SUSITNA HYDROELECTRIC PROJECT
FISHERIES MITIGATION OPTIONS

REVISED (MARCH, 1982)

13

ACRES

memo TO: MEMBERS of FISHERIES & WILDLIFE MITIGATION REVIEW GROUP

RE: ACRES LETTER MAR 2/82 SUBJECT AS OF ABOVE.

THIS DOCUMENT WAS NOT RECEIVED UNTIL TODAY.

[signature]
Deputy Resident Manager

ACRES AMERICAN INCORPORATED

SUSITNA HYDROELECTRIC PROJECT

FISHERIES MITIGATION OPTIONS

Revised (March, 1982)

DRAFT

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INTRODUCTION

Mitigation alternatives for impacts associated with the Susitna Hydroelectric Project can be divided into the categories avoid, minimize, rectify, reduce or eliminate, or compensate. However, except for a few very clear, well defined alternatives the placement into one or another of these categories may be very subjective. The intent of this report is to describe, in detail available at this time, the various choices that exist for mitigation of impacts that are believed feasible at this time. The technology is available to accomplish any or all of the mitigation techniques described or mentioned. Mitigation techniques described in one section may also be suitable for other impacts. However, for the purpose of this report, repetition of description has been avoided as much as possible. For example: temperature control is discussed in detail in the section on temperature impacts, but it also may be an integral part of other impact mitigation techniques.

In summary, all mitigation options are viewed as reasonable and possible at this point in time. Additional studies are planned, or being planned, that will add information that will be useful in selecting the most appropriate mitigation method. These studies include the cost of the options, and their conflict with other project objectives.

IMPACT: Loss of grayling habitat in the impoundment areas.

The creation of the Watana and Devil Canyon impoundments will cause the inundation of the mainstem Susitna River and reaches of the tributaries in the impoundment area below the high water (full reservoir) elevation. The tributaries of the Susitna provide grayling habitat in the impoundment zones, supporting approximately 10,000 grayling (ADF&G, 1981). The mainstem Susitna has useful habitat areas in clearwater zones, usually associated with stream mouths. The stream reaches above the high water mark should not be affected negatively. A positive impact for grayling in the stream reaches above the impoundments could come from the reservoirs providing an abundance of overwintering area, if overwintering habitat is population limiting.

A secondary impact, increased fishing pressure, could be caused by the construction personnel working on the project and increased access after the project is operational. Grayling are sensitive to fishing pressure and the populations may not respond well to increased sport fishing pressure.

MITIGATION: Avoiding, minimizing, or reducing the impact on the grayling fishery in the impoundment zones all have project limiting implications. They would all include such options as lowering the height of the dams, relocating the dams, or possibly building only one of the dams. Inasmuch as both dams are needed for the project to be viable, and other more suitable dam locations are not as viable economically and/or environmentally other mitigation options will be more viable. The most practical mitigation methods appear to be associated with management and enhancement of fishery resources. The reservoirs' fishery potential is not completely predictable. However, based on the water quality report (Peterson, 1981) and the reservoir sedimention report (R&M, 1981) some potential may exist for a limited fishery in the Watana reservoir. Additional areas that may be investigated for mitigation of the sport fishery resource that will be lost to inundation include any barren clearwater lakes and streams in the Susitna drainage for their potential for providing a viable sport fishery. It is probable that any clearwater lakes, or streams, that have potential already have fish resources in them. Therefore, although this should be investigated, it is not probable that this will be the most viable option.

The reach of the Susitna mainstem between Devil Canyon and the Chulitna River confluence should also be evaluated in light of the postproject conditions that will exist there. The potential for developing a downstream fishery, in the Devil Canyon to the Chulitna confluence section, is contingent upon the water quality conditions that exist in the postproject period. The post-project water quality conditions will be an improvement over the current summer conditions. A reduction in the solids and turbidity during the summer will result from settling of solids in the reservoirs (R&M, 1981). Also, other mitigative measures associated with controlling the temperature of the discharged water and the flow rates from the project are necessary to develop a sport fishery in this region. These measures are described in other sections of this report. If the proper downstream flow criteria could be met and if the turbidity of this reach of the Susitna is similar to the conditions of the Kenai River, it is possible that substantial improvement in the chinook and coho salmon populations in the Susitna mainstem could occur. Continued and future investigations may further define the potential of this area. These investigations should be designed to provide very specific information about the future possibility of increasing the production of this stretch of river.

Mitigation of reservoir impoundment impacts on the fishery resources could also be accomplished by increasing the fishery resources in other areas, outside the Susitna drainage. However, several lakes in the Susitna drainage have been identified as having potential for increased production of one or more species of salmon. Larson Lake, an 800 acre lake near Talkeetna is a candidate for fertilization, as is Shell Lake, a 1,000 acre lake on the Skwentna, and Byers Lake, a 400 acre lake on the Chulitna drainage. These lakes have been identified as having the potential for increased sockeye production. Finger, Delyndia, and Butterfly lakes have also been identified as lakes that may have increased fishery production potential for additional coho salmon.

