- bank has no vegetation.
- above bank mainly grasses for first 30' - 60', then changing to white spruce.

SECTION 2



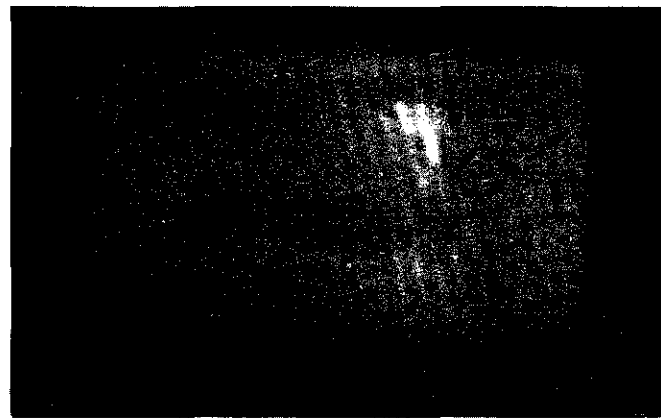
Shoreline terrain
from 100'



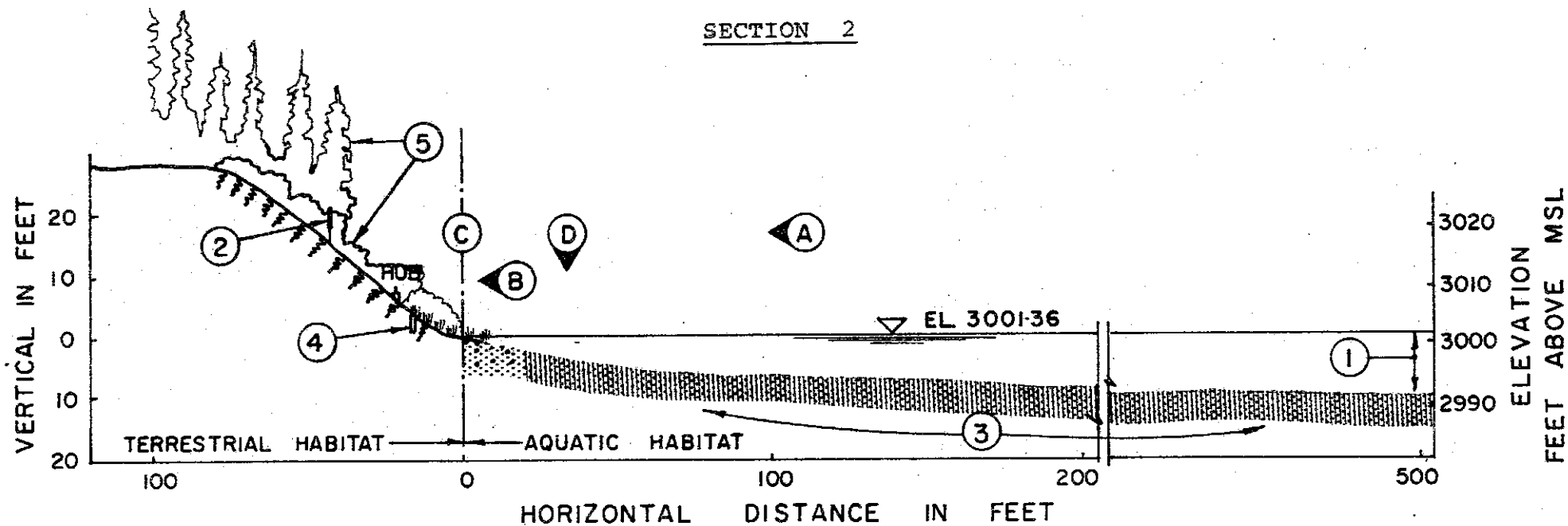
Shoreline perpendicular to section
showing dense vegetation.



Close-up view of mosses
and lichen on bank.



Sandy bottom photographed through
periscope 30' from shoreline.



③ UNDERWATER SUBSTRATE:-

- first 15' mainly fine gravel and sand.
- remainder to 10.5' depth, sand and silt.

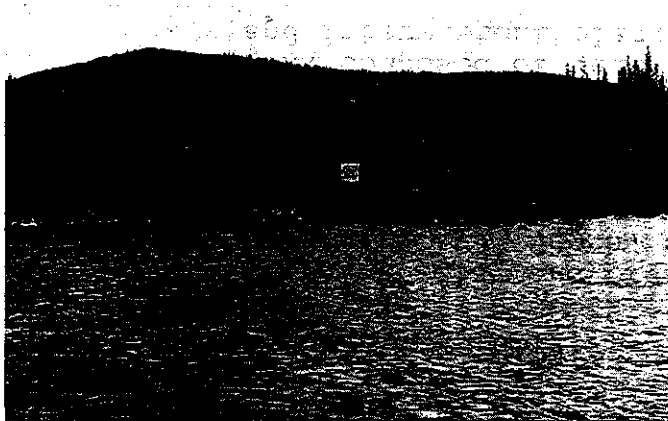
④ TEST PIT COMPOSITION:-

- peat moss to a depth of 0.2 feet.
- next 1.0' clay and organic material.
- remaining 1.3' depth, sand and gravel.

⑤ VEGETATION:-

- low shrubs, stunted willow and grasses terminating 30' - 40' from water surface.
- bank composed of peat moss with lichen (fungus) and intermittent black and white spruce.

SECTION 3



General view of shoreline
from 100' showing very dense community
of stunted willow.



Shore perpendicular to section
showing bouldery lower section area
with low shrubs and stunted willow.

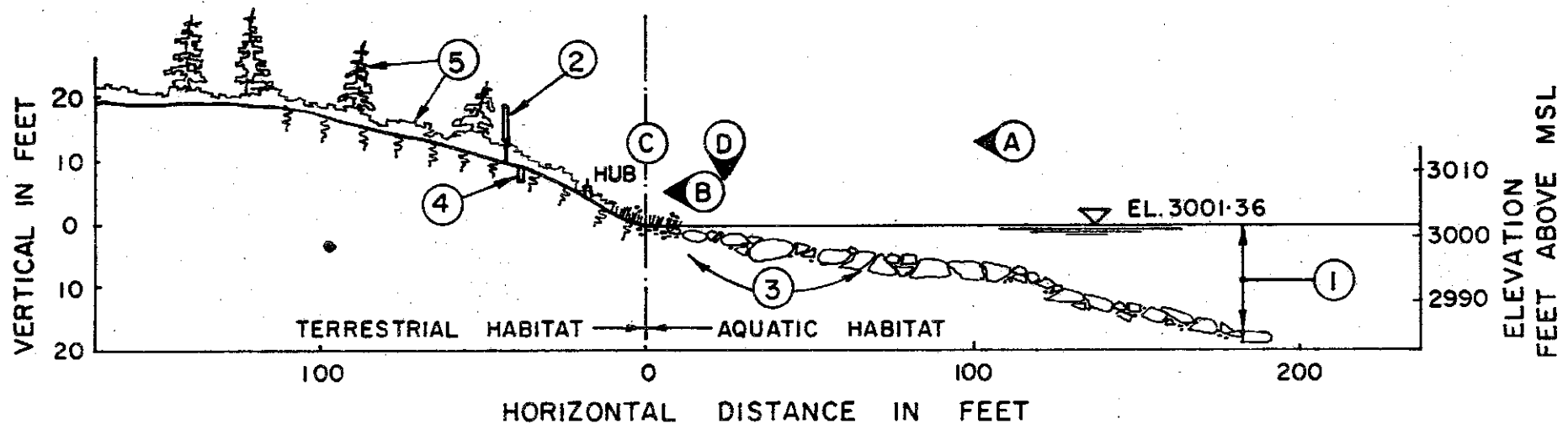


Close-up of rocky beach area.

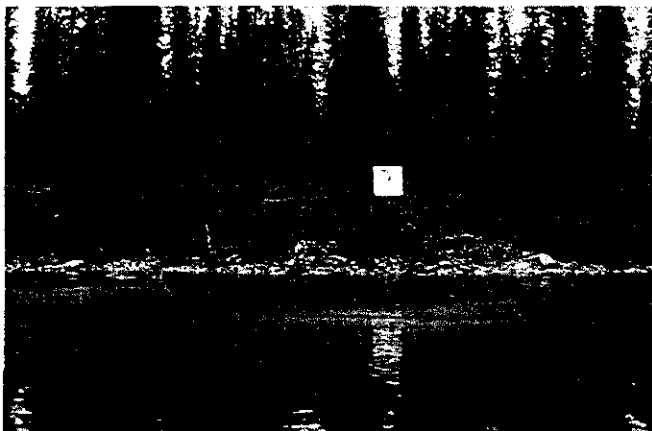


Cobbles and boulders common.
Photographed 20' from shoreline.

SECTION 3



- ③ UNDERWATER SUBSTRATE:-
- cobbles and boulders to 15' depth.
- ④ TEST PIT COMPOSITION:-
- top 0.5' organic soil with fine sand.
 - next 2.0' clay with organic material.
 - remaining 0.5' depth, clay and gravel.
- ⑤ VEGETATION:-
- low shrubs, stunted willow and grasses terminating 20' - 30' from water surface.
 - remainder very dense stunted willow with occasional white spruce.



Shoreline terrain from
100'

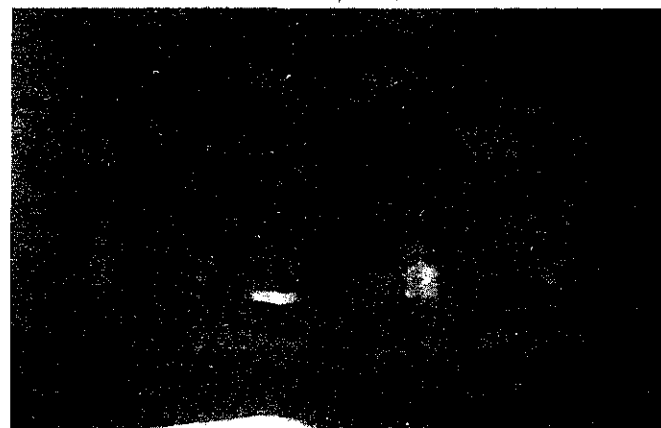


Close-up view of bank.

SECTION 4

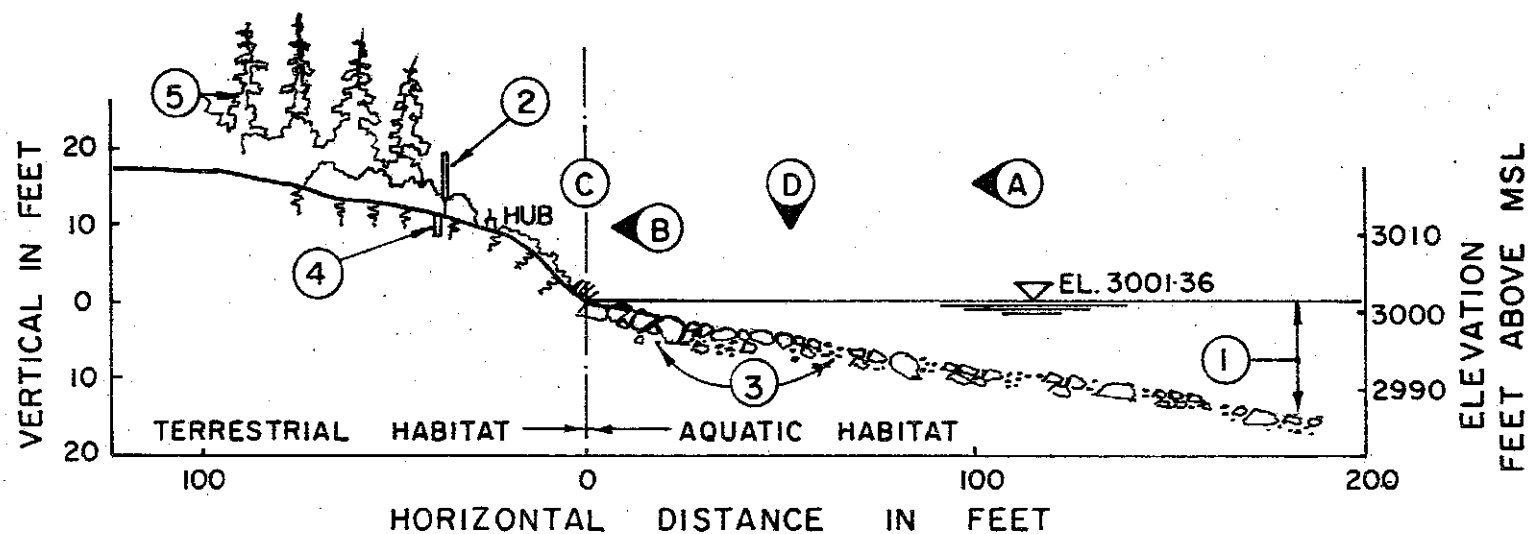


Shoreline perpendicular to section
showing bouldery beach area, low shrubs
and white spruce.



Boulders and cobbles common.
Photographed 50' from shoreline.

SECTION 4



③ UNDERWATER SUBSTRATE:-

- first 25' mainly large boulders, cobbles and sand.
- remainder to 15' depth, mainly cobbles, but with some gravel and sand.

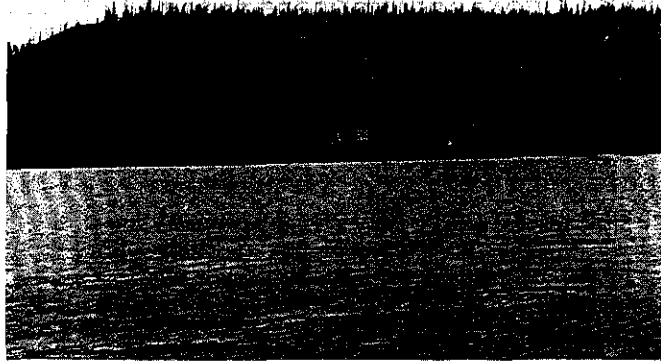
④ TEST PIT COMPOSITION:-

- top 0.3' organic soil
- next 1' sandy organic soil (loam).
- remaining 1.2' depth, sandy soil with some traces of clay.

⑤ VEGETATION:-

- stunted cottonwood and willow, cranberry bushes, lichen (fungus) and other shrubs terminating 30' - 40' from water surface.
- remainder of section mostly white spruce and low shrubs.

SECTION 5



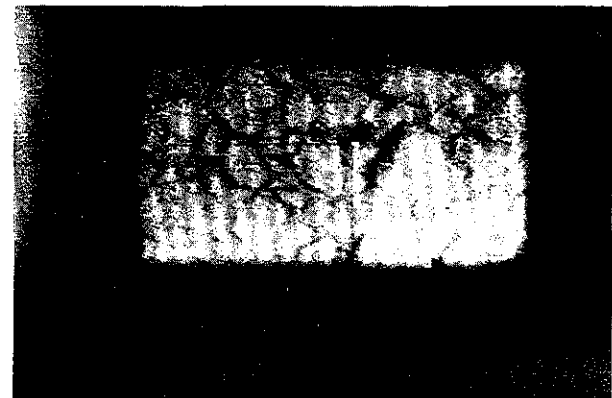
General view of shoreline terrain.



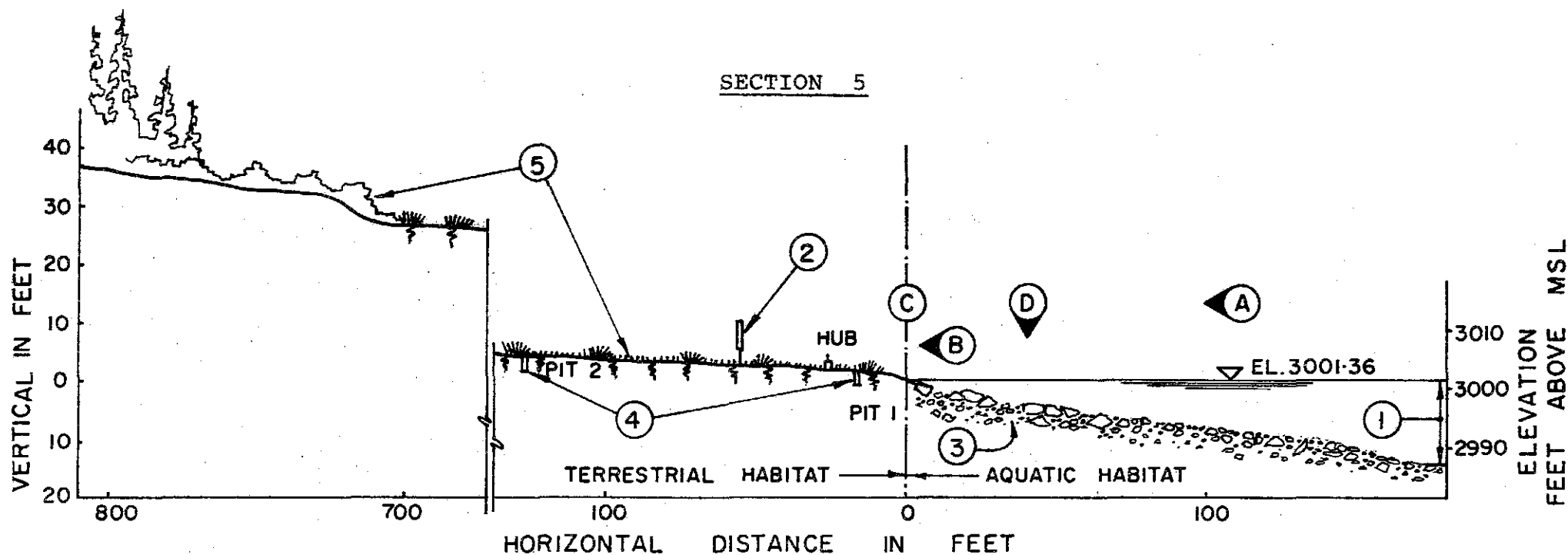
Shoreline perpendicular to section showing extensive flat semi-alpine tundra area with spruce in background.



Close-up view of beach area and tundra type vegetation.



Cobbles and gravel bottom photographed 40' from shoreline.



③ UNDERWATER SUBSTRATE:-

- first 65' mainly mixed cobbles, gravel and sand.
- remainder to 15' depth, sand and gravel.

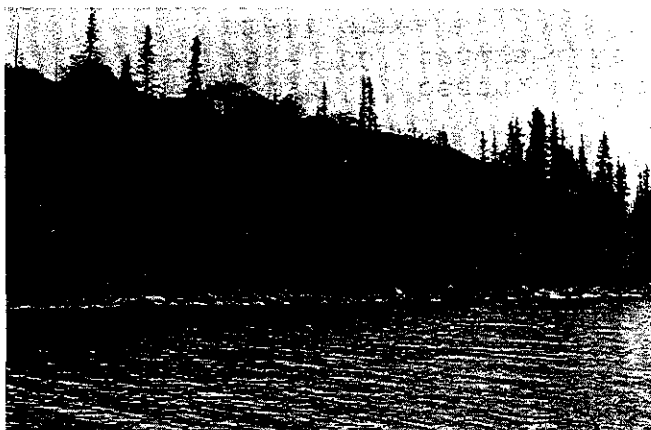
④ TEST PIT COMPOSITION:-

- top 0.2' organic soil (tundra).
- next 1', sandy clay with some gravel and organic material.
- remaining 1.3' depth, sandy clay.
- (both pits similar in composition)

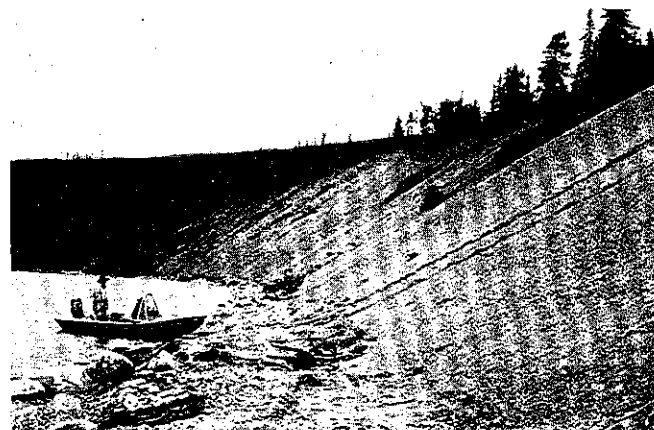
⑤ VEGETATION:-

- first 25' beach, no vegetation.
- 25 - 700' tundra-like terrain interspersed with numerous small streams.
- +700' stunted willow and then mainly a mixture of black and white spruce.

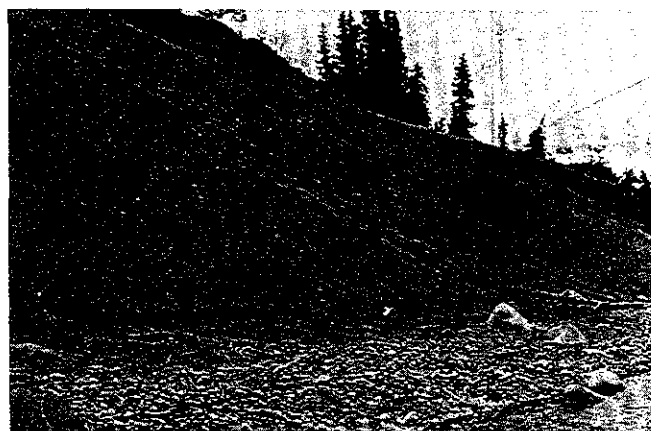
SECTION 6



General view of sandy bank area
on west side of lake from 100'.



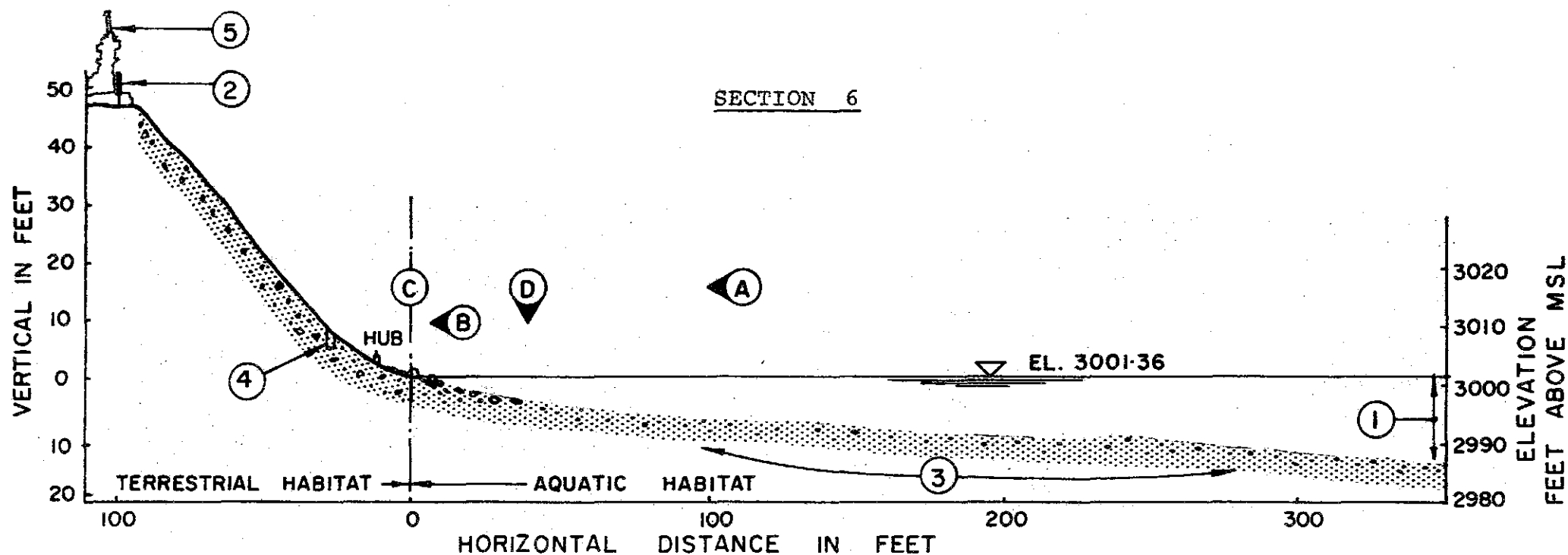
Shoreline perpendicular to section
showing steepness and height of bank.



Close-up view of bank and beach area.



Boulders and gravel bottom
photographed 40' from shoreline.



③ UNDERWATER SUBSTRATE:-

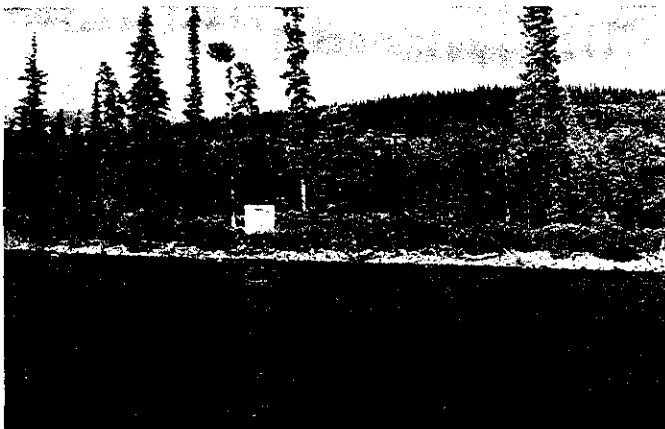
- first 45' gravel and sand with some boulders.
- remainder to 15' depth, mainly sand and some gravel.

④ TEST PIT COMPOSITION:-

- 2.5' depth - coarse sand with some gravel mixed.

⑤ VEGETATION:-

- no vegetation on or below bank.
- above bank balsam, poplar, willow, white spruce, and low shrubs.



View of shoreline from 100'

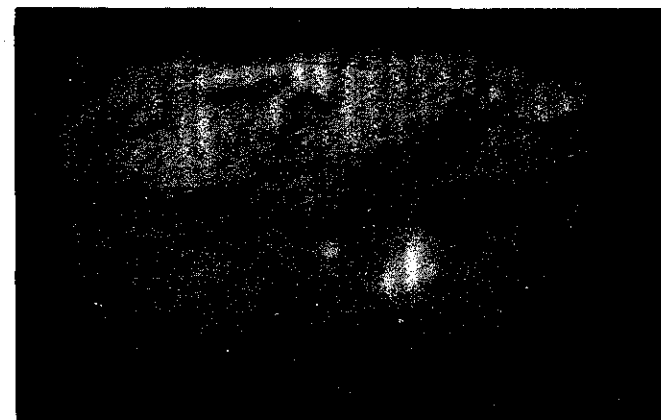
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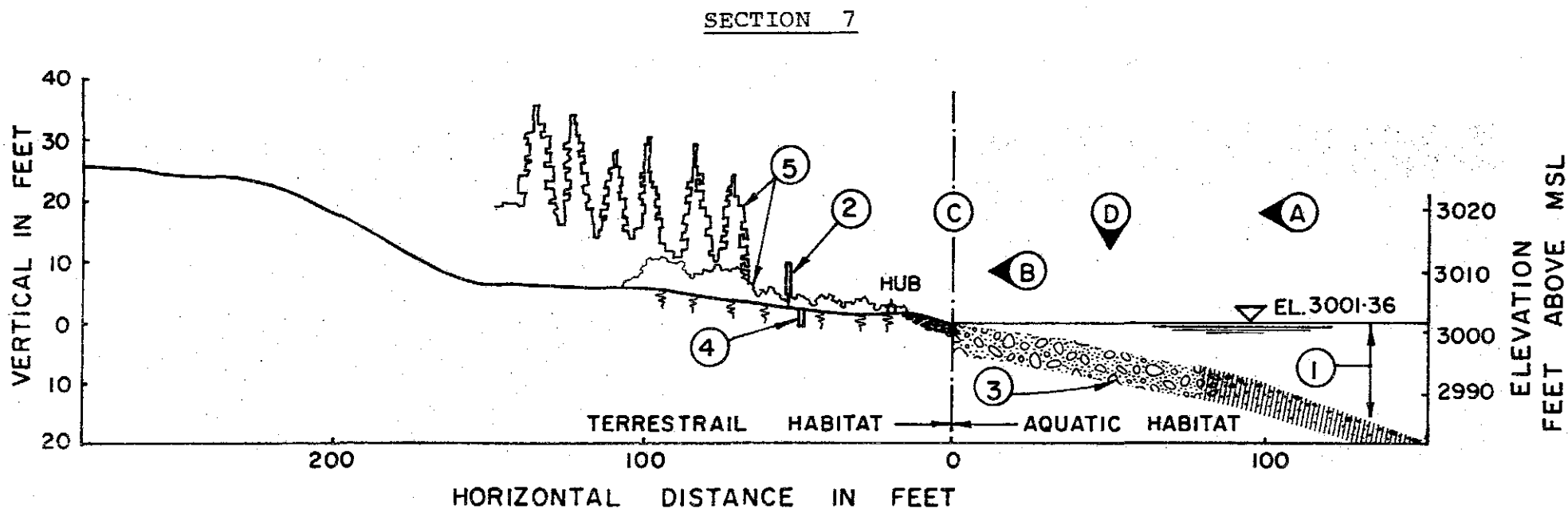
Shoreline perpendicular to section.



Close-up view showing sedge and mosses.



Cobbles and gravel bottom photographed
50' from shoreline.



- ③ UNDERWATER SUBSTRATE:-
- first 80' cobbles and gravel.
 - remainder to 15' depth, mainly sand and fine gravel and silt.
- ④ TEST PIT COMPOSITION:-
- top 0.7' black organic soil.
 - next 0.3' silt and sandy clay.
 - remaining 1.5' depth, clay with organic material.
- ⑤ VEGETATION:-
- first 20' beach, no vegetation.
 - next 50' mainly sedge and mosses.
 - remainder mainly white spruce, willow and shrubs.



General view of shoreline from 100'

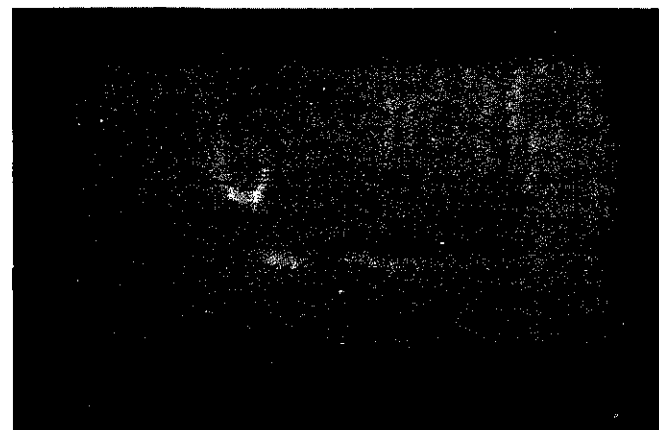
SECTION 8



Shoreline perpendicular to section showing shrubs and white spruce.

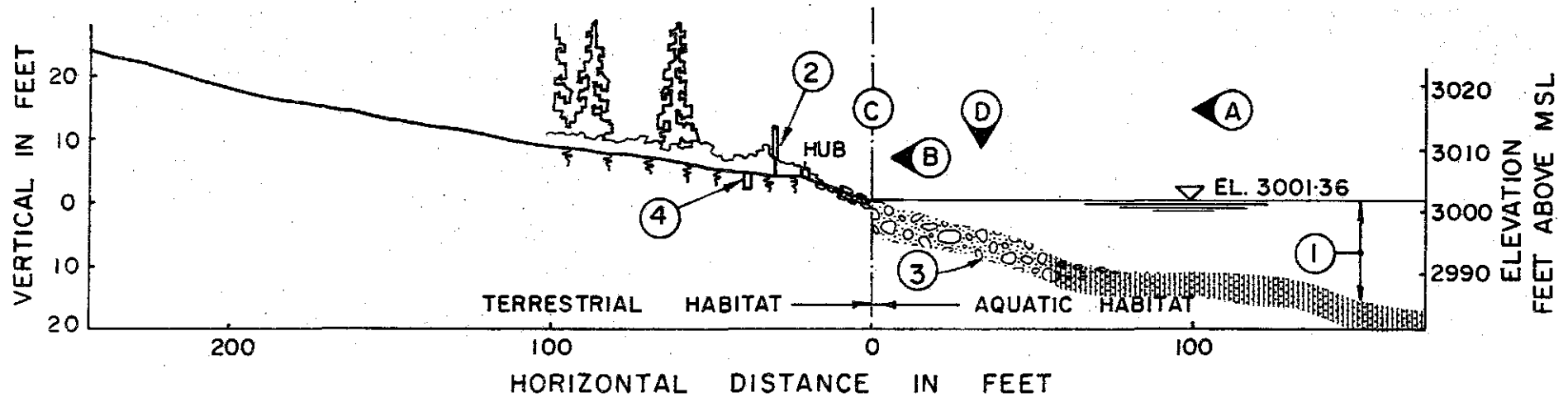


Close-up view of beach and vegetation.

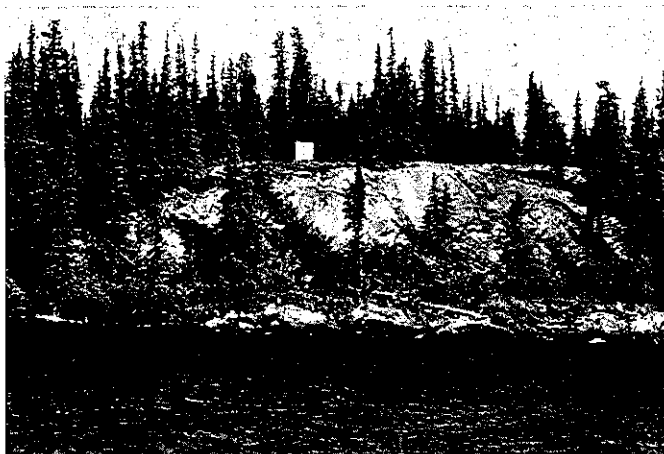


Sandy bottom photographed 30' from shoreline.

SECTION 8



- ③ UNDERWATER SUBSTRATE:-
 - first 25' mainly boulders with cobbles and sand.
 - remainder to 15' depth, sand and silt.
- ④ TEST PIT COMPOSITION:-
 - top 0.3' organic, fibrous soil.
 - next 0.3' sandy, organic soil.
 - remaining 1.9' depth, silty clay.
- ⑤ VEGETATION:-
 - first 10' beach, no vegetation.
 - remainder mosses and low shrubs spotted with white spruce.



View of shoreline from 100' showing
bed rock and white spruce.

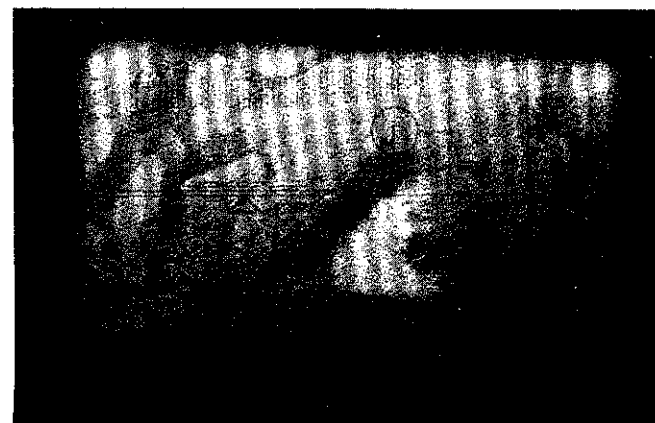
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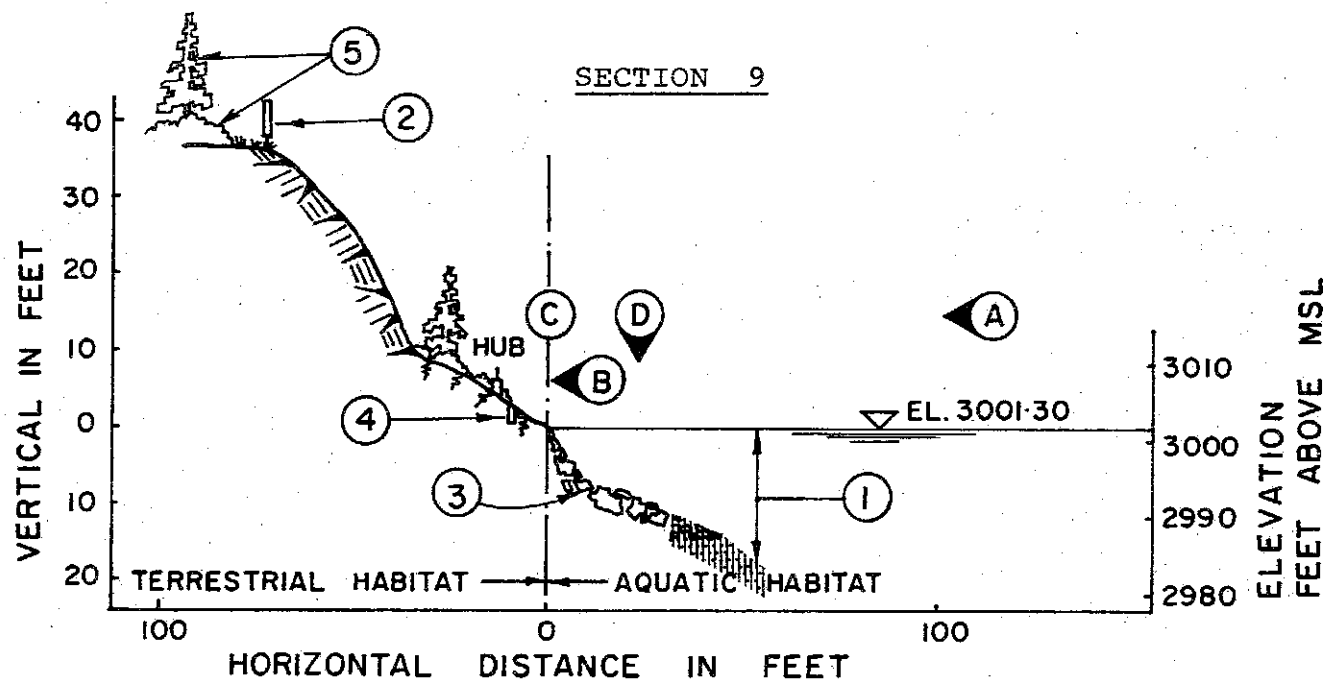
Shoreline perpendicular to section showing
steepness and height and bank.



Close-up view rock cliff and vegetation.



Jagged boulders and cobbles photographed
25' from shoreline.



- ③ UNDERWATER SUBSTRATE:-
- boulders and cobbles over first 45 feet.
 - remainder to 15' depth, sand and silt.
- ④ TEST PIT COMPOSITION:-
- top 0.1' organic, fibrous soil.
 - next 1.0' white, sandy clay with organic material.
 - next 2.0' sandy clay.
 - remainder bed rock.
- ⑤ VEGETATION:-
- first 8' bed rock (no vegetation)
 - next 25' mosses, low shrubs and stunted white spruce.
 - next 40' bed rock cliff with mosses growing in cracks.
 - remainder mainly white spruce and low shrubs.



View of shoreline from 100'

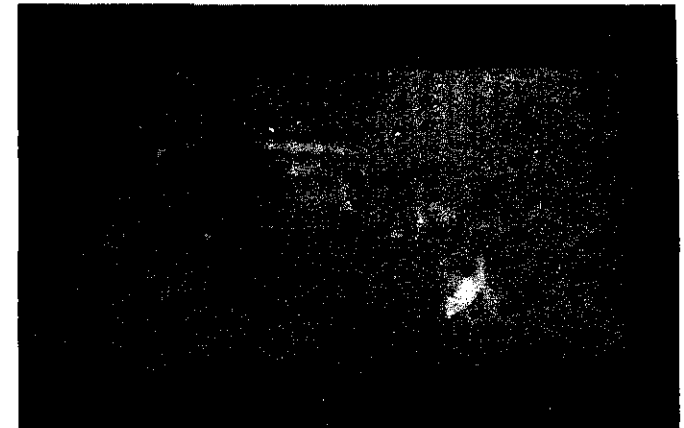
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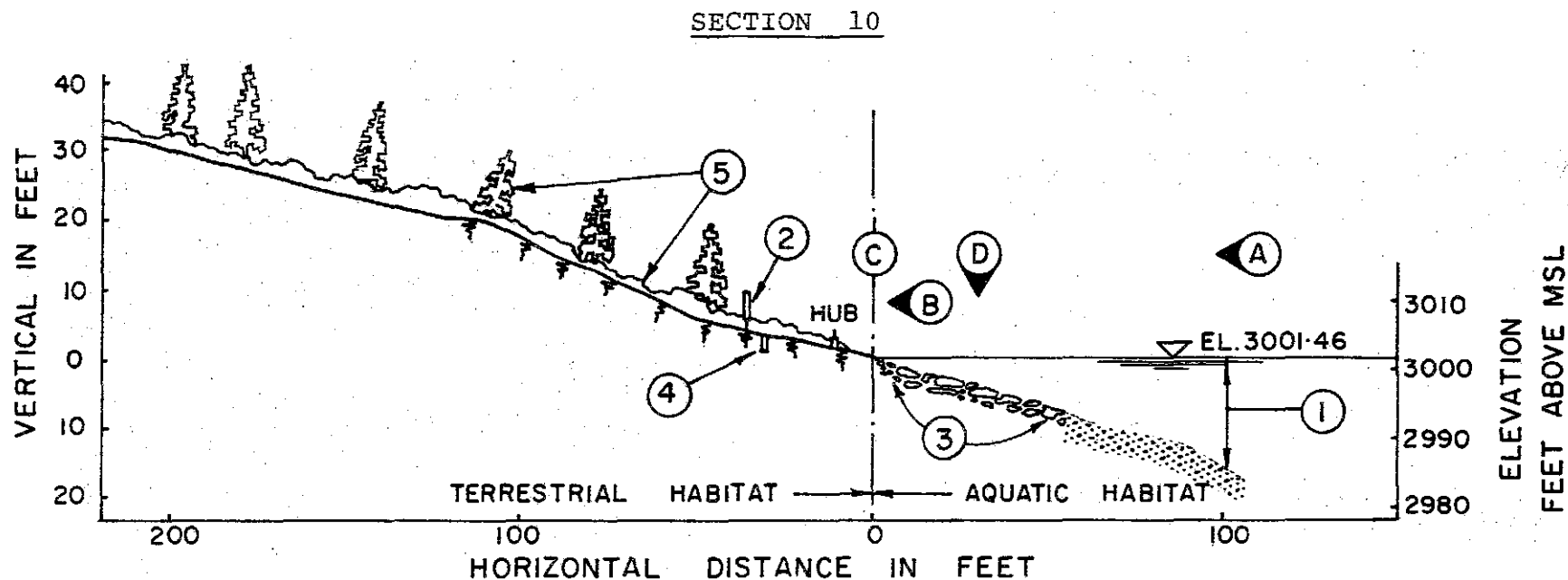
Shoreline perpendicular to section showing beach area; grasses, and white spruce.



Close-up view of vegetation in test pit area.



Sandy bottom photographed 20' from shoreline.



③ UNDERWATER SUBSTRATE:-

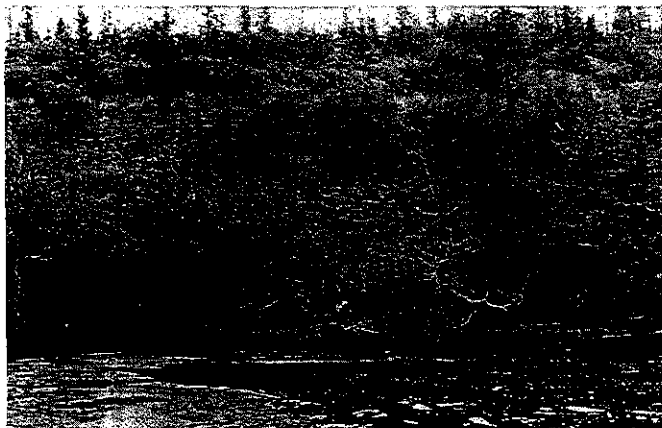
- first 50' mainly boulders, cobbles and some gravel.
- remainder to 15' depth, coarse sand.

④ TEST PIT COMPOSITION:-

- top 1.0' black organic soil.
- remaining 1.5' depth, consists of coarse grey, sandy clay.

⑤ VEGETATION:-

- first 100' mainly mosses, low shrubs, dwarf willow and grasses with lichen (fungus).
- next 100' mainly aspen, willow, white spruce and low shrubs.

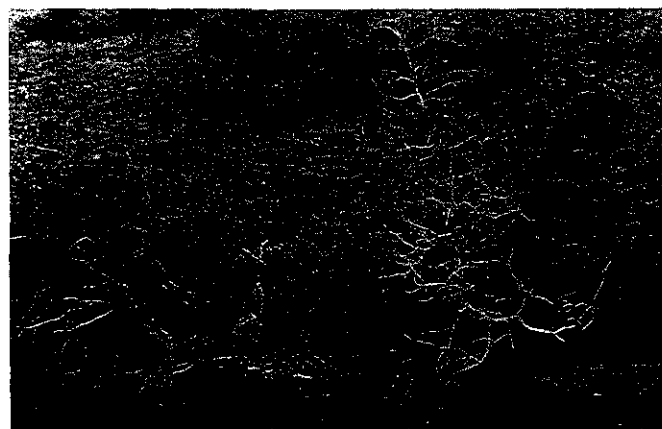


View of shoreline from 50' showing mosses, balsam poplar, willow, and white spruce.