Increased fishing pressure, caused by construction personnel, can be mitigated for in the writing of the labor contract. The contract can be written in such a fashion that fishing is prohibited. This would probably be more effective than trying to control fishing through regulation. Regulation control will probably be required when general public access is provided.

The loss of grayling habitat, because of the uncertainty of the reservoir potential, should be considered for mitigation outside of the reservoir areas at this time. In the future, when more is known about the postproject reservoir conditions this view might change. The technology is available to enhance the fishery in other areas, such as the ones previously mentioned. However, because the loss is primarily of a sport fishery nature, the mitigation efforts should, most appropriately be directed toward the enhancement of other sport fishery resources. Increased coho and chinook production in the regions previously discussed could satisfy that goal.

IMPACT: Dissolved gas supersaturation downstream of the Watana and Devil Canyon reservoirs and in the Devil Canyon reservoir.

Nitrogen and oxygen supersaturation downstream of hydroelectric developments can be a problem for fish survival. Gas bubble disease can be caused below dams by total gas supersaturation of about 116 percent. The gas embolism that accompanies this condition occurs when a fish swims near the surface of the river or reservoir where the hydrostatic pressure is less than the pressure required to keep the excess gas in solution. As a result, the gas comes out of solution in the gills and bloodstream causing small bubbles to form in the circulatory system of the fish. If the embolism is sufficiently severe, the fish will die directly from the gas bubble disease. In the milder cases, the fish often dies from secondary infections which set in the damaged tissues.

As large volumes of water spill over a dam into a stilling basin below, air bubbles are entrained and plunged with the main flow deep into the stilling basin. Here, the gas, under high pressure is driven into solution in the water causing a supersaturated condition to exist. The excess gas is not easily liberated from the water. Should a slackwater condition exist downstream, as in another impoundment, the supersaturated condition will exist through the entire slackwater pool and be passed along downstream, In addition, Alaska statutes call for dissolved gas concentrations no higher than 110%. These levels are exceeded under natural conditions downstream of Devil Canyon during the summer.

This problem was recognized early in the design of the Susitna project. In addition, the sequence of development, Watana first then Devil Canyon nine (9) years later, has to be considered in mitigating this impact. Thus, gas supersaturation mitigation is incorporated in the design of both the Watana and Devil Canyon dams.

MITIGATION: The mitigation alternatives that can be used to avoid or minimize nitrogen supersaturation impacts are associated with operational modifications and design of the spilling structures. The following information explains the techniques that have been incorporated to avoid dissolved gas supersaturation at the Watana and Devil Canyon developments.

1. Watana

a. Spill Frequency

Several operational procedures for power production were studies to minimize the frequency of spilling from the Watana reservoir. A simulation of monthly reservoir operation over a period of 32 years of recorded streamflow has been carried out (Appendix A1). The results indicate that the Watana reservoir would spill only rarely, once, in say, 30 years (See Table 1).

b. Spill Discharge

On the basis of monthly simulation (Table 1), the spill rates are estimated to be around 2,300 cfs averaged over one month period. To take account of shorter duration summer floods when spills occur, a flood routing analysis was carried out to estimate peak discharges from the dams.

c. Design and Operation of Outlet Works

In consultation with the fisheries study team, it was decided that spills from the reservoir up to 1:50 year recurrence frequency should be discharged in such a manner as to reduce the potential of nitrogen supersaturaion in the spill discharge and the river flow downstream. Special facilities incorporating fixed-cone valves (Figure 1) have been designed to cater to this requirement. These valves are designed to disperse and break upstream the discharge into small droplets which fall into the river water below with little plunging. For description of the values refer to Volume 1 of main report. It is expected that nitrogen levels in spill discharges will be reduced below about 110% by these facilities. It

SPILL CFS

Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept.
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2342.4	0.0