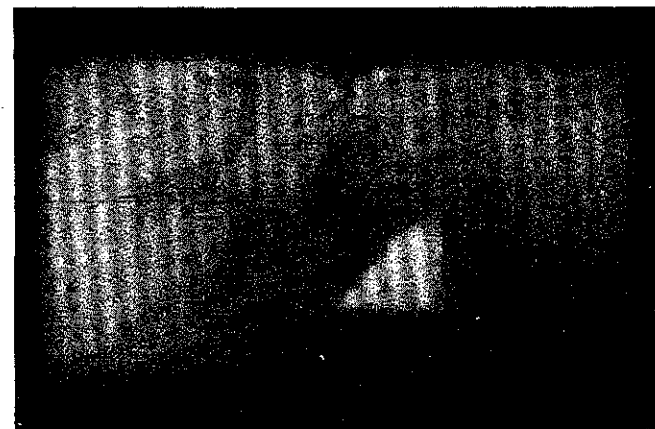
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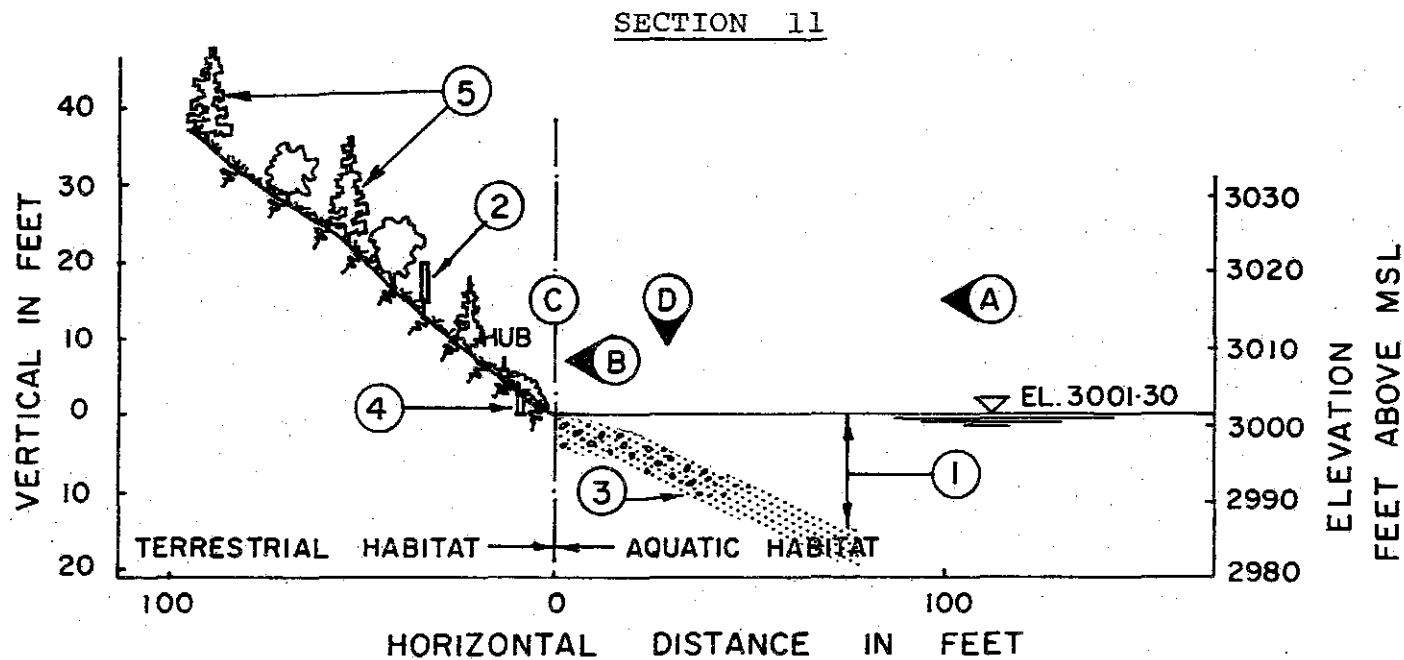
Shoreline perpendicular to section showing vegetation.



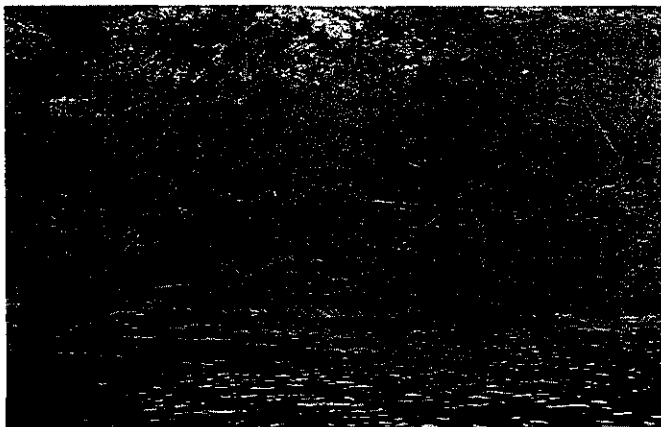
Close-up view of vegetation on bank and beach area.



Cobbles and gravel bottom photographed 25' from shoreline.



- ③ UNDERWATER SUBSTRATE:-
- first 45' mainly cobbles, gravel, sand with some silt.
 - remainder to 15' depth, sand.
- ④ TEST PIT COMPOSITION:-
- 2.5' depth - organic soil with gravel and sand.
- ⑤ VEGETATION:-
- ferns, mosses, flowers and low bush cranberries throughout bank.
 - bank spotted with balsam poplar, willow and white spruce.

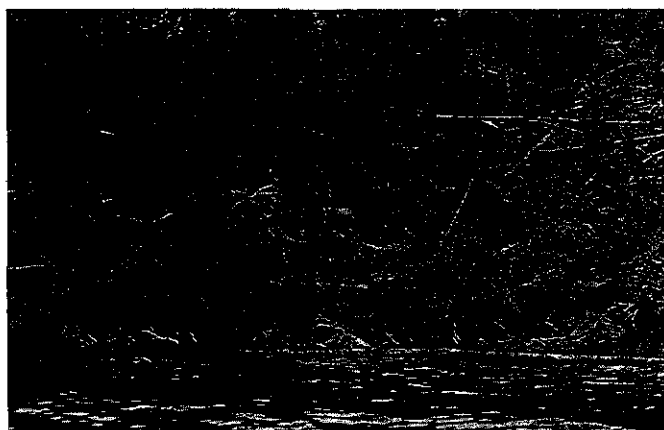


General view of shoreline
showing past burnt-off area.

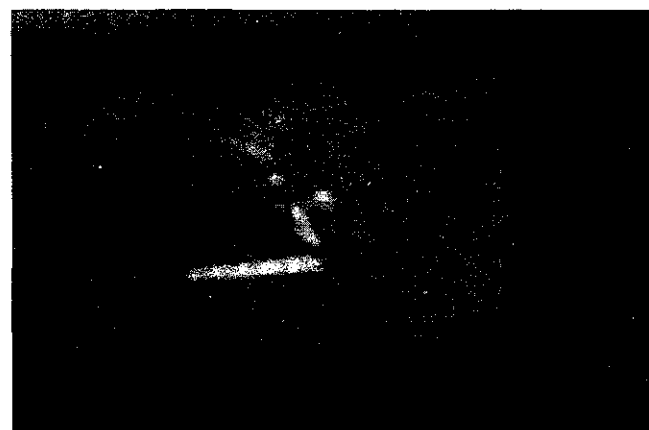
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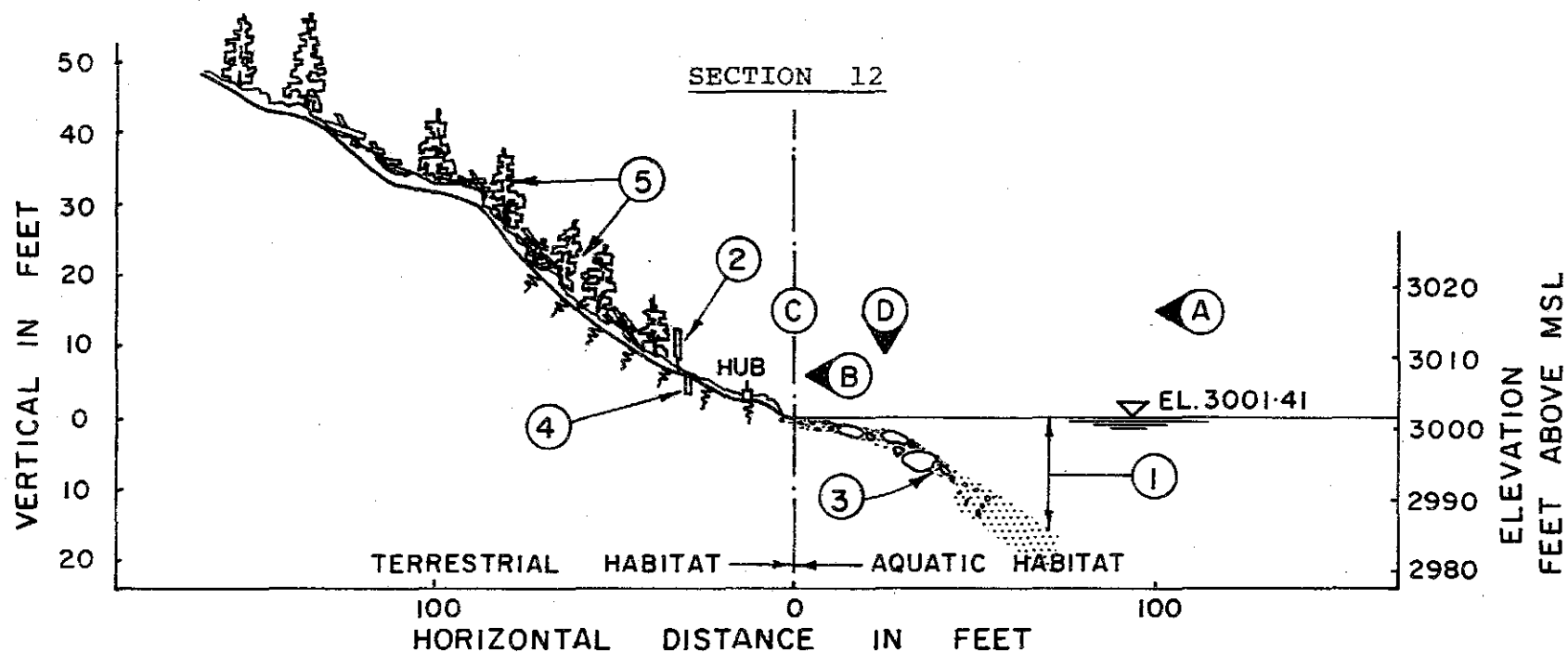
Shoreline perpendicular to section
showing bouldery beach area.



Close-up view showing new growth of
white spruce and willow.



Sandy bottom photographed through
periscope 20' from shoreline .



③ UNDERWATER SUBSTRATE:-

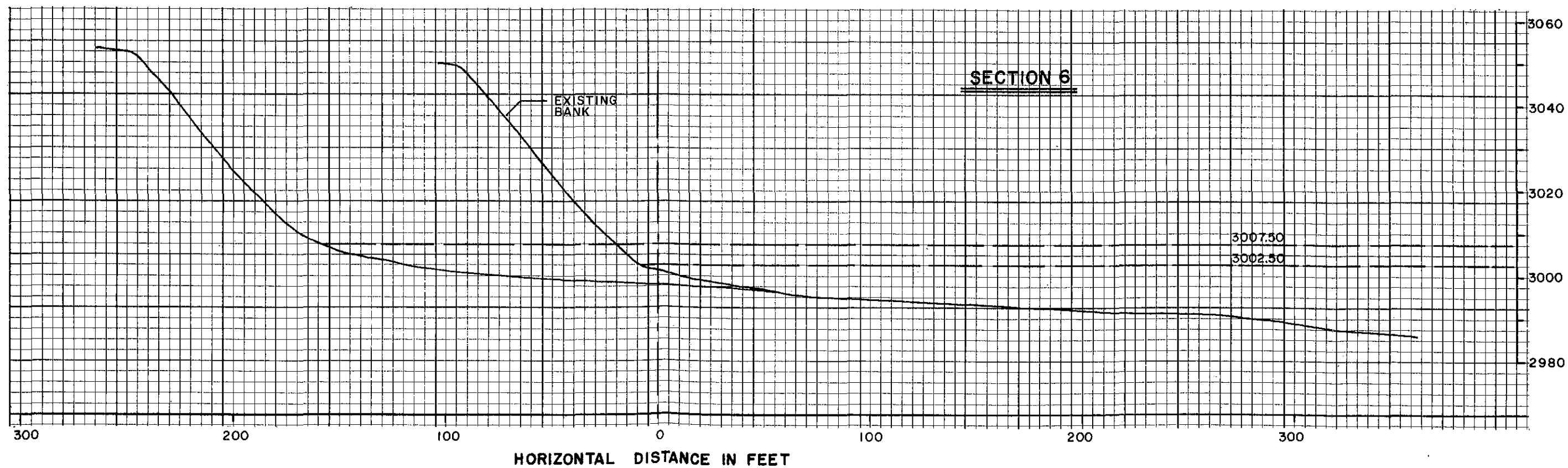
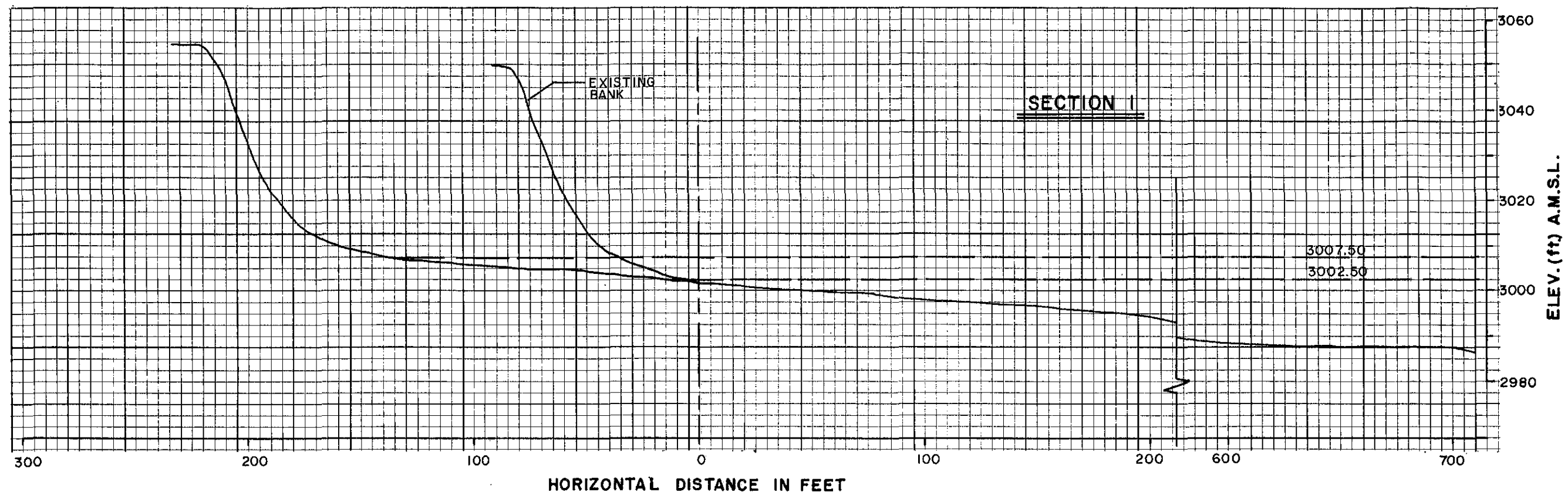
- first 15' mainly boulders, cobbles and gravel.
- next 40' gravel and sand.
- remainder to 15' depth, sand.

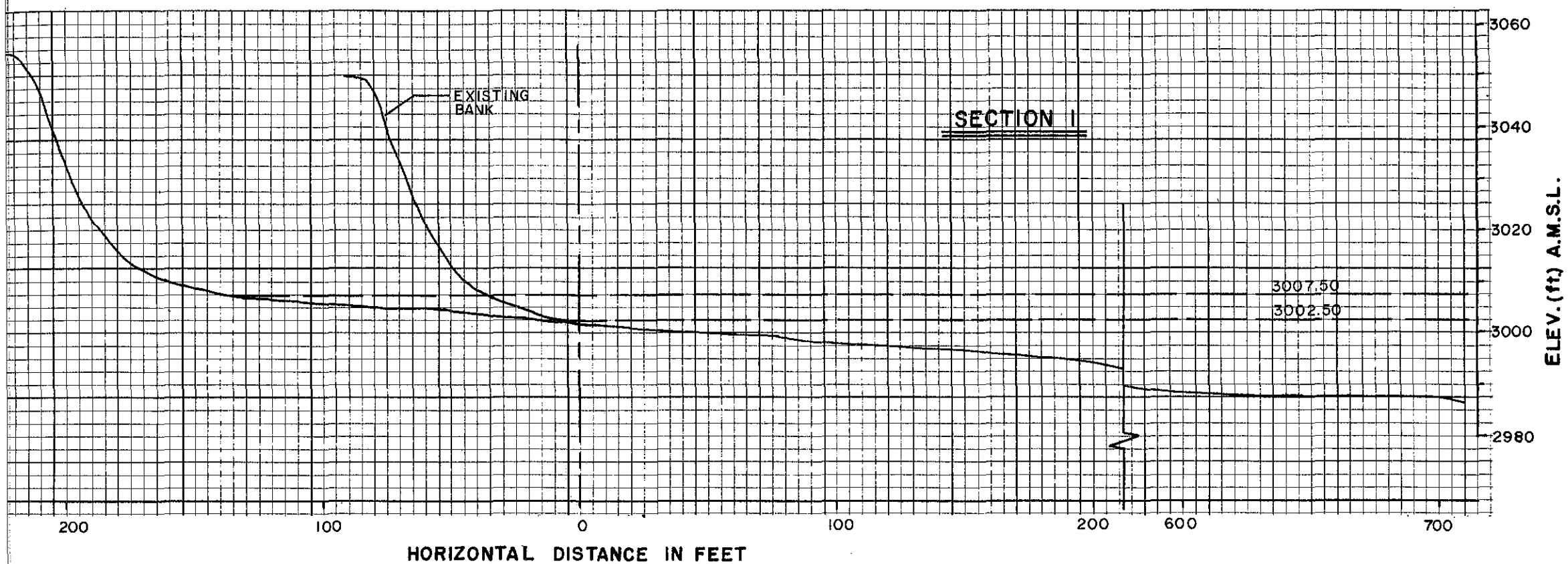
④ TEST PIT COMPOSITION:-

- top 0.4' black organic soil with thin layers of clay and sand.
- remaining 2.1' depth mainly fine gravel with some sand and cobbles.

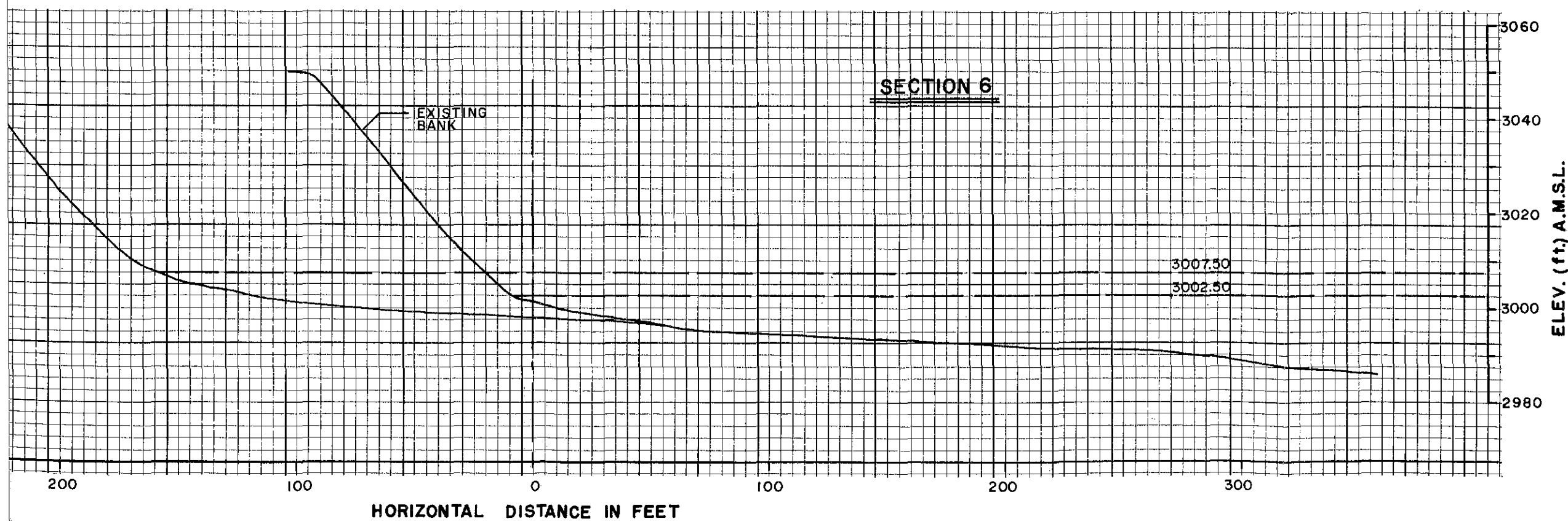
⑤ VEGETATION:-

- first 30' low shrubs and mosses.
- remainder mainly white spruce, willow and mosses (burnt-off area containing small size trees).





PROBABLE BANK RECESSION RESULTING
FROM INCREASED STORAGE LEVELS AT
SECTIONS I AND 6.



A P P E N D I X C

STREAM STUDIES IN THE AISHIHIK SYSTEM WITH
REFERENCE TO HYDROELECTRIC DEVELOPMENT

C. E. WALKER AND R. F. BROWN,
FISHERIES AND MARINE SERVICE,
1974

STREAM STUDIES IN THE AISHIHIK
SYSTEM WITH REFERENCE TO
HYDROELECTRIC DEVELOPMENT

BY

C. E. WALKER AND R. F. BROWN

DEPARTMENT OF THE ENVIRONMENT
FISHERIES AND MARINE SERVICE
NORTHERN OPERATIONS BRANCH

1974

ABSTRACT

The Aishihik River system located approximately 100 miles west of Whitehorse is under development for the production of hydro power. The Fisheries and Marine Service, Department of the Environment, carried out studies in 1972 and 1973 to assess the effects of the proposals on the productivity of the aquatic ecosystem. Responsibility was subdivided between agencies. This report discusses the program to evaluate streams and stream populations which was conducted by the Northern British Columbia and Yukon Division. The most important question is one of controlled minimum flows originating at Aishihik Lake. The effect of flow reduction on an all-purpose, all-season waterway and the fish therein is examined and discussed.

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Stream Studies in the Aishihik System

INTRODUCTION

C. E. Walker and R. F. Brown

In 1972 the Northern Canada Power Commission (NCPC) made application for a water licence to the Yukon Water Board for the use of the Aishihik system to generate electric power. This application was made under authority of the Inland Waters Act of 1970 and resulted in the immediate implementation of studies related to environmental and social affairs by various parties. The activities of the Fisheries and Marine Service to March 1973 in this regard are outlined by Kussat (1973).

In 1973 a second year of biological and engineering studies was undertaken in the Aishihik Lake system to determine the effects on the fish resource arising from hydro-power development. The studies were designed to provide a knowledge base from which to draw alternatives to construction, design and operation proposals and to measure losses in fish if such occur. The responsibility for study is divided between the Northern British Columbia and Yukon Division (NBCYD) and the Habitat Protection Unit of Fisheries and Marine Service, Vancouver, and Pacific Biological Station (FRBC), Nanaimo. This memorandum discusses only that for the NBCYD group and therefore outlines studies related to streams and stream populations.

The Aishihik River system is located approximately 100 air miles west of Whitehorse. It consists of three major lakes, namely Sekulmun, Aishihik and Canyon which are interconnected by short streams. A number of lateral tributary flows enter the system. Drainage is by way of the Aishihik, Dezadeash and Alsek Rivers to the Pacific Ocean (Fig. 1).

The proposed hydro-electric project will involve the storage of water in Aishihik Lake and the diversion of water from the south end of Canyon Lake to a canal which will extend to a

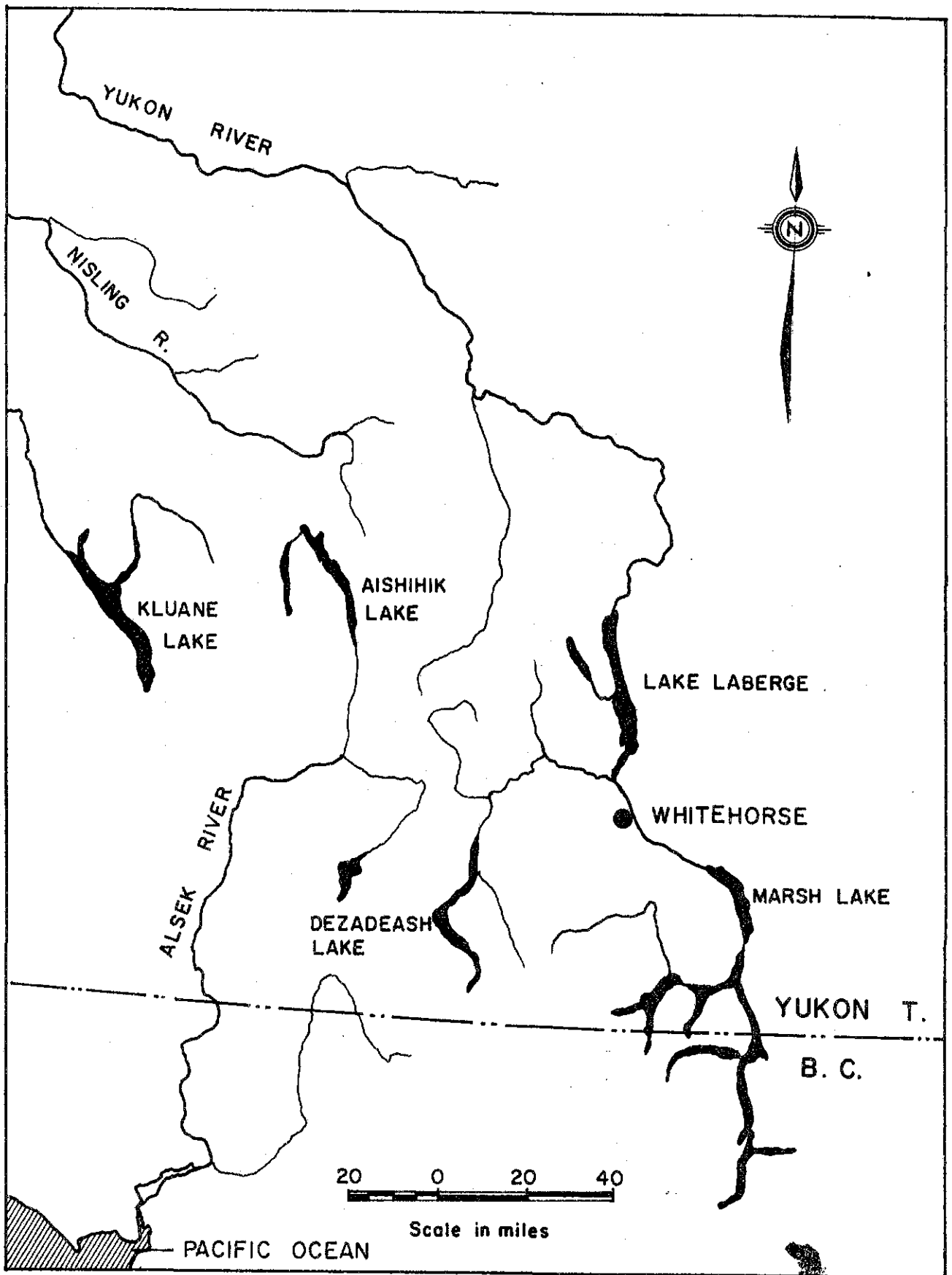


Fig. 1 Site map

powerhouse located near the confluence of the East and West Aishihik Rivers. Control structures will be erected at the outlet of Aishihik and Canyon Lakes for storage and diversion purposes respectively. A later development may transfer water from Stevens and Long Lakes, which lie within the Yukon River system, to Aishihik Lake (Fig. 2).

The Aishihik power plant will be incorporated in a grid system with Whitehorse and Mayo and tentatively will generate power during the winter months.

Storage in Aishihik Lake will take place during June, July, August, and September, and release of water for powerhouse use will occur for eight months commencing late September or early October. Currently the discharge from Aishihik Lake ranges from a monthly mean high of 760 cfs, most frequently occurring in July, to a winter low of 100 cfs, usually in April (Fig. 3). Following development discharges from Aishihik Lake will be in the order of 350 cfs from October to May inclusive and this amount exceeds the current flows in all months but one for this period. Some flows will be released during the summer to maintain the fish populations. The question of summer minimum flows is the crucial one connected with this study.

The problems raised by the proposal on streams and stream populations are as follows: One, changes in the level of Aishihik Lake will directly affect the lowermost areas of tributary streams. Drawdown will result in stream bed cutting and bank erosion; a raised lake level will inundate current riffle areas. The effect of these happenings on the fish resource depends upon the ability of the fish to adapt to the new conditions and/or to relocate.

Two, a drastically reduced outflow from Aishihik Lake during the time of storage, i.e. June, July, August and September, will directly result in lesser wetted area, lower water depths and lower velocities from Aishihik Lake to Canyon Lake. Lower stream

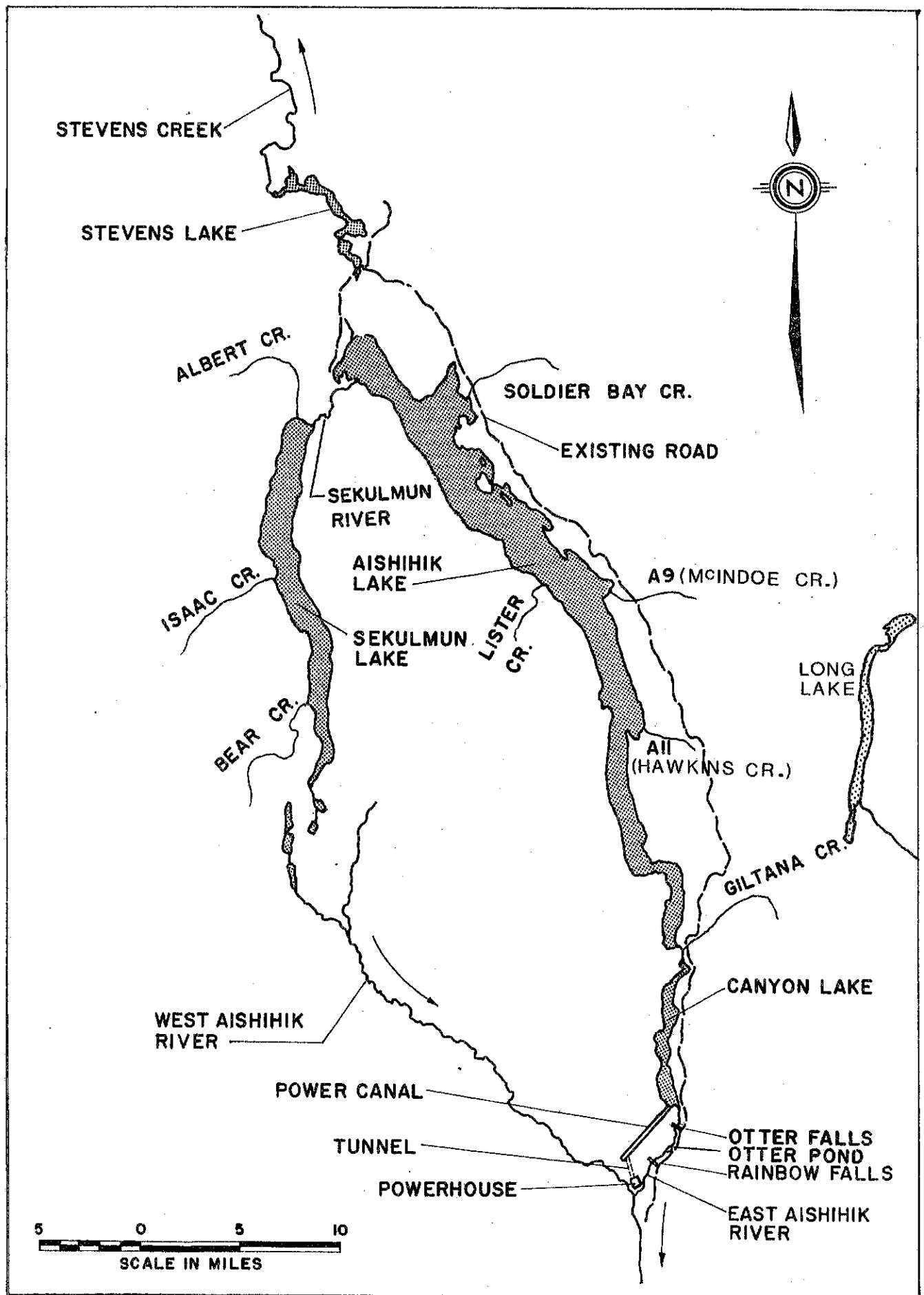


Fig. 2 Aishihik System

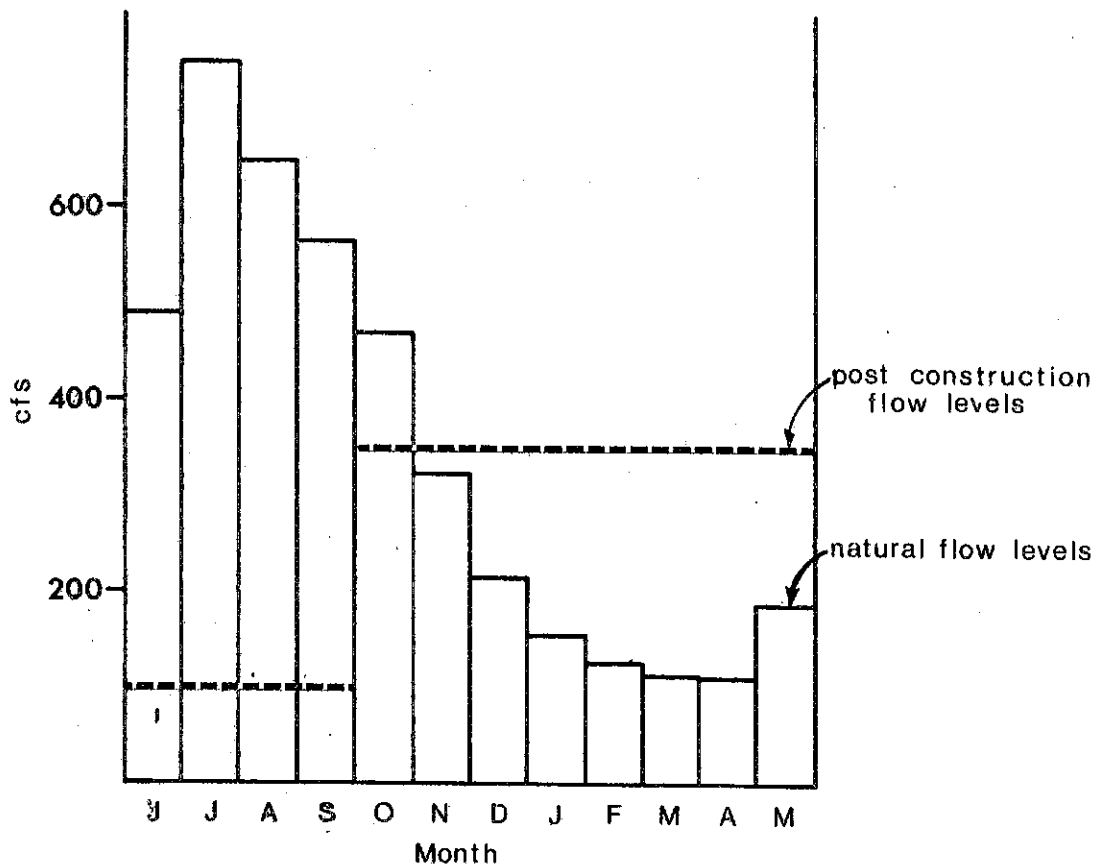


Fig. 3 Mean monthly flows from Aishihik Lake for the period 1961-1970, inclusive. The approximate flow levels following construction are shown as a dashed line.

levels and velocities may affect migration, spawning, spawn incubation, space, shelter and food requirements. A lower level in Canyon Pond will no doubt reduce the food and shelter opportunities afforded to the young by the aquatic grass lands, particularly if the water is withdrawn from the grasses. Further, the chemical and temperature properties of the flow from Canyon Pond will change in that a tributary stream, namely Giltana Creek, will contribute a higher proportion of the discharge during the summer than it did under natural conditions.

Three, flows over Otter Falls will be absent for periods of each year, thus endangering the fish inhabiting the East Aishihik River. It is highly unlikely that fish will survive in the East Aishihik River. It is proposed to rescue the rainbow trout population below Otter Falls and utilize them in an aquaculture program. However, small populations of grayling and whitefish may be lost. No study was made below Otter Falls in 1973 as these potential losses are accepted as an unfortunate part of the scheme.

The fish stocks in the Aishihik system are represented by the following nine species:

humpback whitefish	<i>Coregonus clupeaformis</i>
round whitefish	<i>Prosopium cylindraceum</i>
Arctic grayling	<i>Thymallus arcticus</i>
lake trout	<i>Salvelinus namaycush</i>
northern pike	<i>Esox lucius</i>
longnose sucker	<i>Catostomus catostomus</i>
burbot	<i>Lota lota</i>
slimy sculpin	<i>Cottus cognatus</i>
rainbow trout	<i>Salmo gairdneri</i> .

A commercial fishing quota of 15,000 lbs of whitefish and lake trout was established for Aishihik Lake by Canada Order in Council in 1961. However, the quota was eliminated in 1968 to resolve conflicts between commercial, subsistence and

recreational interests. Subsequently, fish has been taken for subsistence purposes to supply up to 20 persons from time to time. Sport fishing activity is on the increase and the area provides good catches of rainbow trout, grayling and lake trout.

The following report has been prepared to present the results of studies conducted in 1973 by NBCYD personnel. The principal study area was the watercourse from Aishihik Lake to Canyon Lake. A select number of tributary streams were superficially examined.

The 1972 studies were previously reported in memorandum form and are presented as such in Appendix A to this report.

DESCRIPTION OF PRINCIPAL STUDY AREA

The principal study area in 1973 for the NBCYD group within the Aishihik system extended from the outlet at Aishihik Lake to entry at Canyon Lake, a distance of approximately 6,500 feet. For reporting purposes this watercourse is divided into three areas, namely Upper Aishihik River "A", Canyon Pond and Upper Aishihik River "B". Included in this area is a tributary stream named Giltana Creek which enters Canyon Pond on the southeast corner (Fig. 4).

Upper Aishihik River "A" is 1,100 feet in length with a normal wetted width ranging from 45 to 135 feet. The drop is in the order of 20 feet. Cascades are a dominant feature (Fig. 5). The stream bed is composed of bedrock and boulder with the smaller material being prevalent in the lowermost 200 feet. The stream is confined within shallow rock walls and the bottom is very irregular (Fig. 6). The water temperature ranged from 40° F in late May to 55.5° F six weeks later.

Canyon Pond (Fig. 7) measures approximately 2,000' by 1,000' with a depth generally not more than 5 feet. However, a pool, located at the point where Upper Canyon River enters the pond measures approximately 300' by 100' and has a maximum depth of 18 feet. The pond generally has a mud and sand base with some flat boulders. Aquatic plants are abundant on the east side of the pond. Water temperatures generally correspond to those of the Upper Aishihik River "A"; however, a warming of 1° F is sometimes measured near the outlet of the pond. The water level change from late May to mid-July was 1.8 feet and this has a great effect on total wetted pond area particularly in the area of aquatic plant stands.

Upper Aishihik River "B" is approximately 2,600 feet in length with a normal wetted width ranging from 105 feet to 240 feet. Total drop is in the order of 30 feet. The stream bed is

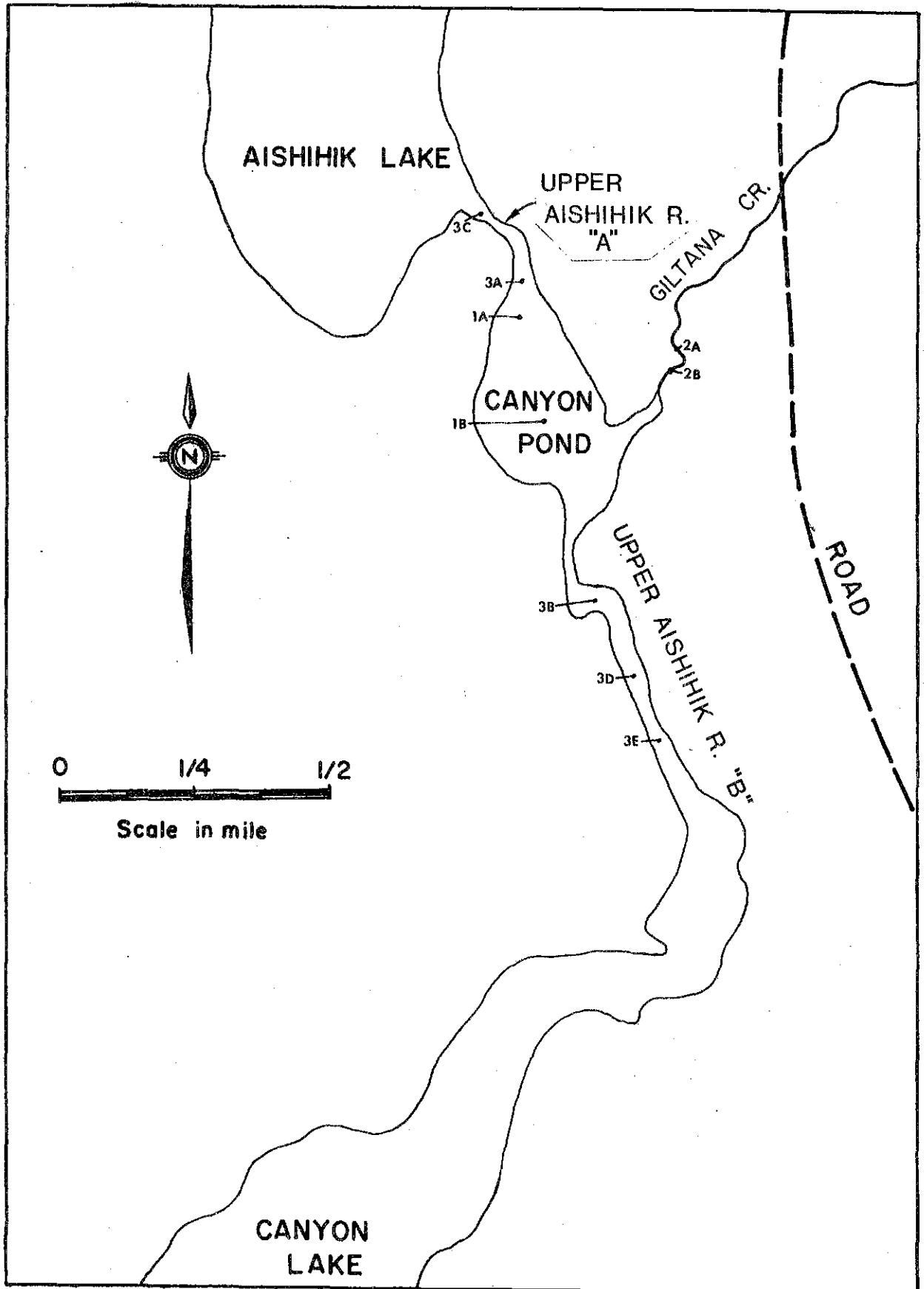


Fig. 4 Principal study area in 1973

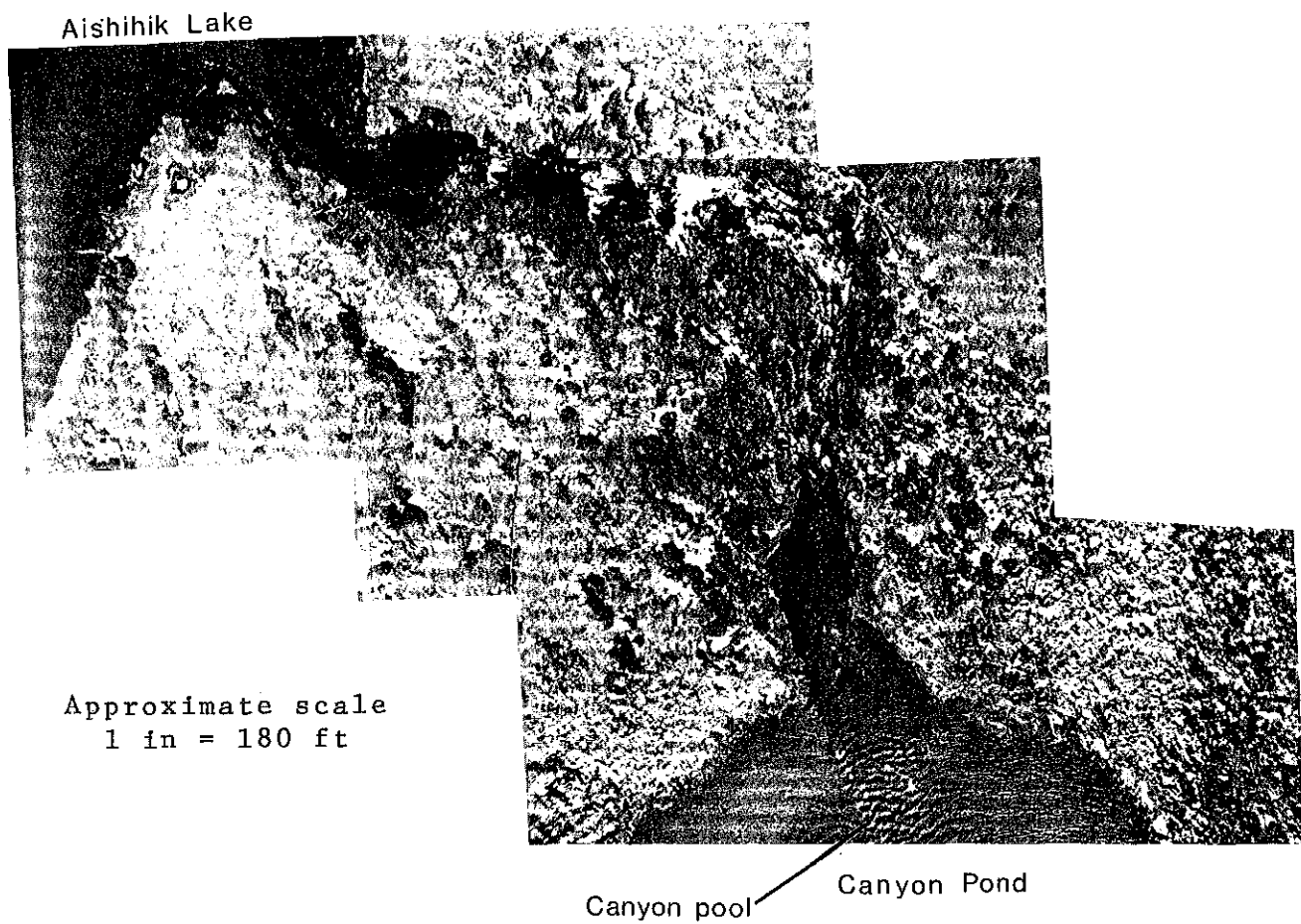


Fig. 5 Upper Aishihik River "A"

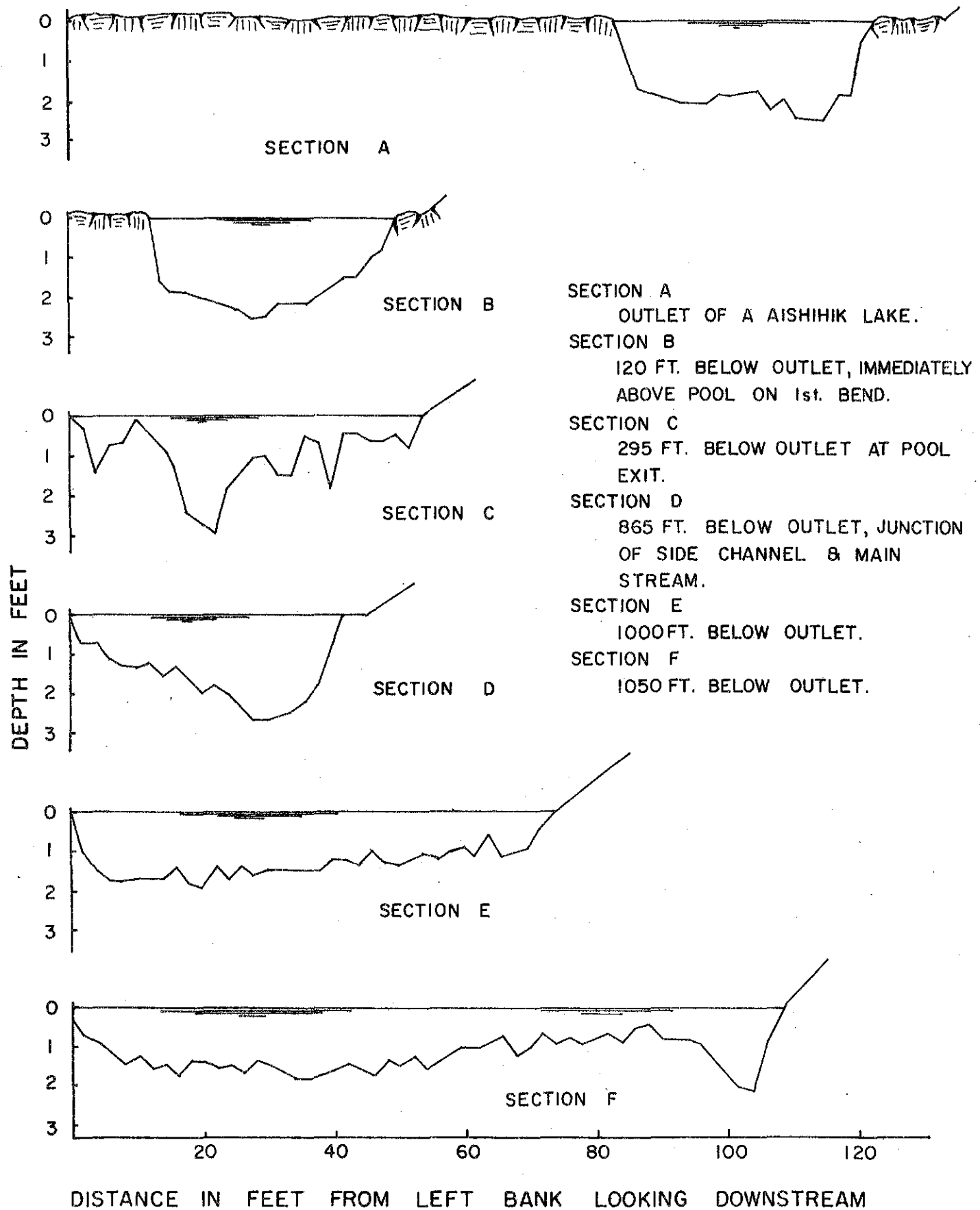


Fig. 6 Cross-sections of outlet stream from Aishihik Lake, namely Upper Aishihik River "A".

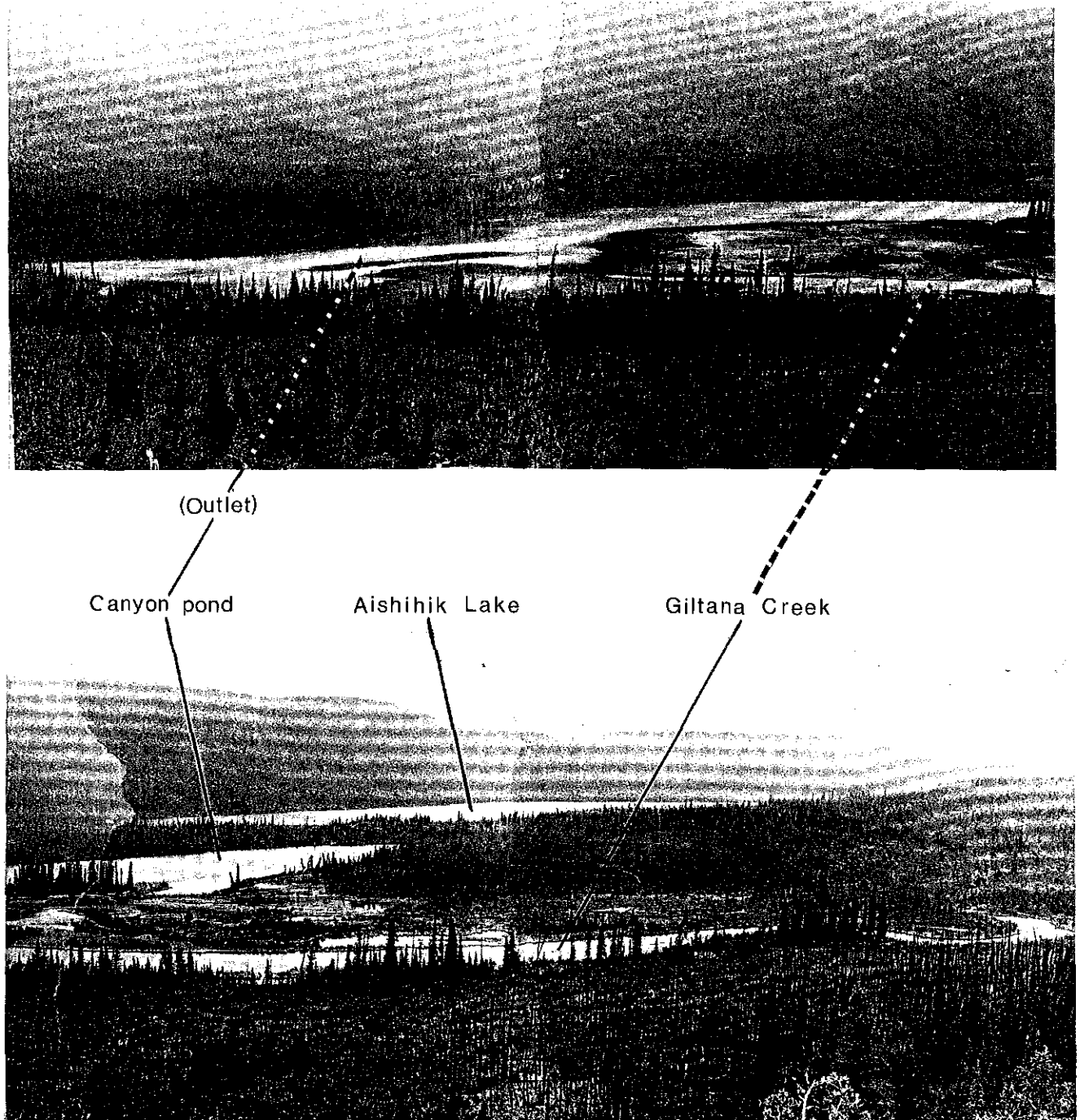


Fig. 7 Canyon pond and Giltana Creek

bedrock and flat boulders with small quantities of gravel. Characteristically the stream has a trench throughout its length with extensive shelf areas on one or both sides of the trench. The trench averages approximately 25 feet in width and 2 feet in depth (Fig. 8). Between 800 and 1,400 feet below Canyon Pond the trench enlarges and forms two pools. The upper pool measures approximately 200 by 100 feet and the lower one 250 by 150 feet (Fig. 9). Maxima depths are 10.5 and 17.0 feet respectively. From Canyon Pond to the second pool the water on the right side (looking downstream) is clear and that on the left brownish. Water temperature differences range from 3° to 9°F at a given time with the left side being the warmest. These differences are due to unmixed waters originating with Aishihik Lake and Giltana Creek respectively.

Giltana Creek drains a small lake system located east of Canyon Pond. Only that part from the Aishihik road to entry at Canyon Pond, a distance of approximately 4,000 feet was examined. The top half of the area is steep, rocky and turbulent and the bottom half (Fig. 7) is low gradient, silty, weedy and slow. A very short transitional section of approximately 300 feet contains some gravel. The water temperature ranged from 42°F in late May to 60°F in mid-July. The temperatures of Giltana Creek were consistently higher than those in Upper Aishihik River "A" the difference being from 3° to 9°F during the summer (Fig. 10).

Properties of flow from Upper Aishihik River "A" and Giltana Creek as determined by the HACH Kit method are given in Table I.

Photos of general interest appear in Appendix B.

Table I. Some properties of Giltana Creek and Upper Aishihik River "A"

	GILTANA CREEK		UPPER AISHIHIK RIVER "A"	
	May 29	June 21	May 29	June 21
Alkalinity: Ca Cl	0	0	0	0
MO	6	5	4	4.5
Hardness	7	6	5	5
Acidity: free	0	0	0	0
Total	.33	.33	.33	.33
pH	8.5	8.5	8.5	8.5
dissolved oxygen	12.0	11	12.5	11.5
CO ₂	5	2	5	7.5

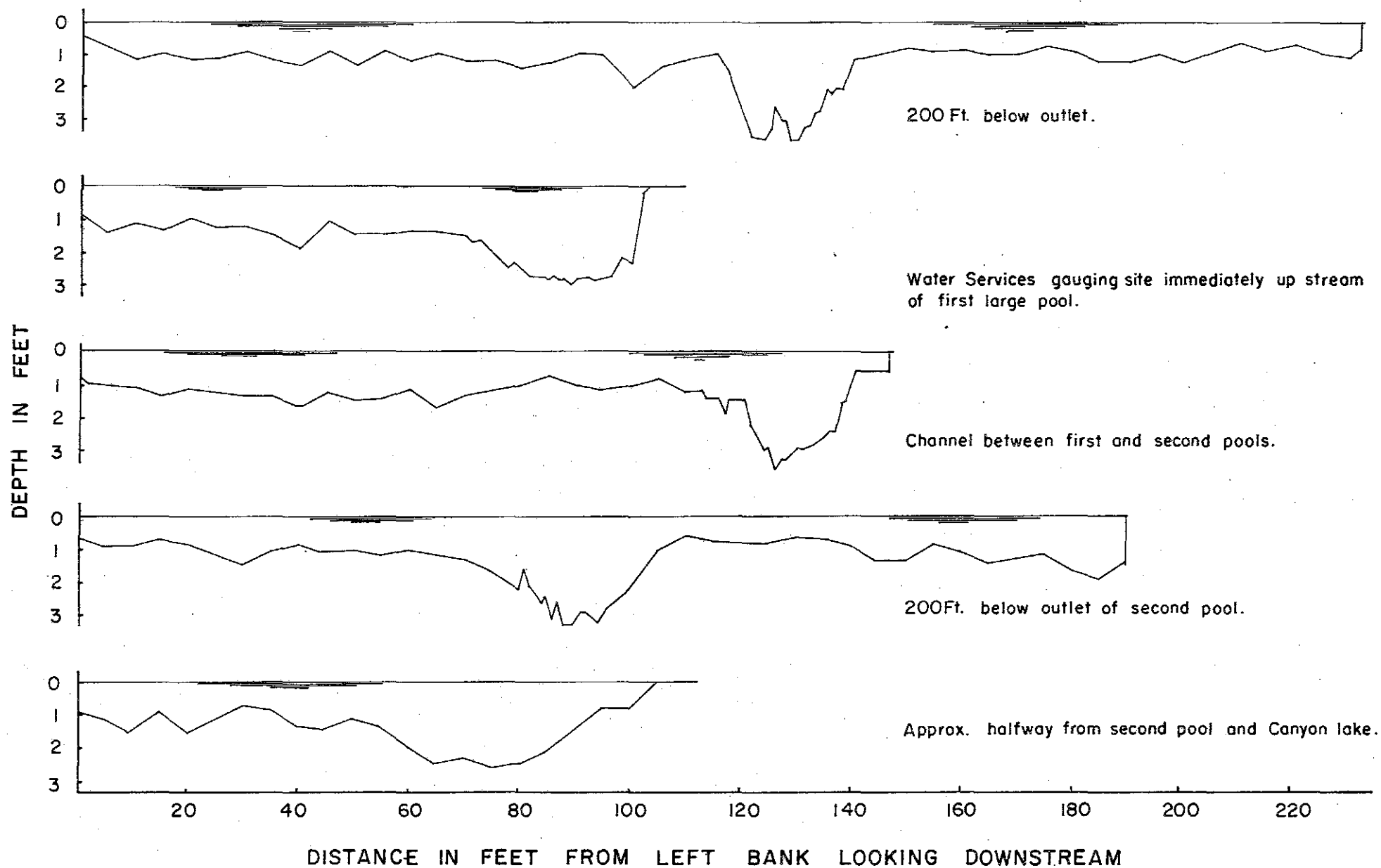
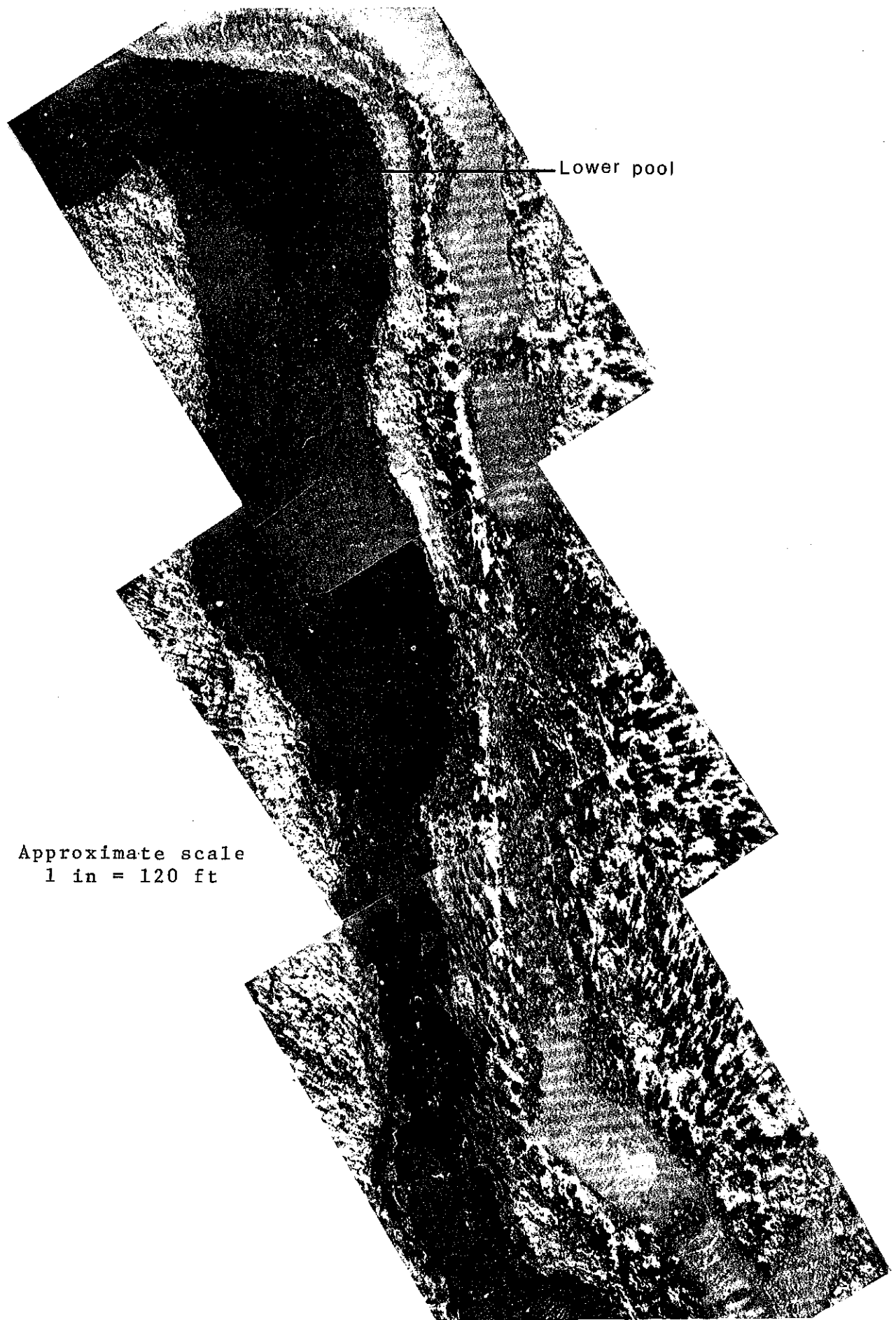


Fig. 8 Cross-sections of outlet stream from Canyon Pond, namely Upper Aishihik River "B".



Canyon Lake

Fig. 9 Lower 1200 feet of Upper Aishihik River "B".

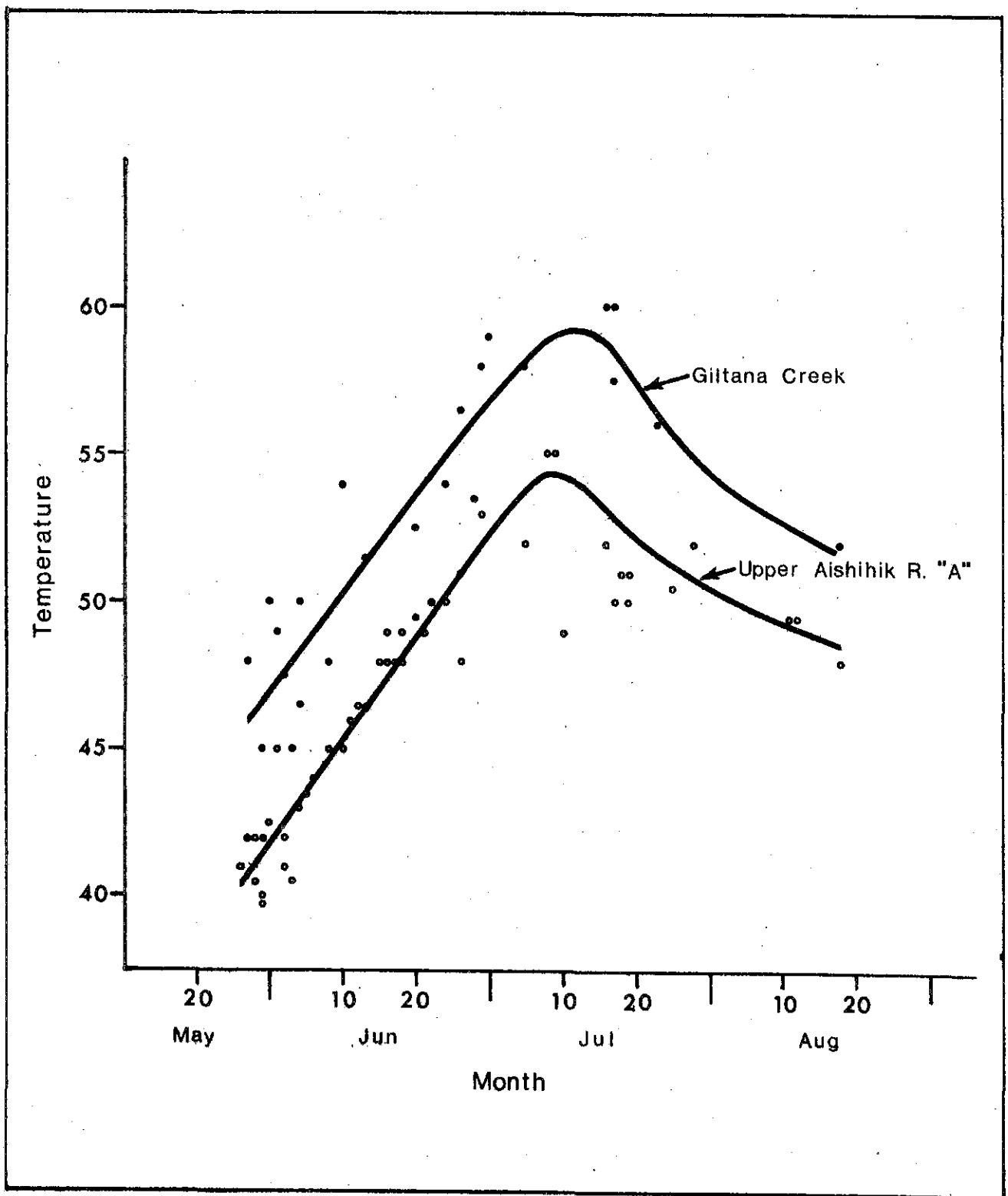


Fig. 10 Water temperatures (°F) in Giltana Creek and Upper Aishihik River "A".

METHODS

In 1973 the activities in the principal study area included the observation, capture, measurement and tagging of fish; the collection and analysis of invertebrate populations; and the examination of stomach contents in fish.

Studies were carried out in the periods May 25 - September 10, October 3-6, November 5-9, November 13-23 and December 10-13.

The capture techniques for fish were gillnet, seine, dipnet, fyke net and sport gear.

Gillnet mesh was monofilament nylon with sizes ranging from $1\frac{1}{2}$ " to $3\frac{1}{2}$ " stretched mesh. The netting was hung in panels measuring 50' x 8', both sink and float types were available. A panel contained only one mesh size. Up to three panels were tied together to form a net. The size of net and size(s) of mesh used depended upon the purpose for which the sample was taken. Gillnets were utilized more widely in both time and place than any other gear. However, the catch was restrictive to fish of adult and near-adult size.

Seines measured from 10' x 3' to 50' x 8'. Each net had a bunt with mesh in the order of $1/8$ ". This gear was used in pond, pool and slow-riffle areas. It was most effective on fish intermediate in size between adult and infant.

The dipnets were rectangular frames (2' x $1\frac{1}{2}$ ') covered with 20-mesh-per-inch netting. The equipment was useful to capture fry-of-the-year (infant) and was effective in pools and slow riffles.

The fyke nets were the two throat-type with a front opening of 4' x 4'. One-eighth-inch mesh was used in the cod end and $\frac{1}{4}$ " on the sides, body, and wings. These nets were used

to test for outmigration from Aishihik Lake. Generally two nets were installed, one within 200 feet of the lake outlet and the other within 100' of Canyon Pond. The distance between nets was in the order of 600 - 1,000 feet. The nets were fished for 5 days per week in the period May 27 - June 15. Usage at other places and times was too infrequent to warrant mention.

Spin and fly cast equipment represented the sport effort. Sport activity was carried out almost continuously during the summer and over a wide variety of places and times. Sport gear was particularly effective for sampling grayling. The risk of obtaining highly selective samples in terms of size of individual and contents of stomach was recognized. Lake trout and pike were also taken on sport gear.

Tags were applied to the body in the vicinity of the dorsal fin to provide information on migration and magnitude of stock. The tags were Petersen disc, 9 1/6" diameter. A total of 542 fish were tagged with the following composition:

133 humpback whitefish; 29 round whitefish, 201 Arctic grayling, 2 northern pike, 176 longnose sucker and 1 lake trout. A summary of the tags applied is given in Table II.

Stomach contents were examined on 50 whitefish and 50 Arctic grayling. Stomachs were removed and preserved in 10% formalin. At a later date the stomachs and contents were weighed to the nearest gram, then the stomachs were emptied and re-weighed. Stomach contents were identified and the percentage occurrence of Order and/or Family groups was estimated based on its mass relative to total content .

Length was taken as the distance from tip of snout to fork of tail. Length measurement totals: 237 humpback whitefish, 55 round whitefish, 243 Arctic grayling, 174 longnose suckers.

Table II. Numbers of fish tagged - Aishihik, 1973.

Date	Area *	Nos. Tagged			
		Ta	Cc	Pc	Cac
29/05/73	1A	1	20	4	
18/06/73		6	28	9	
23/07/73		2	6	6	
		9	54	19	
27/05/73	1B				2
01/06/73			8		8
			8		10
02/06/73	2A				23
04/06/73		1	2		4
05/06/73		3	20		136
		4	22		163
28/05/73	2B		6		3
02/06/73			4		
			10		3
28/05/73	3A		8		
29/05/73			5		
05/06/73			1		
12/06/73			12		
13/06/73			4		
27/06/73		34			
29/06/73		6	1	1	
28/07/73		24			
29/07/73		19			
		83	31	1	
01/06/73	3B	9	3	3	
03/06/73		11	3		
20/06/73		10	1	6	
21/06/73		4	1		
28/06/73		15			
		49	8	9	
30/07/73	3D	40			
		40			
29/07/73	3E	9			
30/07/73		7			
		16			
		201	133	29	176

27/03/73 - 1A - 1 Sn Total Number Fish Tagged = 542
 01/06/73 - 1B - 1 El
 28/05/73 - 2B - 1 El

Ta = Arctic grayling Pc = round whitefish
 Cc = humpback whitefish Cac = longnose suckers
 Sn = lake trout El = northern pike

* See Fig. 4.

Scales were removed for age and growth analyses in the following numbers: 20 humpback whitefish, 10 round whitefish and 30 Arctic grayling.

Interpretation for age was made by personnel of the Technical Services Group utilizing standard techniques.

Invertebrate drift was sampled in two ways. The sampler reported by Miller (1961) was used with 250-micron mesh. Depending upon the depth of water, one or two standard tubes were attached to the undersurface of the float to sample a 4" diameter flow centering at 9 and 13 inches below the surface. The second method used to sample invertebrate drift was one modified from a trap design reported by Mundie (1970). The apparatus consisted of a front-end, bagnet, and sample container. The front end was made of 10-gauge aluminum plate which flared from a rectangular opening measuring $1\frac{1}{4}$ x 12 inches (fishing area) to one 3 x 12 inches over a distance of 8 inches. The bag net was made of 250-micron nylon; its length was 34 inches. The sample container was made of ABS black plastic tubing and measured $1\frac{5}{8}$ inches inside diameter with windows of 250-micron mesh (Fig. 11). In instances where the depth of water was greater than 12 inches a second similar unit was stacked on top. The samples were analyzed by laboratory groups under the direction of Dr. D. N. Gallup, University of Alberta, and Mr. W. Schouwenburg, Fisheries and Marine Service. The method was designed by Dr. Gallup and is given in Appendix C.

The standing crop of stream bottom organisms in gravel and rock areas was measured by sampling an area measuring 20 x 20 in. which was marked out by a metal frame. Rocks within the enclosed area were scrubbed with a brush and the remaining substrate disturbed by shuffling and digging with the heel and toe. The resulting drift was captured by a rectangular-mouthed bag net with a mesh of 250 microns. In areas of sand, silt and mud an Ekman dredge measuring 6 x 6 in. was utilized to obtain a sample.

The second and minor part of the 1973 studies was to survey the tributary streams of Aishihik Lake. Sekulmun River was surveyed its full length on June 24 - 26, July 2 and July 14. In

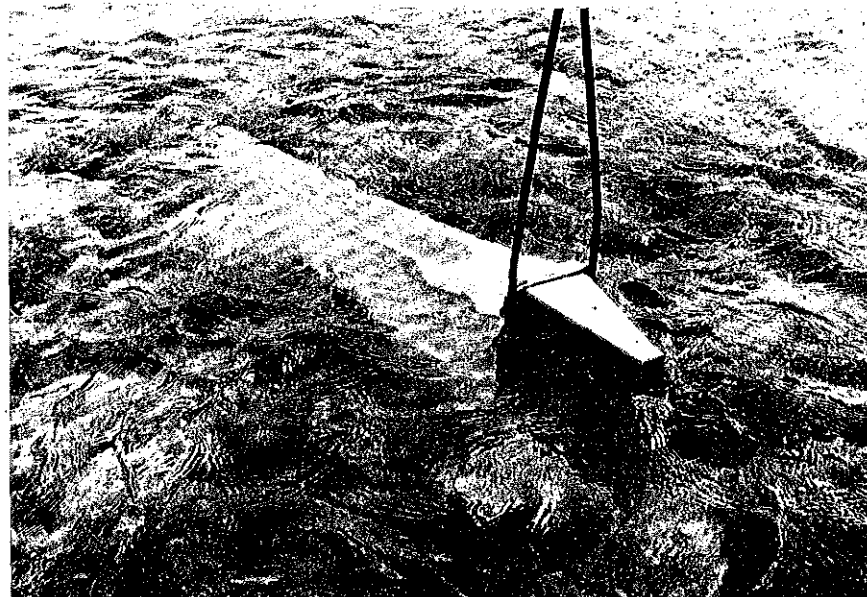
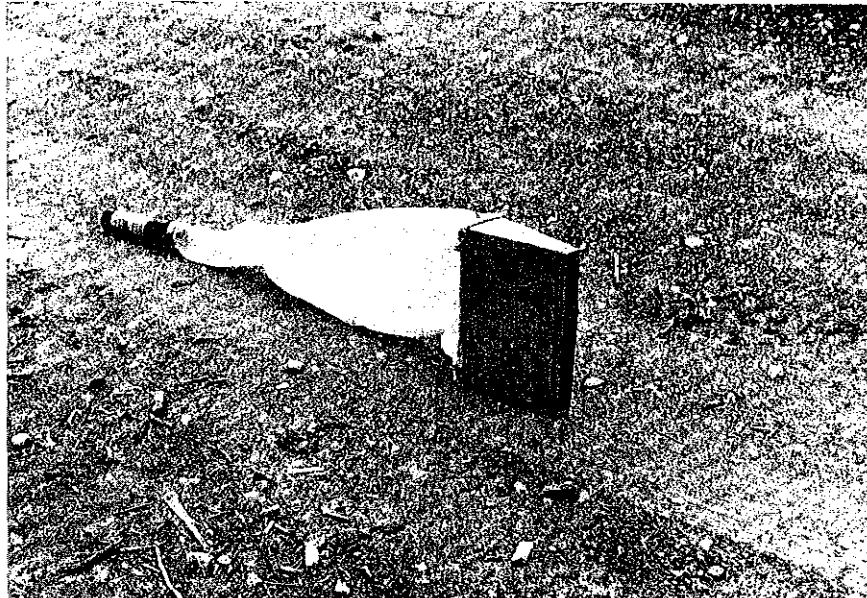


Fig. 11 Sampling apparatus for invertebrate drift

the course of the June 24-26 survey, gillnets with mesh sizes of $1\frac{1}{2}$, $2\frac{1}{2}$, 3, $3\frac{1}{2}$ and $5\frac{1}{2}$ inches were set in 6 widely separated places and lifted after 24 and 48 hours of soak. Small mesh seines were used in the uppermost 1 mile of stream, and sport gear (fly and small spinner) in the upper $2\frac{1}{2}$ miles. Observations were carried out at all times, with particular attention being given to the gravel areas with a view toward locating spawning areas for grayling. The net catches were identified to species, measured for length (TSFT) and examined for sexual maturity and stomach contents. In the course of the surveys of July 2 and 14 the activities were limited to sport fishing and observation with the exception of one "sweep" with a small mesh seine in the latter survey. Hawkins Creek was surveyed for 600 feet on June 29, Lister Creek for 3,000 feet on June 29, McIndoe Creek for 6,000 feet on June 29 and Soldier Bay for 3,000 feet on June 1. In each case general stream characteristics were noted, photographed and in some cases measured. The presence of fish was determined largely by observation because the rocky nature of the stream and/or the high flows inhibited effective use of nets.

RESULTS

Principal Study Area

Fish Stocks:

Eight species of fish were found in the principal study area, namely humpback and round whitefish, Arctic grayling, lake trout, northern pike, longnose sucker, slimy sculpin and burbot. Rainbow trout which inhabit the Aishihik River have not been observed between Aishihik and Canyon Lakes.

The whitefishes and grayling were most abundant throughout the study period; however, suckers were present in relatively good numbers in late May and early June.

Grayling:

The grayling were more widely distributed than the other fish inhabiting a wide range of velocity conditions, from "white" water to placid flows.

Sexually maturing grayling measuring 265-455 mm "appeared" at the inflow area to Canyon Pool and in the lower area of Giltana Creek at the end of May. Spawning was observed in Giltana Creek in the period of May 28 - June 10. It is likely that grayling spawned in Upper Aishihik River "A" and "B" also because newly emerged fry appeared in or close to these areas at a later date.

As June progressed, adult-size grayling extended their distribution throughout the watercourse, presumably away from spawning areas and/or overwintering sites. They were observed to occupy the swifter and deeper parts of the watercourse between Aishihik and Canyon Lakes. This extension in distribution resulted in migration through at least Upper Aishihik River "A". This was evident by the appearance of grayling progressively upstream through June eventually reaching the outlet pool on July 3 and

by the capture of two tagged grayling at the outlet area of Aishihik Lake. These fish had been tagged in Canyon Pond two weeks earlier.

Intermediate size fish (200-270, mode at 230 mm) occupied shelf areas through the summer and were very apparent by their jumping activity which was associated with feeding. This was particularly noticeable in Upper Aishihik River "B" from the outlet of Canyon Pond to the second pool. This size group could not be found in October and later.

Newly emerged fry measuring 16-18 mm in length were first observed in Giltana Creek on June 24. Similar size fry showed in Upper Aishihik River "B" and Canyon Pond (north end) on June 26 and July 5 respectively. Grayling fry distributed throughout the aquatic grasses of Canyon Pond, Giltana Creek and adjacent ponds. Distribution extended into the grass areas as the water level increased; here the fish benefited from shelter, relatively high water temperatures, and abundance of planktonic food. Growth of grayling fry was rapid attaining an approximate average length of 50 mm by late August. Fry of the year were not sampled after that date.

The magnitude of the adult populations (i.e. >275 mm) is difficult to estimate because of migration into and out from the study area, loss of tagged fish, lack of reliable tagged to untagged ratio information from the sport fishermen and low recovery effort by scientific means.

Suckers:

A gillnet located at the extreme north end of Canyon

Lake and operated by Natives for personal use began catching maturing suckers in the third week of May. Suckers were observed in a school estimated at 100 fish in Canyon Pond on May 27 near the outlet end. Their position was evident by the presence of "dirty" water in a very small area of the pond. The "dirty" water was caused by agitation of the bottom of the pond by fish. It was not determined if the fish were involved in spawning or pre-spawning activities. Two members (490 and 500 mm in length) were caught in gillnet and found to be sexually mature. On the following day mature suckers were present in Giltana Creek. Spawning was casually observed in Giltana Creek up to June 10. With one exception, the length of mature fish ranged from 435 to 550 mm with a mode at 470 mm. (Stream temperatures were 45 to 54°F during spawning.) Spawning was observed from the lowest riffle to the vicinity of the bridge, an approximate distance of 3,000 feet. The areas for spawning had gravel and velocity conditions not unlike those utilized by salmon for this purpose. At the precise moment of egg deposition males appeared to outnumber females 6:1. Sucker spawners were not observed elsewhere in the system, however new fry appeared at the point of inflow into Canyon Pool and in Upper Aishihik River "B" at a later date suggesting suckers did spawn in both parts of the Upper Aishihik River, i.e. "A" and "B". Adult suckers were not seen or sampled within the study area after June 10.

Newly emerged fry, measuring 10-12 mm in length, were observed along the stream banks in the low velocity parts of Giltana Creek below the beaver dam and in adjacent pools from June 24 to July 23. They were particularly prevalent on June 30. The length measurements did not change over a four-week period which suggests samples were continually taken from new emergents.

The 10-12 mm fish were initially observed in Upper Aishihik River "B" on June 26 and in Canyon Pond near the water level gauge commencing July 7. It is unlikely that the fry originated from any source other than Upper Aishihik River although

spawning was not observed here.

During the summer intermediate-size suckers, in the order of 100 mm in length, were caught in small numbers in Giltana Creek in the low-velocity areas. The samples were too small from which to draw conclusions but it would appear that a limited number of juvenile suckers, possibly of age 1, rear here. On October 5 juveniles of approximately 60 mm in length were sampled in the lowest section of Giltana Creek. This probably indicates winter residence in creek waters.

Round whitefish:

This species was present throughout the summer in moderate flows in Upper Aishihik Rivers "A" and "B" and in low-velocity areas of Canyon Pool; they were not observed or captured in Giltana Creek. Fyke net catches obtained above Canyon Pool during the summer suggest that round whitefish made feeding forays into Upper Aishihik River "A" from time to time. The length of fish at this time ranged from 270 to 435 mm. In October sexually mature fish measured 285 - 330 mm. Spawning occurred in November at the outlets of Aishihik and Canyon Ponds. Water temperature at this time was in the range of 33 - 37°F. The spawning activity is being reported in detail by J. E. Bryan at a later date. The abundance of round whitefish in the study area appeared to maximize in October coinciding with spawning.

Humpback whitefish:

Generally humpback whitefish occupied Canyon Pond and the two large pools in Upper Aishihik River "B" almost exclusively. However, in late May and early June they were found in Giltana Creek up to the beaver dam and in the lower 200 feet of Upper Aishihik River. Stomachs contained fish eggs tentatively identified as sucker and grayling. Individual size ranged from 335 to 480 mm

with a mode at 410 mm. Sexually mature fish were present in Canyon Pond in early October but spawning was not observed. However, eggs were found on aquatic plants at the outlet of Aishihik Lake in November.

Lake trout:

Lake trout were relatively scarce in the study area. The maximum number seen at any one time was 6 and these were located in the major flow areas of the Upper Aishihik River. Length measurements on trout are lacking but weight varied approximately 2 to 17 pounds. There is no information on sexual maturity, migration, or other matters.

Northern pike:

Pike were found in the weedy, slow-moving areas on the east side of Canyon Pond and in the lowermost 500 feet of Giltana Creek. Under good conditions up to 5 adult-size fish were observed on a single pass with a boat. Information on life history is lacking.

Slimy sculpin:

Sculpins were present in good numbers in all waters. Sexually mature fish were found in mid-May. The largest sculpin measured 128 mm in length.

Age and growth:

Reference was made to length of fish in the section titled fish stocks. This one attempts to relate length to age. Age interpretation from scales of northern fishes has proven to be controversial and the length frequency data is limited due to an apparent inability to adequately sample all size (age) groups in the population.

To date age and growth have been satisfactorily worked out for grayling only, that is, the length frequency data corroborates age interpretation made from scales. The results are given in Table III.

Table III. Age and length of stream grayling in the Aishihik system.

Age of sample	Calculated mean lengths of fish				Sample size
	Age I	Age II	Age III	Age IV	
Age II	95	176			25
Age III	89	172	243		2
Age IV	104	172	242	295	12
	Modal values in length frequency data				
		170	230	285	235

The oldest grayling found in Aishihik streams was Age V.

In the other species there was little relationship between size and age suggesting further study is required.

The age of humpback whitefish obtained by sampling was interpreted to range from Age III to Age IX. Mode values of 370 and 410 mm appear in the length data and fish of these sizes are believed to be largely Ages VII and VIII respectively.

Round whitefish ages were interpreted as ranging from Age V to Age VIII. A mode value of 310 mm was represented by Ages V and VI.

There is no age-growth information available for the other species.

Stomach contents:

The Arctic grayling in the size range of 297 - 372 mm consumed largely black flies (Simuliidae), which frequently represented 80-90% of the bulk of the stomach contents. Caddis fly (Trichoptera) and midges (Chironomidae) were of next importance in that order. The average weight of food was 8.5 gm.

The caddis fly was the dominant organism (80-90%) found in the stomachs of round whitefish (300-383 mm). Midges and black flies and molluscs were also represented. An average of 1.4 gm of food was found in the gut.

The stomach contents of humpback whitefish were more varied. Major items were molluscs, black flies and midges. Minor components were crustacea and plants. The amount of food was extremely variable from a trace to 5.2 gm.

Most insects were in the larval stages.

Invertebrate Populations:

The results on invertebrate sampling are given in Appendix Report "D" prepared by D. N. Gallup and Alan Clements, University of Alberta; some samples are yet to be processed. A calculation for total invertebrate biomass in the stream drift is not made for reasons explained by Gallup and Clements. Also, irregularities in methodology preclude making direct quantitative comparison with results obtained elsewhere by similar types of gear. However, the data is valuable as base-line information to make comparison with samples to be obtained in 1974. The main points of the Aishihik stream invertebrate study are:

- the number of invertebrate species present are relatively scarce. Hence interdependence on each other for survival may be high and if this is true there is great risk of collapse in the "balance" of interrelationships if one or more species is adversely affected by modified flows. If an upset does occur the food supply to the fish may be drastically diminished or altered in kinds of available organisms;
- the quantity of stream drift is relatively high. This is based on in-situ observations made by Dr. D. Gallup. The drift has two components, i.e. plankton originating from Aishihik Lake and insect larvae and adults arising with the stream itself. The minimum amount of drift that is required for consumption and fertilization in the stream, pond and lake waters is not known. However, it must be expected that a "balance" of sorts has been established since creation of the present system and that a drastic change in flow pattern would upset this balance;
- invertebrate production appears to be extremely high on the stream and pond shelf areas. Desication of shelf area would have very serious adverse effects on invertebrate production and in turn on the fish stocks.

Tributary Streams

Lister Creek:

Date of survey:	June 29	Length of survey:	3,000 ft.
Temperature:	45° F	Width of stream:	40' - 60'

Within the area surveyed the stream is pool and riffle with a gravel and sand base and appears to offer the best opportunity for lateral stream spawning within the Aishihik system. The area is heavily forested with spruce (Fig. 12). No fish were sighted.

A reduction in lake level will result in stream bed cutting and bank erosion with a fall-in of spruce. An increase in lake level will inundate the forested fan.

The stream appears to have the potential to maintain a fish stock and further study is recommended.

Hawkins Creek:

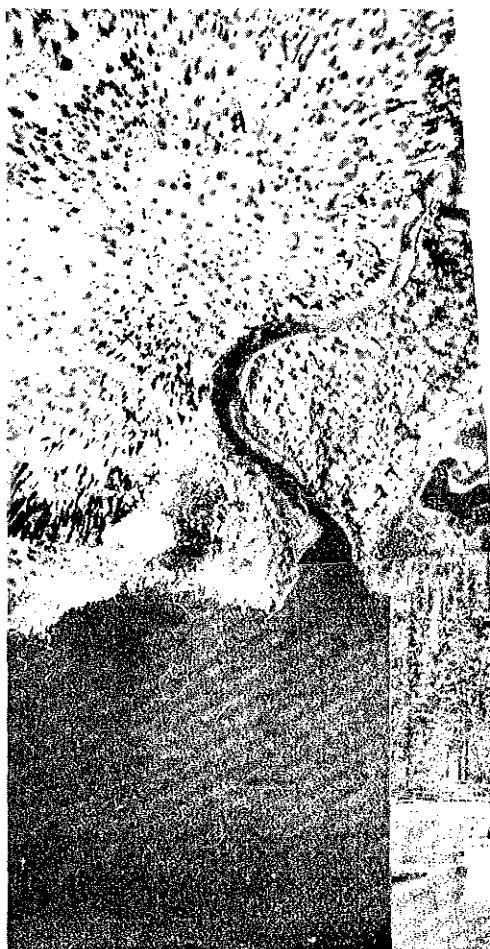
Date of survey:	June 29	Length of survey:	600 feet
Width at mouth:	12'	Depth 6" - 20"	Current 3'-5'/sec.
Temperature:	55° F		

The stream has rock and boulder base with rapid drop; chutes exist at 300' upstream from mouth and cascades at 600' (Fig. 13); does not appear to have potential for spawning; no further study required.

McIndoe Creek:

Date of survey:	June 29	Length of survey:	6,000 ft.
Temperature:	49° F		

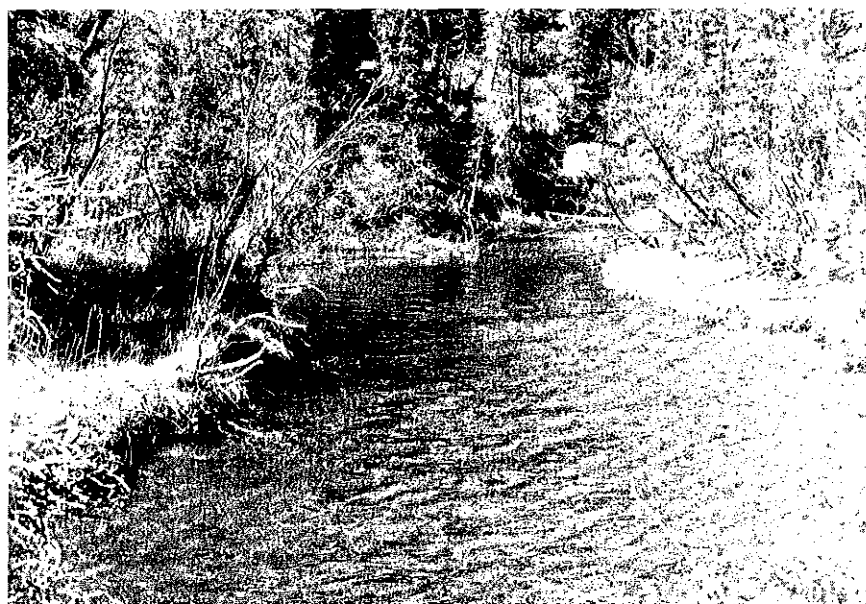
Stream meanders through extensive fan; lower 1 mile has slow current, width up to 100' and sufficient depth to operate



Delta area
mid-September 1972



Mouth area June 29/73



"Typical" pool and
riffle section



Mouth

100 ft. above mouth



Chute

Above chute



Fig. 13. Hawkins Creek

propeller-equipped outboard motor; from 1.0 to 1.5 miles stream is largely riffle with mud and sand banks and base and insignificant quantities of gravel (Fig. 14); beaver houses plentiful; bank sloughing exists; grayling and whitefish are abundant in lower 1 mile. Any change in lake level most likely will result in extensive stream bed and bank erosion and general deterioration of a relatively extensive rearing habitat; area requires more study.

Sekulmun River:

Dates of survey: June 24-26, July 2, July 14.

Length of Survey: 5.0 miles.

Temperature: 45°F 24-26/06/73, 48°F 02/07/73; 49°F 14/07/73.