YEARS

Table I
Watana Spill Predictions

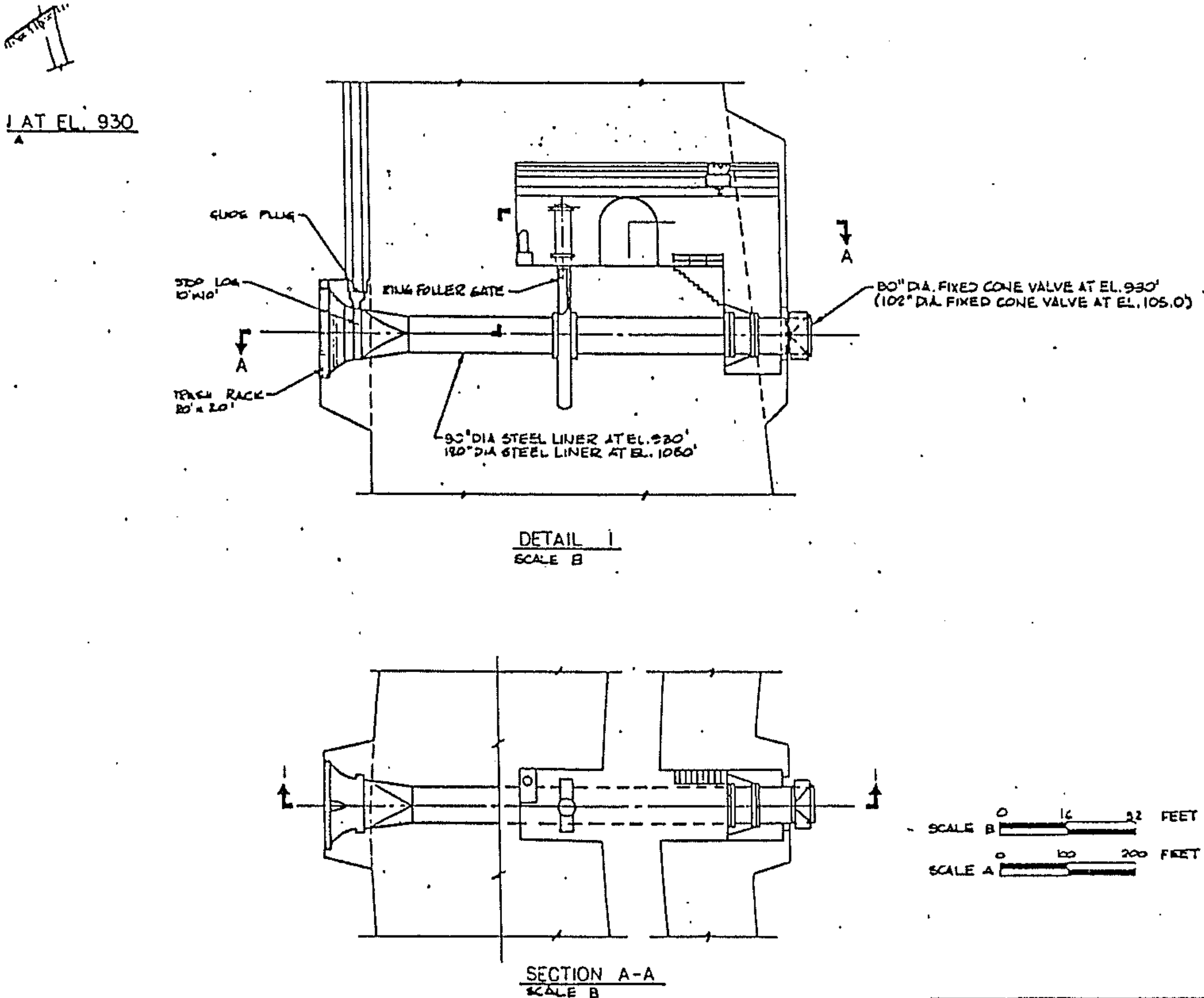


Figure 1
Cone Valves
Watana and Devil Canyon

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

DEVIL CANYON
OUTLET FACILITIES

MARCH 1982

PLATE
76A

is, of course, possible that for floods of lesser frequency than 1:50 year, higher supersaturation levels will occur and such risk is considered acceptable.

2. Watana and Devil Canyon

a. Spill Frequency and Discharge

A similar analysis, as described above, was carried out for the period when both Watana and Devil Canyon development are operational. The frequency of spills increase somewhat (4 times in 30 years, Table 2). Results of the flood routing analysis are presented in Table 3 where pre- and postproject flood peaks are compared.

As in Watana, the spill discharges up to 1:50 year return frequency will be discharged through fixed-cone valves in the Devil Canyon dam. The facility will avoid increasing the gas supersaturation below Devil Canyon to levels higher than natural levels due to project operation.

b. Spilling Rate

The rates of spills that are expected to occur are approximately 321, 1390, 1149, and 3138 c.f.s. (Table 2). The rates are averaged over a 30 day period and the actual spills that occur can be expected to be greater than this average and for a shorter duration than a 30 day period because the flood periods that occur in the Susitna drainage are generally of shorter duration than 30 days. In addition, the reservoirs should be full, or near full, at the time when floods are expected and the excess water will have to be passed by spilling.

SPILL CFS

YEARS

Oct	Nov.	Dec	JAN	Feb	Mar.	Apr.	May	JUN.	July	Aug	Sept.
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	321.6	0.0
0.0	0.0	0.0 *	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	361.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1390.5	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1149.8	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3136.8	0.0

* This spill occurred because of unusual fall run off conditions, and is projected to occur under the operation assumptions used in this simulation model. Under actual operation practice, winter spills would not occur.