Net catches were: 57 humpback whitefish, 3 round whitefish, 11 Arctic grayling and 2 lake trout for a total of 73 fish. Fish were effectively caught in the 1½", 2½", 3", 3½" mesh nets; the 5½" mesh net caught no fish. Sport caught fish were represented by 11 grayling. Seines accounted for 2 unidentified fry during the first survey, and numerous grayling fry in mid-July.

Size composition of the species was as follows:

humpback whitefish: 335-445 mm; mode at 370 mm

round whitefish: 245, 285 and 310 mm

arctic grayling: 122-445 mm; modes at 165-170 and 335 mm.

No spawning was observed for any species nor were sexually mature fish positively identified. Some grayling examined on the first survey exhibited a spawn-out condition.

Stream deserves further study.

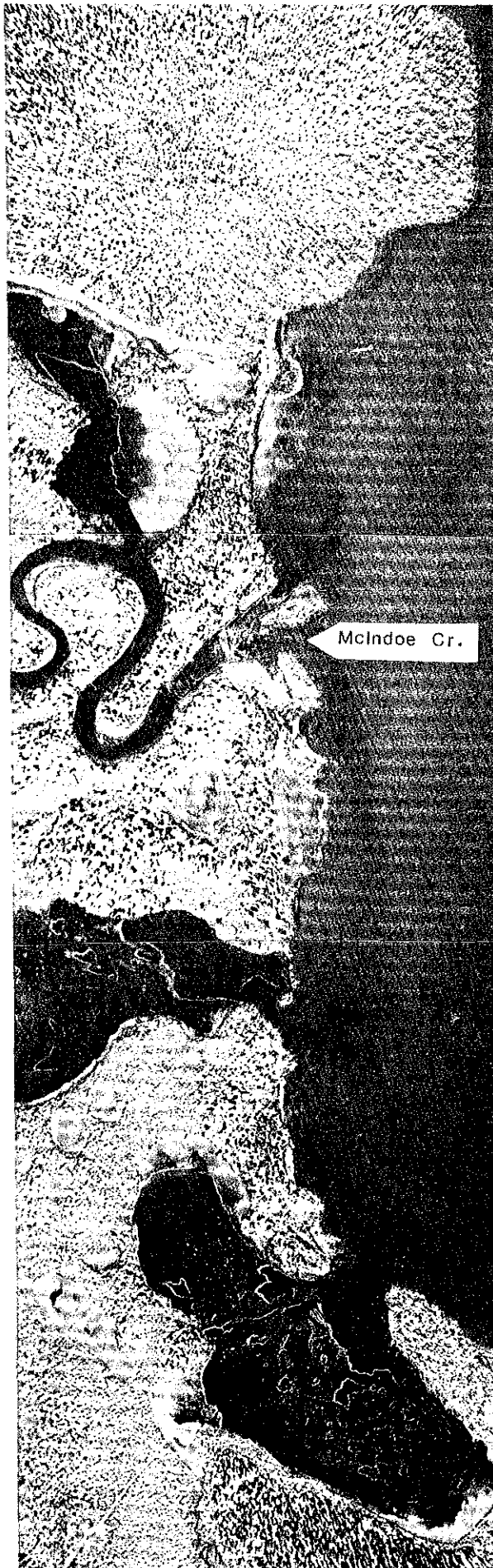
Soldier Bay Creek:

Date of survey: July 1

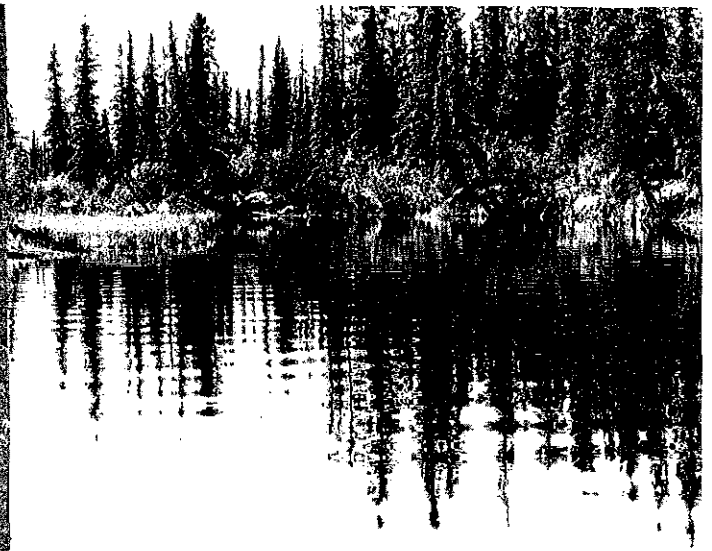
Length of survey: 3,000 ft.

Temperature: 56° F

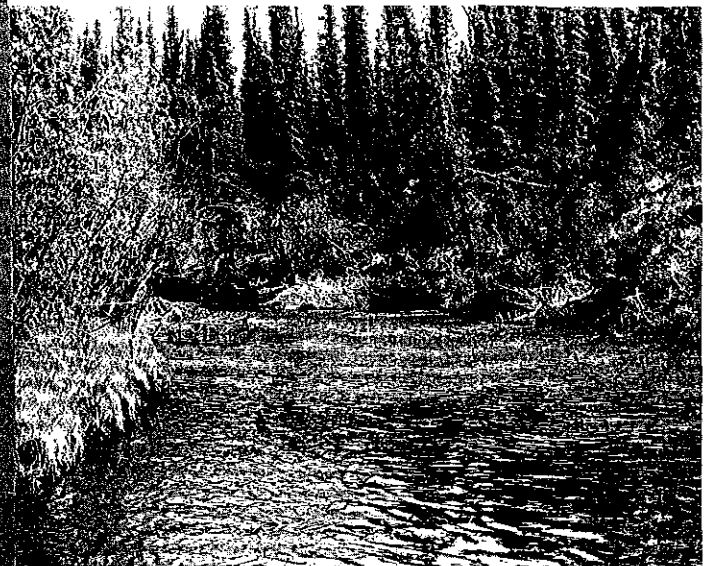
Width of stream: 20 ft.



McIndoe Cr.



Mouth area June 29/73



First riffle



Sluff bank area

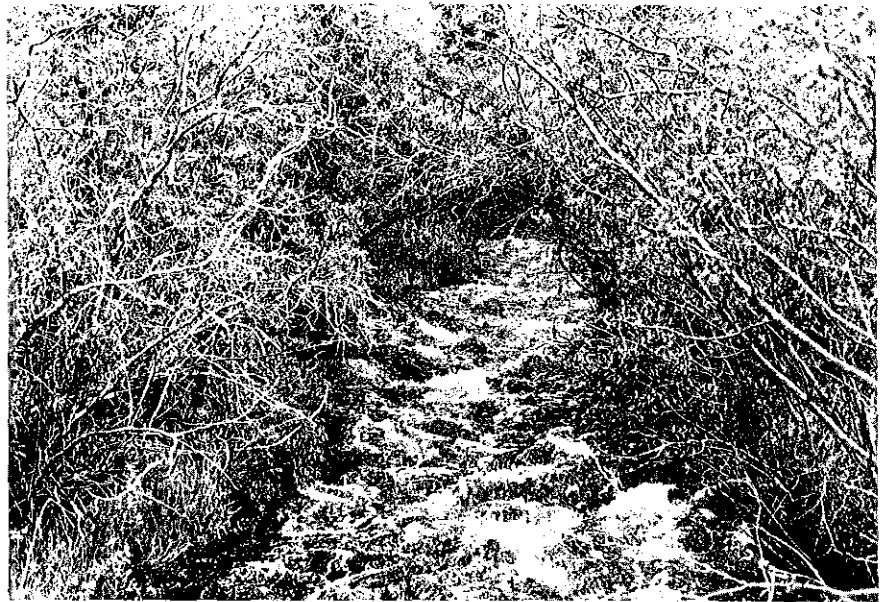
Fig. 14 McIndoe Creek

This is a fairly rapidly dropping stream with a rock and gravel base; mouth area is slough-like (Fig. 15); juvenile and adult fish sighted in mouth section. Further study is required.



Mouth area July/73

Section of creek
near mouth



"Typical" section
of creek

Fig. 15 Soldier Bay Creek

SIGNIFICANCE OF FINDINGS TO HYDRO-POWER SCHEME

The watercourse between Aishihik and Canyon Lakes is inhabited by fish of eight species for one or more of the following functions: spawning, egg incubation, nursing, feeding, migration and shelter. Fish have been present on all surveys which collectively represent 9 months of a year. Therefore, the watercourse can be classified as an all-purpose, all-season habitat as far as some fish are concerned.

The turn-about in flow pattern that will arise with the generation of power from low to high in winter and from high to low in summer raises serious questions.

Practically nothing is known of the requirements of the fish to survive through the winter. At this time it is presumed that the fish are sedentary and that wetted area and adequate oxygen are the prime factors involved in their survival but food may be important with some species. If so, increased winter flows, if maintained on a continuing basis, may improve conditions and enhance survival. Conversely, during the summer the fish are active. Therefore, reduced discharges may have significant adverse effects on fish and in some instances go so far as to eliminate a species or a specific group within a species from the study area. The question of summer minimum flows out of Aishihik Lake becomes paramount.

Fraser (1972) in review of the effects of discharge on the stream environment summed it as follows:

"Discharge effects relate to food production, stimulus for migration, success of migration, spawning, survival of eggs and juveniles, spatial requirements and shelter needs. Excessive high and low flows have caused major changes in fish populations.

Discharge has different effects in stimulating migrations of anadromous fish, both with different species

and with the same species in different streams. Reduced flows cause undesirable delays in both upstream and downstream migrations. Natural freshets are important in migration patterns. Salmonids demonstrate a narrow tolerance to velocity and depth in choosing spawning areas. Velocity of flow is perhaps the most important aspect of discharge for salmonid spawning, embryo development, food production and rearing. The strong territoriality of resident salmonids in streams influences the relationship of discharge to production of salmonids. Discharge also influences water temperatures, other water quality factors, growth of terrestrial and aquatic vegetation and the transport of solids."

The direct effects of flow reduction on stream flows can be predicted. These amount to a lesser wetted area, a lesser average depth, and most significantly, a much lesser average velocity (Kraft, 1972). In Canyon Pond the direct effect will be a lower water level which will result in a reduction in wetted area, particularly in areas of aquatic grasses. This, in turn, will affect the lowermost areas of Giltana Creek.

Upstream migration has been demonstrated by adult grayling and suckers. It is possible that the movements of these fish in the study area are of greater scope than observed to date. Also lake trout and whitefish may migrate within the water body.

In Upper Aishihik River "A" migration of fish could be complicated, if not made impossible, at very low discharges because of the dispersion of flow by the irregular configuration of the stream bed. This problem may be resolved, however, by cutting a channel in the stream bed. In Upper Aishihik River "B" a flow of approximately 75 cfs or less ($25 \times 2 \times 1.5$) will accumulate in the stream trench and leave the shelves dry. No problem in transport of fish is anticipated with this. However, the stimulus for

migration may be lost. Baxter (1961) in review of minimum flows suggests artificial freshets may be needed to stimulate fish into migration. He suggests that these need not be longer than 18 hours of which 12 hours should be at 30-70 per cent of the average daily flow at a given time. The onset of migration of salmon with increase in discharge has been reported by various workers (Andrew and Geen, 1960). There is a possibility, therefore, that artificial freshets may be required at Aishihik to stimulate upstream migration by fish. The degree and time of stimulus, if found necessary, has yet to be determined.

The severe channeling of flows in Upper Aishihik River "A" and "B" would concentrate the fry and remove them from the protective niches now provided by stream banks and shallow flows. Hence they would become vulnerable prey to other fishes and possibly birds. Also, the shelf rearing areas utilized by fry would be lost. Fry losses could be extremely high as a result of these consequences.

Summer spawning has not been observed in Upper Aishihik River "A" and "B" but is suspected based on the presence of eggs and "newborn" juveniles within or closely adjacent to these streams. Water depth and velocity are two very important factors connected with spawning and spawn incubation (Andrew and Geen, 1960). Obviously a flow must be maintained at all times to permit the continuation of spawning and spawn incubation. However, without knowledge of species requirements in terms of depth, velocity, substrate and spawning area it is not feasible to present a figure on minimum flow for these life stages at this time.

The most readily observed activity on the part of the fish during the summer was that of feeding. The consumption of food appeared to take place at all hours through at least late May, June, July to at least late August. This intake of vast quantities of "groceries" is necessary at least for some fishes, in order for them to store body reserves to permit the continuation of life during seven months of winter conditions. The kinds

of food consumed by the fish in Upper Aishihik River "A" and "B" arise in the stream proper. However, the exit water from Aishihik Lake carries planktonic forms and nutrients that are essential to produce the stream invertebrate populations. The invertebrate mass is directly related to at least two very important factors, namely velocity and wetted area. The distribution of species of stream invertebrates is based more or less on preference for specific velocity range (Ambuehl, 1959; Curtis, 1959, Macan, 1962). A reduction in discharge from Aishihik Lake during the summer will significantly reduce stream velocity which in turn will affect species composition. As a result fast-water species will become less abundant and slow-water ones more so under control conditions.

It must be assumed that the fish will be opportunists and consume the kinds of food made available to them thus not be affected by diet changes.

The quantity of fish food produced is another question and a factor here is wetted area. In the Upper Aishihik River "A" wetted area may be little affected until the discharge approaches approximately 50 cfs. Velocities will be more affected for any reduction in discharge. What this means in terms of quantities of invertebrates is unknown. Summer flows of 1/8, 1/5 and 1/4 a.d.f. (average daily flow) are suggested for adequate food production by Baxter (1961) for fishes in British streams. On this basis the absolute minimum flow at Aishihik for July @ 1/8 a.d.f. is 100 cfs. The question of wetted area is paramount to Upper Aishihik River "B", particularly where a trench and shelf situation exists. With the trench averaging 25 feet in width and 2 feet in depth, a minimum of 75 cfs (@ 1½'/sec.) is required to fill it. A withdrawal of water to this value would expose the stream shelf and reduce the wetted area by approximately 75%. It is safe to assume that this would virtually destroy the production of invertebrates in Upper Aishihik River "B". This, in turn, would have disastrous results to the fish stocks. It is estimated that the shelf

areas require 75 cfs to keep wetted and permit fry and intermediate size fish to inhabit. Therefore, the minimum requirement in terms of discharge for the Upper Aishihik River "B" is estimated at 150 cfs.

The invertebrate population in Aishihik River is eaten in part by the fish population. The unconsumed part drifts into Canyon Pond and Canyon Lake, drops to the bottom, decomposes and serves as nutrient. Since the time of glaciation a check and balance situation between invertebrate production and fish has no doubt been established (but it is unknown to the researcher). Also, the minimum invertebrate production that can satisfy food and nutrient needs exists (but is unknown). In this regard it is important that invertebrate production and fish needs be examined under various control flow conditions to determine what flows best serve the situation. This can be investigated upon completion of the Aishihik Lake control structure at which time test flows can be provided for experimental purposes.

In a very recently published work on the subject of minimum stream flows for two mid-U.S. streams Wesche (1973) discusses the matter based on hydrologic parameters, surface area and its composition relative to water depth and velocity and available cover for fish. He concludes that as a minimum flow, a discharge in the 25% ADF range will avoid the flow range for which the rate of habitat decrease is greatest. In terms of outflow from Aishihik Lake this represents the following discharges (the mean monthly averages of the natural run-off is given in parentheses): Jan (157) 39, Feb (126) 32, Mar (115) 29, Apr (113) 28, May (188) 47, Jun (491) 123, Jul (756) 189, Aug (650) 162, Sep (564) 141, Oct (468) 117, Nov (323) 81, Dec (214) 54. It is noted that the above values for the months of June to September incl. are greater than the 100 cfs minimum given earlier in the discussion.

It is impossible to evaluate the effects of lake level changes on the tributary streams and their productivity until the range of lake levels and operating rule curves become known.

ACKNOWLEDGEMENT

R. A. C. Johnston, D. Kato, D. Neave, R. Salmond, J. Stephen and R. Truelson collected data at various times. Additionally, D. Kato was particularly effective with his practical approach to various problems. G. Jones and staff of the Whitehorse office assisted in resolving many logistic problems. J. Bryan was instrumental in carrying out a study on the spawning of round whitefish. Some operational problems were handled by B. Lawley, Habitat Protection.

Dr. D. N. Gallup, University of Alberta, provided valuable in-situ advice on the sampling of invertebrate populations and processing of samples. Some equipment and literature were supplied by Dr. H. Mundie, Pacific Biological Station (FRB).

A. Gibson gave general direction and administered the funds. Miss E. Nolting kindly typed this report.

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A P P E N D I X C

STREAM STUDIES IN THE AISHIHIK SYSTEM WITH
REFERENCE TO HYDROELECTRIC DEVELOPMENT

C. E. WALKER AND R. F. BROWN,
FISHERIES AND MARINE SERVICE,
1974

APPENDIX "A"

Memorandum Report of 1972 Aishihik Lake Program



MEMORANDUM NOTE DE SERVICE

Our file Notre référence 31-5-17-5

TO: A. Gibson, Chief,
A: Northern B. C. and Yukon Division

FROM: C. E. Walker, Senior Biologist,
DE: Northern B. C. and Yukon Division

SUBJECT:
SUJET:

RE: AISHIHIK LAKE PROGRAM

Introduction

This memorandum outlines the studies made and results obtained within the Aishihik watershed during 1972 by NBCYT personnel. The responsibility area for this group lay with stream waters and stream populations. The objectives for this program are described in a memorandum prepared by the undersigned and R. Kussat, dated January 4, 1972, file 34-6-4.

Methods

Initially the Aishihik area was entered with helicopter and vehicle on May 4 and 5 respectively for familiarization with geography and ice conditions. The lakes and streams were found to be frozen with the exception of limited areas below Aishihik and Canyon Lake. However, conditions were too hazardous for work. Also road access was limited to the Canyon Lake area.

Re-entry was made on May 17 and a camp established at Otter Falls, however, road access to the north end of Aishihik Lake was not possible until June 7. Lake travel became feasible following ice melt on the following dates: Canyon Lake - June 16, Aishihik Lake - June 18, and Sekulmun Lake - June 22. Day to day activities ceased on August 20, however, occasional observations continued to September 24.

Observing/netting/trapping activities were carried out on the following streams and at the indicated effort and times. E. Aishihik River between Rainbow Falls and Otter Pond; 20 activity days from May 4 to July 15. Otter Pond; 10 activity days from May 30 to July 25. E. Aishihik River above Otter Pond; 23 activity days from May 17 to July 23. Outlet stream from Aishihik Lake; 18 activity days from May 4 to August 13, plus Sept. 23. Giltana Creek; 3 activity days June 13, June 27, July 2. Sekulmun River; 19 activity days from June 17 to September 21 (floating ice was present in stream in June 20). Lister Creek; 4 activity days, June 17, July 21, 22, and September 23. Stream A3: 1 activity day, June 17. McIndoe Creek; 3 activity days, June 30, July 1 & 2. Albert Creek; 10 activity days from June 8 to Sept. 21. Bear Creek; 3 activity days, June 17, June 23, and August 5. Isaac Creek; 3 activity days, June 17, June 23 and August 18.

.../2

.....Dec. 29.....1972.....

Stream measurements and descriptions were made as per standards developed in the stream catalogue series. Fyke nets (4 x 4 front frame, 2 throat, $\frac{1}{4}$ " mesh on sides and wings and $\frac{1}{8}$ " mesh bag) were utilized in the East Aishihik River above and below Otter Pond and in the Aishihik Lake outlet stream to sample for downstream migration. Box traps (2' x 2' x $3\frac{1}{2}$ ', plastic wire coated mesh of 6 mesh to inch, single throat) were used adjacent to the fyke nets to test for directional movements of small fish. The test for upstream and downstream movements was done on alternate nights. Bag nets (metal frame 2' x 1' with an attached mesh bag, 8 meshes/inch and 4' long) were set in the Aishihik River to sample for the drift of eggs, larvae and newly emerged fish. Seines (35'-50' long and $\frac{1}{2}$ ' deep with $\frac{1}{4}$ " mesh; 150' x $91\frac{1}{2}$ " mesh with $\frac{1}{4}$ " mesh pocket) were operated where feasible with regularity to capture fish for identification and measurements of vital statistics. Gill-nets (50' x 8', $2\frac{1}{2}$ " and 3" stretched mesh, monofilament) were used in Otter and Canyon Ponds, and Sekulmun River to catch larger size fish. Sport gear (spin cast & fly) were used extensively throughout the system to supplement other sampling techniques.

A heavy algal * growth in lake fed waters precluded continuous use of nets and traps. The gear was operated during the time of minimal light, usually 2300-0100 hours. Gill-nets were generally set at these hours also because they would be less visible to the fish.

Peterson disc tags were applied on fish in the Sekulmun R. and Canyon Pond as shown below.

Place	Date	Species	#Tagged	Length range in mms.	Modal Length
Sekulmun	July 9	Humpback whitefish	31	270-410	370-390
		Round whitefish	11	205-360	---
		Burbot	1	490	---
		Grayling	3	350-430	---
			46		
	August 8 & 9	Lake trout	2	418-426	---
		Grayling	54	225-405	250-300
			56		
	August 11-13	Humpback whitefish	26	250-440	390
		Round whitefish	8	290-375	---
		Grayling	162	220-415	285
			196		

Eight streams are considered to be important in the Aishihik system and are discussed in this report. These are;

E. Aishihik River - drainage stream of system outlet stream from Aishihik Lake.

Lister Creek - west side of Aishihik Lake.

* Tentatively identified as belonging to the Genus Gomphonema, courtesy of Dr. T. Northcote and U. B. C. assistants.

McIndoe Creek - east side of Aishihik Lake.
Link (Sekulmun) River - between Sekulmun and Aishihik Lakes.
Albert Creek - north end of Sekulmun Lake.
Isaac Creek - west side of Sekulmun Lake.
Bear Creek - lower west side of Sekulmun Lake.

An undetermined number of samples were measured for length (tip of snout to fork of tail), identified to sex, and had stomach and gonads removed for further study. Unfortunately the material has not been analyzed with the exception of length composition for the tagged samples, therefore, this report is incomplete on these matters.

Results

E. Aishihik River

Length: 7.5 miles Width: 80' - 120'

Discharge: Annual mean approximately 350 cfs; est. 495 cfs. July 15.

Gradient: Approximately mean of 30'/000.

Temperature: Water temperature relatively similar throughout. A series of temperatures gives the following trend;

35° May 4, 40° May 17, 45° May 29, 50° June 15, 55° June 30, 60° July 3,
64° (max.) July 8, 60° July 19.

ph 8.5 June 16. D.O. 12 mg.l.

Description: The stream has three characteristically differing areas.

(1) From outlet of Canyon Lake to Otterpond (approx. 2000') mostly "white" water, bedrock and boulder, one large pool half way with fine and coarse gravel in tailrace section.

(2) Otter Pond: measures approx. 1700' x 1200'; pond depth generally 3'-4', however, pool at inlet is 10-15' deep; mud bottom throughout

(3) From Otter pond to W. Aishihik River the stream is subdivided as follows:

Otter Pond - 1000': Pool, largely boulders but some fine material also present.

1000'-4000': Narrow riffle area with some side channels; coarse stream bed.

4000'-9000': Broad riffle, relatively shallow.

9000'-11000': Pool; largely fines.

11000'-18000': series of lengthy rapid and short abrupt drops; bedrock and relatively large boulders; little or no gravel; one pool area located at 15,500'; high aesthetic value.

18000': rainbow falls.

Below rainbow falls river is again a series of chutes and cascades and falls to junction with west Aishihik River.

Species Composition and Other Data

Grayling: Largely inhabit the stream area below Otter Pond: 110- 120 mm. early June; 25-30 mm. and 168-200 mm. (late June). The small size group was located at 15,000' below Otter Pond; sexually mature fish were not observed, however, the presence of newly emerged juveniles in mid June suggests spawning occurred at time of break-up.

Rainbow trout: Found only between Otter Falls and Otter Pond. Three size groups were sampled: 131-152 mm., 200-225 mm. and greater than 260 mm. (July). Neither fry nor sexually mature fish were found; the trout became readily catchable on sport gear on or about July 7 when the water temperature exceeded 60° F., the larger fish were caught in "white" water immediately below Otter Falls whereas the smaller size ones were taken from the pool area.

Round whitefish: Found only in Otter Pond, all fish were feeding adults, no juveniles seen. Long nose sucker: 100 mm., found at outlet of Otter Pond.

Burbot: Represented by one specimen only.

Remarks

The most apparent salmonid spawning area exists in the tailrace section of the pool above Otter and at 4000'-9000' and 15000' - 16000' below Otter Pond. No spawning populations of any species were observed. Likewise, migrations were not identified. A surprising feature was the complete lack of small fish in the shore water of Otter Pond.

Outlet Stream from Aishihik Lake
Length: 6500' Width: 75' - 125'.

Discharge:

Gradient: 27' from Aishihik to Canyon Lake.

Description: The stream has three characteristically distinct areas;

- (1) From outlet of Aishihik Lake to Canyon Pond (1000') relatively narrow, drops 20', water fast, largely bedrock and boulder base, some coarse gravel in lower 200'. Stream temperatures show the following trend. 40° June 2, 45° June 12, 50° June 27.
- (2) Canyon Pond: Measures approx. 2000' x 1000' with a depth in the order of 5'-6', however, the inlet pool is 15'-20', mud and sand base with much peripheral weed growth; Giltana Creek enters on SE corner.
- (3) From Canyon Pond to Canyon Lake (3500') -- relatively wide drops 7', coarse material, one pool 1/3 distance from pond to lake, area utilized for recreation fishing and has high aesthetic values, road access available. An interesting & possibly significant biological situation is that the flow on the west side of the stream is Canyon Pond water and, therefore, relatively clear, whereas the east side water largely originates with Giltana Creek, and has a brown colouration.

Significant difference in water temperature and quality from side to side exists in some periods, eg. June 13, W. side 46°, E. side 53°. This entire area requires a high priority in future studies.

Species Composition and other Data

Grayling: Present throughout the stream; were not observed nor were fry; spawning areas are unknown as are migrations if such occur. Samples of grayling gave length as 220-415 mm. with a mode at 285 mm.

Humpback whitefish: Occupies Canyon Pond, size range of samples was 250-440 mm. with a mode at 390 mm.; sexually mature individuals found Sept. 23.

Round whitefish: Through summer occupied Canyon Pond; sample size ranged from 290-375 m. Sexually mature fish were found in the pool below Canyon pond on Sept. 23; spawning was not observed but was about to occur.

Suckers: Sexually mature fish were caught in the mouth area of Giltana Creek on June 13 (temp. 53.5°), eggs similar to those of suckers were found in the stomachs of small grayling and whitefish at that time; water coloration and high velocity and depth prevented sampling for fish in Giltana Creek upstream of the pond.

Note: This is a prime sport fish area for Arctic grayling.

Lister Creek

Length surveyed: 7 miles

Width: 25' - 35'

Discharge: 75 (est.) July 21 ph 8.5

Gradient: 12.5' - 15.0'/1000. (Average)

Temperature: 50° June 17, 48° July 21, 32.5° Sept. 23.

Within the first mile the creek flows on a delta and has low velocity, a meandering course and silt and sand bottom. Upon leaving the delta, the gradient becomes steep with the stream being confined between 500' banks. Three miles upstream the gradient lessens, and pools and riffles are present, also beaver dams. The stream eventually enters alpine meadow where the current is approximately 1/2-1 1/2'/sec. and the pools deep (6'-8'). Ice conditions prevailed on September 23.

Species composition and other data:

Grayling: Found above three miles.

McIndoe Creek

Length surveyed: 3 miles,

Width:

Discharge:

Gradient:

Temperature: 45° June 30, 51.5° July 2.

Description: In lower one mile creek; slow and meanders. Above one mile the gradient steepens with boulders and coarse bottom. Brown coloration to water.

Species composition and other Data:

Grayling: Throughout observed area but principally in lower one mile.

Lake whitefish: Adults netted close to lake.

Pike: Netted close to lake.

Sekulmun River (Link R.)

Length: 4.5 miles, Width:

Discharge: 512 cfs. (est.) July 13

Gradient: 0-2.5'/sec. (av.)

Temperature: See note below.

Description: Sekulmun Lake - 1/5 mile; broad riffle, coarse gravel, 5'/sec. velocity. 1/5 mile - 2 miles; narrow riffle, coarse, fine and silt and sand; 2.5'/sec. velocity. 2 miles - Aishihik Lake; pool, mud base, 1/2'/sec. velocity. Joins with a number of adjacent ponds and lakes.

The stream was frozen over on May 4. On June 7 ice conditions precluded travel by boat and floating ice chunks, presumably from Sekulmun Lake were present to June 22. The temperature regime is complex. Un upwelling areas one mile below Sekulmun Lake, sub-surface temperatures were 45°-48° compared to 65°-67° on the surface in mid July. Also the adjoining pond waters heat rapidly resulting in significant differences between the main stream flow and the pond; eg. pond water 60°-65° F vs. main stream 45°-50° in late June and 49° to 54° respectively in July 28; the lower 4/5 of the stream is contained by banks 10'-50' high.

Species Composition and other Data:

Grayling: All sizes present; sexually mature individuals (running milt or loose eggs) were netted on June 23 and spawned out females were angled on July 4; at no time was a spawning actually observed; fry tentatively identified as grayling were sampled from July 9 to August 3; one mature individual tagged on July 9 was recovered in Albert Creek one month later.

Lake trout; angled from stream on several occasions, two individuals measured 418 and 426 mm. (16"-17" approx.)

Lake whitefish: Occupied lower part of stream within and close to adjoining ponds, gillnetted fish, measured 270-410 mm.

Round whitefish: Found more in stream proper close to areas with relatively intermediate velocities, gillnetted fish measured 205-260 mm.

Pike: Occasionally caught on sprout gear and one netted on Sept. 21.

Burbot: Juveniles found on August 3 and one adult netted on Sept. 21.

The Sekulmun River is an area occupied by a variety of species over a great range in size. Unfortunately, the majority of the juvenile fish are not identified. The stream is classified as an all specie and all purpose habitat and is rated as the most important stream in the Aishihik system.

Albert Creek

Length surveyed: 15 miles. Width: 45' - 50' (generally)
Discharge: 255 cfs (est.) July 27 ph 7.5
Gradient: 7.5 - 10.0' / 000
Temperature: 35° May 4, 50° June 22, 57° (max). July 3, 51° July 28, 36.5° Sept. 20.
Description: A clear water stream having largely coarse gravel with some boulder, arises from ice fields; creek frozen on May 4.

Species Composition and other data:

Grayling: All sizes present during summer; scattered pairs and single fish which appeared to be mature were seen in the lower three miles on June 22, observers believed some pairs were mating; fry were abundant on July 28, one tagged specimen was recovered on July 28 from the tagging in Sekulmun River on July 9, majority of adult fish seen above 3 miles, sport caught fish measured 355-445 mm.

Lake trout: Single specimen seen at 2 miles on June 24.

Round whitefish: Single sexually mature female found dead and unspawned on September 21 in lower 1 mile.

Isaac Creek

Length surveyed: 10 miles Width: 35' - 40'
Discharge: 94 cfs. (est.) August 18 ph: 7.5
Gradient: 12.5 - 15.0' / 000.
Temperature: 39° June 17.
Description: Largely a boulder stream, the lower $\frac{1}{2}$ mile is relatively flat delta, highest gradient exists from the delta to 3 miles upstream, and a series of rapids and cascades exist here. These, however, are not considered to be impassible to grayling; the water colour is slightly brownish as a result of Gladstone Lake - one head water reservoir.

Species Composition:

Grayling: Few observed and these mostly above the 3 mile point.

Bear Creek

Length surveyed: 5 miles Width: 60-70'
Discharge: 302 cfs. (est) ph: 7.0
Gradient: 10.0 - 12.5' / 000
Temperature: 42° June 17, 53.5° June 23, 49° Aug. 5.
Description: 0-1 mile delta, slow current with many meanders, sand bottom, grassy banks. 1-3 mile, steepest part of stream with rapids, cascades, shute; boulders

and bedrock prevail; appears to be passible to grayling. Above 3 mile moderate gradient in alpine meadow, mostly broad riffles and pools.

Species composition and other data:

Grayling: Found above $2\frac{1}{2}$ mile; one female on August 5 had some mature eggs in the ovary.

Round whitefish: Approximately 20 adult fish seen in lowest 1 mile on August 6.

The results can be summarized as follows:

(1) Spawning areas were not identified. However, the presence of a few sexually "ripe" fish, spawned eggs, and/or newly emerged juveniles suggest that spawning occurred at or close to:

- the lower 1 mile of Albert Creek - grayling and round whitefish
- throughout the Sekulmun River for all species
- the lower 500' of the stream between Aishihik and Canyon Lakes - round whitefish
- from Canyon Pond to $\frac{1}{4}$ mile in Giltana Creek - round whitefish
- tailrace of pool midway between Otter Falls and Otter Pond
- 2 $\frac{3}{4}$ mile below Otter Pond

(2) Spawning populations comprised of significant number of individuals were not found. In the case of grayling two dozen paired fish represents the greatest number observed at any one time and place. For round whitefish 100-200 individuals in the stream below Canyon Pond represents the greatest population for this species.

(3) The presence of ripe individual grayling from late June to early August and also the extended appearance of newly emerged juveniles suggests that grayling spawn over a period of at least one month.

(4) Migration of populations were not recognized. However, the capture of a grayling in Albert Creek, that was tagged in Sekulmun River and also reports by natives on fish movements in this stream suggests that up and down migrations occur regularly in Sekulmun River. There was no indication of migration between Aishihik and Canyon Lakes nor into or out from Otter Pond.

(5) The lateral tributary streams in Aishihik and Sekulmun Lakes are basically similar in the that the lower part flows on a delta where gradient and velocity are low, sand and fine predominate and grass banks exist. The delta areas may serve as feeding areas for immature fish and possibly as spawning areas for grayling and round whitefish. Above the delta the gradient is steep, "white" water rapids cascades and shutes prevail and the bottom is usually bedrock and boulder or coarse material at the best. The productive role of this type of habitat is unknown. The upper parts of the stream are situated in alpine meadow where gradients and velocities are low to moderate, and pools and broad riffle prevail. Grayling are more frequently observed here than elsewhere. Some spawning occurs here but feeding is a principal activity.

(6) The most important stream water in the Aishihik system is that of the Sekulmun River where the widest variety of species exist, the size composition ranges from very young to mature adult, and migration occurs. The second important stream water is that from Aishihik Lake to Canyon Lake.

Relation of Findings to the Hydro Power Proposal

The discontinuance of flow from Canyon Lake at any time will destroy populations of rainbow trout, grayling and whitefish in the East Aishihik River. If continuous flows are maintained from Canyon Lake to the outlet of Otter Pond only, it is speculated that the rainbow trout and round whitefish populations will survive; however, a complete closure at the outlet of Otter Pond will eliminate the stream below that point as a productive unit, therefore a grayling population will cease to exist. Also high aesthetic values in the form of cascades and shutes will be lost.

The cessation of flows at any time from Aishihik Lake makes Canyon Pond and the stream below dependent upon Giltana Creek. Giltana Creek lacks the discharge to compensate for the loss of Aishihik Lake flow, therefore, a decrease in water level throughout the pond and stream area will occur. Also there are considerable differences in chemical and physical properties between Aishihik and Giltana out flows, therefore, the whole ecology of the area will change. Further suspected spawning areas upstream of the canyon pool will not be available and the food and oxygen supply will be eliminated or significantly reduced to pool residents. Therefore, the cutoff of water from Aishihik could be expected to result in severe adverse effects on those populations of grayling, whitefish and suckers which are dependent upon Aishihik Lake outlet stream, Canyon Pond, and the stream below for completion of their life activities. Therefore, discharge from Aishihik Lake at all times is mandatory to the preservation of the stocks in this area. It must be remembered that the abundance of fish, road access and certain aesthetic values makes this a prime recreational area. Although migrations between Aishihik Lake and Canyon Lake have not been found, some provision for such should be considered in the storage dam.

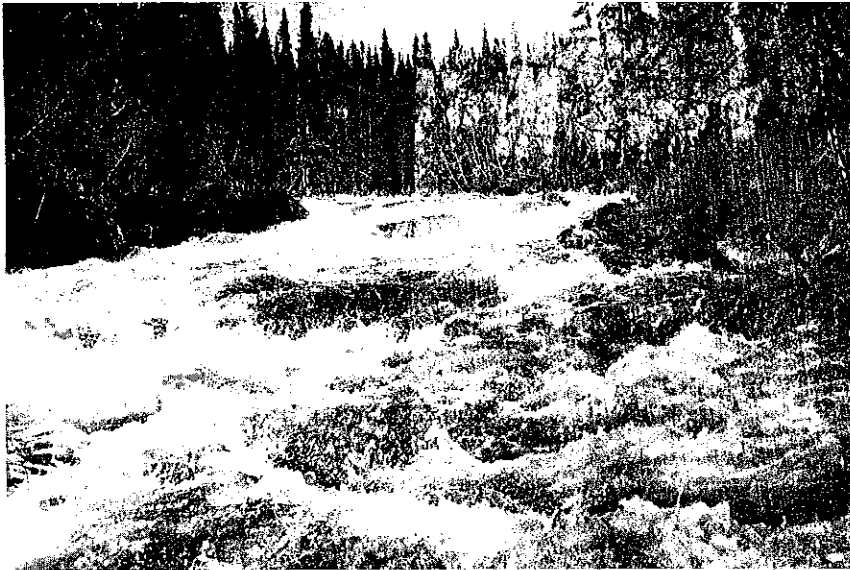
For the discussion on the effect of changing water levels on creek productivity, Sekulmun River and lateral streams, see separate notes.

Sekulmun River: Lowering the water level will decrease pool volume and increase riffle area, therefore, favouring some species such as grayling. Whereas raising the water level will favor the production of lake and pool preferring species such as pike and lake whitefish. It is mandatory that this stream and its populations be more carefully examined in 1973 to more completely understand the requirements of each species.

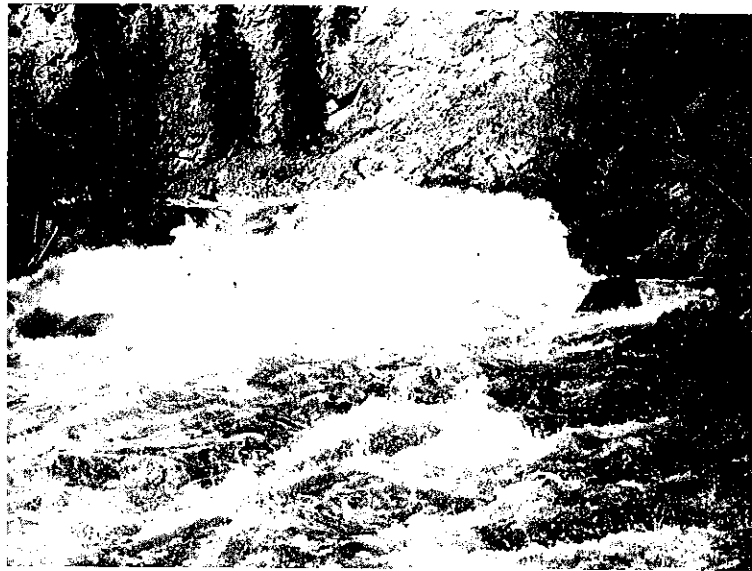
Lateral streams: A lower water level will result in stream bed cutting, stream bank sloughing, and course change on the delta areas with the result the physical features will be completely changed. In this event it is highly likely the delta area will have practically no value in stock maintenance.

Raising of the water level will result in inundation of whole or part of the delta. By such action some potential spawning area will be lost but feeding opportunities may remain to some degree. Also lake spawning delta areas remain intact. In other words some flooding appears to be preferable to lowering the water level.

C. E. Walker,
Senior Biologist,
Northern B. C. & Yukon Div.



Start of
Rainbow Falls



Rainbow Falls



Rainbow Falls



E. Aishihik River
above Rainbow
falls



Sport fish area
between Otter pond and
Rainbow falls





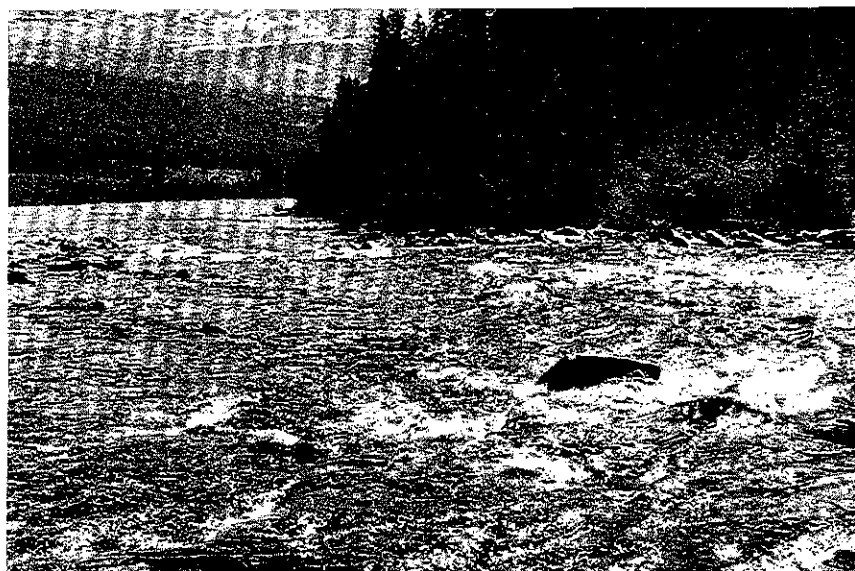
East Aishihik River
1 mile below outlet
of Otter pond
May 5/72



East Aishihik River
1 mile below outlet
of Otter pond
May 30/72



Otter pond May 30/72



East Aishihik River entering Otter pond, mid-summer.



E. Aishihik River
outlet of
Canyon Lake

E. Aishihik River
at outlet of large
pool midway between
Canyon Lake and Otter pond.



E. Aishihik River
approx. 100 yds.
upstream of Otter pond.



Otter Falls May 5/72



Otter Falls mid-summer



North end of Canyon Lake May 5/72



North end of Canyon Lake at mid-summer



Canyon Pond.



Giltana Creek immediately upstream of Canyon Pond



Outlet Stream
from Aishihik Lake
within 100 yds.
of lake.



Outlet Stream from
Aishihik Lake
approx. 200 yd.
below outlet

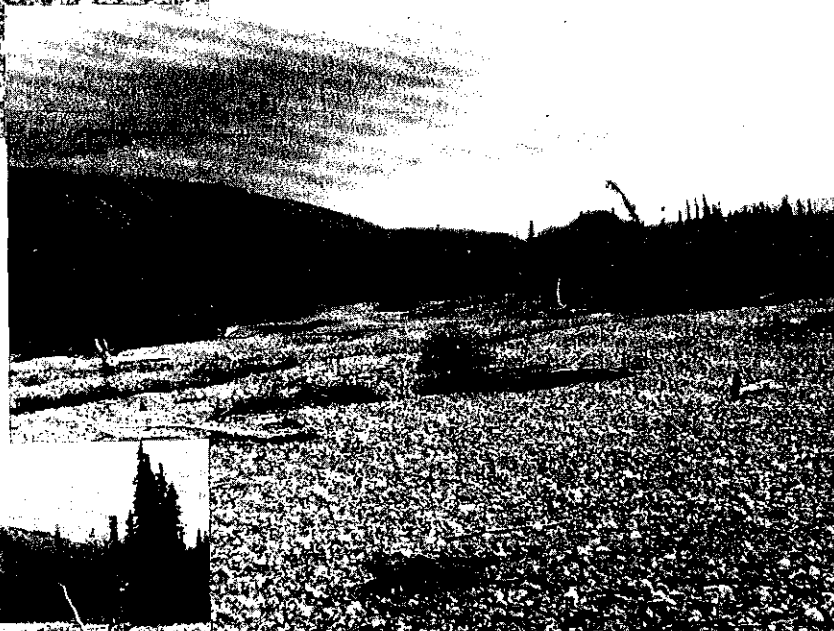


Outlet stream
from Aishihik Lake
entering Canyon
pond.

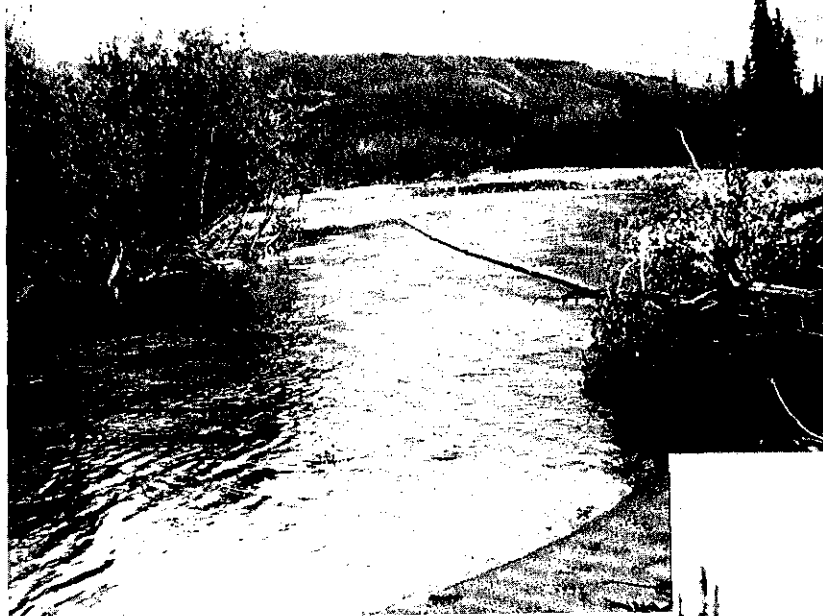


Albert Creek

1 mi.



Albert Creek 2 mi.



Albert Creek 3 mi.



Albert Creek 5 mi.