Table 2
Devil Canyon Spill Predictions

TABLE 3
ESTIMATES OF PRE AND POST PROJECT
DISCHARGE AND STAGE FREQUENCY ANALYSIS

Devil Canyon Damsite

	Preproject	Postproject
Recurrence Interval	Q (cfs)	Revised Q (cfs)
2	47,000	11,000
5	61,000	12,000
10	71,000	13,000
25	84,000	28,000

Susitna River at Gold Creek

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	49,500	13.4	13,500	8.7	-4.7
5	66,000	14.9	17,000	9.6	-5.3
10	78,000	15.8	20,000	10.1	-5.7
25	94,000	16.7	38,000	12.3	-4.4

Susitna River at Sunshine Station

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	95,000	12.5	59,000	9.3	-3.2
5	124,000	14.8	75,000	10.8	-4.0
10	144,000	16.3	85,000	11.7	-4.6
25	174,000	18.4	118,000	14.3	-4.1

Susitna River at Delta Islands

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	105,000	94.6	69,000	92.7	-1.9
5	138,000	95.6	89,000	94.0	-1.6
10	159,000	96.3	101,000	95.0	-1.3
25	193,000	97.3	137,000	96.0	-1.3

Susitna River at Susitna Station

	Preproject		Postproject		
Recurrence Interval	Q (cfs)	Stage (ft)	Q (cfs)	Stage (ft)	Change In Stage (feet)
2	157,000	16.7	121,000	14.8	-1.9
5	206,000	19.3	157,000	16.7	-2.6
10	239,000	20.9	181,000	18.0	-2.9
25	289,000	23.0	233,000	20.5	-2.5

c. Design and Operation of the Spilling Structures

The structures incorporated into the Devil Canyon dam design for spilling of excess water are cone type valves exactly like the ones in the Watana dam (Figure 1). The valves are designed to disperse and breakup the spilled water. The droplets will fall onto the surface of the stilling basin below and will not penetrate very far below the surface. This will avoid increasing the nitrogen and oxygen supersaturation below Devil Canyon above that which occurs naturally as a result of project operation.

3. Summary Discussion

Total dissolved gas pressure (supersaturation) values are directly related to the waterhead pressure and inversely related to temperature. Thus an increase in the pressure caused by water depth on plunging flows with entrained air below the water surface will increase the amount of dissolved gas in solution. The spill water from a dam can cause this to happen. The mitigation measures described in the preceding paragraphs describe the equipment designed into this project to avoid increasing the amount of gases in the downstream waters or the reservoir waters.

Dissolved gas levels were taken at sites in the Devil Canyon region in 1981 (T.E.S., 1981). The total dissolved gas supersaturation ranged from 105.3% just above Devil Canyon to 116.7% just below Devil Canyon and above Portage Creek at relatively high discharges. Design and operational procedures have been incorporated into the project to avoid the possibility of having an increase in the amount of dissolved gas downstream as a result of the project. In addition to the cone type valves for spilling, operational modes have been explored that reduce the magnitude and frequency of spills to the point that up to the one in 50 year flood can pass through the cone valves and the generating units. The problem of supersaturation of gases has been minimized through design and operation of the facilities.