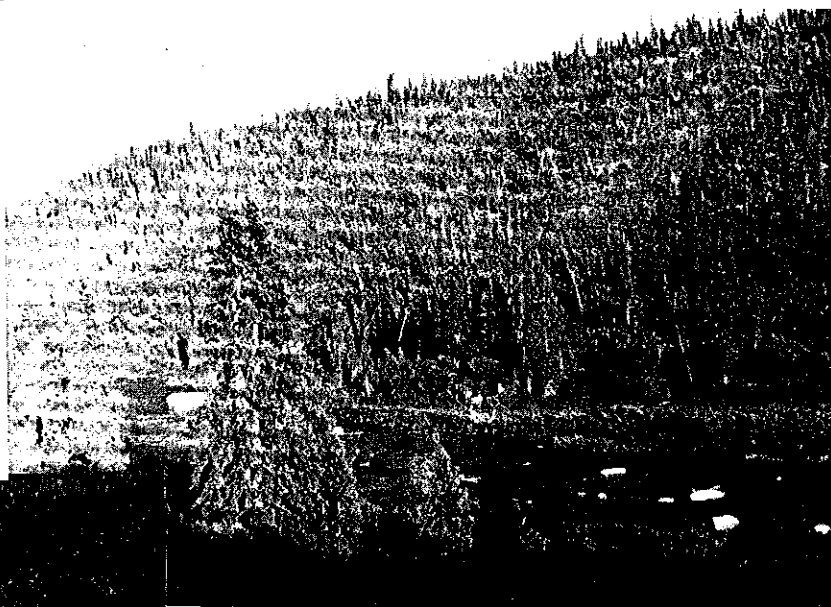


Albert Creek

9.5 mi.

Albert Creek

12 mi.



Albert Creek

13 mi.

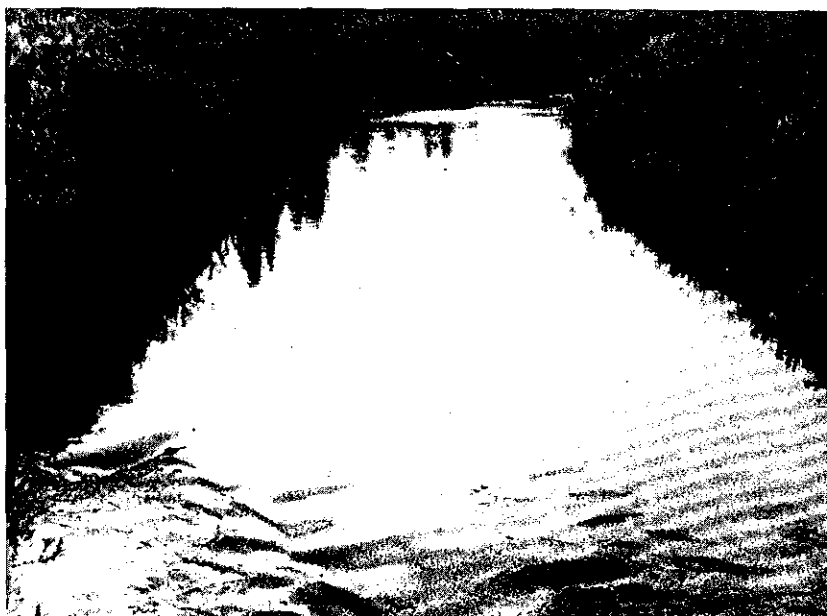
Albert Creek

15 mi.





Lister Creek
8.5 mi.



Lister Creek 10 mi.



Lister Creek
11 mi.



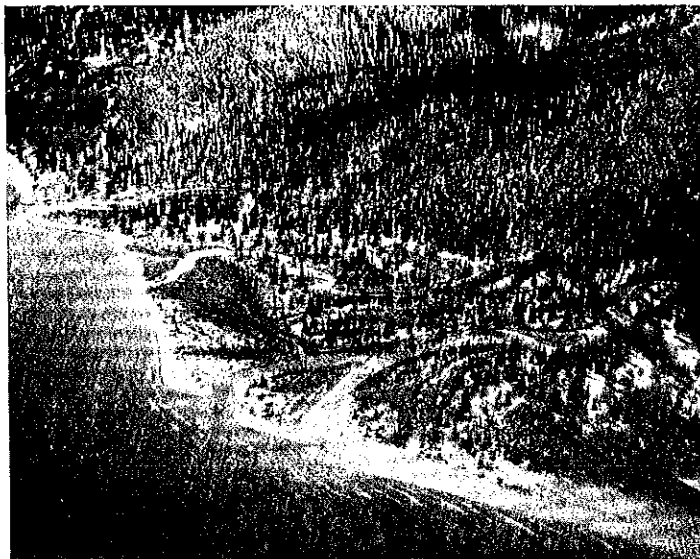
Aishihik Lake looking south
from north end of lake.



Aishihik Lake



Sekulmun Lake
looking South on west side



Delta of Isaac Creek
Sekulmun Lake, west
side.

Delta of Bear Creek,
Sekulmun Lake, west
side.

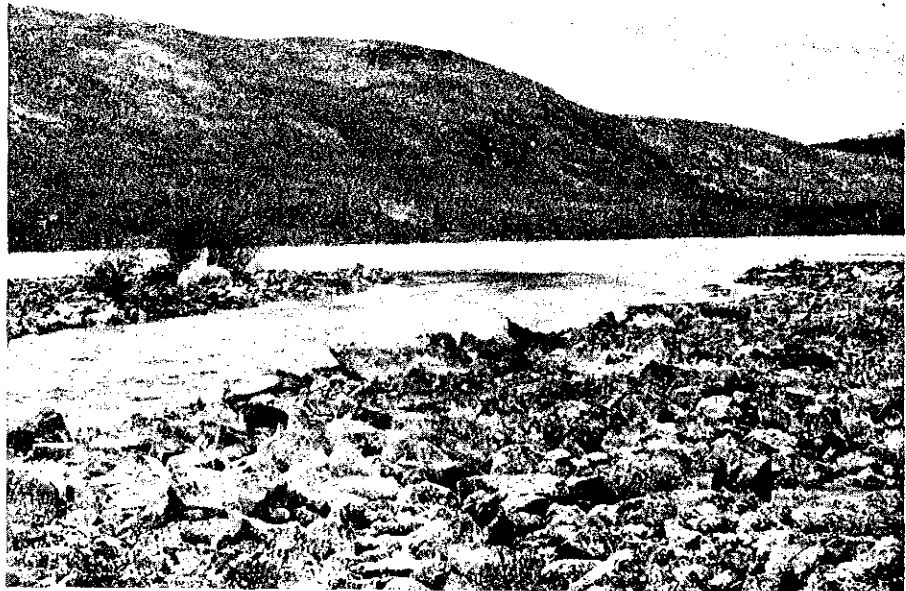


Mouth of McIndoe Creek
Aishihik Lake east side.

APPENDIX "B"

- Photographs of
- (a) Upper Aishihik River "A"
June 15, 1973.
Discharge approx. 200 cfs.
 - (b) Upper Aishihik River "B"
June 21, 1973.
Discharge approx. 313 cfs.

Outlet of
Aishihik Lake.



250 ft below
outlet of
Aishihik Lake.



475 ft below
outlet of
Aishihik Lake
(falls area).



575 ft below
outlet of
Aishihik Lake



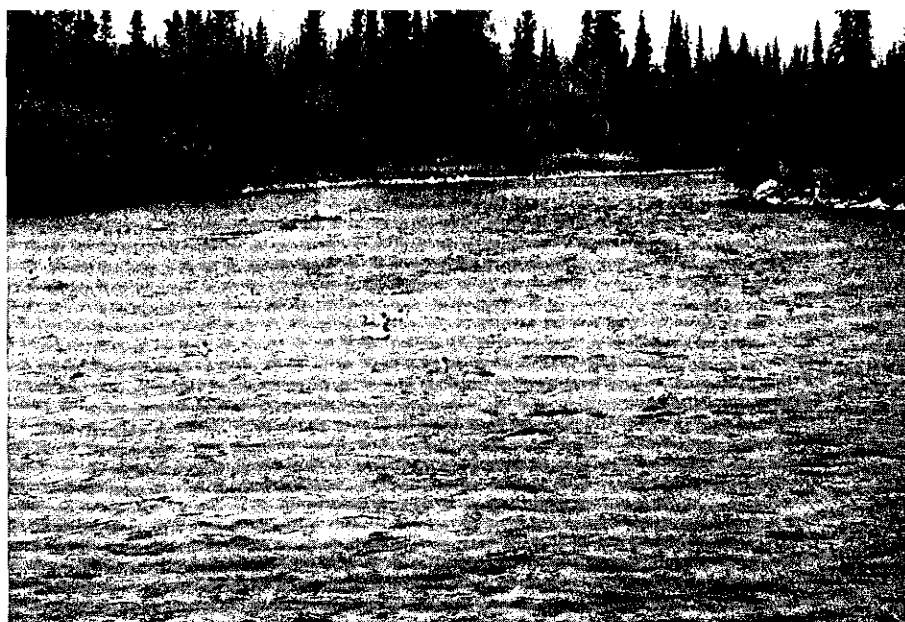
800 ft below
outlet of
Aishihik Lake



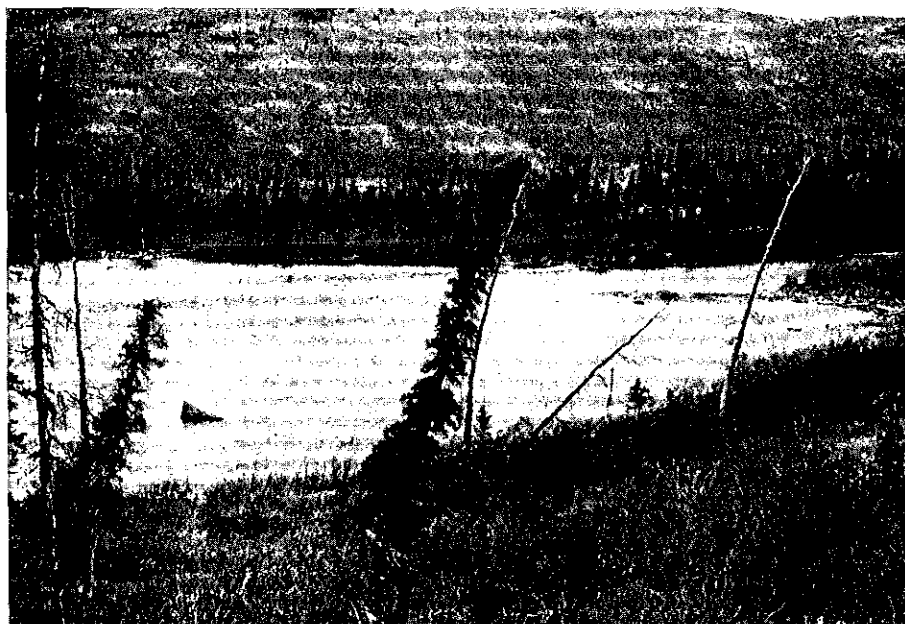
990 ft below
outlet of
Aishihik Lake



1100 ft below
outlet of
Aishihik Lake
(inlet to
Canyon Pond;
fish and bird
feeding area).

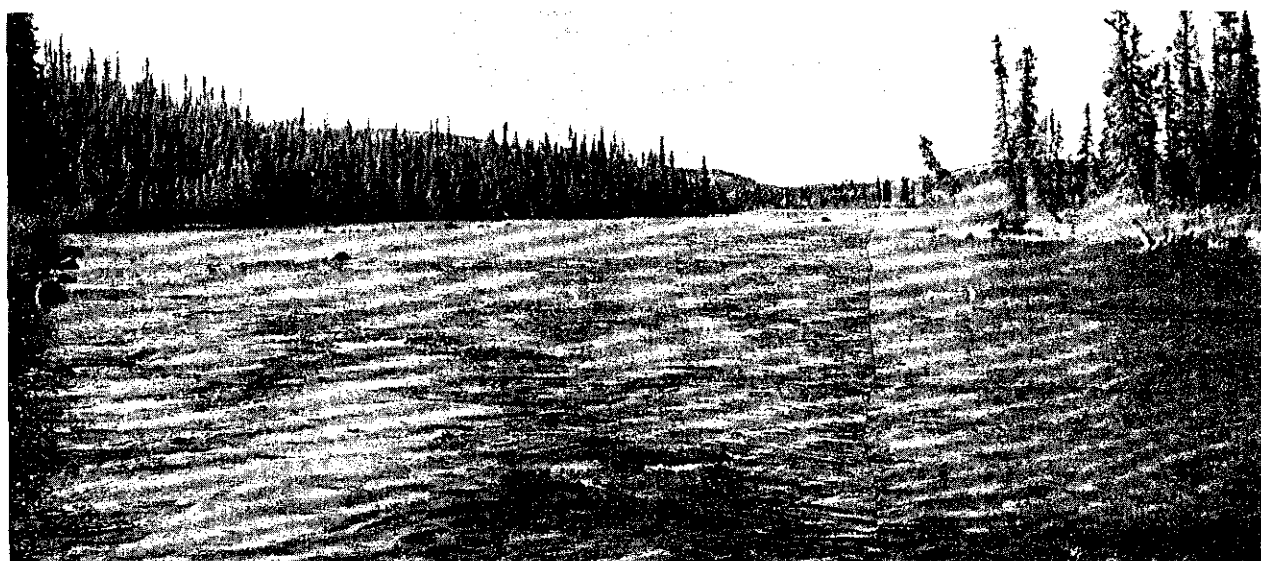


Entry of stream
to Canyon Pond.

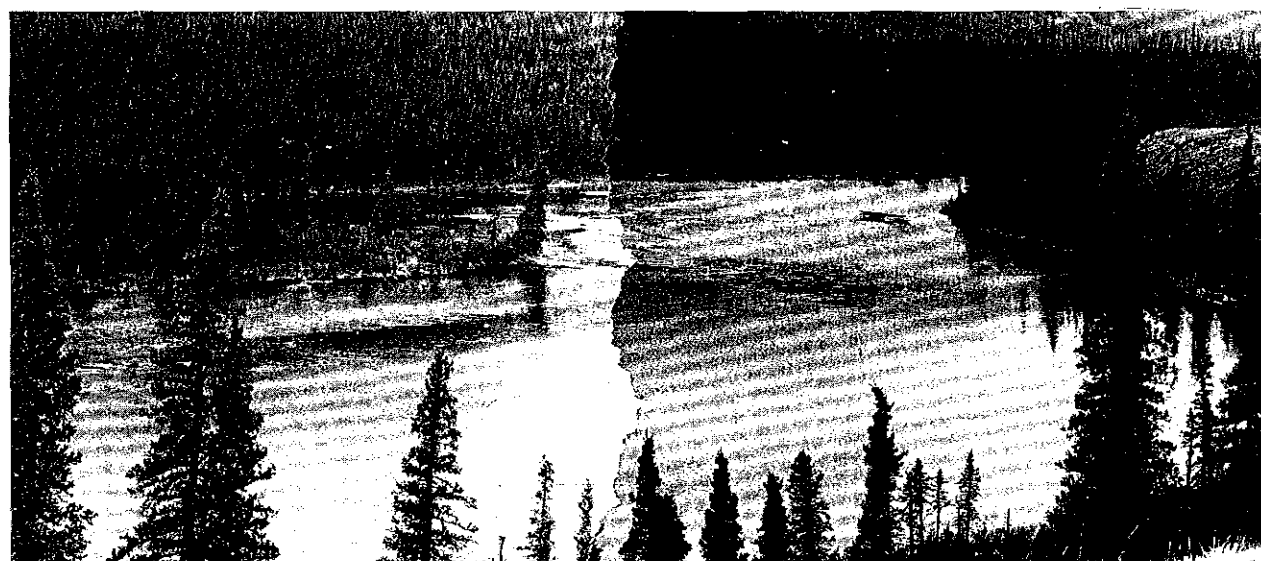




Outlet of Canyon Pond.



640 ft below outlet of Canyon Pond (metering site).

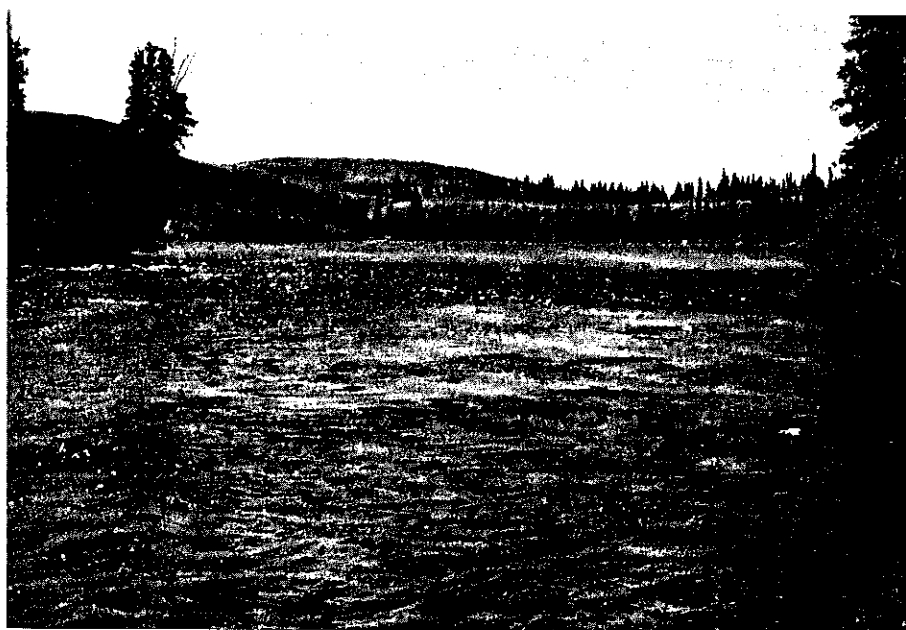


1200 ft below outlet of Canyon Pond (pool area).

1600 ft below
outlet of
Canyon Pond.



1800 ft below
outlet of
Canyon Pond.



2300 ft below
outlet of
Canyon Pond
(entry to
Canyon Lake).



APPENDIX "C"

Report on the techniques used on samples
from Aishihik Lake area.



Report on the techniques used on samples from Aishihik Lake area.

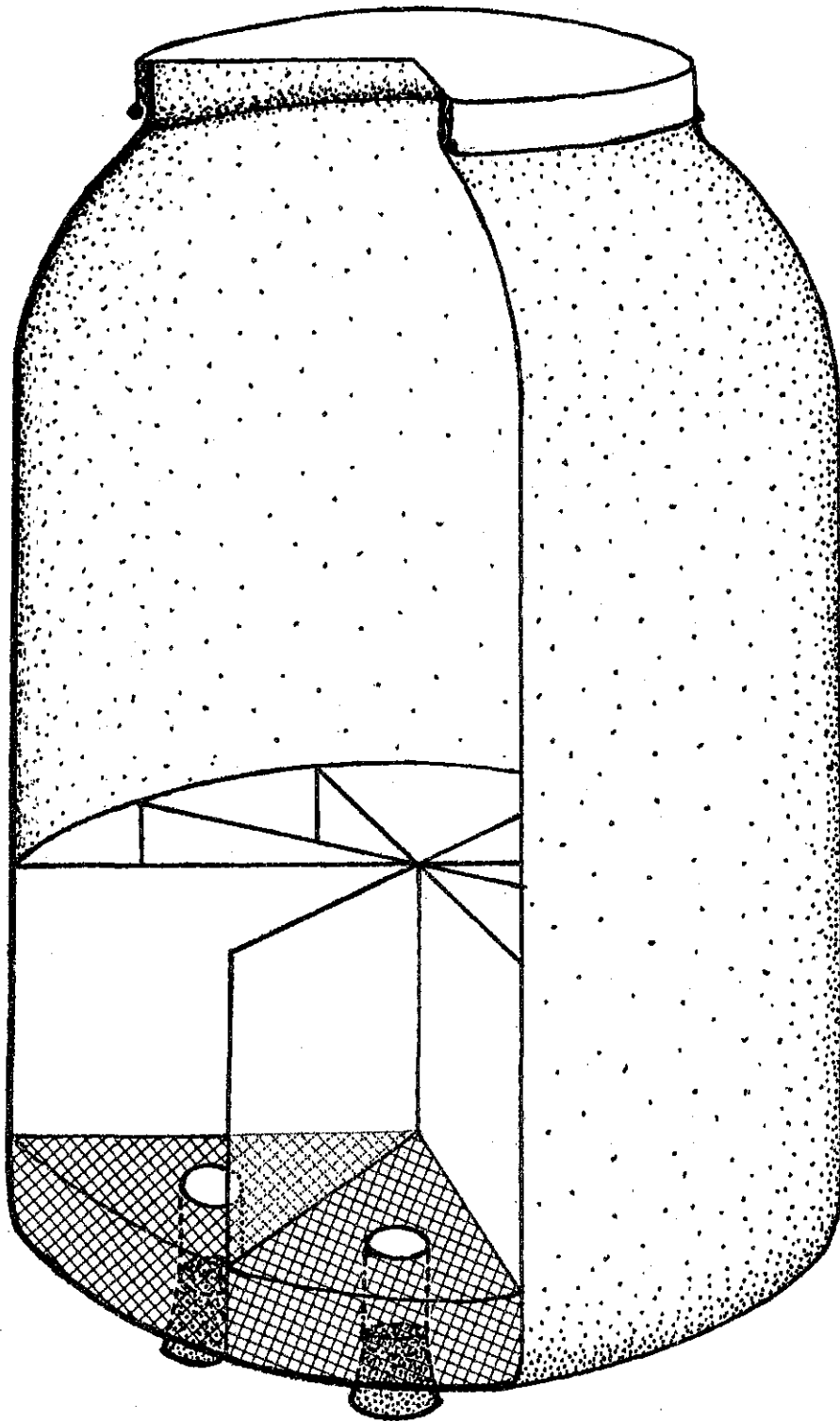
Several physical difficulties were encountered during the initial stages of the survey; due to the condition of the samples. The majority of the collections were extremely large, necessitating sub-sampling. This process was hampered by the presence of large amounts of fibrous fungal and algal material which tended to bind up a large number of specimens, not allowing them to distribute evenly within any liquid medium.

In the hope that both methods will prove useful in the correct circumstances, this report will include the normal method of sub-sampling (which could not be used in this study) as well as the alternative method employed.

Initially all the samples were washed in a fine sieve (# 100) and all the large, solid clumps of algal material were extracted and carefully washed and picked to ensure that no animals were left entangled. The algal material can be retained, dried and weighed; or an estimate of abundance can be made visually before the collection is cleaned. The samples were then replaced in the jars taking care to wash all the zooplankton from the sieve to the jar.

The form of the sub-sampler is shown in the accompanying diagram. A large plastic storage jar has its lower section divided into eight equal cells with the aid of strips of plexiglass (3" by 1/8"). These

Diagram of eight-celled sub-sampler.



are fixed in position by setting them in $3/4$ " of paraffin wax. The dividers are of course forty five degrees to each neighbour. The vertical joints were also sealed with wax making each cell watertight. To facilitate extraction of the required fraction a hole is bored in the base of each cell and plugged with the correct size rubber bung. It is more accurate to be able to drain any of the eight cells so that you can pick a cell at random; if only one cell is used all the time there may be a mechanical bias in the sub-sampling.

To use this sampler, the collection is added along with a regular amount of water, enough to three quarters fill the jar. The lid is screwed on tightly and the whole thing is inverted and righted several times until the collection is evenly distributed throughout the water. It is then allowed to stand on a flat surface until all the specimens settle into the cells. One cell ($1/8$ th. of the whole) is then drained through a sieve; or if further division is necessary ($1/16$ th. to $1/64$ th.) then the cell can be drained into a second sub-sampler. If more than one eighth is required, two or more cells can be drained.

This sub-sampler was unsuccessful with these particular collections for two reasons:

1. The algal material left in the collections was sufficient to bind and clump the specimens, not allowing even distribution.
2. As the collections had been preserved in formalin their body weight had been altered such that they floated in water; and a large percentage floated in alcohol.

Another method of sub-sampling was necessary. This involved the use of a large flat tray (18 " by 12 " by $1/2$ ") and a plexiglass quadrat whose internal area was a known fraction of the area of the tray (say $1/50$ th. or $1/100$ th.). It is more accurate to use a smaller quadrat since then a larger number of fractions will be required to

make up the sub-sample.

The collection is placed in the tray along with 750mls. of water. The large specimens, which are unlikely to be accurately represented in the sub-sample, are removed at once. The remainder is spread over the whole area as evenly as possible and the quadrat placed firmly in a random position. Everything within the quadrat is sucked out with a wide-mouthed pipette and placed in a large petri-dish. This process is repeated until the required sub-sample has been collected. The fraction which makes up a countable sub-sample will vary with the size of the collection; if the latter is sufficiently small the whole sample can be picked.

The specimens in the sub-samples are separated into organisms belonging to the following groups:

Annelida; Amphipoda; Trichoptera; Ephemeroptera; Odonata; Plecoptera; Hemiptera; Coleoptera; Diptera and Gastropoda.

For the purpose of speciation a selection of the individuals from each sample was placed in a series of nine vials retaining spacial and time separation in the hope of noting variations in such. The vials, therefore, pertain to:

Morning - Bottom; Morning - Middle; Morning - Top;
Afternoon - Bottom; Afternoon - etc.

Examples of the larger species, all of which have been removed for weighing, must be placed in the vials after their weight has been noted.

Methods of estimating biomass of small, aquatic species are either of limited accuracy or extremely time consuming. Wet weight estimation is extremely variable due to the retention of external water in varying amounts. Dry weight estimation consumes more time

than can be allowed in this particular survey. The method used produces comparative results while remaining within the realms of simplicity.

Filter papers were used as collecting trays; these were soaked with tap water, layed out to dry, and weighed in the morning, after overnight drying. This was done as the papers would soak up water from the specimens and they may retain variable amounts of water after overnight drying. The specimens were collected on these papers, the whole left to dry over night and reweighed in the morning. The difference in weight between the second and the first reading is an approximate figure for the dry weight of the specimens. With such a long drying time, differential water loss between animals will not be significant. Alternatively the animals could be collected on the papers and allowed to dry overnight. The whole weighed, then the animals removed and the filter papers weighed on their own. The dry weight produced is not classical dry weight as body fluids will still be retained. The weights produced are compareble and can later be related to constant dry weight by calculating a correction factor. The results are noted down on a data sheet and the total weight within a collection can be calculated.

Due to the vast numbers in some of the collections, the zooplankton numbers and distribution were estimated separately. Each collection was shaken vigorously with 250mls. of water to distribute the fauna equally throughout. Using an hyperdermic syringe with the nozzle removed, a known fraction is extracted (5ccs., 10ccs., etc.). This fraction is placed in a counting dish, divided into eight numbered compartments of equal area,- the compartments facilitate the

counting process. Numbers of the following groups are then counted:

Copepods

Cyclopoid

Calanoid

Cladocera

Daphnia sp.

Bosmina sp.

Diaphanosoma sp.

A mean length for each group is then estimated by measuring a number of individuals, and their approximate weight calculated using the formula:

$$w = \frac{ql}{b}$$

where q and b are

constants for a known species. The necessary constants are:

Daphnia	q = 0.052	b = 3.012

Bosmina	q = 0.124	b = 2.181

Diaphanosoma	q = 0.092	b = 2.449

Copepods	q = 0.055	b = 2.730

It is often easier to see copepods, etc., when the sub-samples are added to a solution of 75% alcohol and 25% glycerin plus a drop of lignin pink.

Possible improvements in collection technique:

1. Samples could be preserved in 70% alcohol plus 10% formalin to prevent bacterial breakdown. Formalin makes the specimens extremely brittle and also affects the body weight.
2. Collection time for drifts could be cut to one or two hours, being repeated at maybe six hour intervals.
3. If practical the animals in each sample could be separated immediately after collection by a flotation technique using either salt or sugar.

APPENDIX "D"

Report of drift and Ekman dredge samples
from Aishihik River.

REPORT

DRIFT AND EKMAN DREDGE SAMPLES — AISHIHIK RIVER

All the samples were treated in the two phase way outlined in the methods report previously submitted; the biomass of the macroscopic material was estimated by direct weighing methods; the microscopic zooplankton was estimated by derivation through a formula equating length and weight. The two weights are not directly comparable as they were derived by different methods. They do, however, give an indication of the amount and flux of organisms passing down the river.

Unfortunately, the information on the labels within the sample jars was not sufficient to make it possible to calculate biomass to standard conditions. There were no flow rate recordings, cross-sectional map of the river at the sampling transect, and in many cases it was not known how long the drift net was set. The situation was further complicated by only having the results for a fraction of the samples, and having to make deductions on some rather ambiguous labelling.

However, a few tentative comments can be made concerning zonation, although we did not have enough results, or continuity of samples, to make concrete statements. It appears that while the plankton drift increased during the day the drift of the other invertebrates tended to decrease; the latter probably

reaching a maximum during midnight and the early morning hours. As far as special zonation is concerned, it was difficult to interpret; the top and the bottom samples were similarly stocked (though a detailed species and life-stage examination would probably produce noticeable differences); the middle zone, however, was peculiarly lacking in life. This was noticeable upon initial perusal of the sample jars; it was evident that the middle net trapped little or nothing. This may be either a result of zoning, or a mechanical effect or defect in the sampling system.

A species list has been compiled and enclosed; the list is not complete since funds did not allow for detailed consideration. However, many of these organisms could not be identified to species due to a lack of adult specimens. By far the most abundant family is Tendipedidae; and within this the sub-families of Orthocladinae and Diamesinae. The literature concerning taxonomy of these two families is somewhat confusing and constantly changing. This confusion is compounded by the fact that most studies have been carried out in more southern locations and accurate descriptions of northern species are infrequent. With only larvae and pupae to work with, it is not possible, in most cases, to key further than genus.

There appeared to be no general difference between species or groups caught in top or bottom drift nets. However, it was

noted that the top or bottom nets caught more total organisms than the middle net. Ranking of importance for all organisms sampled on a weight basis is as follows: Tendipedidae - extremely abundant; Simuliidae - abundant; all other groups - not very abundant. This also applies to numbers of organisms. However, the zooplankton numbers were very high at times in the top and bottom drift samples, thereby contributing considerably to the biomass. The ranking of zooplankton species as to numbers sampled is as follows:

Copepoda

<i>Heterocope septentrionalis</i>	+ + + +
<i>Cyclops</i> (strenuus?)	+ +
<i>Diaptomus sicilis</i>	+
Harpacticoid	present

Cladocera

<i>Eubosmina longispina</i>	+ + +
<i>Daphnia galeata mendotae</i>	+
<i>Chydorus</i> sp.	present

This is only a relative abundance scale for the Copepoda and Cladocera separately, but hold true for all the samples analyzed. It should be noted that *Heterocope septentrionalis* was by far the most important organism in the plankton group both by numbers and weight (since this is a large copepod).

Apart from the chironomids it appears that although there is an abundance of organisms present in the river system, the variety of species is somewhat limited, indicating that only a few varieties can adjust to the more severe conditions of this northern river system. It is possible, therefore, that the ecosystem is in a delicate state of balance and small changes in conditions could cause drastic detrimental changes in the system as a whole.

Conspicuous by their absence from the samples were the distinctive stonefly nymphs. It is difficult to believe that there are no such nymphs in this section of the river. It is possible that these powerful aquatic insects crawled back out of the net before the sample was collected. This, of course, is one possibility, making one hesitant to rely too heavily on the other results; i.e., the results may under-estimate the amount of drift due to the long periods for drift collection.

A great deal of information can be extracted from this survey if the remaining samples fill the spaces in the present results. The size and condition of the samples, however, will necessitate the allocation of considerable time and effort to this task.

It is suggested that modification be made concerning length of time for drift collections. Other modifications would include a more complete determination of stream velocity, methods of

handling drift samples in the field, as well as positioning of samplers in the stream. This can all be reviewed in detail before continuing the study during 1974.

It should be noted that the results given in the following table are only some of those analyzed from samples taken in the Aishihik River and do not include any of the Ekman dredge samples. Complete analyses of all samples are recorded on the enclosed data sheets.

A complete list of references used to identify organisms will follow at a later date.

Results of biomass estimations on samples from Aishihik Lake area.
(in grams)

Date	Time	Time set	Bottom		Middle		Top	
			Plankton	Other invertebrates	Plankton	Other invertebrates	Plankton	Other invertebrates
<u>Morning</u>								
8/7/73	02:00	?	0.0274	0.4232	0.0004	0.0045	0.0206	0.6606
9/7/73	08:45	?	0.0510	0.6423	0.0022	0.0160	0.0042	0.4553
11/7/73	03:00	13 hrs	0.0157	0.5440	0.0006	0.0043	0.0008	0.2620
12/7/73	03:00	6 hrs	0.7509	0.8542	0.0024	0.0066	0.5744	0.2915
12/7/73	09:00	6 hrs	0.9152	0.0540	0.1907	0.0018	1.4809	0.1085
13/7/73	03:00	?	0.5179	0.7780	0.0339	0.0098	0.3689	0.8369
13/7/73	09:00	?			0.0339	0.0058		
24/7/73	09:00	13 hrs	0.0077	0.0069	1.8104	0.7266	0.2234	1.0432
25/7/73	10:45	12 hrs	0.0081	0.0464	0.0244	0.0041	0.0044	0.0141
26/7/73	11:30	25 hrs	0.5754	0.1137	0.0494	0.0009	0.0057	0.0020
<u>Afternoon</u>								
9/7/73	14:00	?			0.0162	0.1513	0.0232	0.6830
10/7/73	14:00	12 hrs	0.0168	0.8040	0.0002	0.0059	0.0093	0.4586
11/7/73	15:00	6 hrs	0.0680	0.2570	0.0002	0.0116	0.0336	0.7483
12/7/73	15:00	6 hrs	0.6369	0.1774	0.1354	0.0198	0.3290	0.5311
<u>Evening</u>								
10/7/73	20:00	?	0.0031	0.0209	0.0035	0.0091	0.0139	1.1936
11/7/73	21:00	?	0.1063	0.1209	0.0044	0.0151	0.0056	0.0395
9/7/73	20:00	?	0.0300	0.0359	0.0604	0.2102	0.0466	1.8663
10/7/73	20:00	12 hrs	0.0095	0.2020				
11/7/73	21:00	?	1.6368	0.1640			0.0714	0.8877
12/7/73	21:00	?	2.2067	0.1367	0.0056	0.0074	0.1750	0.1324
13/7/73	21:00	?					0.8071	0.0797
23/7/73	20:00	24 hrs	0.0036	0.0050	0.7371	0.4326	1.1316	0.5083
24/7/73	21:30	12 hrs			0.6032	0.0836	0.5933	1.2178

Note: Plankton refers only to zooplankton caught in the drift.

Results of biomass estimations on samples from Aishihik Lake area.
(in grams)

Date	Time	Time set	Bottom right		Top right		Left		Centre	
			Plankton	Other invertebrates	Plankton	Other invertebrates	Plankton	Other invertebrates	Plankton	Other invertebrates
<u>Morning</u>										
12/7/73	03:00	6 hrs	0.2615	0.4790	0.5982	0.4569	0.6780	0.3645		
12/7/73	09:00	6 hrs	2.9358	0.0282	0.7464	0.0891	0.1098	0.0694	2.2765	0.1950
13/7/73	03:00	?	0.7267	0.4710	1.6261	0.5979	0.1223	0.4353	1.7324	0.9612
13/7/73	09:00	?	0.2457	0.0423	1.1454	0.1070			0.8872	0.2000
24/7/73	09:00	13 hrs	0.0171	0.0771	0.0220	0.0698	1.7452	0.1496	0.2049	0.4140
12/8/73	06:00	6 hrs	0.5571	0.0273	1.5809	0.0311	4.1072	0.0633		
<u>Afternoon</u>										
12/7/73	15:00	6 hrs	0.8058	0.0713	0.6304	0.1009	0.7984	0.0598	0.4906	0.3552
<u>Evening</u>										
12/7/73	21:00	?	0.3838	0.0717	0.6592	0.0861	0.6223	0.0228	1.2204	0.2123
13/7/73	21:00	?					0.2275	0.0277		
23/7/73	20:00	24 hrs					1.3291	0.2624		
24/7/73	21:30	12 hrs	0.2086	0.0597	0.0734	0.0239	0.2048	0.0421	0.3688	0.0755
11/8/73	24:00	6 hrs	0.2981	0.0544	0.1598	0.0211	2.5612	0.0845	2.2272	0.2580

LIST OF SPECIES FOUND IN SAMPLES FROM AISHIHIK LAKE AREA

AMPHIPODA

Gammarus lacustris

EPHEMEROPTERA

Baetidae

Ephemerellinae

Ephemerella grandis ingens
Ephemerella aurivillii

Baetinae

Baetis sp.

TRICHOPTERA

Rhyacophilidae

Rhyacophila hyalinata

Hydroptilidae

Hydroptila sp.

Limnophilidae

Discomoeocus sp.

COLEOPTERA

Elmidae

Stenelmis sp.

GASTROPODA

Lymnaeidae

Lymnaea (*Bulimnaea*) sp.

Valvatidae

Valvata heliciodes

DIPTERA

Tendipedidae

Pelopiinae
(Tanypodinae)*Pentaneura* spp. (melanops group)
(two species)

Diamesinae

Syndiamesa branickii
Diamesa
Prodiamesa spp. (two species)Orthocladinae
(Hydrobaeninae)*Cardiocladius* sp.
Cricotopus slossonae
Eukieferiella bavarica
*Trichocladius fuscipes*Tendipedinae
Tendipedini*Tanytarsus tendens*
Tendipes (tendipes) tentans

Calopsectrini

Calopsectra sp. (micropsectra group)

Simuliidae

Simulium vittatum
Simulium arcticum
Cnephia sp.

Tipulidae

Tipula sp.
Antocha sp.

COPEPODA

Heterocope septentrionalis
Diaptomus sicilis
Cyclops (strenuus?)
Harpacticoid

CLADOCERA

Eubosmina longispina
Daphnia galeata mendotae
Chydorus sp.

Dr. D.N. Gallup,
Department of Zoology,
University of Alberta

and

Alan Clements,
Department of Zoology,
University of Alberta.

December 13, 1973.

References used for the identification of species

- S.S. Roback, 1957; The Immature Tenthredinids of the Philadelphia Area.
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Philadelphia, No. 9.
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A P P E N D I X D

MEMORANDUM REPORT -
AISHIHIK LAKE STUDIES, 1973

B. C. LAWLEY,
FISHERIES AND MARINE SERVICE,
1973

MEMORANDUM NOTE DE SERVICE

DATE September 12, 1974

FROM: Mr. B. C. Lawley,
Habitat Protection Unit,
DE: Northern Operations Branch.

Our file Notre référence
5460-85-A13

TO: Mr. W. J. Schouwenburg,
Chief, Habitat Protection Unit,
A: Northern Operations Branch.

Your file Votre référence

SUBJECT: Re: Aishihik Lake Studies
SUJET:

1. Fry Distribution

A major effort to determine areas of fry rearing was undertaken during the summer of 1973. Beach seining was undertaken at all suitable beaches on the lake using a 50' x 8' beach seine made of 1/8" mesh with a double weight lead line and a 150' x 6' beach seine with the bunt in the middle.

The beaches on the north end of Aishihik Lake along with the shallows in Soldier's Bay appear to be the major Humpback Whitefish rearing areas in Aishihik Lake. Each set at the north end with the beach seine (50' x 8') produced from 300 to 7,000 Humpback Whitefish fry 2.5 to 3.1 m. long on July 2, 1973. Soldier's Bay produced large numbers of Humpback Whitefish fry in the shallows. A pole seine 8' x 3' was used as the bottom was unsuitable for beach seining. A good set produced approximately 200 fry. The water of the north end of Aishihik Lake and Soldier's Bay averaged approximately 3°C warmer than the rest of the lake.

Humpback Whitefish fry were not obtained in any numbers in other areas of the lake, (< 5 fry/set).

The lake trout fry appear to be evenly distributed throughout the lake. Most sets with the 50' x 8' seine produced between 0 - 3 trout fry.

Tow netting was tried at several sites during the day and evening. No fish were obtained by this method.

Continued

. . . . /2

2. Adult Fish Sampling

All species of adult fish collected in Aishihik Lake and Stevens Lake during the summer and fall of 1973 were obtained using gillnets (of various sizes from 1 1/2" to 4 1/2"), beach seines and by angling. These fish were primarily caught for the use by the Fisheries Research Board in determining what parasites, bacterial and viral diseases could be introduced into the Aishihik or Yukon system if Aishihik and Stevens Lakes were joined.

The fish obtained for bacterial examination were also used for stomach content examination and sexual maturity. From visual examinations of all specimen, it appears that individual lake trout spawn every third year and that spawning commences in the month of October.

3. Diving Survey

A diving survey was carried out by 3 divers from August 22 to September 18, 1973 primarily to locate spawning areas used by lake trout. Although no evidence of spawning could be observed, several schools of trout and whitefish were seen on various occasions, usually at depths between ten and twenty-five feet.

It would appear from the diving survey and from surface visual observations that a great portion of Aishihik Lake is suitable for lake trout spawning.

On September 16, 1973 three divers went into Canyon Pond. Large numbers of adult Arctic grayling, Humpback whitefish and Round whitefish were observed in and near the inlet to the pond. Approximately five hundred to a thousand fish of the three species mentioned were seen.

4. Benthic Survey

Two dredging surveys were carried out, one in July (11) and the other in August (15). The results were analyzed and there was no deviation noticed from the results obtained in 1972 in so far as species composition. The existence of a narrow productivity pond suspected by Kussat appeared to be confirmed in that the bulk of the benthic organisms came from depths of between 3 and 15 meters: (see Kussat's report.)

Stomach Analysis

Approximately 200 fish were analyzed for stomach contents. No significant difference was noticed from the results obtained in 1972: (see Kussat's report.)

B. C. Lawley
B. C. Lawley, Habitat Protection Unit,
Northern Operations Branch.

AISHIHIK LAKE
Temperatures, °C.

July 30, 1973.

Depth Meters	Stn 1	Stn 2	Stn 3	Stn 4	Stn 5	Stn 6	Stn 7	Stn 8
0	13.5	13.0	11.0	10.5	8.0	5.2	8.0	10.2
2	13.5	13.0	11.0	10.5	8.0	5.2	7.5	10.2
5	13.5	12.5	11.0	10.5	8.0	5.0	5.5	10.0
10		12.0	10.5	10.0	6.5	5.0	4.0	
15		11.5	10.5	8.0	6.0	5.0	4.0	
20			10.0	6.5	5.5	5.0		
30			8.0	5.0	5.5	5.0		
40			4.0	5.0	5.5	5.0		

August 18, 1973.

	Stn 1	Stn 2	Stn 3	Stn 4	Stn 5	Stn 6	Stn 7	Stn 8
0	9.0	8.5	9.0	9.5	9.0	9.0	9.5	9.0
2	8.5	8.0	8.5	9.0	9.0	8.5	9.0	9.0
5	8.0	7.0	8.0	9.0	8.5	8.5	8.5	9.0
10		6.5	8.0	9.0	8.0	8.0	8.5	
15		5.0	7.5	9.0	8.0	8.0		
20			7.0	9.0	8.0	8.0		
30			6.5	8.5	7.2	8.0		
40			5.0	7.5	6.0	7.0		

A P P E N D I X E

REPORT ON THE 1972 AISHIHIK LAKE, YUKON
TERRITORY LIMNOLOGICAL SURVEY

R. KUSSAT,
FISHERIES AND MARINE SERVICE,
JULY, 1973

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TERRITORY LIMNOLOGICAL SURVEY

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BY

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ENVIRONMENT CANADA
FISHERIES AND MARINE SERVICE
NORTHERN OPERATIONS BRANCH
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JULY, 1973

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I INTRODUCTION

In 1972, the Northern Canada Power Commission applied to the Yukon Territorial Water Board for a water licence for hydro-electric development on the Aishihik River. Shortly thereafter, the Fisheries Service, Department of Environment, presented a brief to the Water Board requesting that the application be held in abeyance until an environmental impact study of the proposal could be made.

In January, 1973, the Fisheries Service presented an interim report to the Yukon Territorial Water Board reporting cursory results and interpretations of the fisheries studies conducted in the summer of 1972. This report summarizes and reviews the results obtained from the limnological survey of Aishihik Lake and attempts to assess the impact of the power proposal on the fish resource of the lake. Previous Fisheries Service reports related to the proposed power development are listed below for reference.

- 1) *Brief Presented to the Yukon Territorial Water Board Public Hearing into the Proposed Aishihik Hydro-Power Development, May, 1972.*
- 2) *Aishihik Lake Shoreline Study, Preliminary Report, December, 1972.*

- 3) *Fisheries Problems Associated with the Proposed Aishihik River Power Development, Interim Report, January, 1973.*
- 4) *A Report on Aishihik Winter Survey, February 5, 1973.*

Present plans call for the construction of a control structure at the outlet of Aishihik Lake to regulate flow into Canyon Lake and a 3.5 mile canal paralleling the east arm of the Aishihik River to divert water from Canyon Lake. The power plant will be located near the confluence of the East and West Aishihik Rivers. A licence has recently been issued by the Department of Indian Affairs and Northern Development permitting a six feet maximum fluctuation of lake levels. An outline of the Aishihik system and proposed power development are depicted in Figure 1.

Aishihik Lake is 36.6 miles long with a area of 58 square miles and approximately 87 miles of shoreline. The Aishihik drainage area encompasses 1190 square miles. The lake is narrow and deep (mean depth 108 feet) with the exception of the extreme northern and southern ends and several lateral bays which are quite shallow. Depth contours are depicted in Figure 2. The lake is usually ice-covered from October to early June and subject to constant wind action during summer days. Ambient air temperatures are relatively low resulting in cold lake temperatures even in the surface waters. Annual precipitation in the area is in the order of 10 inches.

The 1972 limnological study consisted of four parts:
(1) a fish inventory program to determine the abundance

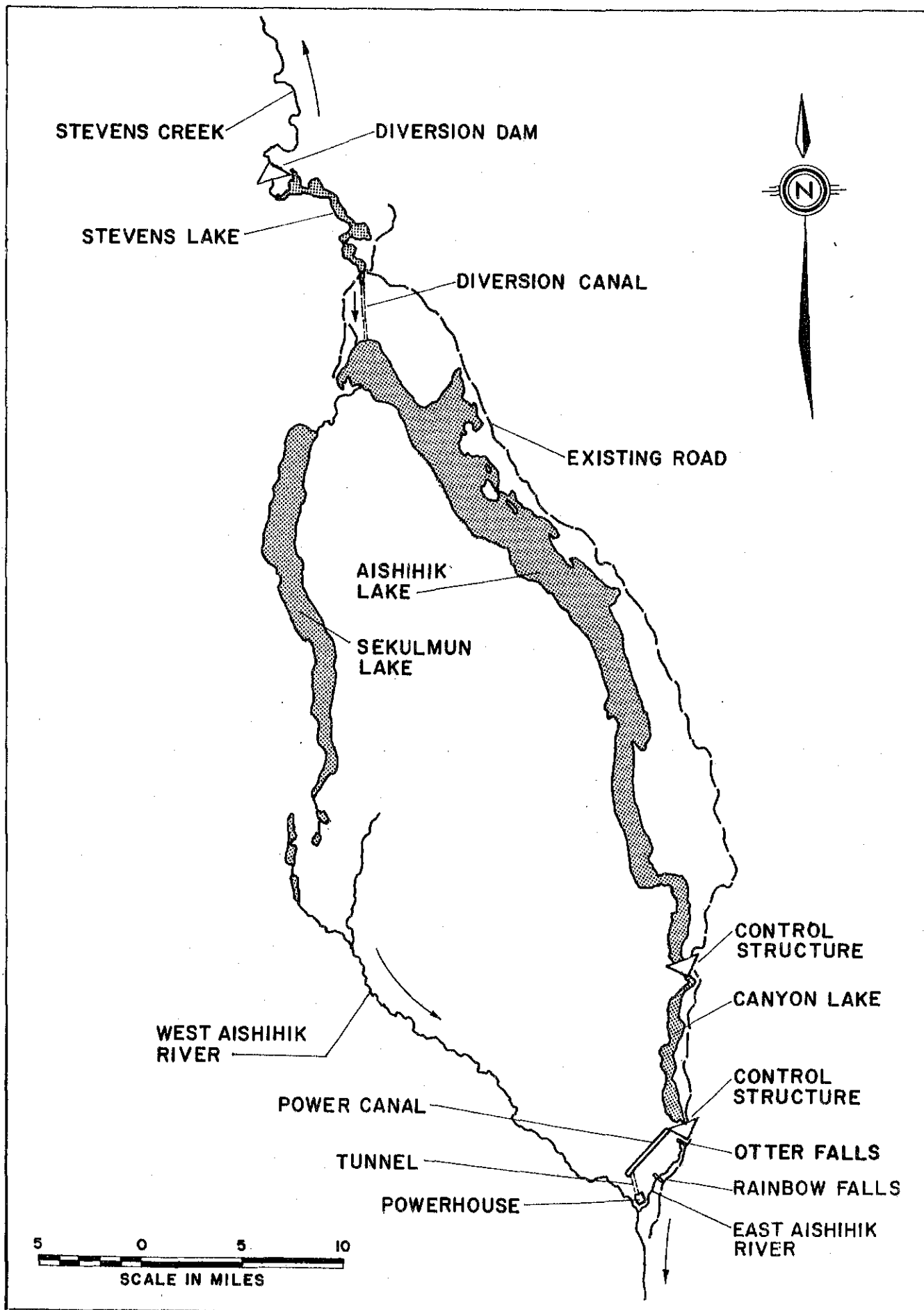


FIGURE 1.
AISHIHIK - PROPOSED POWER DEVELOPMENT

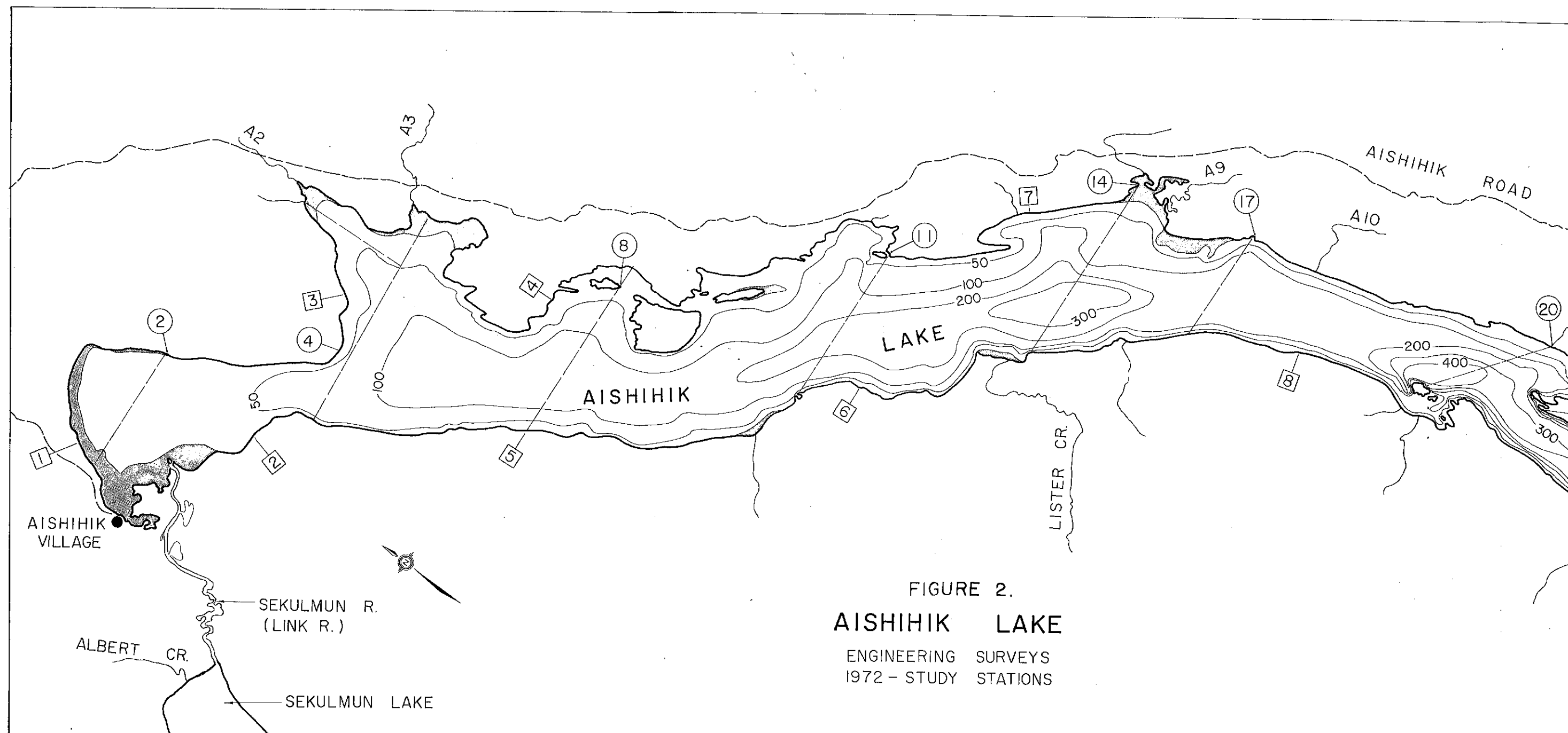
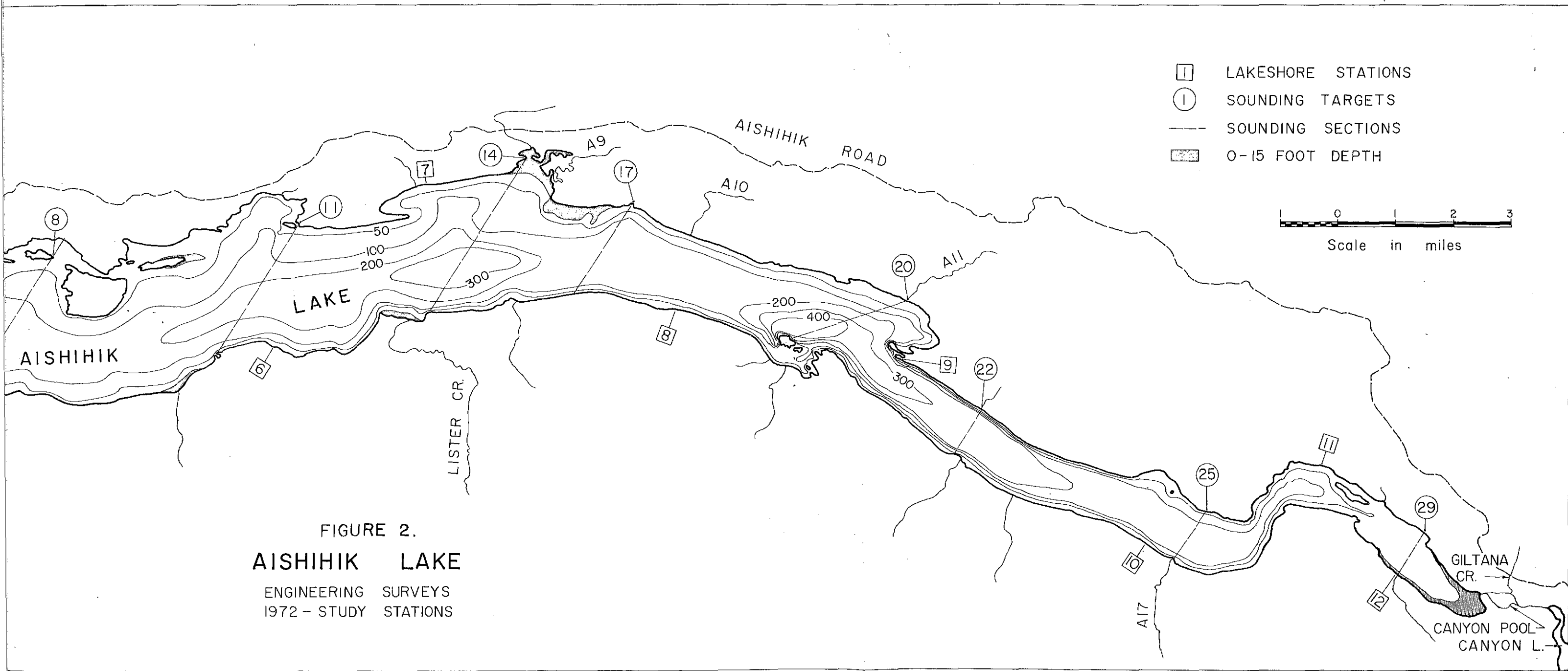


FIGURE 2.
AISHIHIK LAKE
 ENGINEERING SURVEYS
 1972 - STUDY STATIONS



and geographic location of the major fish species in the lake; (2) a sampling program of the fish populations in different lake areas in terms of age, weight, length, condition factor, stomach content, and sex ratio; (3) the productivity of various lake areas by the collection and enumeration of benthic organisms and zoo-plankton; and (4) limnological determinations in the main lake basin consisting of physical and chemical parameters.

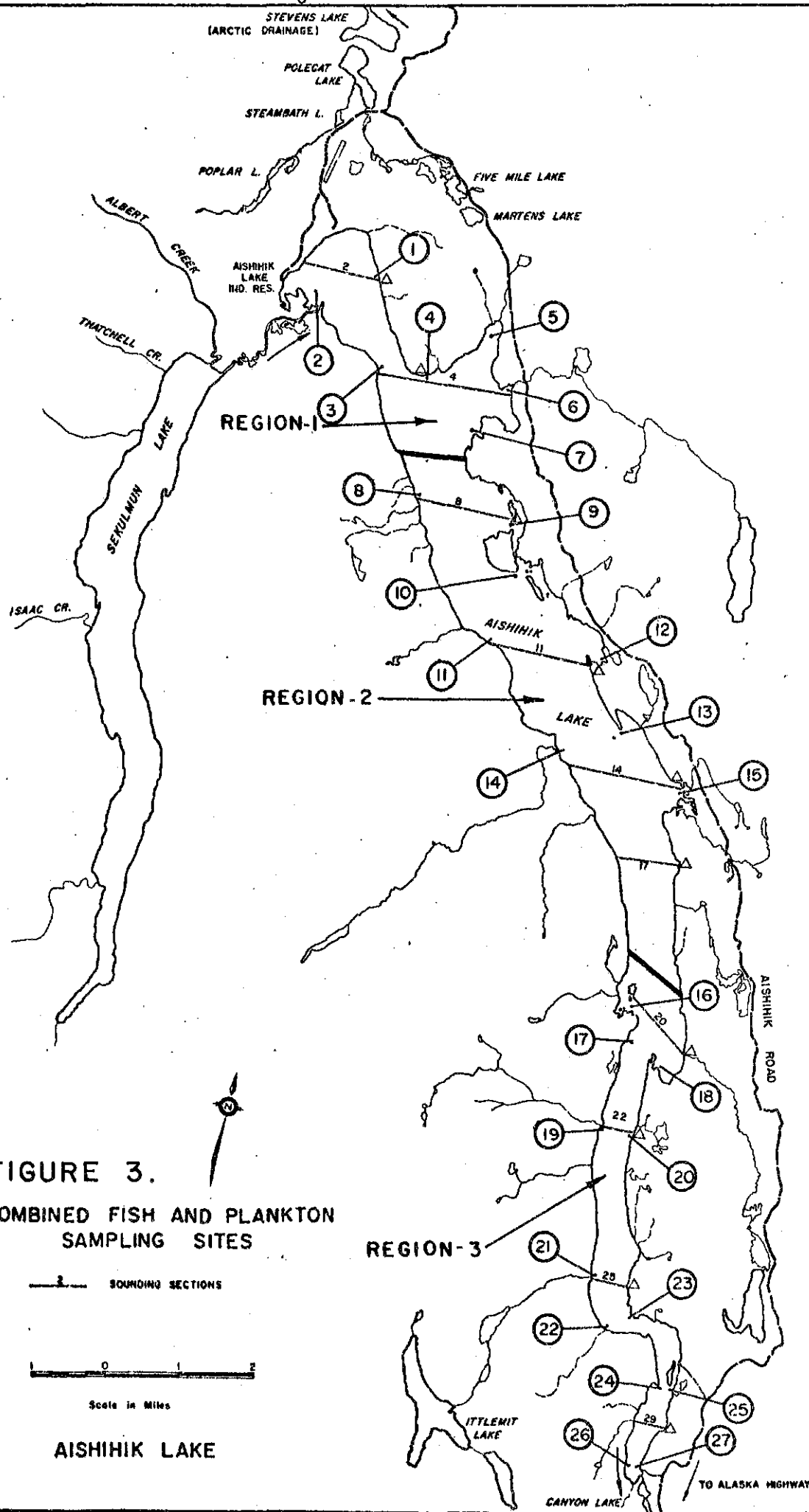
II METHODS AND MATERIALS

(1) Fish Inventory

Fishes were collected at 27 stations throughout the lake (Figure 3) between June 10 and September 19, 1972. Monofilament gillnets of 1.5, 2.5, 3.5 and 4.5 inch mesh were utilized. Each net was 20 feet deep and 50 feet long. A combination of the different size nets was used at most stations. The nets were set in the evening, generally perpendicular to the shoreline and retrieved the next morning. Limited numbers of fish were also caught by angling and are included in the samples. The 29 netting stations were grouped into Regions 1, 2 and 3 as outlined in Figure 3. The numbers and kinds of fish caught in each region were then recorded to permit comparison of population parameters between the geographic locations of the lake.

(2) Comparison of Fish Populations

The fish were immediately taken from the nets to the camp and weighed in a spring loaded scale calibrated in pounds. These measurements were later converted to the



metric system. The fork length (tip of snout to fork of tail) was recorded using a hypural stick calibrated in centimeters. Scales were collected from the preferred area (three rows above the lateral line on an imaginary line from posterior of the dorsal fin to anterior of the anal fin). Scales were then placed in a pre-numbered scale book and aged at the Nanaimo Biological Station. Sex of the fishes was determined by examination of the gonads. The stomachs were removed and placed into a solution of 10 percent formaldehyde and shipped to the laboratory. Stomach contents were identified using compound and dissecting microscopes. Because of the difference in size of ingested food organisms, each group of organisms received a value of one to ten depending on its mass relative to the total content.

The age, length, weight, sex and stomach content data was computerized and is stored on tape for future reference. The condition factor (K) for each species and age group was determined using the formula $K_{FL} = W \times 10^2 / FL^3$ where FL = fork length in centimeters and W = weight in grams. The K values of various age groups of the species was then related to geographical catch areas.

(3) Productivity

(a) Benthos

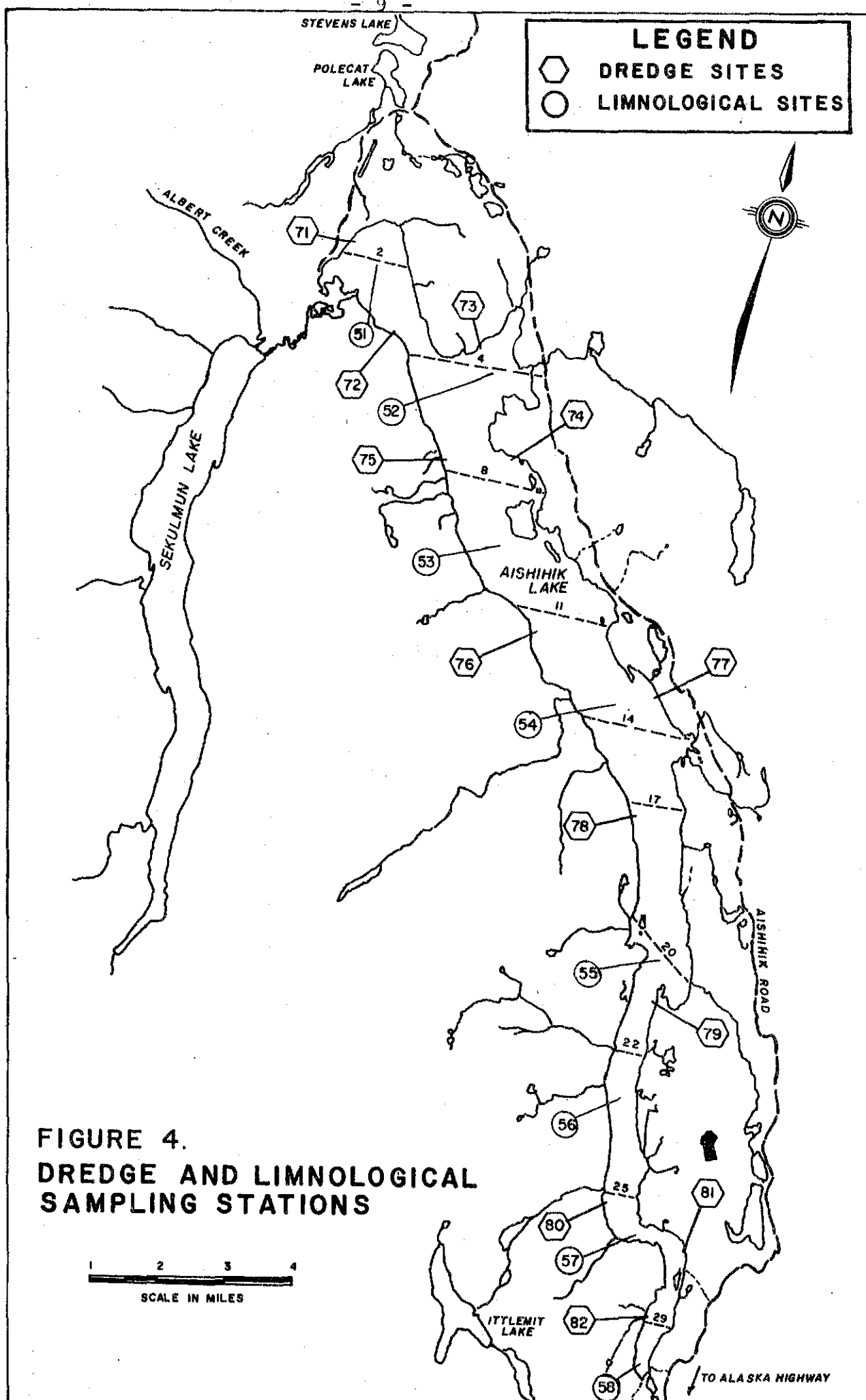
Approximately thirty stations in the lake were dredged using a Ponar dredge (inside area 81 inches²). Sampling sites corresponded with fish netting locations (Figure 3). In many instances hard, rocky substrate was encountered yielding no dredgate. Twelve "typical" shoreline areas were established as outlined in the Aishihik

Lake Shoreline Study Report, and aquatic substrates identified. Dredge samples were procured at these "typical" sites (Figure 4) from depths of 2, 5, 10 and 15 meters. Three samples were taken at each site and type of substrate and faunistic components recorded. Organisms were preserved in approximately 10 percent formaldehyde and identified in the laboratory at Vancouver.

An attempt was made to compare the abundance of invertebrates in the littoral zone surface water with that away from shore. An invertebrate drift sampler with a rectangular opening of 1 square foot was pulled behind the boat for a distance of 75 yards at constant speed. In this manner the top 3 - 4 inches of water and 4 - 6 inches of air above the water surface were sampled.

(3) (b) Plankton

Approximately 40 plankton stations were established in shallow and deep lake regions. Fish sampling, dredge and limnological stations were used. Vertical hauls of 2, 5, 10, 15 and 20 meters were obtained with a modified Wisconsin sampler (100 mesh size net, 44 micron bucket). Samples were preserved in approximately 5 percent formaldehyde. Preliminary identifications were made in the field using a compound microscope. Final identifications and Coulter counts were made at the Vancouver laboratory and at Simon Fraser University. The abundance and kinds of zoo-plankters in deep and shallow water regions was compared. Only limited numbers of phytoplankton observations were made.



(4) Limnological

Physical-chemical limnological determinations were conducted at eight main lake sites (Figure 4) and included temperature and dissolved oxygen profiles, nutrient and heavy metal concentrations, hydrogen ion concentrations and light penetration. Water samples were collected with a Nansen bottle. Chloroform was added to part of the water sample to facilitate the determination of nitrite, nitrate, ammonia and phosphates in the Vancouver laboratory. Conductivity, turbidity, alkalinity, filterable residue, zinc, copper, iron and lead were determined from cooled nonpreserved samples at Vancouver. Temperature, pH, dissolved oxygen and secchi disc determinations were made in the field. Techniques used for the chemical laboratory determinations are found in "Standard Methods for the Analysis of Water and Waste Water" and "Practical Handbook of Seawater Analysis".

III RESULTS AND DISCUSSION

(1) Fish Inventory

Humpback whitefish (*Coregonus clupeaformis*) were netted most frequently. Other species netted in decreasing order of frequency were lake trout (*Salvelinus namaycush*), arctic grayling (*Thymallus arcticus*), round whitefish (*prosopium cylindricum*), burbot (*Lota lota*), northern pike (*Esox lucius*) and longnose sucker (*Catostomus catostomus*). Grayling, lake trout and pike were also caught by angling.

A total of 1007 fish were sampled by gillnetting as depicted in Figure 5. The shading of the bars indicates the numbers caught in each of the three regions. Fish

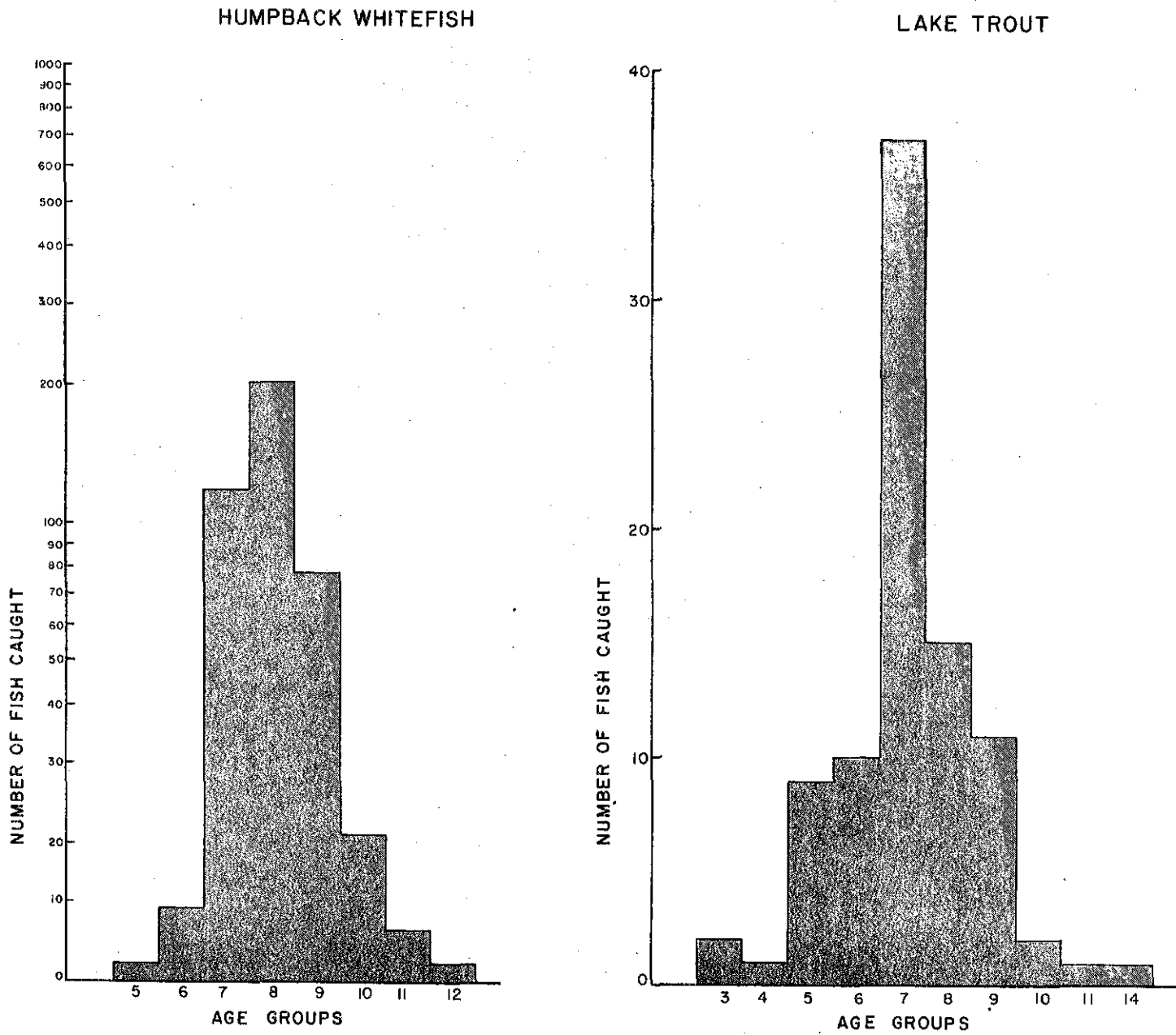


FIGURE 6. POPULATION STRUCTURE OF NETTED HUMPBACK WHITEFISH AND LAKE TROUT.

were captured in all regions indicating a general distribution. The net sizes were obviously selective for the capture of older fish as shown in Figure 6. Also, as mentioned previously, the nets were set only in the littoral zone. Therefore, the catch data reflects only the relative abundance of fish near the lake shores.

Humpback whitefish are typically found in lakes and spawn from late summer to early winter. Mature whitefish were captured at all net stations. Egg deposition occurs generally over rocky reefs. No eggs or spawning fish were observed during the survey and no juvenile whitefish were caught. Juvenile distribution and spawning of whitefish will be studied in 1973.

Lake trout were captured throughout the lake. These fish also spawn in late summer or early fall and deposit eggs over rubble or gravel areas. Although mature trout were repeatedly captured in certain lake areas, no definite spawning sites could be delineated. The location of lake trout spawning sites and distribution of juveniles are also one of the objectives of the 1973 summer lake program.

Round whitefish, arctic grayling, burbot, northern pike and longnose sucker were only incidental catches compared to humpback whitefish and lake trout. However, the low abundance of the "incidental" fishes may be function of the sampling gear utilized. The lake residence time of these fish especially the spatial distribution and their juvenile forms will also have to be studied further.

TABLE I - Data Correlation of Weight, Length, Areas, Time Periods for Three Fish Species

REGION	TIME	<u>Grayling</u>				<u>Humpback Whitefish</u>				<u>Lake Trout</u>			
		x wt (gms)	S.D.	x length (cm)	S.D.	x wt (gms)	S.D.	x length (cm)	S.D.	x wt (gms)	S.D.	x length (cm)	S.D.
1	1	602	0.81	34.99	2.13	789	2.57	39.43	3.55	1641	11.16	49.26	10.10
1	2	567	0.49	35.30	0.89	812	2.93	38.83	4.80	1166	4.96	44.53	7.71
2	1	709	0.70	36.20	1.11	721	7.56	37.30	5.13	1135	13.24	42.53	10.76
2	2	661	0.87	38.63	1.56	682	1.98	37.39	3.22	1176	4.98	45.64	5.71
3	1	652	0.0	37.50	0.0	806	11.57	38.28	6.70	1357	22.20	42.25	12.24
3	2	718	0.16	39.80	0.69	650	1.97	37.35	3.32	1373	21.52	42.49	15.94

The abundance of humpback whitefish and lake trout in littoral lake regions suggests that a regulated commercial fishery could be sustained at Aishihik Lake. Sports fishing effort is presently restricted primarily to the southern end of the lake because much of the lake is inaccessible and boat launching facilities are limited. Frequent winds and wave action further restrict much of the movement of small boats to bays, shorelines and the proximity of a few islands. The proximity of the lake to the Alaska Highway, Kluane Park, and Whitehorse suggests that utilization of the lake by anglers will increase in the near future.

(2) Comparison of Lake Fish Populations

Net selectivity and non-uniform geographic sampling effort only permit cursory comparisons of fish populations in Regions 1, 2 and 3. Age determinations for a large number of specimens were not possible due to missing or regenerate scales. Therefore, frequency tables for lengths and weights were utilized. Table I lists the mean weight in grams, and length in centimeters for the three regions and two time periods (June 1 - July 31 and August 1 - September 30). The data suggest homogeneity in lake populations. However, due to small sample size of grayling and lake trout only the whitefish should be considered. High standard deviations in some categories are probably due in part to the inadequacy of the sample size. Table II summarizes the sex ratio of humpback whitefish and lake trout. No significant differences between areas and time periods were noted.

TABLE II - Numbers of Male and Female Fish Related to Region and Time Period.

REGION	TIME	Humpback Whitefish		Lake Trout	
		Male	Female	Male	Female
1	1	20	22	2	1
1	2	12	11	4	8
2	1	46	39	13	7
2	2	38	33	3	3
3	1	65	43	8	7
3	2	54	58	16	17

The condition factor (K) for humpback whitefish and lake trout are given in Table III. The number of fish used for the computation of the K-value in each year class is bracketed. It should be noted that in many year classes this number is quite small. Furthermore, the number of fish which could not be aged due to loss of scales or scale regeneration was quite large. Only the eight and nine year old humpback whitefish are represented in large enough numbers to permit comparison. Indications are that for the eight year old fish the K-values are similar in the three regions. The nine year old fish appear to be in better condition in region 1. Seven year old lake trout in regions 2 and 3 yielded similar condition factors.

Region 1 is characterized by two large shallow bays and the inflow of the Sekulmun River. Increased productivity

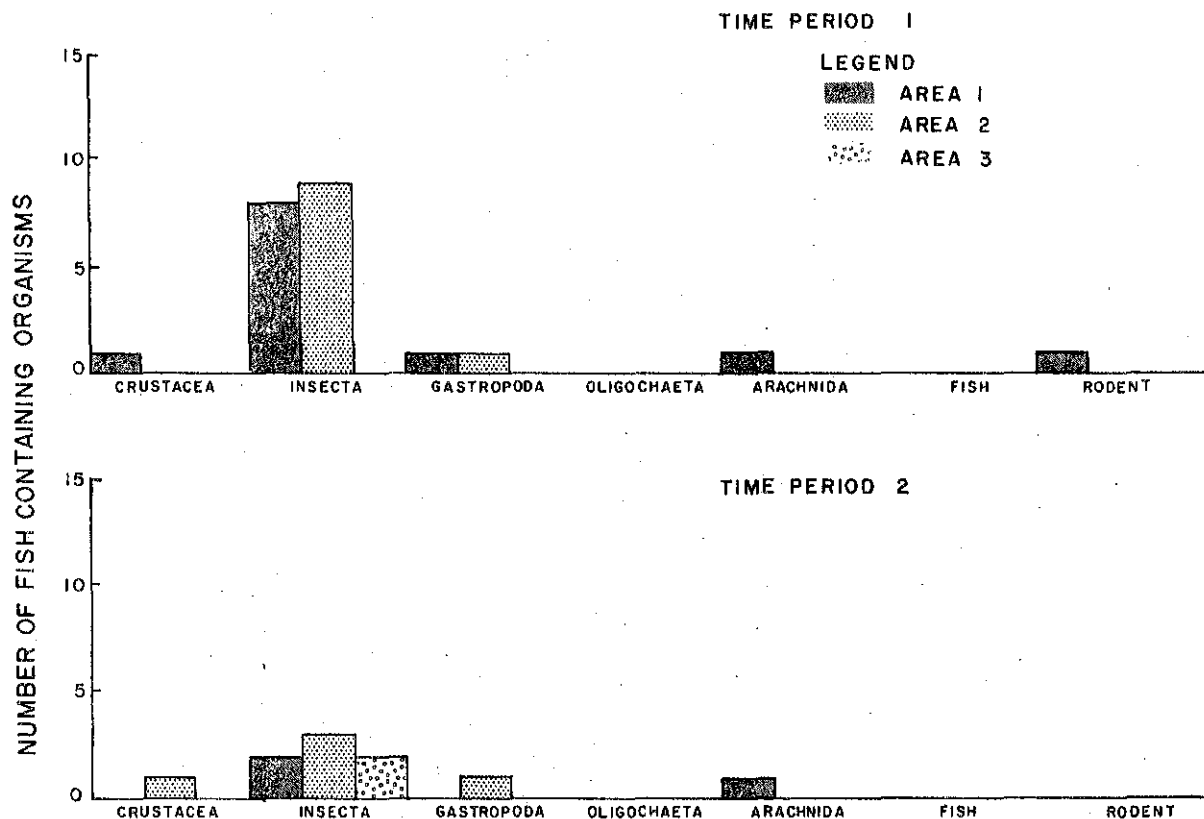
TABLE III - Average Conditions Factor for Humpback Whitefish and Lake Trout in Regions 1, 2, and 3.

Year	Region 1		Region 2		Region 3	
	HW	LT	HW	LT	HW	LT
3	-	-	-	-	-	1.45(2)
4	-	-	-	-	-	1.28(1)
5	-	1.20(6)	-	-	1.99(2)	1.59(3)
6	1.29(1)	1.23(4)	-	-	1.16(8)	1.33(6)
7	1.31(8)	1.29(5)	1.29(38)	1.20(14)	1.22(73)	1.26(18)
8	1.20(23)	-	1.24(74)	1.34(7)	1.20(107)	0.93(8)
9	1.33(21)	-	1.22(36)	1.28(4)	1.24(21)	1.03(7)
10	1.27(10)	-	1.24(6)	1.48(1)	1.26(5)	1.12(1)
11	1.43(1)	-	1.31(2)	-	1.27(3)	1.40(1)
12	1.69(1)	-	-	-	1.52(1)	1.05(1)
13	-	-	-	-	-	-
14	-	-	-	-	-	-

due to rapid warming of the water and the influx of food organisms from the Sekulmun River could be two reasons for the higher condition factor of the nine year old whitefish. Also the sampling program commenced in Region 3 in early summer and proceeded north. At the time of fish capture in Region 1 the plankton productivity in the lake had probably increased drastically compared to the time of fish capture in Region 3.

The diet of 677 humpback whitefish, 231 lake trout, 29 arctic grayling and 24 round whitefish was related to the three lake regions and the two time periods. The

- 18 -
GRAYLING



ROUND WHITEFISH

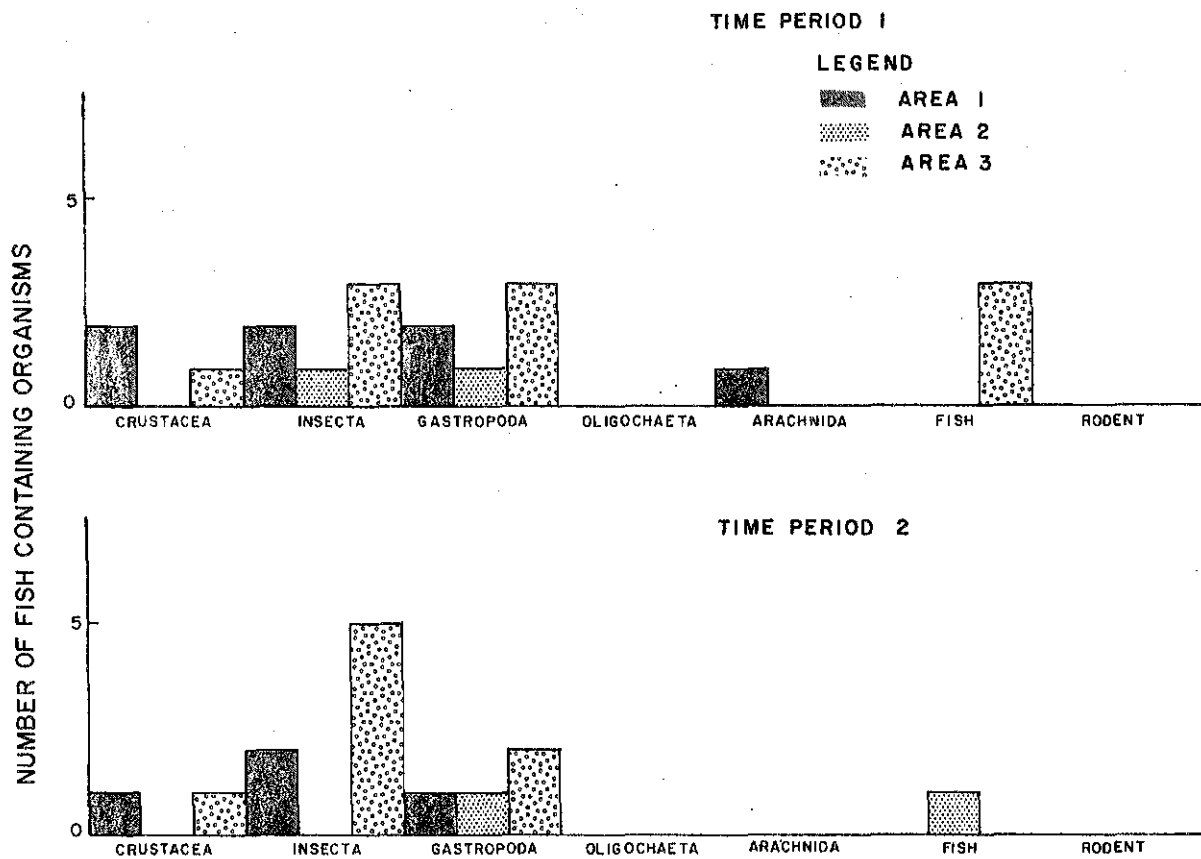


FIGURE 7. RESULTS OF STOMACH ANALYSIS OF GRAYLING AND ROUND WHITEFISH.

HUMPBACK WHITEFISH

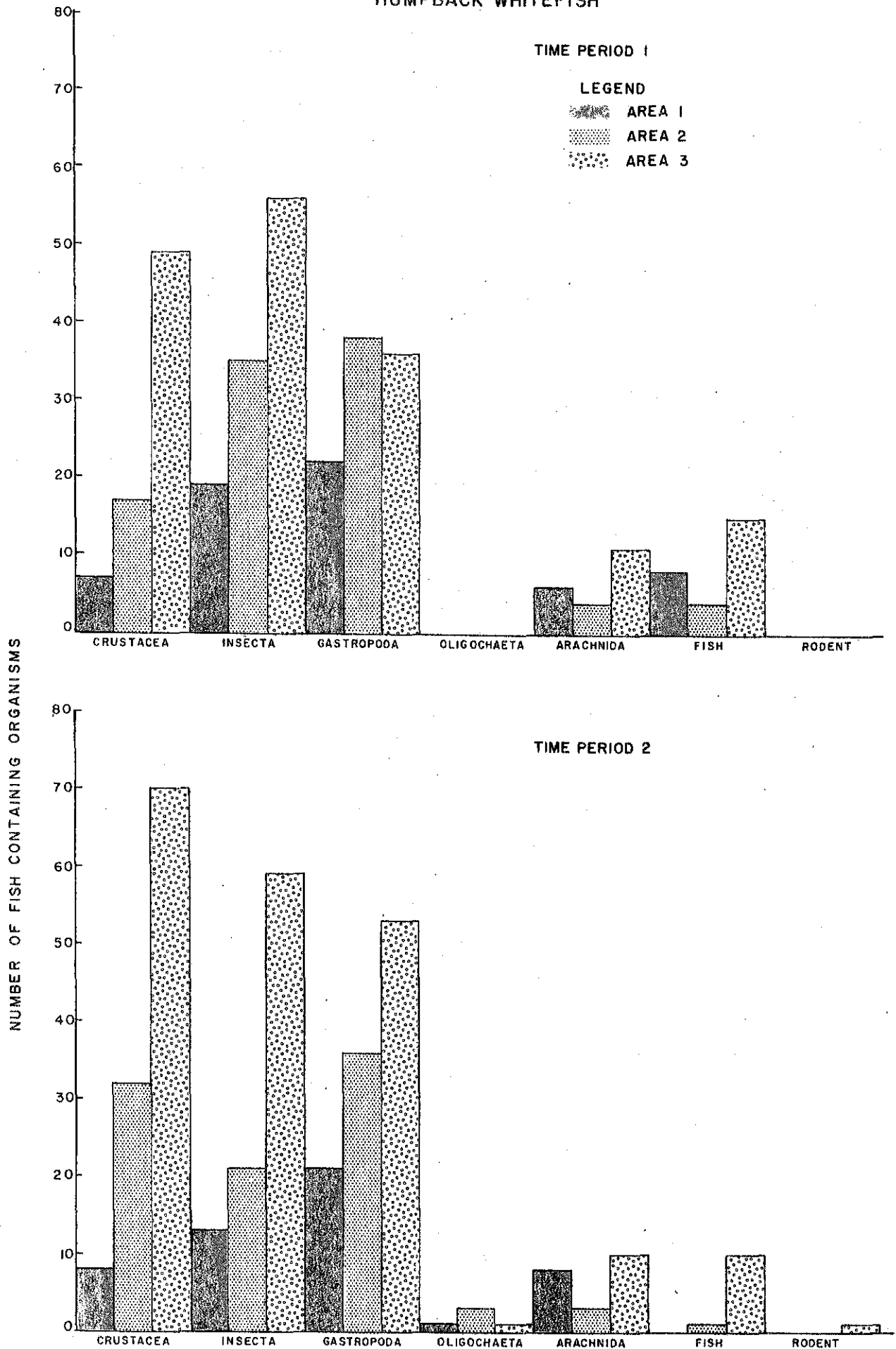


FIGURE 8. RESULTS OF STOMACH ANALYSIS OF HUMPBACK WHITEFISH.

LAKE TROUT

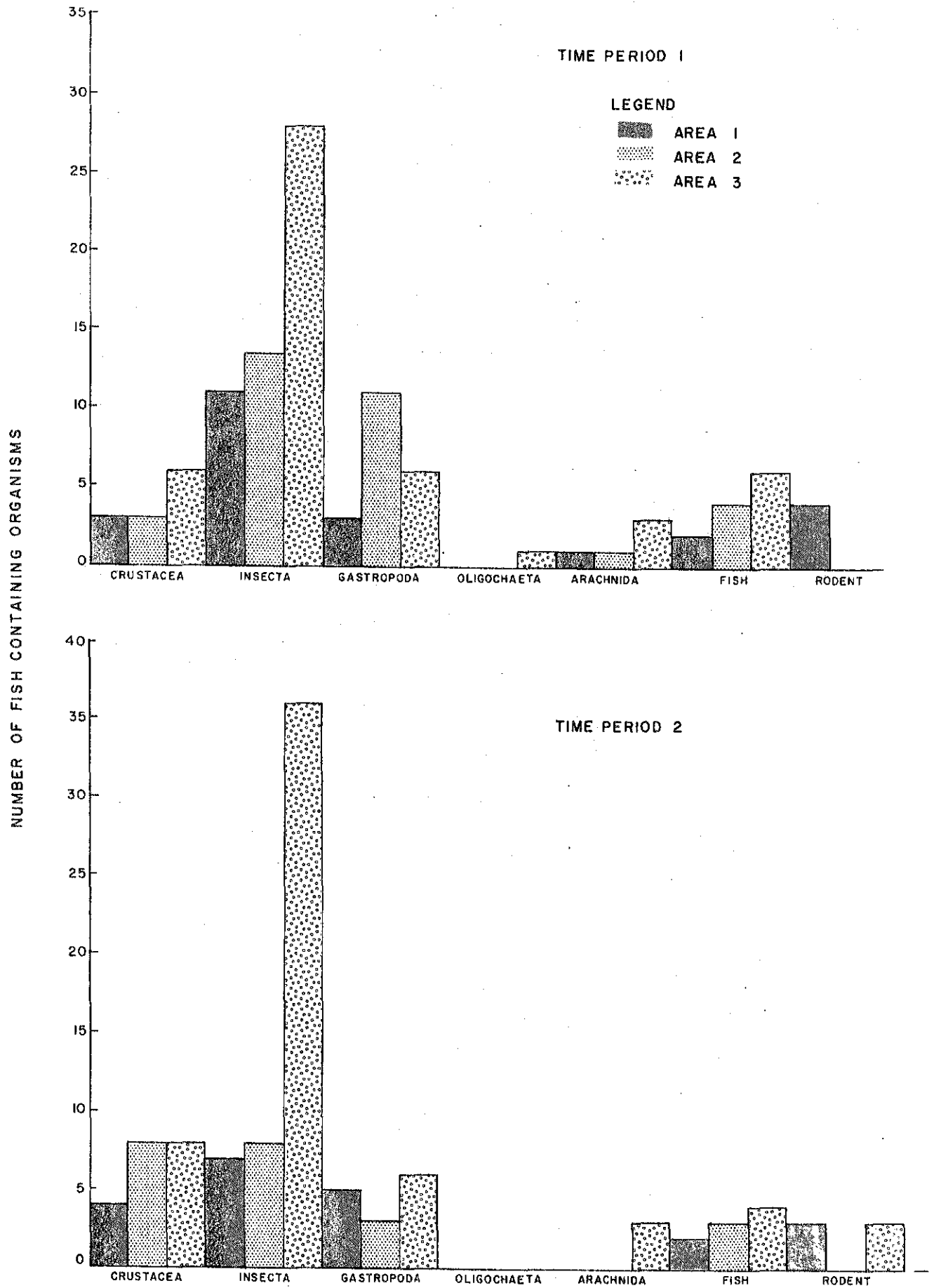


FIGURE 9. RESULTS OF STOMACH ANALYSIS OF LAKE TROUT.

TABLE IV - Frequency of Occurrence and Relative Volume
of Major Food Items Utilized by Humpback Whitefish and
Lake Trout for Time Periods June 1 to July 31 and
August 1 to September 30.