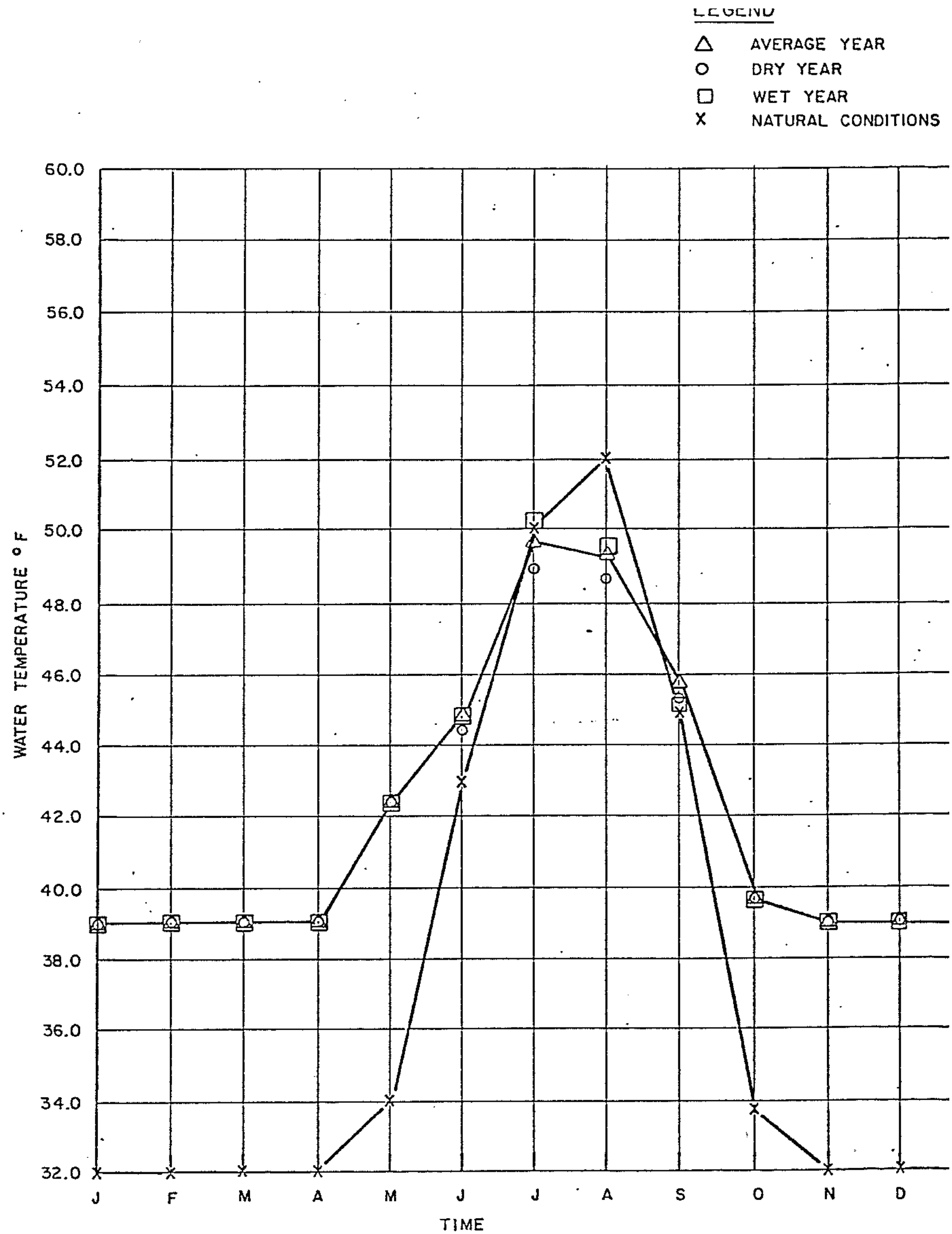
IMPACT: Alteration of the natural temperature regime of the water downstream of the project.

The changes in temperature regimes downstream of hydroelectric projects have caused serious problems for survival of fish stocks downstream of the discharge outfall. Shifting of the temperature events, increased winter temperatures, and decreased summer temperatures have commonly occurred. Structures that provide for selective withdrawal of water from the reservoir to control downstream temperature are essential to avoid adverse impacts on downstream fisheries. Several configurations of the intake structures at Watana and Devil Canyon have been examined to achieve acceptable control of downstream water temperatures during the different seasons.

The temperature structure that normally occurs in the Devil Canyon to Chulitna confluence reach is available from many sources (R&M, 1981, ADF&G, 1981, ADF&G 1975-77, USGS data record, ACRES, 1981). Figures 2 through 8 present the temperature structure of the river reach previously mentioned for wet, dry, and average postproject conditions as well as natural conditions. The winter projections assume 4 C. water discharged from Devil Canyon reservoir. In addition, ADF&G (1975) reports the slough surface waters in the winter to be about 1.2 C. on the average. A slough intergravel measurement taken in September 1981 (ADF&G) reported the temperature at 3 C.

An intergravel temperature study presently being conducted will provide needed information concerning the winter intergravel temperatures in the reach of the river between Devil Canyon and the Chulitna confluence. Predictions of the extent of winter impacts of post-project temperature regimes will be facilitated by the information gathered during this investigation. The source of the water in the sloughs that are productive is from groundwater. The temperature of this groundwater and the intergravel water in the mainstem will be compared to postproject water temperature predictions. The degree of impact associated with the postproject temperature regime will depend on the variance from the normal intergravel conditions.