Points	1	2	3	4	5	6	7	8	9	10	Period	Fish
Juvenile Diptera	20	9	8	6	4	6	1	3	1	7	I	HW
	17	4	1	9	6	0	2	0	1	2	II	
	3	2	1	1	4	2	2	0	1	1	I	LT
	1	2	0	1	0	1	0	0	0	2	II	
Large Snails	3	2	2	0	1	1	1	1	1	4	I	HW
	0	0	1	1	2	1	1	1	2	8	II	
	1	0	0	0	1	1	0	0	0	2	I	LT
	0	1	0	0	1	0	0	0	0	3	II	
Medium Snails	4	6	4	5	4	2	7	4	3	15	I	HW
	7	6	2	6	6	3	4	3	7	7	II	
	1	0	2	1	1	0	1	0	1	5	I	LT
	1	0	1	0	4	0	0	0	1	0	II	
Small Snails	6	2	2	2	1	1	1	1	0	4	I	HW
	5	1	1	4	3	5	1	0	0	4	II	
	0	0	0	1	0	0	0	0	2	2	I	LT
	0	1	1	0	0	0	0	0	0	0	II	
Piscidium (clams)	6	13	6	9	4	3	2	0	0	0	I	HW
	11	5	12	11	4	1	0	1	1	0	II	
	1	0	0	0	1	0	0	0	0	0	I	LT
	0	0	0	0	0	0	0	0	0	0	II	
Fish	5	2	5	4	2	1	1	1	0	6	I	HW
	1	2	1	1	1	0	1	0	2	2	II	
	0	1	2	1	1	0	1	0	0	6	I	LT
	1	1	0	0	0	2	0	0	2	3	II	
Rodent	0	0	0	0	0	0	0	0	0	0	I	HW
	0	0	0	0	0	0	0	0	0	0	II	
	0	0	1	0	0	0	0	0	0	4	I	LT
	0	0	0	0	0	0	0	0	5	6	II	
Daphnia	5	2	1	1	2	1	2	1	2	10	I	HW
	8	6	4	1	5	2	2	2	4	10	II	
	1	0	0	0	0	0	0	0	0	0	I	LT
	3	0	1	1	1	0	1	1	1	5	II	

number of fish in which each food item occurred is depicted in Figures 7, 8 and 9. Crustacea, insecta, and gastropoda were by far the most utilized food organisms in all regions between June 1 and September 30, 1972. These organisms are tabulated in Table IV. Diptera larvae were present in the largest number of whitefish but comprised only 10 percent of the total food in 20 and 17 fish for periods I and II respectively. Snails and clams were also present in large numbers of whitefish. Snails made up 100 percent of the diet of 23 fish in period I and 19 fish in period II. Only few fish stomachs contained rodents and fish. However, this data is included in Table IV because the large size of this food source probably represents an important source of energy. Fish were utilized by whitefish and lake trout alike and appeared to be more important in period I. Voles made up the whole diet of four and six lake trout in periods I and II respectively. The utilization of rodents by lake trout may be a cyclic phenomenon related to the life history of this rodent.

The fish diet data does not indicate major differences of feeding habits with lake regions or time period. Some shift in diet may occur throughout the summer, however, it was not detectable from the data gathered.

(3) Productivity

(a) Benthos

Results of the dredging survey are appended (Appendix I). Relatively few organisms were encountered because of many instances hard rocky substrates made the dredge ineffective. The numbers lists represent the total of three dredgings. Tendipedidae larvae and oligochaeta

were present at most stations with soft substrate. Other dipteran larvae, gastropods and polychaetes were also found.

Results from the twelve "typical" lakeshore sites (Figure 4) are listed in Appendix II. A detailed description of the typical sites can be found in the 1972 Aishihik Lake shoreline study report. Table V is a summation of the numbers of organisms found at various depths. As can be seen the 0 - 10 feet samples contained few specimens indicating a rather unproductive littoral zone in terms of dredgeable benthic fauna. The 15 feet samples yielded

TABLE V - Numbers of Organisms Collected at Various Depths
at Ten "Typical" Sites

Stn. No.	Depth (ft)				
	2	5	10	13	15
71	0	2	5	-	68
72	0	83	62	187	-
75	0	0	0	0	0
76	0	0	3	-	0
77	0	0	0	-	259
78	0	0	2	-	3
79	0	0	0	-	82
80	0	0	12	-	6
81	0	0	4	-	6
82	0	4	0	-	66

(-) indicates no sample

relatively large numbers of tendipedidae larvae. Snails and clams were also abundant at this depth. Other species were represented by few numbers only. Deep samples in the centre of the lake yielded no organisms indicating the possibility of a narrow productivity band around the lake. Rooted aquatic vegetation was restricted to the shallow bays and few other limited shoreline areas.

As mentioned previously the benthic survey was highly biased towards soft substrate fauna because of the inability of the dredge to sample hard or rocky bottom. Snails were found in all areas of the lake on submerged rocks to a depth of 40 feet. Since snails represent a substantial portion of the diet of humpback whitefish it may be advisable to determine the possible effect of fluctuating lake levels on suitable snail habitat.

A modified Surber sampler was used to sample the type and abundance of organisms to the lower reaches of some lake tributaries. Results are tabulated in Appendix III. These few benthic stream samples yielded a variety of immature stages of aquatic insects, crustaceans and oligochaetes.

Results of surface water trawls are shown in Table VI. Sample areas are related to the closest fish sampling sites (Figure 3). The inshore sampling was conducted in zones of aquatic plant growths. Although only two comparative runs were made it is obvious that the littoral areas sampled are by far more productive than surface waters in the centre of the lake. Net catches indicated that the littoral regions of the lake are frequented by mature whitefish and lake

trout. The importance of this region to juvenile fish will be studied in 1973.

TABLE VI - Surface Trawl Comparison

Station	Location	Organisms	
5	Parallel to shore	Crustacea	5
5	Centre of Bay	-	-
16	Parallel to shore	Insecta	18
16	Lake centre	Insecta	3

(3) (b) Plankton

Species composition and numbers of zooplankton were tabulated and listed in Appendix IV. Copepods were by far the most abundant plankton captured. These included *Diaptomus pribilofensis*, *Cyclops* spp., *Senecella calanodides*, *Heteroscope septentrionalis*, juvenile copepods, and the cladoceran *Daphnia pulex*. The composition of plankton for all lake stations in July 1972 is presented in Table VII.

TABLE VII - July Zooplankton Composition

Juvenile copepods	54%
<i>Diaptimus pribilofensis</i>	27%
<i>Cyclops</i> spp.	16%
<i>Daphnia pulex</i>	2.4%
<i>Senecella calanoides</i>	0.5%
<i>Heterescope septentrionalis</i>	0.1%

A comparison of the numbers of plankton sampled from two and five meter depths in shallow and deep waters was conducted. Data from July and August for two shallow and two deep stations is given in Table VIII.

TABLE VIII - Plankton Counts of 2 and 5 Meter Samples from Shallow and Deep Lake Stations.

Date	Station No.	Depth (m)	No.	Total
July	3 shallow	2, 5	613	1219
	18 shallow	2, 5	606	
	53 deep	2, 5	731	1284
	54 deep	2, 5	553	
August	1 shallow	2, 5	754	992
	13 shallow	2, 5	238	
	53 deep	2, 5	664	1614
	54 deep	2, 5	950	

The cursory examination of the total number of planktons from these four stations indicates that the shallow lake regions are not more productive in terms of primary (plankton) production than the deep lake waters. One explanation for the uniformity of lateral plankton distribution could be the almost constant wind action resulting in homogeneous mixing of surface waters. One point of interest is the increase in numbers of zoo-plankton at station 54 from 553 in July to 950 in August. Although the comparison was only for one station higher primary productivity in August could be due to increased

TABLE IX Results of June 21, 1972 Dissolved Oxygen Survey

Concentrations - ppm (% saturation bracketed)

Depth (m)	Station No.	51	52	53	54	55	56	57	58
Surface	10.8(100)	11.1(88)	11.4(90)	11.1(87)	10.7(82)	10.8(83)	10.6(89)	10.9	
2m	10.7(99)	11.1(91)	11.2(90)	11.2(88)	10.6(81)	11.0(85)	10.6(86)	10.9	
4m	10.4(105)	11.2(92)	11.4(90)	10.5(80)	10.5(80)	10.8(83)	10.5(83)	10.8	
6m	11.9(94)	11.2(93)	11.3(90)	11.3(88)	10.5(80)	10.8(83)	10.5(84)	10.9	
10m		11.0(86)	11.3(91)	11.3(86)	10.7(82)	10.8(83)			
15m		11.0(88)	11.3(90)	11.3(87)	10.8(83)	11.0(85)			
20m		11.3(90)	11.2(88)	11.2(87)	10.6(81)	11.0(85)			
30m		11.5(92)	11.1(88)	11.1(86)	10.6(81)	10.9(84)			

lake temperatures in late summer.

The counting of planktonic organisms was rather time consuming and it is suggested that volumetric measures should be used in future.

(4) Limnological

Average summer temperatures for the first six meters from two stations in each region were as follows: Region 1 - 10.7°C; Region 2 - 8.6°C; Region 3 - 8.4°C. No definite thermal stratification was evident in the lake. An increase in temperature with depth was noted during the summer suggesting a constant mixing of the top 30 meters of the lake. Figure 10 depicts the relationships between time, temperature and depth for station 54. The same relationships were observed at all stations except 51 and 58. These shallow waters at the lake extremities were uniformly mixed throughout the summer. Higher temperatures at station 51 probably are the result of the warm water inflow from the Sekulmun River. Detailed lake temperatures are listed in Appendix V.

Dissolved oxygen samples were taken at all eight stations on June 21. The results are shown in Table IX. Levels ranged from 10.3 ppm (94 percent saturation) at 6 meters at station 51 to 11.5 ppm (92 percent saturation) at 30 meters at station 52. No further dissolved oxygen determinations were made.

The hydrogen ion concentration of the water samples was also determined on June 21. Values are uniformly slightly higher than 8.5 indicating alkaline conditions.

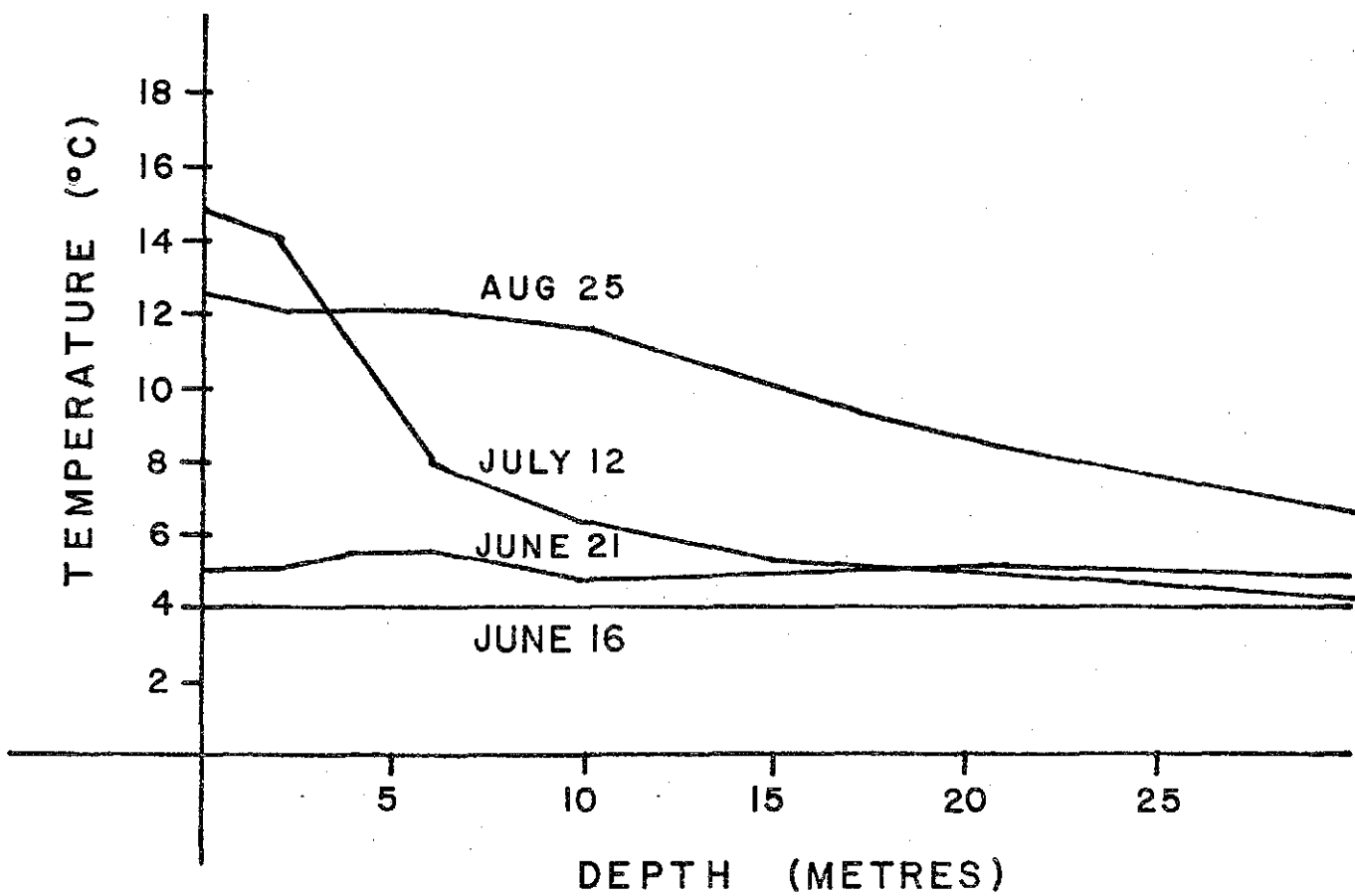


FIGURE 10.
THERMAL CHARACTERISTICS OF AISHIHIK LAKE
STATION NO. 54

Limited numbers of secchi disc observations were made in the central lake. July and August values ranged from 6 meters to 9 meters indicating clear water.

Results of surface water analyses for various chemical and physical parameters are presented in Table X. Aishihik Lake and its watershed is presently void of human activity, save for a limited number of Indian families which reside at the north end of the lake, and weekend visitors which camp primarily at the southern end of the lake. Therefore, it can be assumed that the water quality results in Table X present pristine conditions and can be utilized as baseline values. Some anomalies are evident in these results when comparison are made between stations and sampling periods. September results for copper, nitrate, zinc, iron and total phosphate all deviate from the expected norm.

It was further noted that water quality varied significantly with depth. Table XI compares samples from station 54 taken at the surface, 15-18 meter depth and 30-36 meter depth. Unit concentrations are those listed in Table X. The significance of the variance in certain water quality parameters and its effect on the biological productivity of the lake is poorly understood at the present time. Special care in sampling techniques are suggested to confirm the variance in concentrations of the water quality parameters with depth and location.

Present data does not suggest that the biological activity of the lake will be drastically influenced by a six feet fluctuation range of lake levels. It is

TABLE X - Chemical - Physical Surface Water Conditions

	Stn 51				Stn 54				Stn 58			
	Jul 9	Jul 21	Aug 17	Sep 21	Jul 9	Jul 21	Aug 17	Sep 21	Jul 9	Jul 21	Aug 17	Sep 21
Nitrite (mgN/l)	-	<0.005	<0.01	ND	-	<0.005	<0.01	ND	-	<0.005	<0.01	ND
Nitrate (mgN/l)	ND	ND	ND	0.10	<0.1	ND	ND	0.40	ND	ND	ND	-
Ammonia (mgN/l)	-	ND	0.025	<0.01	-	ND	0.025	<0.01	-	0.09	0.025	<0.01
Total PO ₄ (mg/l)	<0.01	<0.01	0.01	<0.02	ND	<0.01	<0.01	<0.02	<0.1	<0.01	<0.01	0.03
Poly PO ₄ (mg/l)	ND	-	-	0.03	ND	-	-	0.01	ND	-	-	0.02
Ortho PO ₄ (mg/l)	ND	<0.01	-	ND	<0.1	<0.01	-	ND	ND	<0.01	-	ND
Alkalinity (mgCaCO ₃ /l)	-	49	-	-	-	48	-	-	-	54	-	-
Spec Conductivity (µmhos/cm)	-	56	85.3	103.6	-	124	94.2	101.1	-	70	94.2	-
Turbidity (FTU)	-	1.2	0.51		-	1.0	0.2		-	0.7	0.15	-
Filtrable Residue	50.3	-	-	-	59.8	-	-	-	99.1	-	-	-
Zinc (mg/l)	-	<0.01	<0.01	<0.01	-	<0.01	<0.01	0.03	-	0.01	<0.01	0.02
Copper (mg/l)	-	<0.01	≈0.01	0.03	-	ND	<0.01	<0.01	-	ND	<0.01	<0.01
Iron (mg/l)	-	<0.05	0.11	<0.05	-	<0.03	<0.03	1.75	-	<0.03	<0.03	<0.05
Lead (mg/l)	-	<0.03	<0.02	<0.02	-	<0.02	<0.02	<0.02	-	<0.02	0.13	0.02

TABLE XI - Water Quality Measurements, July 2, Station 54.

	<u>Surface</u>	<u>15-18mm</u>	<u>30-35m</u>
Nitrite	<0.005	<0.005	<0.005
Nitrate	ND	0.23	0.04
Ammonia	ND	0.13	0.32
Total PO ₄	<0.01	0.015	0.02
Ortho PO ₄	<0.01	0.01	<0.01
Spec. Conduc.	124	93	97
Turbidity	1.0	6.5	5.2
Zinc	<0.01	0.03	0.12
Copper	ND	<0.01	<0.01
Iron	<0.03	<0.03	0.83
Lead	<0.02	0.26	0.46

anticipated that the biological communities, i.e. plankton, benthos and fish will be able to adapt to minor physical changes in lake morphometry. Localized major effects, i.e. sloughing of hillsides, changes in tributary deltas and effects on spawning substrates have not been considered in this report. These may be detrimental to the fish resource of the lake. Generally speaking, productivity in a new impoundment increases for the first few years. This is followed by a decrease in available energy and subsequent decline in desirable fish populations.

SUMMARY AND CONCLUSIONS

A power development has been proposed for Aishihik Lake. A licence has been issued by the Department of

Indian Affairs and Northern Development to the Northern Canada Power Commission permitting a six feet fluctuating range of lake levels.

Aishihik Lake is situated approximately 100 miles west of Whitehorse, Yukon Territory. The lake is long (36.6 miles), narrow, and deep ($\bar{x}$ depth 108 feet). Annual precipitation in the area is light and ambient air temperatures relatively low.

Humpback whitefish and lake trout abound in the lake. Round whitefish, grayling, burbot, pike and long-nose suckers are also present. No spawning beds or juvenile fish were located.

The main diet of the fish sampled was comprised of crustacea, insecta, and gastropoda. Fish and rodents also were present in many whitefish and trout stomachs. The importance of snails to the diet of these fish should be studied in more detail because these animals are tied intimately to the littoral substrate. The littoral zone is also quite productive in terms of adult aquatic insects. The relationship between the adult insects and the juvenile fish of the lake will be studied in 1973.

The benthic and plankton fauna was relatively sparse. Species composition did not vary significantly with lake region or time (June to September). No benthic fauna was found at deep lake stations suggesting limited littoral productivity zones around the lake. Plankton abundance was similar in shallow bays and the centre of the lake.

Lake waters were clear and cool and dissolved oxygen plentiful. Water temperatures were slightly higher in the northern part of the lake. Lake stratification was not evident in the summer. Limited nutrient and dissolved metal concentrations of lake water were recorded and should serve as baseline levels for future studies. Lake shores are presently virtually uninhabited. Since Aishihik Lake is located close to the Alaska Highway, Kluane Park and the City of Whitehorse, it is anticipated that the recreational activity on the lake will increase in the near future. Access to the lake is presently limited primarily to a few shallow bays. The effects of concentrated activity may affect the water quality in these areas.

Under the present terms of reference (6 feet fluctuation range) the change in biological productivity will in all likelihood not be measurable. However should the license be amended at a future date and lake fluctuations exceed those presently recommended, the important biological energy source of the littoral zone could be adversely affected.

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APPENDIX I

General Dredge Results

APPENDIX I - General Dredge Results

Stn.	Depth (m)	Dist (m) Offshore	Substrate	Organisms		Comments
1	4.5	30	mud, fine sand	-		some rooted vegetation
2	2.5	10	mud, some sand	Pisidium	13	extensive vegetation
				Amphipoda	2	
				Nematoda	2	
				Trihoptera	2	
3	8	10	-	-		gravel, beach large rock
4	5	10	-	-		large rocks
5	0.5	20	sand	Tendipedidae	21	rooted vegetation
				Pisidium	9	
6	0.5	30	mud, fine sand	Tendipedidae	3	rooted vegetation
				Pisidium	6	
				Oligochaeta	13	
				Muscidae	7	
7	8	5	sand, gravel	Tendipedidae	2	cliffs to shore
				Pisidium		
				Gastropoda (snails)	1	
8	4	8	-	-		rocks
9	10	10	mud	Pisidium	4	rooted vegetation
				Tendipedidae	7	
				Acari	1	

Stn.	Depth (m)	Dist (m) Offshore	Substrate	Organisms	Comments
10	5	10	mud	Tendipedidae 6 Pisidium 3 Gastropoda 2 (snails) Oligochaeta 1	some rooted vegetation
11	25	30	-	-	large rocks
12	3	10	-	-	large rocks
13	3	10	-	-	rocks
14	5	10	gravel, sand	-	gravel beaches
16	15	15	sand	-	gravel and sand beach
18	60	1/2 mile	mud	Tendipedidae 2	grey mud and clay
19	14	15	mud, sand detritus	-	narrow gravel beach
20	5	8	mud, sand	Tendipedidae 6	small rocks, rooted vegetation
21	4	10	mud, sand	Tendipedidae 2	some rooted vegetation
22	6	20	-	-	sand, large rocks

Stn.	Depth(m)	Dist (m) Offshore	Substrate	Organisms	Comments
23	5	15	-	-	large rocks, gravel
24	5	8	-	-	large rocks
25	5	7	-	-	large rocks
26	2	5	sand, mud	-	rooted vegetation
27	3	5	sand, mud	-	rooted vegetation

APPENDIX II

Dredge Results From Typical Lake Shore Stations

APPENDIX II - Dredge Results from
Typical Lake Shore Stations

Stn.	Date	Depth (ft)	Substrate	Organisms	(2 Ponar)	Total
71	Jul 29	2	small rocks			
		5	small rocks	Pisidium	1	2
				Gastropoda	1	
		10	sand	Tendipedidae	1	5
				Pisidium	4	
		15	sand, mud	Pisidium	7	
				Snails	5	
				Nematoda	1	68
				Tendipedidae	51	
				Oligochaeta	3	
72	Jul 29			Acari	1	
		2	rock, sand, veg.	Tendipedidae	1	1
		5	sand, veg.	Pisidium	48	
				Snails	7	
				Amphipoda	14	
				Tendipedidae	2	
				Simuliidae	1	83
				Oligochaeta	3	
				Cypridae	3	
				Cladocera	4	
				Hirudinea	1	
		10	sand, veg.	Acari	2	
				Tendipedidae	17	
				Snails	17	
				Pisidium	13	62
				Cladocera	2	

APPENDIX II - continued

Stn.	Date	Depth (ft)	Substrate	Organisms	(2 Ponar)	Total
				Oligochaeta	2	
				Amphipoda	8	
				Nematoda	1	
		13	sand, veg.	Pisidium	23	
				Snails	40	
				Amphipoda	11	
				Tendipedidae	92	187
				Muscidae	1	
				Acari	4	
				Cladocera	3	
				Cypridae	5	
				Oligochaeta	8	
75	-	2	rocks	-		
		5	rocks	-		
		10	sand	-		
		15	sand	-		
76	Aug 21	2	rocks, sand	-		
		5	rocks, sand	-		
		10	sand	Snail	1	
				Pisidium	1	3
				Oligochaeta	1	
		15	sand	-		
77	Aug 21	2	rocks	-		
		5	rocks	-		
		10	rocks	-		
		15	mud	Snails	12	
				Pisidium	20	

APPENDIX II - continued

Stn.	Date	Depth (ft)	Substrate	Organisms	(2 Ponar)	Total
				Simulidae	2	259
				Tendipedidae	200	
				Oligochaeta	25	
78	Aug 12	2	rocks	-		
		5	sand	-		
		10	sand, mud	Snails	1	2
				Pisidium		
		15	sand, mud	Amphipoda	1	
				Tendipedidae	2	3
79	Aug 12	2	rocks	-		
		5	rocks	-		
		10	rocks	-		
		15	sand, mud	Amphipoda	3	
				Pisidium	8	
				Snails	2	
				Nematoda	2	
				Tendipedidae	56	82
				Muscidae	1	
				Cladocera	2	
				Cypridae	3	
				Oligochaeta	5	
80	Aug 7	2	rocks	-		
		5	sand, gravel	-		
		10	sand, rocks	Snails	1	
				Tendipedidae	11	12
		15	sand	Tendipedidae	6	6

APPENDIX II - continued.

Stn.	Date	Depth (ft)	Substrate	Organisms	(2 Ponar	Total
81	Aug 7	2	rocks	-		
		5	rocks	-		
		10	sand, small rocks	Tendipedidae	4	4
		15	sand	Tedipedidae	6	6
82	Aug 7	2	rocks	-		
		5	rocks	Tendipedidae	4	4
		10	small rocks	-		
		15	silt, mud	Amphipoda	1	
				Tendipedidae	32	66
				Pisidium	26	
				Snails	7	

APPENDIX III

Lake Tributary Invertebrates Counts

APPENDIX III - Lake Tributary Invertebrates Counts

Stn.	Date	Organisms	(B. ft ²)	Total
20	Aug 24	Tendipedidae	67	
		Simulidae	25	
		Amphipoda	1	
		Nematoda	1	
		Heterescope	4	126
		Plecoptera	7	
		Ephemeroptera	18	
		Leptophlebiidae	3	
South of				
14	Aug 24	Tendipedidae	25	
		Simulidae	1	
		Oligochaeta	1	32
		Amphipoda	1	
		Ephemeroptera	1	
		Plecoptera	3	
6	Aug 20	Dixidae	1	
		Simulidae	4	
		Centroptilum	1	27
		Plecoptera	12	
		Trichoptera	9	
6	Aug 20	Simulidae	152	167
		Centroptilum	15	
14	Aug 24	Muscidae	5	
		Tendipedidae	2	
		Ephemeroptera	2	11
		Plecoptera	2	

APPENDIX III - continued

Stn.	Date	Organisms	(B. ft ²)	Total
5(1)	Aug 20	Ephemeroptera	5	
		Oligochaeta	1	
		Simulidae	3	16
		Plecoptera	7	
5(2)	Aug 20	Simulidae	249	
		Tendipedidae	12	
		Oligochaeta	4	
		Plecoptera	12	279
		Ephemeroptera	2	
5B	Aug 20	Tendipedidae	19	
		Simulidae	8	
		Tipulidae	4	
		Ephemeroptera	17	51
		Amphipoda	2	
		Trichoptera	1	

APPENDIX IV

Lake Zooplankton

APPENDIX IV - Lake Zooplankton

LEGEND

1. Diaptomus pribolofensis
2. Cyclops spp
3. Juvenile copepods
4. Heteroscope septentrionalis
5. Senecella calanoides
6. Daphnia pulex

Station 1

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									
16/6	1330	2	50	28	8	0	0	3	89
		5	197	62	5	0	0	1	165
21/6	1300	2	17	27	9	-	-	-	53
		5	33	93	19	-	2	12	
3/7	1100	2	97	17	2	2	3	-	121
		5	285	79	16	11	12	0	
11/7	1230	5	21	112	195	0	49	0	367
22/7	1340	5	38	129	364	0	59	0	590
27/7	Unfixed	2	51	18	10	-	41	-	120
18/7		5	177	35	37	2	185	0	436

Station T2E

7/8	-	2	59	17	31	-	1	13	121
7/8	1040	5	272	62	124	-	2	173	633
20/8	1100	2	45	52	13	-	-	1	111

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station: T3E

21/6	1240	2	21	22	11	-	2	5	71
3/7		1.5	37	16	2	-	6	2	63
11/7	1220	1	28	6	8	-	-	3	45
22/7		1.5	139	40	9	5	-	3	186

This station was discontinued; there wasn't 2m of water.

Station: T3W off target #2

3/7		2	31	11	14	-	-	-	68
		5	120	28	36	2	-	40	226
11/7	1240	2	142	42	32	-	7	-	223
		5	120	98	93	-	1	-	319
18/7	1900	2	143	12	90	0	1	0	246
		5	153	57	89	2	58	2	361
27/7	1530	2	48	49	60	0	87	0	244
		5	150	57	113	0	170	5	495
7/8	1040	2	75	67	75	-	-	264	481

Station T4W

3/7	1140	2	38	23	15	3	5	-	84
		5	286	98	13	3	7	0	301
11/7	1250	2	86	41	83	-	16	-	226
		5	80	74	185	-	33	-	372
18/7	1210	2	178	21	55	-	42	-	296
		5	158	60	88	4	31	-	341
27/7	1500	2	141	36	58	0	61	0	296
		5	316	78	82	-	57	3	536
7/8	1000	2	66	58	12	-	-	4	140

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station: T4 Middle

3/7		2	57	21	28	-	4	3	113
		5	117	121	41	-	3	3	285
11/7	1300	2	74	28	114	-	3	2	221
		5	64	98	118	-	13	-	293
18/7	1800	2	150	23	37	-	50	-	260
		5	462	51	63	-	160	-	736
27/7	1600	2	109	21	33	-	7	-	170
		5	348	79	107	-	33	-	567
7/8	1100	2	375	185	170	-	-	120	850
7/8	1100	5	34	11	28	-	-	29	102

Station: T4E

7/8	1200	2	44	13	3	-	1	18	79

Station: T5North

18/7	1900	2	141	42	121			78	382
		5	406	38	48	-	-	292	784
27/7	1545	2	190	9	12	-	4	3	218
		5	192	14	52	-	2	7	267
7/8	1115	2	44	50	135	-	-	15	244
7/8	1115	5	181	106	99	-	2	27	415

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station: 2 - Soldier Bay

16/6	1350	2	36	26	6	-	-	-	68
		5	158	55	-	-	-	-	213
		10							

21/6		2	30	26	9	-	-	-	65
		5	51	53	4	-	-	1	109
		10	156	67	28	-	-	1	252

3/7		2							
		10	506	374	470	12	10	0	1372
		15	548	536	1040	4	0	0	

11/7	1320	2	37	8	22	0	10	0	77
		5	24	54	150	2	0	0	
		10	352	250	252	12	8	10	1084
		15	44	220	620	6	0	0	

27/7	1600	2	253	44	41	0	13	0	351
		5	327	83	45	0	9	0	464
		10	746	146	128	4	8	8	1040

18/7	1900	2	110	17	33	0	4	1	165
		5	162	118	178	3	0	5	466
		10	352	250	252	12	10	8	1084

Station T6E

11/7	1500	2	31	31	61	0	0	6	129
		5	102	108	175	-	-	10	395

18/7

27/7	1700	2	52	11	97	-	-	4	164
		5	109	24	111	3	1	8	248

7/8	1200	2	48	49	72	-	6	10	185

7/8	1200	5	147	80	73	-	-	5	305

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									
<u>Station: T8E</u>									
3/7	1400	2							
		5	145	79	10	2	1	3	240
		10	156	88	22	2	-	5	273
11/7	1550	2							
		5	68	48	165	8	1	2	292
		10	38	44	178	-	2	10	272
18/7	2010	2	101	15	133	2	-	24	275
		5	104	66	234	-	-	6	410
27/7	1740	2	199	26	71	2	0	10	308
		5	255	23	76	1	0	11	465
7/ 8	1250	5	168	30	128	-	1	1	328

Station T8W

11/7	1515	2	14	10	18	-	-	-	42
		5	317	103	332	-	2	3	757
18/7	1920	2	99	49	87	-	2	-	237
		5	148	72	182	-	1	-	403
27/7	1650	2	201	29	78	-	4	4	316
		5	251	64	93		3	10	421
7/8	1230	2	164	101	197	-	4	3	469
7/8	1230	5	155	144	57	-	-	5	361

Date	Time	Depth(m)	1	2	3	4	5	6	Total
<u>Station 3: Main Station</u>									
16/6	1430	2	31	13	2	-	-	-	46
		5	26	24	-	-	-	-	
		10	151	63	2	-	-	-	216
21/6	1630	2	58	18	11	2	-	-	89
		5	51	47	27	3	-	-	
		10	127	110	22	2	-	-	261
11/7	1530	15	274	205	33	6	-	-	
		2	72	22	30				124
		5	178	32	204	4	0	2	420
		10	120	190	415	2	2	2	731
		15	92	152	608	4	20	0	876
		20	516	424	1420	16			2376
18/7	1800	2	137	34	163	1	2	1	338
		5	324	59	227	0	5	4	619
		10	224	80	908	2	0	0	1214
		20	640	336	1256	24	-	-	2256
27/7	1730	2	151	40	87	2	3	1	284
		5	200	87	111	3	6	-	407
		10	396	105	164	6	-	3	674
		20	479	163	186	4	-	2	834

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station TllE

11/7		2	202	20	30	8	-	-	253
		5	238	98	129	-	-	3	677
18/7	1430	2	61	59	122	-	-	-	242
		5	unfixed; probably low						266
27/7		2	240	58	61	6	7	6	378
		5	141	38	25	-	3	2	209
7/ 8	1400	2	53	65	205	-	-	30	353
7/8	1430	5	416	181	107	-	-	-	704
25/8	1500	2	360	210	112	-	-	236*	918
		2	87	69	156	-	-	8*	320
		5	3	51	29	-	-	385*	468
		5	309	211	61	-	2	57*	640
		5	7	2	-	-	-	691*	700

Station TllW

3/7		2	88	29	141	4	1	1	264
		5	146	94	286	0	2	0	528
12/7		2	29	-	-	10	-	-	39
		5	186	96	1538	10	-	-	1830
18/7	1650	2	94	26	93	0	5	0	218
		5	133	33	203	0	0	0	369
7/ 8	1330	2	417	113	336	-	1	5	872
		5	420	118	248	-	-	6	792

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									
<u>Station T13.5W</u>									
3/7	1340	5	236	88	482	-	2	2	810
11/7	1415	2							
		5	256	134	812	-	-	10	1212
		10	180	156	1420	-	-	2	1576
18/7		2	78	35	61	-	5	4	183
		5	332	79	70	-	8	6	495
27/7	1400	2	23	87	219	1	1	4	345
		5	47	134	187	-	-	9	377
<u>Station 4 Main</u>									
16/6	1510	2	27	20	1	-	-	-	48
		5	55	34	3	-	-	-	92
		10	124	87	5	0	-	1	217
		15	129	127	-	4	-	-	250
21/6	1720	2	29	16	-	-	-	-	45
		5	70	36	18	0	-	-	124
		10	45	58	53	1	-	-	157
		15	64	91	20	4	-	-	179
2/7	1500	2	84	51	13	0	1	0	149
		5	135	74	174	0	16	0	399
		10	214	202	434	1	2	0	853
		15	250	272	778	12	6	0	1318
12/7	1345								
		5	280	30	21	1	1	3	336
		10	600	176	316	8	8	16	1124
		15							
18/7	1430	2	65	11	25	1	6	0	108
		5	203	37	201	2	6	0	449
		10	538	146	674	5	5	6	1374
27/7		2	91	28	69				
		10	181	62	185	0	10	4	442
		20	432	258	582	4	4	7	1284

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T12E (12.5E)

21/6	1700	2	20	19	5	1	-	-	45
25/6		2	13	20	2	-	-	-	35
2/7		2	97	106	102	-	-	-	305
		5	216	196	203	-	-	-	615
12/7	1400	2	102	72	35	-	-	-	
18/7	1430	2	155	18	24	0	1	0	198
		5	68	164	1020	6	6	0	1264
27/7		2	201	23	8	0	10	0	242
		5	251	43	45	0	8	0	347
9/8	1540	5	50	94	285	-	-	3	432
20/8	1100	2	31	46	25	-	-	6	108
	1100	5	28	31	70	-	-	1	130

Station T 9.5 E

3/7		2	67	115	133	18	-	1	334
		5	83	102	159	1	-	-	335
11/7	1610	2	120	51	31	-	-	1	203
		5	137	34	65	-	-	4	240
18/7	1700	2	67	59	109	-	1	26	262
		5	133	78	592	1	-	4	808
27/7	1730	2	206	27	11	-	-	11	255
		5	925	33	22	-	-	17	997
7/8	1310	2	63	37	75	-	-	15	190
		5	133	44	59	-	-	33	269

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									

Station T 14E

9/8	1530	5	64	42	31	-	-	-	137

Station 14.5 E Lagoon

3/7	1340	2	81	22	115	-	1	1	220
		5	236	88	482	-	2	2	810
11/7	1415	2	119	51	348	1	-	-	519
		5	256	134	812	10	-	-	1212
		10	180	156	1420	-	2	-	1576
18/7		2	41	62	313	-	-	7	413
		5	66	130	739	-	-	5	931

Station 5 - Main Station

16/6	1620	2	7	6	-	-	1	-	-	14
		5	43	16	-	-	-	-	-	59
		10	61	51	3	2	-	-	-	117
		2	8	2	-	-	-	-	-	10
		5	56	32	2	1	-	-	-	91
		10	97	57	6	2	-	-	-	162
3/7		2	65	21	35	-	-	-	121	
12/7	1520	2	77	28	185	0	15	-	305	
		5	276	32	98	2	-	2	410	
		10	352	116	726	16	-	-	1210	
		15	571	300	2016	30	-	-	2917	
18/7	1300	2	86	14	4	-	7	-	111	
		5	322	40	57	-	10	-	429	

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station 19.5 W

30/6 Unfixed

21/6		2	35	37	2	1	-	0	75
		5	101	209	0	0	-	1	311
24/6	1650	2	18	88	2	-	-	-	108
		5	91	195	-	6	-	2	294
		10	93	227	3	10	-	3	336
3/7		2	38	15	47	1	2	-	103
		5	90	33	125	1	2	-	251
12/7	1515	2	63	36	116	-	-	-	215
		5	172	94	212				478
		10	216	162	1234	4	-	2	1616
18/7	1245	2	151	21	26				198
		5	275	104	25	-	2	-	406
8/8		2	128	40	4	-	-	-	172
		5	321	158	4	1	4	0	488
8/8	1400	2	104	33	46	-	-	2	185
		2	117	85	33	-	1	7	243
		5	214	234	95	-	1	1	545
12/8	1440	5	138	42	95	-	-	-	275
20/8	1415	2	126	69	60	-	-	-*	255
	1415	2	56	39	64	-	-	-*	159
		5	78	21	98	-	-	1	198

Station 22E

20/8	1500	5	134	266	154	-	-	28	582
12/8	1545	2	135	48	300	-	1	1	
		5	290	118	612	6	4	0	
		10	192	71	66	3	0	0	
25/7	0830	2	152	23	23	-	2	-	200
		5	447	48	39	11	-	1	546
9/8	1630	2	145	73	59	-	1	-	278
		5	140	127	244	-	2	3	516
20/8	1500	2	369	419	422	-	-	2*	1212
		2	66	145	182	-	-	-*	393

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T 22 W

12/7	1600	2	73	21	111	1	-	-	206
		5	166	58	113	-	1	-	338
		10	142	141	114	-	7	1	405
18/7	1045	2	152	18	91	-	-	1	262
		5	284	42	221	-	8	3	558
25/7	0830	2	139	35	9	-	4	-	187
		5	241	79	58	-	3	-	381
9/8	1700	2	197	67	84	-	-	1	349
		5	130	42	157	-	1	21	351
20/8	1530	2	71	42	34	-	-	-*	147
		2	40	14	65	-	-	4*	123
		5	99	39	42	-	-	1	181

Station T 24

12/8	1300	5	206	91	79	-	-	457*	833
		5	98	43	72	-	-	257*	470
12/8	1900	2	277	222	74	-	1	56	630
		5	157	123	110	-	2	220*	612
		5	220	112	126	-	-	305*	763
		12	67	44	39	-	-	142	292
20/8	-	2	61	31	29	-	-	154	275
		2	94	39	99	-	1	263	496

Date	Time	Depth(m)	1	2	3	4	5	6	Total
16/6	1650	2	35	41					81
		5	66	36					102
		10	74	37					111
27/6		2	35	77	1	5	-	1	119
		5	52	43	2	-	-	-	98
		10	94	104	2	-	-	1	201
3/7		2	120	74	323	-	-	-	517
		5	165	102	937	3	-	-	1207
		10	213	104	1106	7	-	-	1330
12/7		2	114	63	101	15	4	-	297
		5	219	71	215	1	3	-	509
		10	156	90	1100	10	-	-	1356
		15	384	240	2842	16	-	-	3484
18/7	1200	2							
		5	151	42	186	0	8	0	387
25/7	0830	2							
		5	219	18	13	0	6	2	258
		10	413	105	114	6	3	-	641
		15	554	92	85	2	5	2	750
9/8	1645	2	71	66	6	-	-	2	145
<u>Station 25W</u>									
18/7	1030	2	29	17	70	-	-	-	116
		5	90	48	136	-	-	-	274
27/7	0815		51	23	18	-	-	1	93
			277	31	11	-	2	8	320
9/8	1715	2	72	19	137	-	1	2	231
		5	75	41	130	-	1	1	248

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									
<u>Station T 26 E</u>									
3/7		2	138	51	34	-	-	6	229
		5	204	83	97	-	1	10	395
11/7	1625	2	37	114	30	-	-	3	184
		5	102	312	61	-	-	5	480
18/7	1030	2	41	19	53	-	-	5	118
27/7		2	71	11	28	1	-	3	114
		5	381	12	37	3	-	6	439
9/8	1720	2							
		5	230	77	32	-	-	408	747
9/8	1720	2	97	30	131	-	-	109	367
		4	81	56	28	-	-	206	371
12/8		5	325	149	37	-	-	22	533
20/8		2	126	78	33	-	3	25	265

Station 7

19/6	1420	2	27	28	-	-	1	1	67
		5	30	48	-	2	-	-	80
		9	22	62	-	2	-	-	86
24/6		2	34	109	8	6	-	-	157
		5	2	117	7	10	-	-	136
		9	44	182	1	12	-	2	266
3/7		2	128	51	62	28	-	11	280
		5	309	87	67	7	-	1	471
11/7		2	80	46	122	-	-	10	258
18/7	1015	2	47	14	41	-	-	2	104
		5	212	17	91	-	-	1	321
27/7	0735	2	47	13	41	-	-	2	103
		5	278	9	6	1	1	3	298

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T 26 W

12/7	1635	2	135	26	145	-	-	-	366
		5	211	80	238	-	-	-	529
18/7		2	90	71	30	-	-	3	194
		5	219	70	87	-	-	4	380
9/8	1730	2	98	94	173	-	1	9	375
12/8		2	211	59	48	-	-	5	323

Station - T 28 E

3/7 Spilled

11/7	1000	2	43	181	72	-	-	16	312
		5	80	452	216	-	-	62	810
18/7	0930	2	54	174	40	-	-	19	287
		5	137	137	362	5	-	61	702
27/7		2	50	43	13	1	-	4	111
		5	178	201	23	1	-	6	409
9/8	1740	2	71	25	61	-	-	336	493
		5	42	23	25	-	-	195	275
12/8	1000	2	97	62	52	-	-	242*	453
		2	70	25	28	-	-	92*	215
		5	92	33	25	-	2	214	366
19/8	2000	5	119	103	67	-	-	167	456

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T 20 W

9/8	1620	5	242	73	252	-	1	20	588
20/8	1430	2	224	26	220	-	1	23*	494
		2	247	36	190	-	5	5*	483
		5	7	7	-	-	-	-	14

Station T 20.5 E

3/7		2	31	31	4	-	-	-	65
11/7	1500	2	96	18	140	-	-	-	254
		5	174	26	-	4	-	2	206
		10	268	68	486	20	-	16	858
18/7	1230	2	139	49	43	-	-	3	234
		5	208	22	104	-	2	4	342
27/7		2	103	81	91	-	-	-	270
		5	314	92	101	-	-	4	511
20/8	1400	2	199	115	35	-	-	10*	359
		2	237	142	152	-	-	13*	544
		5	260	138	104	-	4	3	509

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T 28 W

11/7	1645	2	42	36	10	-	-	127	215
		5	78	112	114	-	-	615	919
18/7		2	31	34	42	-	-	121	228
		5	104	60	98	-	1	328	591
9/8	1745	2	146	17	11	-	-	77	251
		5	271	25	16	1	-	364	676
9/8	1745	2	99	9	110	-	-	98	316
	1745	5	270	105	51	-	-	349	775
11/8	0700	2	132	56	40	-	-	404*	632
11/8	0700	2	82	47	29	-	-	296*	454
12/8	0700	5	91	59	46	-	-	340	536
12/8	1300	2	234	78	52	-	3	311*	678
		2	49	8	14	-	2	53*	126

Station 8

28/6	1500	2	4	10	-	2	-	4	20
		5	30	70	-	-	2	0	102
3/7		2	31	28	17	5	5	7	93
		5	103	91	35	1	1	27	258
11/7	1655	2	8	24	16	-	-	214	262
		5	125	116	156	-	1	32	430
18/7	0900	2	34	242	12	-	-	15	303
		5	85	318	11	-	-	37	451
27/7	1800	2	65	182	40	1	-	26	314
		5	142	221	35	-	-	6	404

Station T 30 W

9/8	1800	2	24	13	25	-	1	61	124

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station 51

7/8	1020	2	55	88	53	-	3	197	396
		5	89	27	63	-	-	180	359

Station 52

7/8	1140	2	105	127	210	-	-	38	480
		5	164	115	97	-	-	5	381
		10	429	166	283	-	5	-	883
11/8	1900	5	189	67	62	-	1	-	319

Station 53

7/8	1140	2	151	158	67	1	-	11	388
		5	78	64	114	-	1	19	276
		10	420	387	463	-	-	2	1272
		15	367	254	310	-	-	67	998
		20	433	241	267	1	-	2	944
		28	358	204	342	-	1	12	917

Station 54

7/8	1415	2	56	77	24	-	1	3	161
		5	368	271	142	-	-	8	789
		10	367	130	380	-	2	13	892
		15	472	193	454	-	7	37	1163
		20	440	119	417	-	-	-	976
		28	328	128	386	-	3	30	875
20/8	1020	2	208	242	116	-	-	4*	570
		2	74	85	110	-	-	-*	269
		5	233	191	109	-	4	5	542
		10	266	181	131	-	-	4	582
		15	510	473	456	1	2	6	1448
		20	581	392	194	1	3	-	1171

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station 55

9/8	1500	5	170	110	244	-	-	4	528
9/8		10	277	132	206	-	-	4	619
		15	432	258	149	-	3	-	842
20/8	1315	2	118	215	83	-	1	-*	417
		2	31	58	14	-	-	2*	105
		5	60	86	73	-	1	9	229
		10	279	98	165	-	1	-	543
		10	340	182	171	-	-	6	699
		20	250	239	126	-	-	2	617
	2130	20	786	693	775	-	2	7	2263

Date	Time	Depth(m)	1	2	3	4	5	6	Total
1972									
<u>Station 56</u>									
9/8	1645	10	211	155	385	-	-	70	821
		15	262	90	466	-	-	5	823
	1745	2	101	54	131	2	-	19	307
		20	611	272	164	2	-	15	1064
11/8	0700	2	390	169	111	-	-	47	717
11/8	1000	2	149	59	43	-	-	-*	251
		2	257	161	137	-	-	-*	555
		5	257	101	173	-	1	-*	532
		5	321	186	202	1	-	1*	711
		10	660	300	338	-	-	1*	1299
		10	545	306	81	-	-	2*	934
		15	243	129	90	-	-	1*	463
		15	399	203	243	-	4	-*	849
		20	195	86	146	-	-	1*	428
		20	342	141	117	-	-	7*	607
11/8	1041	2	280	95	-	-	-	-	375
11/8	1300	2	201	205	94	-	-	-	500
		5	465	241	286	-	-	12*	1004
		5	11	19	2	-	-	-*	32
		10	341	200	178	-	4	6*	729
		10	356	161	56	-	-	4*	577
		15	235	97	88	-	-	-*	420
		15	309	190	116	-	-	3*	618
		20	344	104	85	-	-	6*	539
		20	364	156	142	-	2	-*	664
		15	224	134	216	-	-	22	596
20/8	1515	20	829	513	646	-	6	21	2015
		2	362	79	45	-	-	1	487
		5	227	32	156	-	-	1	416
		12	149	73	81	-	-	3	306

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station 57

7/8	1730	2	132	114	35	-	-	19	300
9/8	1730	5	92	39	184	-	1	16	332
12/8	1730	2	5	15	2	-	-	6	28
20/8	1730	2	103	59	58	-	-	9	229
		5	2	4	7	-	-	-	13

Station 58

9/8	1800	2	114	47	122	-	3	-	286
		5	206	109	140	1	-	56	512

Station 61

10/8	1600	2	53	34	46	-	-	41	174
10/8	1900	2	40	40	95	-	1	60	236
11/8	0700	2	876	309	253	-	-	21	1459
		5	310	132	104	-	-	3	549
		10	429	287	191	1	4	2	914
		15	678	356	219	1	5	59	1318
11/8	1900	2	245	54	55	-	1	5	360
		5	270	106	52	1	5	6	440
		10	298	76	515	-	-	-	889
		15	215	114	515	-	2	2	848
		20	730	369	252	-	7	21	1379
12/8	1000	2	49	41	34	-	1	33*	158
		2	32	48	42	-	-	25*	147

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station 62

8/8	1900	15	272	226	395	-	3	5	901
10/8	1600	2	47	18	20	-	-	8	93
11/8	0700	2	300	111	96	-	-	23	530
		5	460	156	94	-	-	4	714
		10	202	85	59	-	1	1	348
		15	682	392	205	1	3	-	1283
		20	569	308	280	-	-	4	1161
11/8	1900	2	107	36	145	-	1	-	289
		10	353	208	430	-	4	82	1077
12/8	1000	2	26	23	19	-	-	11	79
		5	196	27	135	-	2	2	362

Station 66

11/8	1600	2	193	65	215	-	2	-*	475
		2	138	67	69	-	3	15*	292
		15	267	138	432	-	-	6	843
		20	493	104	610	-	7	14	1228

Station T 13 W

7/8	1400	2	159	133	235	5	3	8	543
		5	225	137	126	1	-	6	495
20/8	0930	2	42	26	16	-	-	2*	86
		2	74	54	45	-	-	5*	108
		5	152	77	47	-	-	5	280

Date	Time	Depth(m)	1	2	3	4	5	6	Total

1972

Station T 15 E #85

20/8	1130	2	164	63	44	-	-	-*	271
		2	85	99	138	-	-	4*	326
		5	215	90	94	2	-	-	401

APPENDIX V

Lake Temperatures

APPENDIX V - Lake Temperatures

Temperatures, °C

June 16, 1972

	Stn 1	Stn 2	Stn 3	Stn 4	Stn 5	Stn 6	Stn 7	Stn 8
<u>Depth</u> <u>metres</u>								
Surface	11.2	3.5	3.5	4.0	3.5	3.2	3.4	4.0
2m	11.8	4.0	3.8	4.0	3.7	3.7	4.0	4.0
4m	11.8	4.5	4.5	4.0	4.0	4.0	4.0	4.0
6m	11.6	4.0	4.0	4.0	4.0	4.0	4.0	4.0
10m		4.0	4.0	4.0	4.0	4.0		
15m		4.0	4.0	4.0	4.0			
20m			4.0	4.0	4.0			
30m			4.0	4.0	4.0			

June 21, 1972

Surface	12.5	6.0	5.5	5.0	4.5	4.5	8.0
2m	12.0	7.0	6.0	5.0	4.5	4.5	7.0
4m	12.0	7.2	6.5	5.5	4.5	4.5	6.0
6m	11.9	7.5	6.0	5.5	4.5	4.5	6.1
10m		5.3	6.5	4.7	4.5	4.5	
15m		6.1	6.0	4.8	4.5	4.5	
20m		6.1	5.5	5.1	4.5	4.5	
30m		6.1	5.5	4.8	4.5	4.5	

APPENDIX V - TEMPERATURES⁰C (continued)

July 1, 1972

Depth metres	Stn1	Stn2	T4W	Stn3	12.5E	Stn4	13.5W	Stn5	T22E	Stn6	T22W	Stn7	Stn8
Surface	12.0	8.0	11.5	7.0	9.0	9.0	11.5	11.0	8.2	8.5	10.0	10.0	11.0
2m	12.0	8.0	11.4	7.0	6.0	5.0	9.0	8.6	7.5	6.2	8.0	6.5	9.9
4m	11.0	7.1	11.2	7.0	6.0	5.0	8.0	7.0	5.0	4.9	5.5	4.2	8.9
6m	11.0	6.5	11.0	6.5	5.7	5.0	6.5	5.8	4.3	4.2	4.9	4.5	8.7
10m		6.5		6.0		5.0		5.2		4.0			
15m		6.0		5.0		5.0		5.0		4.0			
20m		4.5		4.5		5.0		4.5		4.0			
30m		4.5		4.5		5.0		4.2		4.0			

July 12, 1972

Surface	15.5	15.0	14.8	13.5	12.1	14.8	15.0	14.0	14.2	14.9	14.2	14.8	16.0
2m	13.6	11.8	13.0	13.0	11.5	14.0	12.0	14.0	12.0	14.5	13.5	13.5	14.2
4m	11.0	9.5	11.0	11.2	11.3	11.0	10.0	11.5	8.0	8.0	11.8	9.5	12.8
6m	8.0	6.5	8.0	9.2	11.3	8.0	7.0	7.5	6.5	6.8	6.5	7.0	11.0
10m		6.0		6.0		6.3		5.0		5.2			
15m		5.8		5.7		5.2		4.2		4.5			
20m		5.6		5.0		4.9		4.0		4.2			
30m		5.5		5.0		4.2		4.0		4.0			

Secchi 7.5m 8+m 9m 9m 9.5m

TEMPERATURES AT NETTING STATIONS

July 1, 1972

Depth metres	12.5E	19.5W	20.5E	20W	22W	22E	25W	26W	26E	28W	28E	30W	30E
Surface	9.0	11.0	8.9	9.0	10.0	8.2	13.0	10.5			12.5		
2m	6.0	10.0	6.0	8.2	8.0	7.5	7.8	8.0			9.7		
4m	6.0	8.5	6.0	7.0	5.5	5.0	6.0	6.8			8.0		
5m	5.7		4.2		4.9	4.3	5.0	6.6			7.0		

July 12, 1972

Surface	15.0	13.0	14.2	14.5	14.2		16.5	13.8	15.2	16.0	15.0		
2m	15.2	12.5	13.8	14.0	13.5		14.0	11.8	15.1	15.2	14.2		
4m	15.0	11.1	9.2	11.5	11.8		11.2	11.0	10.6	10.2	11.6		
5m		7.2	7.1	8.4	6.5		5.5	10.5	6.5	9.6	9.5		

July 27, 1972

Surface	11.5		11.7	11.5	11.8	11.5	12.0	12.2	11.8				
2m	11.5		11.7	11.5	11.8	11.5	12.0	12.0	11.8				
4m	11.6		11.6	11.5	11.5	11.4	11.8	11.8	11.6				
5m	11.5		11.6	11.4	11.2	11.3	11.5						

TEMPERATURES AT NETTING STATIONS

July 1, 1972

Depth metre	3W	2E	4W	4M	4E	5	6E	8W	8E	9.5E	11W	11E	13.5W
Surface	12.0	13.0	11.5	9.2	15	13	9.0	8.9		7.0	7.0	7.0	11.5
2m	11.2	12.9	11.4	7.8	12	12.7	7.7	8.9		6.8	6.9	6.5	8.0
4m		9.9	11.2	8.0		12.5	7.2	8.7		5.5	6.9	5.5	6.5
5m		9.7	11.0	7.6			7.0			5.0	6.0	4.9	

July 12, 1972

Surface	12.1	15.5	14.8	14.2	19.0	16.8	12.8			13.2	13.8	14.0	15.0
2m	12.1	13.2	13.0	12.0	13.8	15.1	11.0			13.0	10.0	13.5	12.0
4m		8.0	11.0	7.2	12.7	14.4	10.0			12.5	7.0	13.0	10.0
5m		8.0	8.0	6.8			8.9			12.2	6.0	12.0	7.0

July 27, 1972

Surface			11.0	11.0		11.2	11.0			11.5	11.3		
2m			10.5	10.9		11.2	10.8			11.4	11.3		
4m			10.0	10.6		11.2	10.7			11.4	11.2		
5m			10.0			11.2	10.5			11.4	11.1		

APPENDIX V TEMPERATURES °C (continued)

July 27, 1973

Depth metres	Stn1	Stn2	T4W	Stn3	12.5E	Stn4	13.5W	Stn5	T22E	Stn6	T22W	Stn7	Stn8
Surface	12.0	11.0	11.0	10.8	11.5	10.5			11.5	12.0	11.8	12.1	
2m	12.0	10.9	10.5	10.8	11.5	10.5			11.5	11.5	11.8	12.1	
4m	12.0	10.8	10.0	10.8	11.5	10.4			11.4	11.2	11.5	12.1	
6m	12.0	10.8	10.0	10.8	11.5	9.8			11.3	11.1	11.2	12.0	
10m		10.0		10.8		9.2				11.0			
15m		9.0		10.4		8.0				10.9			
20m		8.0		10.0		7.2				6.0			
30m		7.3		8.0		6.5				5.0			

Secchi	5		8m		8+m		8.5m						
August 8, 1972													
Surface	13.2	13.9	13.1	14.1	12.1	11.5		11.5	9.0	7.7	6.9		11.9
2m	13.2	13.0	13.0	13.0	11.5	11.3		10.5	7.5	6.2	6.5		11.0
4m	13.1	12.8	13.0	13.0	11.3	11.1		10.2	6.2	6.1	5.1		11.0
6m	13.0	12.8	13.0	12.8	11.3	11.0		10.0	6.2	6.0	5.0		10.9
10m		12.8		12.7		10.9		9.2		5.9			
15m		12.0		12.5		10.5		8.5		5.8			
20m		11.0		6.2		10.1		8.0		5.5			
30m		11.0		6.2		9.0		6.3		5.2			

Sechhi	6.0		8.5		8.5		9+m		9+m				

TEMPERATURES AT NETTING STATIONS (continued)

August 8, 1972

Depth metres	3W	2E	4W	4M	4E	5N	6E	8W	3E	9.5E	11W	11E	13.5W
Surface	12.4	13.8	13.1	13.5	15.5	13.8	14.5	13.2		14.2	12.9	13.0	
2m	12.4	13.5	13.0	13.1	15.5	13.2	13.8	13.1		14.0	12.2	12.0	
4m		13.5	13.0	13.1	15.0	13.2	13.3	13.0		12.8	12.0	11.5	
5m		13.5	13.0	13.1		13.1	13.2	13.0		12.5	12.0	11.3	

August 25, 1972

Surface	12.2	10.8	12.0		12.1	12.0	11.0		11.2	10.9	10.5	11.0
2m	12.2	10.8	12.0		12.0	12.0	10.8		11.1	10.8	10.4	10.9
4m	12.2	10.8	12.0		12.0	12.0	10.8		11.1	10.8	10.2	10.5
5m	12.2	10.7	12.0		12.0	11.9	10.8		11.0	10.8	10.0	10.5

TEMPERATURES AT NETTING STATIONS

August 8, 1972

Depth metres	12.5E	19.5W	20.5E	20W	22W	22E	25W	26W	26E	28W	28E	30W	30E
Surface	12.1	11.0	10.7	11.5	6.9	9.0	7.1	8.5	10.1	11.0	12.9	11.9	11.9
2m	11.5	11.0	10.2	10.2	6.5	7.5	5.5	6.2	9.6	10.5	11.8	11.0	11.0
4m	11.3	10.0	10.0	10.0	5.1	6.2	5.0	6.0	6.0	10.2	10.5	11.0	
5m	11.3	9.8	10.0	9.9	5.0	6.2	5.0		5.5	9.8	10.5	11.0	

August 25, 1972

Surface	12.5	10.5	11.1	11.0	9.1	11.0	10.0	9.9	12.0	11.5	11.8	10.1	
2m	12.5	10.1	11.0	10.6	9.0	11.0	9.9	9.5	11.9	11.5	11.7	10.1	
4m	12.5	9.7	10.9	9.9	8.5	10.9	9.8	9.2	11.8	11.4	11.7	10.0	
5m	12.0	9.0	10.2	9.6	8.0	10.6	9.0			11.2	11.5	9.9	

TEMPERATURES (%) °C

August 25, 1972

Depth metres	Stn1	Stn2	T4W	Stn3	12.5E	Stn4	13.5W	Stn5	22E	Stn6	22W	Stn7	Stn8
Surface	13.1	12.0	10.8		12.5	12.5	11.0	11.5	11.0	10.1		10.9	10.0
2m	13.1	12.0	10.8		12.5	12.0	10.9	11.0	11.0	10.1		10.5	9.9
4m	13.1	11.9	10.8		12.5	12.0	10.5	11.0	10.9	10.0		9.9	9.9
6m	13.1	11.9	10.7		12.5	12.0	10.5	10.9	10.6	9.0		8.4	9.8
10m		11.9	10.5		12.0	11.5	8.5	9.0	10.0	8.0			
15m		11.9				9.9		8.7		7.2			1
20m		11.9				8.5		7.0		6.2			08
30m						6.5		6.3		6.1			1

Secchi(meters)

8+m

A P P E N D I X F

MEMORANDUM REPORT ON MINIMUM FLOW REQUIREMENTS
IN UPPER AISHIHIK RIVER, 1974

C. E. WALKER,
FISHERIES AND MARINE SERVICE,
1974

MEMORANDUM NOTE DE SERVICE

DATE 3 September 1974.

FROM:
DE:

C. E. Walker,
Senior Biologist.

Our file Notre référence
31-5-17-5

TO:
A:

A. Gibson,
Chief,
Northern B. C. & Yukon Division.

Your file Votre référence

SUBJECT:
SUJET:

The Question of Minimum Flows in the upper Aishihik River
and Immediate Remedial Measures.

During the summer of 1974 biological studies were carried out on the water-course between Aishihik and Canyon Lakes to determine minimum flows requirements for the maintenance of the fish populations in this area. The study area (fig. 1) actually involved four localities, namely: from Aishihik Lake to Canyon Pond (Aishihik "A"), Canyon Pond, from Canyon Pond to Canyon Lake (Aishihik "B"), and Giltana Creek. The facilities that were constructed to maintain flows in Aishihik "A" and to provide controlled experimental flows were a fish bypass from the outlet of Aishihik Lake to a point 600 feet downstream of the lake and a spillway channel from Aishihik Lake to Canyon Pond (Fig. 2). The periods of study and approximate water levels are given below:

Period	Approximate discharges.			
	Aishihik "A"	Spillway Channel	Giltana Creek	Aishihik "B"
May 23-July 9	150-350	0	25-137	175-450
July 9-July 22	62	0	13	75
July 22-Aug 2	20	65	10	95
Aug 2-Aug 8	59	148	13	220
Aug 8-Aug 20	63	99	19	181
Aug 20 -	133		22	155

The change in discharge from the normal directly to the absolute minimum level was made on the basis that the coffer dam provided no opportunity to store water in Aishihik Lake. Hence, if the lowest flow situations were not studied initially, there was no guarantee that they could be done later in the season. The flows from Aishihik Lake were limited to a narrow range by a combination of design specifications for the control gate and lower than normal lake level (low in-flow year).

.../2

The data have been only superficially examined at this time and are subject to revision. Invertebrate samples have yet to be processed and therefore cannot enter into consideration of minimum flows. The recommendation therefore is based on the distribution and survival of fish at the various flows in combination with the physical conditions of the waterway.

Aishihik "A"

The migrating and feeding activities of the fish appeared to be carried out at all levels of flow. However, a loss of juvenile fish by bird predation was apparent at 20 cfs. Effective stream area at 20 cfs. was estimated to be <60% of the norm.

Aishihik "B"

At flows of 75 & 95 cfs. The fingerling (1 year fish) had abandoned the extensive shelf areas and were found in the stream trench along with the larger fish. Fry were unable to occupy the usual bank area and therefore inhabited stream edge waters over flat shallows. Losses to fry and fingerling arose from bird predation and warm temperatures during the two lowest flows in Canyon Pond. Normalcy in terms of fish distribution and apparent survival ie. fry alongside the stream bank, fingerling on the shelves, and adults in the trench, was found to exist to 155 cfs.

Effective stream area was reduced by approximately 75% of norm at flows of 75 & 95 cfs. Water temperatures increased with the highest being recorded on the flat shelf or beach areas where 72°F was not uncommon on warm days. Previously the maximum edge-of-stream temperature was in the order of 60-62°F.

*Effective stream area is a combination of wetted area and discharge. Wetted area by itself does not appear to be meaningful in that wetness does not necessarily guarantee velocity and depth. The estimate therefore is based on areas having a discernible current and a depth of not less than 4".

Canyon Pond: The most observable change to the fish stock was the distribution of fry. In the large part, the fry which at normal water levels inhabited the area of aquatic plants were forced to retreat to relatively plantless water areas over shallow sloping beaches. This theoretically eliminated the benefit of shelter that the fry enjoyed in the plant community and seriously reduced the production of food. As for the former, predation by birds was evident.

The 0.82' drop in the level of Canyon Pond practically removed 6 adjacent pools in the flats area from use by fry. Water temperature increased in Canyon Pond significantly with lower levels. In an east-west direction (ie. at right angle to the flow) the temperature

variation between mid pond and shore pond waters was in the order of 2.5°F at normal levels but increased to 11°F difference at low water levels. Temperatures in the main flow through Canyon Pond normally increased 1°F however at the lowest flows, the temperature increased 4.5°F depending upon sunshine and wind conditions.

The lower water levels in Giltana Creek had no observable effect on fish in that area.

Overall, the decrease in out-flows from Aishihik Lake appeared to have the greatest detrimental effect on Aishihik "B". Based on the experimental flows provided in 1974, the minimal conditions that are required to maintain the fish stocks in Aishihik "B" appears to be a bench average depth of 0.70 feet and a bench average velocity of 1.08 feet/second at the cable crossing site.

In so far as immediate measures are concerned, two areas will require gravel and rock fill following conclusion of construction activity in the study areas:

1. The lake outlet served as a spawning area for whitefish (Bryan MS) and this has been totally disrupted with the building of the dam. It is recommended that gravel and rock be placed in the water course from the control gate to immediately out side (ie. lake side) of the coffer dam. Specs are 60%-2"-4" 40% 4"-12".
2. The stream bed from the control gate to the island area (500') has been trenched resulting in a 50% loss of the stream invertebrate population. It is recommended that rock be placed in the trench to provide an opportunity for aquatic life to rehabilitate the area. Specs are 6"-12".

A. Crookson
Mr. C. E. Walker,
Senior Biologist.

CEW:djp

Measurements at Aishihik B.

	Shelf			Trench			%water in trench
	discharge	Av.depth	Av.vel.	discharge	Av.depth	Av.vel.	
22/7/73	317	1.5	2.55	253	2.7	3.35	44
15/7/73	271	1.4	2.22	235	2.6	3.18	46
3/7/73	202	1.3	1.87	204	2.5	3.05	50
18/7/74	17	0.6	0.46	75	1.9	1.62	81
23/7/74	24	0.6	0.55	76	1.7	1.54	76
3/8/74	82	0.9	1.24	123	2.3	1.90	60
10/8/74	77	0.7	1.23	122	2.2	1.85	61
22/8/74	68	0.7	1.08	87	1.8	1.67	56

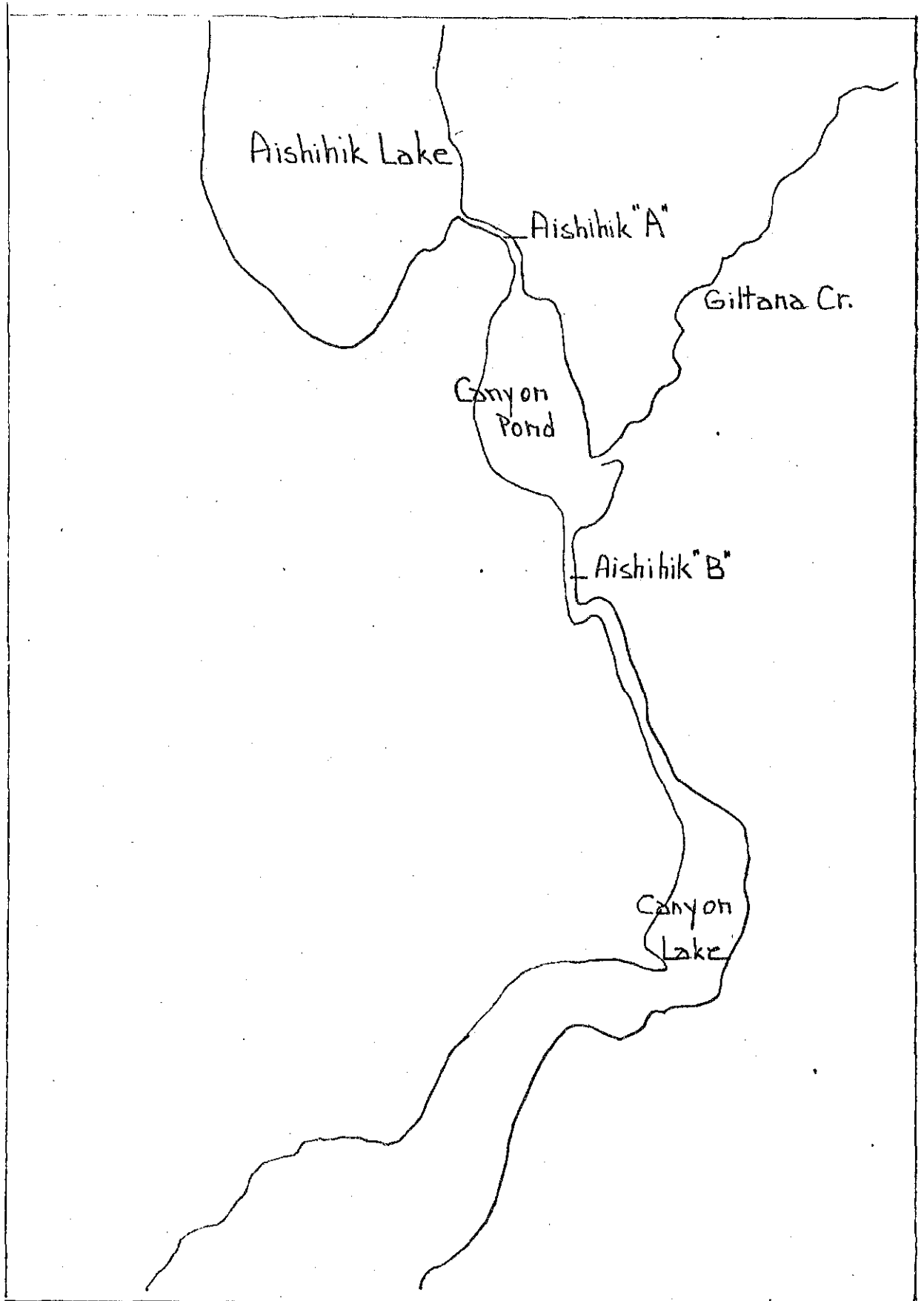


Fig.1. Study area in 1974

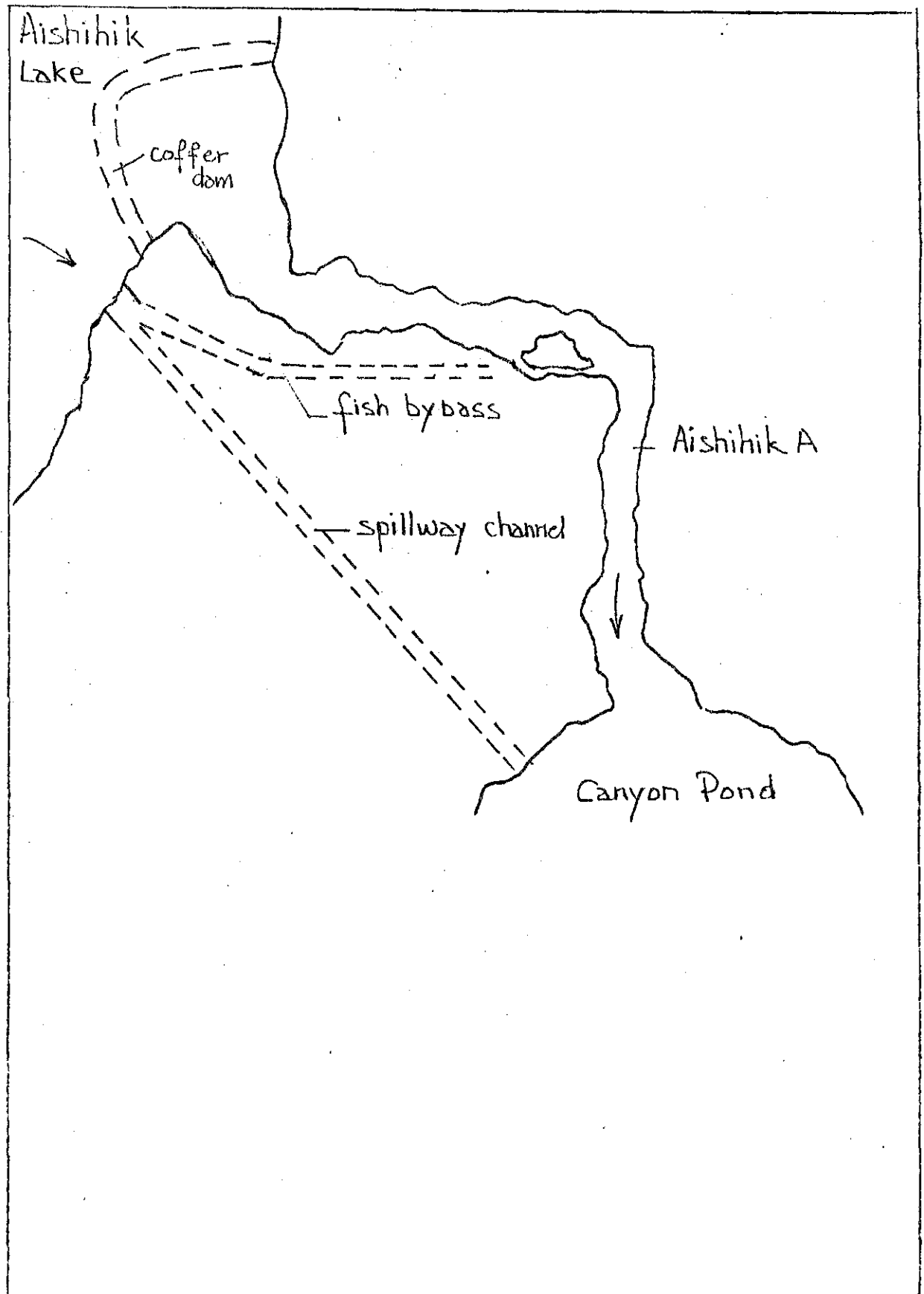


Fig.2 Flow control structures adjacent to Aishihik A



MEMORANDUM NOTE DE SERVICE

DATE Sept. 10, 1974.

FROM:
DE:

C. E. Walker,
Senior Biologist.

Our file Notre référence 31-5-17-5

TO:
A:

A. Gibson,
Chief,
Northern B. C. & Yukon Division.

Your file Votre référence

SUBJECT:
SUJET:

Aishihik problems.

Further to the memo titled "The question of minimum flows in the upper Aishihik River and immediate remedial measures" and dated September 3, 1974, the following comments are submitted for the record:

1. The significant reduction in the outflow from Aishihik Lake commencing July 8 dropped the level of Canyon Pond by almost one foot. This in turn reduced the amount of wetted area available to the two youngest age classes (fry and 1 yr. olds), particularly the shallow wetted areas harbouring aquatic plants. Hence, shelter and possibly food opportunities for small fish were significantly lessened. To correct this situation, the undersigned requested the placement of a rock plug in the trench of Aishihik "B" at the outlet of Canyon Pond. However, the engineering personnel pointed out that a plug would affect the situation in a very small way and advised that a weir across the entire stream would be effective. It appeared that the weir concept introduces a new set of problems therefore the raising of Canyon Pond to former levels was deferred for further study.

2. There is a possibility that the operational flow from Aishihik Lake as approved by the Yukon Water Board may be less than adequate to provide the conditions that are necessary for maintaining the fish stocks at current levels. Consequently, there has been some thought and discussion on ways to modify the stream bed so that smaller flows will or almost will provide the desired depth and

velocity characteristics. Two actions appear to be feasible, one reducing the stream width, and two, placing a series of plugs in the channel or trench. Subsequently engineering personnel have prepared a plan to place a series of plugs in the channel of Aishihik "B" and thus spill water unto the shelf areas. The final design will, however, be dependant upon the minimum flow from Aishihik Lake as declared by the Yukon Water Board.

3. A further area deserving consideration for corrective action is Otter pond. At one time the tentative flow schedule was such that no water was to be released into the Aishihik R from Canyon Lake from September to April inclusive. It was thought, therefore, that fish survival in the stream and pond would be nil and no action other than short term salvage was planned. Now however, it appears likely that some water will be released over Otter Falls for a much greater part of a year. Hence survival of fish appears possible. In view of this, it may be advisable to maintain the level of Otter Pond at a relatively high level and thus may be accomplished by a weir located at the outlet of the pond.

A. Coburn
for C. E. Walker,
Senior Biologist.

A P P E N D I X G

REPORT ON INVESTIGATIONS CARRIED OUT BY PACIFIC
BIOLOGICAL STATION FISH HEALTH PROGRAMME PERSONNEL IN THE
YUKON TERRITORY IN 1973

REPORT ON INVESTIGATIONS CARRIED OUT BY PACIFIC BIOLOGICAL STATION
FISH HEALTH PROGRAMME PERSONNEL IN THE YUKON TERRITORY IN 1973

The diversion of water flow from Lake Stevens into Lake Aishihik, proposed within the framework of hydroelectric development on the latter lake, introduces possibilities of faunal exchanges between these two lakes, and potentially, between the entire Yukon River system and Alsek River system. To look into possible danger of such transfaunation to fish health, several members of the Fish Health Programme from the Pacific Biological Station in Nanaimo, B.C., at the request of Fisheries Operations Branch, carried out investigations in both lakes during the summer of 1973. The danger of introducing a previously absent pathogenic microorganism or parasite into a new environment has been amply documented in the literature and the economic consequences have been nothing short of ruinous.

The investigations were directed, therefore, at detection of possible differences between the parasite fauna, bacterial flora and viruses of fish in Lakes Aishihik and Stevens. Parasitological studies included examination of 389 fish (belonging to eight species collected in Aishihik and three collected in Stevens (Table I). Microbiologists examined 247 fish belonging to six species from Aishihik and 53 fish of two species from Stevens. The fish examined for microorganisms (bacteria and viruses) were divided into "large" (results in Table III) and "small" (results in Table IV). The bacteriological studies involved not only microscopic examination of stained tissue smears but also culturing at 19 C of kidney material on the growth media capable of growing most known bacterial pathogens. The virological assays involved incubating inocula prepared from visceral tissues in two assay systems for 2 weeks at 15 C.

Parasitological findings

Forty-six species of parasites were found in fish in Aishihik; exactly half of that number were found in fish in Stevens. A list of the parasites found is presented in Table II. Among parasites present in Aishihik but not in Stevens several are potentially dangerous: Henneguya zschokkei, Hexamita salmonis, Myxosoma sp., Neoechinorhynchus rutili and Discocotyle sagittata. Only one dangerous parasite was found in Stevens but not in Aishihik. It was a tapeworm, Trienophorus nodulosus. The dangerous potential of Discocotyle sagittata was demonstrated by heavy infection of humpback whitefish in Aishihik causing extreme degree of anaemia and emaciation.

Microbiological findings

No bacterial or viral pathogens were detected in any of the fish examined. Only two obviously diseased fish were collected. They were specimens of northern pike from Stevens, bearing superficial tumours that were not observed in Aishihik. It could not be determined whether this condition is contagious.

Discussion of results

Before drawing conclusions from data outlined above, attention should be drawn to the nature of these data. The first important fact is the relatively

small sample size on which they are based, particularly from Stevens. It is possible that more extensive sampling could uncover more species in either lake and alter the general picture. The second fact is the influence of differences in size between the two lakes. Smaller lakes often contain fewer parasite species because they are usually inhabited by fewer fish species and because of direct ecological limitations imposed on the parasites themselves. Hence, absence of harmful parasites in Stevens does not necessarily imply that they are absent from the entire Yukon system. There is, unfortunately, next to no information on the fish parasite fauna in that system. Should some harmful species absent in Stevens be present elsewhere in the system, the dangers attendant on transfaunation would be correspondingly reduced. The danger to the fish populations in Stevens itself, however, would not be lessened by this circumstance.

A special case of the tapeworm Triaenophorus nodulosus must also be taken into account. This parasite, apparently absent from Aishihik, requires development in three hosts to complete its life cycle: a cyclopoid copepod, certain fish (including salmonoids), and the pike. All three are present in Aishihik, so that the introduction of Triaenophorus-infected pike from Stevens into Aishihik might lead to establishment of that parasite in the lake and possibly elsewhere in the Alsek system. As far as it is known, T. nodulosus does not presently occur in that system or other neighbouring systems draining into the Pacific. A possibility of serious effects on the Alsek system pike and, which is worse, on the salmonoid fishes there, must be considered. The introduction of pike from Stevens might also mean spreading of tumours, found in that lake but not in Aishihik, on that fish.

Conclusions

With the above reservations in mind, it can be concluded that faunal exchanges between Stevens and Aishihik might present some danger to fish health in both lakes and, perhaps in both river systems to which they belong. The danger to fish in Stevens might come from the parasite species listed in Parasitological Findings, particularly from Discocotyle sagittata. The salmonoid fish of Aishihik and of other parts of the Alsek system might be threatened by introduction of Triaenophorus nodulosus, either with infected pike from Stevens or by water transport of egg-containing pike excreta. The harm that might result from this to the salmonoid populations is probably the most disquieting feature of the entire problem.

In view of these possible dangers the following safety measures are recommended.

- (i) Erection of some barriers against fish migrations from one lake into the other in both directions.
- (ii) Prevention of pike excreta from Stevens reaching Aishihik, probably possible only by elimination of pike from Stevens and adjacent waters.

The extent of economic damage resulting from successful establishment of T. nodulosus in the Alsek system or of other species in the Yukon system

cannot be assessed at this stage. Any financial outlay for preventive measures, however, seems to be a lesser evil than the potential danger posed by uncontrolled movement of fish between the two river systems.

Fish Health Programme
Pacific Biological Station
Nanaimo, B.C.
September 16, 1974

Table I. Species and numbers of fishes examined from
Aishihik and Stevens Lakes

<u>Species</u>	<u>North</u>		<u>South</u>	
	<u>Spring</u>	<u>Fall</u>	<u>Spring</u>	<u>Fall</u>
<u>Aishihik Lake</u>				
<u>Catostomus catostomus</u>	-	-	6	-
<u>Coregonus clupeaformis</u>	16(6)*	13(2)	19(19)	15(6)
<u>Cottus cognatus</u>	15(6)	15(-)	16(8)	15(1)
<u>Esox lucius</u>	2(1)	1(-)	2(2)	9(1)
<u>Lota lota</u>	1(1)	2(1)	-	-
<u>Prosopium cylindraceum</u>	9(1)	15(-)	20(19)	13(5)
<u>Salvelinus namaycush</u>	15(3)	15(4)	16(15)	15(9)
<u>Thymallus arcticus</u>	10(5)	3(-)	16(16)	15(15)
 <u>Stevens Lake</u>				
	<u>Spring</u>		<u>Fall</u>	
<u>Coregonus clupeaformis</u>	15(6)		15(8)	
<u>Cottus cognatus</u>	-		15(3)	
<u>Esox lucius</u>	14(14)		15(12) + 2 juv.	

*Indicates number of fish from which blood was obtained.

Table II. Comparison of parasite fauna of fishes in Aishihik and Stevens Lakes.

Parasite	Aishihik Lake	Stevens Lake
PROTOZOA		
<u>Chloromyxum dubium</u>	<u>Lota lota</u>	--
<u>Chloromyxum esocinum</u>	<u>Esox lucius</u>	<u>E. lucius</u>
<u>Chloromyxum</u> sp.	<u>Coregonus clupeaformis</u> <u>Thymallus arcticus</u>	<u>C. clupeaformis</u>
<u>Myxidium lieberkuhni</u>	<u>E. lucius</u>	<u>E. lucius</u>
<u>Myxobolus neurobius</u>	<u>Coregonus clupeaformis</u> <u>Cottus cognatus</u> <u>Prosopium cylindraceum</u> <u>Salvelinus namaycush</u> <u>Thymallus arcticus</u>	<u>C. clupeaformis</u>
<u>Myxosoma</u> sp.	<u>Catostomus catostomus</u>	--
<u>Myxobolus</u> sp.	<u>Cottus cognatus</u>	--
<u>Myxobilatus</u> sp.	<u>C. cognatus</u>	--
<u>Henneguya zschokkei</u>	<u>C. clupeaformis</u> <u>P. cylindraceum</u>	--
<u>Sphaerospora cristata</u>	<u>L. lota</u>	--
<u>Epistylis</u> sp.	<u>C. cognatus</u>	--
<u>Trichodina</u> sp.	<u>C. cognatus</u>	--
<u>Hexamita salmonis</u>	<u>C. clupeaformis</u> <u>L. lota</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	--
<u>Haemogregarina</u> sp.	<u>C. clupeaformis</u> <u>P. cylindraceum</u>	<u>C. clupeaformis</u>
MONOGENEA		
<u>Anonchopator olseni</u>	<u>C. catostomus</u>	--
<u>Dactylogyrus buddi</u>	<u>C. cognatus</u>	<u>C. cognatus</u>

cont'd

Table II - cont'd

Parasite	Aishihik Lake	Stevens Lake
<u>Discocotyle sagittata</u>	<u>C. clupeaformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	--
<u>Gyrodactylus bairdi</u>	<u>C. cognatus</u>	--
<u>Tetraonchus borealis</u>	<u>T. arcticus</u>	--
<u>Tetraonchus monenteron</u>	<u>E. lucius</u>	<u>E. lucius</u>
<u>Tetraonchus variabilis</u>	<u>P. cylindraceum</u>	--
DIGENEA		
<u>Allocreadium isoporum</u>	<u>E. lucius</u> <u>T. arcticus</u>	<u>E. lucius</u>
<u>Crepidostomum farionis</u>	<u>C. clupeaformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupeaformis</u>
<u>Crepidostomum metoecus</u>	<u>C. clupeaformis</u> <u>C. cognatus</u> <u>E. lucius</u> <u>L. lota</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupeaformis</u> <u>C. cognatus</u> <u>E. lucius</u>
<u>Diplostomum spathaceum</u> (metacercariae)	all species	all species
<u>Heterophyidae</u> (metacercariae)	<u>C. cognatus</u>	--
<u>Neascus</u> sp. (metacercariae)	<u>C. cognatus</u>	<u>C. cognatus</u>
<u>Tetracotyle</u> sp. (metacercariae)	<u>C. clupeaformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupeaformis</u>
CESTODA		
<u>Cyathocephalus truncatus</u>	<u>C. clupeaformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u>	<u>C. clupeaformis</u>

cont'd

Table II - cont'd

Parasite	Aishihik Lake	Stevens Lake
<u>Eubothrium salvelini</u>	<u>C. clupearformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupearformis</u>
<u>Glaridacris catostomi</u>	<u>C. catostomus</u>	--
<u>Proteocephalus tumidocollis</u>	<u>C. clupearformis</u> <u>C. cognatus</u> <u>E. lucius</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupearformis</u>
<u>Triaenophorus crassus</u>		
adult	<u>E. lucius</u>	<u>E. lucius</u>
plerocercoid	<u>C. clupearformis</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupearformis</u>
<u>Triaenophorus nodulosus</u>		
adult	--	<u>E. lucius</u>
plerocercoid	--	<u>C. cognatus</u>
<u>Diphyllobothrium</u> sp. (plerocercoid)	<u>C. clupearformis</u> <u>L. lota</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupearformis</u>
<u>Schistocephalus solidus</u> (plerocercoid)	<u>C. cognatus</u>	--
ACANTHOCEPHALA		
<u>Neoechinorhynchus rutili</u>	<u>C. cognatus</u> <u>E. lucius</u> <u>L. lota</u> <u>S. namaycush</u> <u>T. arcticus</u>	--
<u>Neoechinorhynchus tumidus</u>	<u>C. clupearformis</u> <u>C. cognatus</u> <u>E. lucius</u> <u>P. cylindraceum</u> <u>T. arcticus</u>	<u>C. clupearformis</u> <u>E. lucius</u>

cont'd

Table II - cont'd

Parasite	Aishihik Lake	Stevens Lake
NEMATODA		
<u>Cystidicola farionis</u>	<u>C. clupeaformis</u> <u>C. catostomus</u> <u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	<u>C. clupeaformis</u>
<u>Capillaria salvelini</u>	<u>P. cylindraceum</u> <u>S. namaycush</u> <u>T. arcticus</u>	--
<u>Haplonema hamulatum</u>	<u>L. lota.</u>	--
<u>Raphidascaris acus</u>		
adult	<u>E. lucius</u>	<u>E. lucius</u>
larvae	<u>C. clupeaformis</u> <u>C. cognatus</u> <u>T. arcticus</u>	<u>C. clupeaformis</u> <u>C. cognatus</u>
COPEPODA		
<u>Salmincola edwardsii</u>	<u>C. clupeaformis</u> <u>S. namaycush</u>	--
<u>Salmincola extensus</u>	<u>C. clupeaformis</u>	--
<u>Salmincola thymalli</u>	<u>T. arcticus</u>	--
HIRUDINEA		
<u>Piscicola milneri</u>	<u>C. clupeaformis</u> <u>E. lucius</u> <u>S. namaycush</u>	<u>C. clupeaformis</u> <u>E. lucius</u>

Table III. Summary of findings for 300 "large" (mature and near-mature) fish sampled from the Aishihik and Stevens Lake systems, summer 1973.

Species	Source ^a	No. samples cultured for bacterial and viral fish pathogens	No. samples with bacterial or viral fish pathogens	No. blood films prepared ^b	No. blood films with blood parasite ^c
Humpback whitefish (<u>Coregonus clupeaformis</u>)	Aishihik	71 ^d	0	27	7
	Stevens	20	0	7	2
Round whitefish (<u>Prosopium cylindraceum</u>)	Aishihik	52	0	26	3
	Stevens	0	0	0	0
Arctic grayling (<u>Thymallus arcticus</u>)	Aishihik	51	0	19	0
	Stevens	0	0	0	0
Lake trout (<u>Salvelinus namaycush</u>)	Aishihik	62	0	19	0
	Stevens	0	0	0	0
Northern pike (<u>Esox lucius</u>)	Aishihik	10	0	3	0
	Stevens	33 ^e	0	12	0
Burbot (<u>Lota lota</u>)	Aishihik	1	0	0	0
	Stevens	0	0	0	0

^aAishihik = Aishihik Lake system - included Sekulmun Lake (where only one fish was collected), the Sekulmun River, North, Central, and South Aishihik Lake, Aishihik Lake outlet stream, Canyon Pond and its outlet stream, and Giltana Creek. The Stevens Lake system - included Stevens Lake, Polecat Lake, and their connecting sloughs.

^bBlood was taken only from fish captured alive.

^cA haemogregarine of uncertain pathological significance; infected fish contained extremely low numbers of the parasite.

^dTwo of these fish were very emaciated and anaemic, due, apparently, to heavy parasitism by the gill fluke, Discocotyle sagittata.

^eOne specimen bore a large superficial tumour; another bore what appeared to be an incipient tumour. Aetiology of these tumours is unknown.

Table IV. "Small" fish collected from Aishikik Lake system using a fine-mesh beach seine, summer 1973.

Species	No. sampled for viral fish pathogens ^a	Samples with virus
Humpback(?) whitefish ^b	~10 (assayed in 2 pools)	0
Arctic grayling ^c	8 (assayed individually)	0
Lake trout	~30 (assayed in 6 pools)	0
Slimy sculpin (<u>Cottus cognatus</u>) ^d	~140 (assayed in 14 pools)	0
Burbot	1	0

^aSpecimens were not examined for bacterial fish pathogens because of their softened condition (on thawing) and small size.

^bJuveniles were thought to be humpback whitefish rather than round whitefish.

^cBlood smears prepared for the eight arctic graylings were free of foreign agents.

^dSome of the sculpins may have been mature specimens.