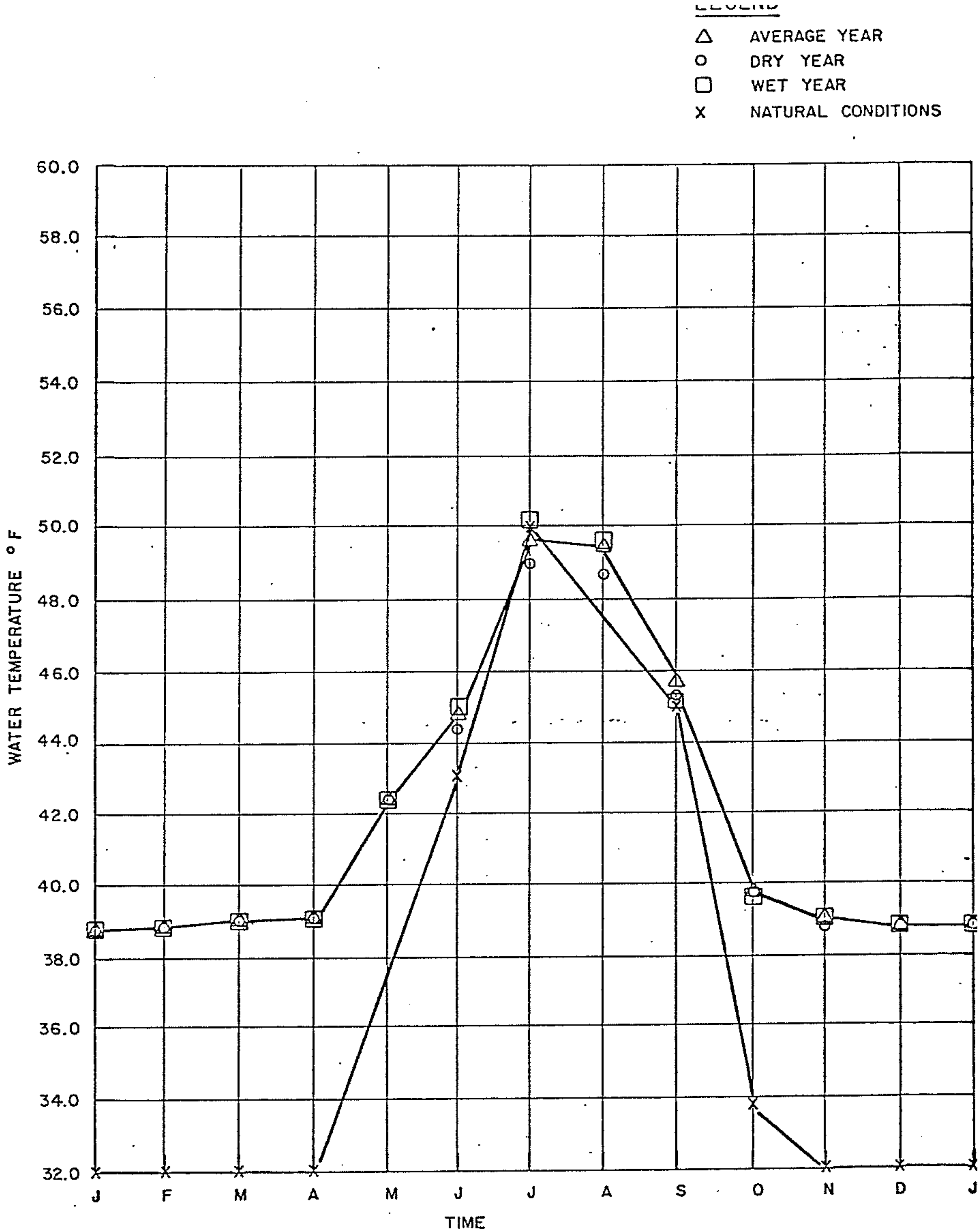
Preliminary data indicate that the intergravel temperatures of the redds is in the vicinity of 2.5 to 4 C. If this temperature is determined, to be the



CROSS SECTION LRX 68

DOWNSTREAM OF DEVIL CANYON DAM SITE

FIGURE 2

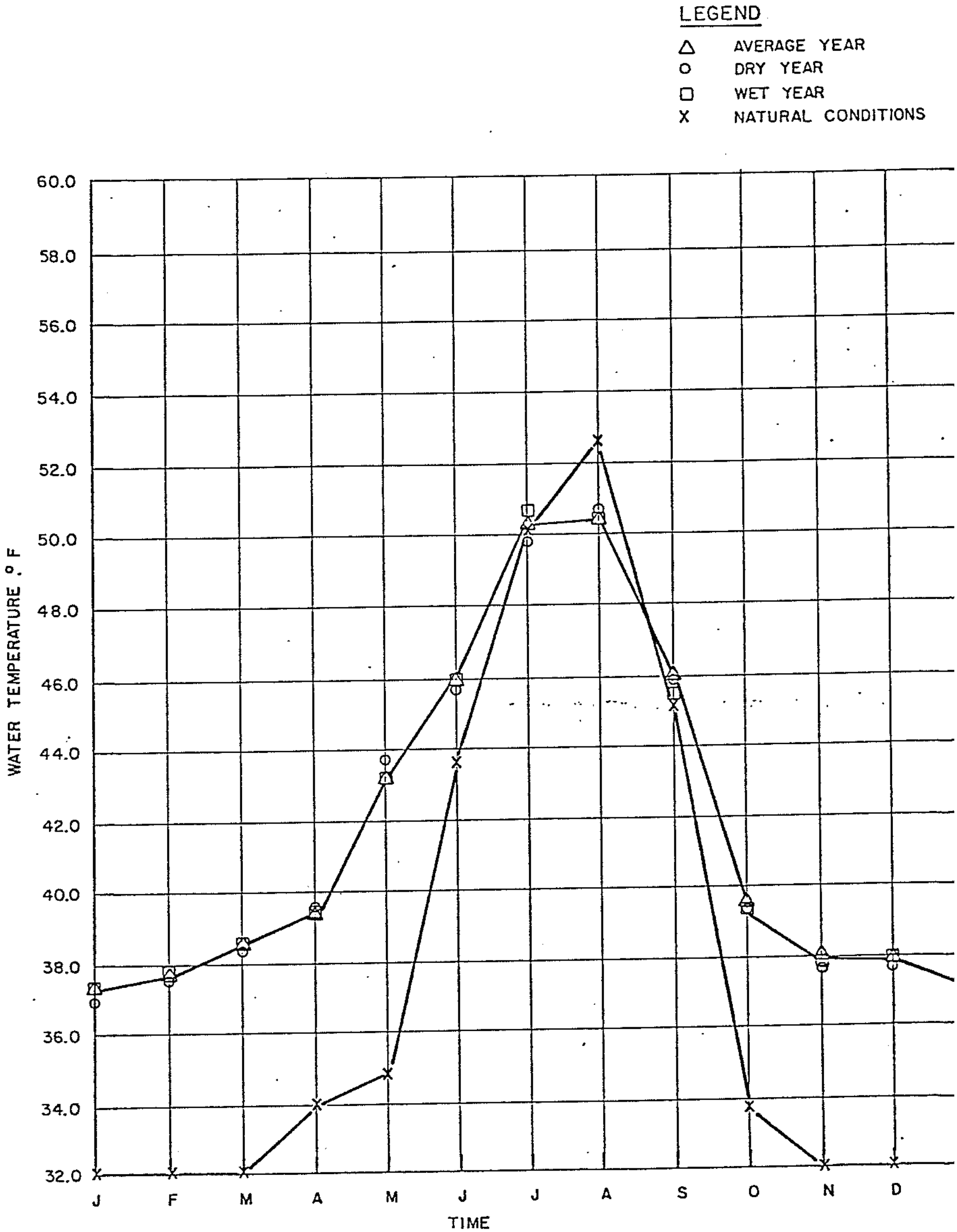


CROSS SECTION LRX 61

DOWNSTREAM OF PORTAGE CREEK

ACRES

FIGURE 3



CROSS SECTION LRX 47

NEAR GOLD CREEK

FIGURE 4

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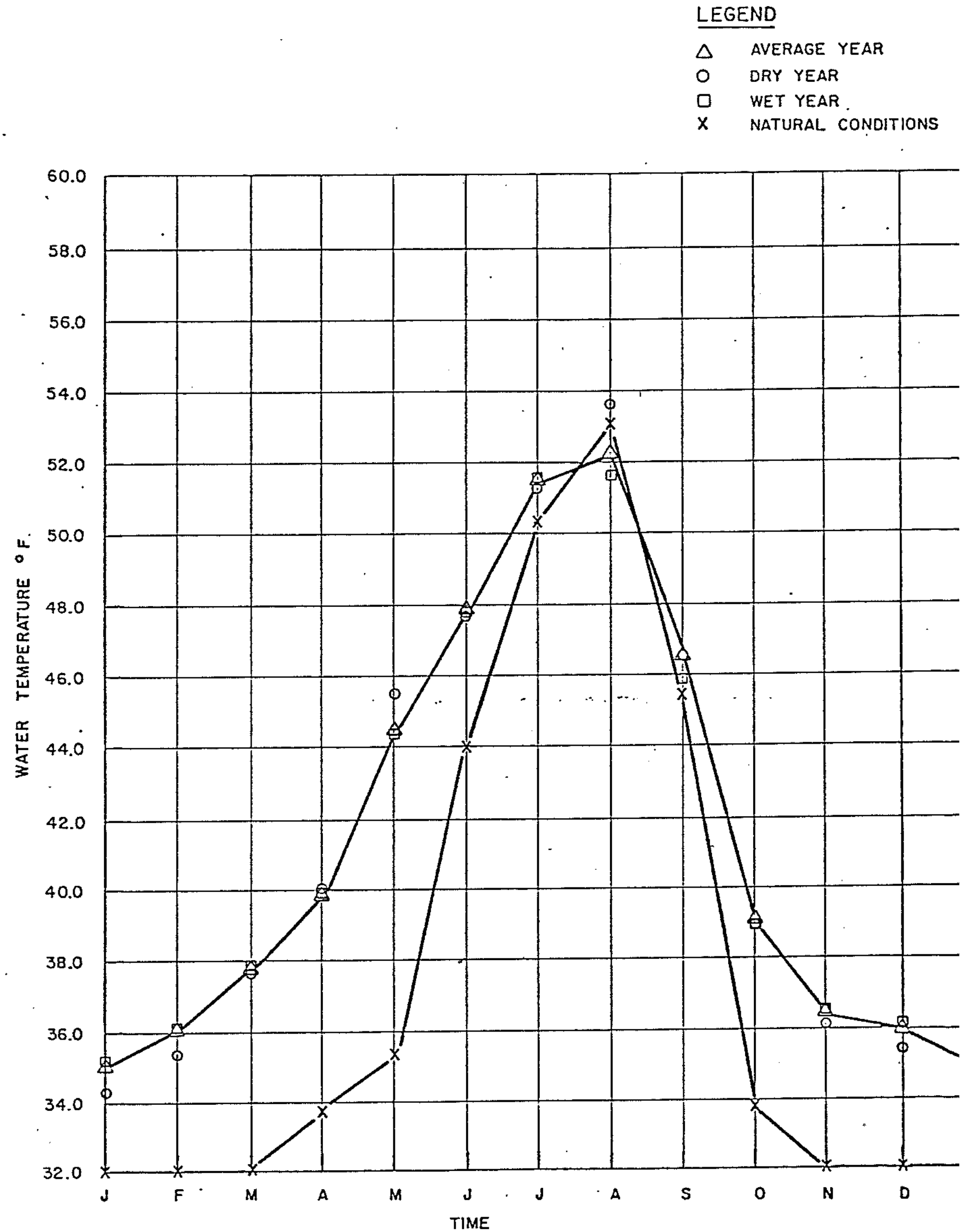
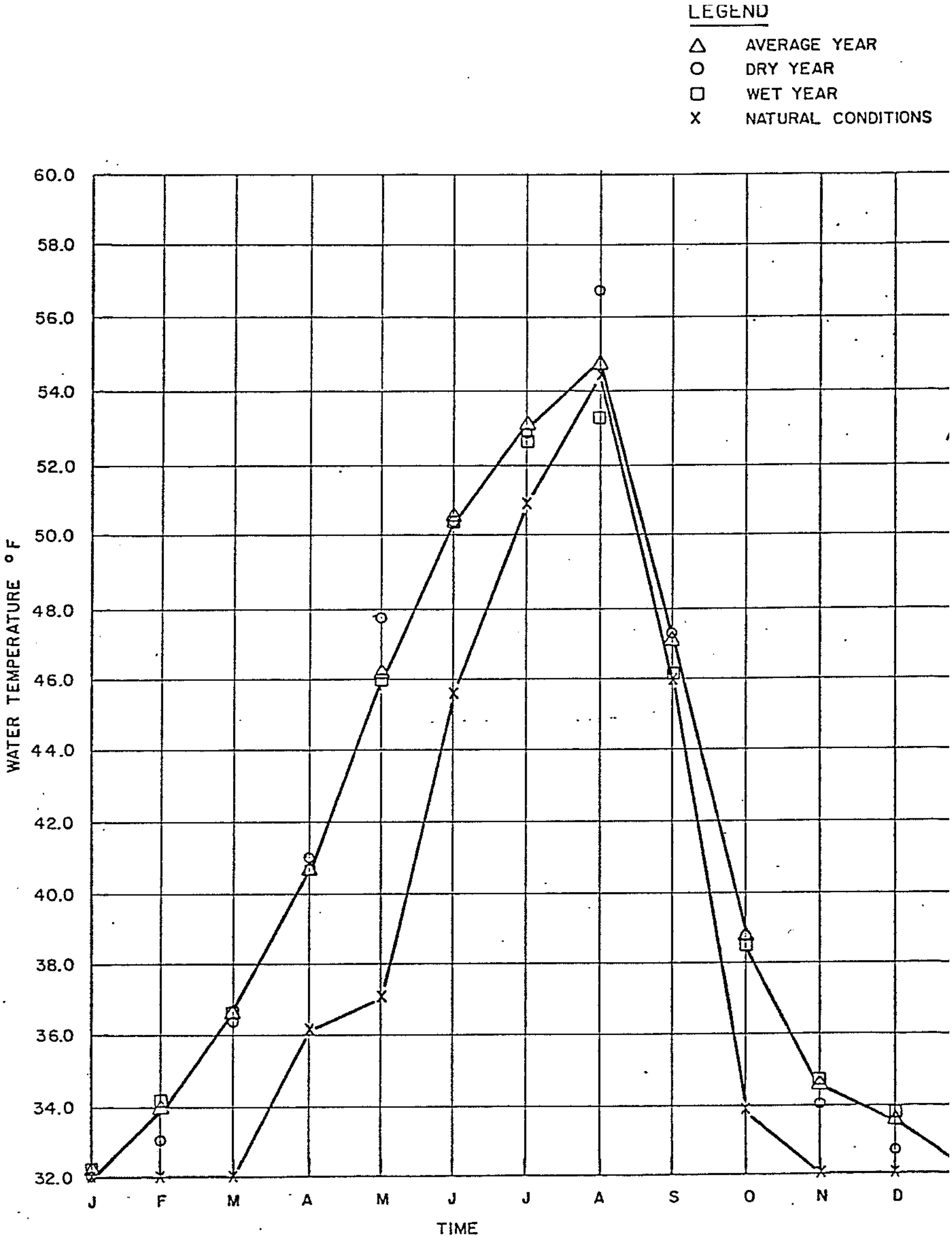


CROSS SECTION LRX 21

BETWEEN CURRY CREEK AND MACKENZIE CREEK

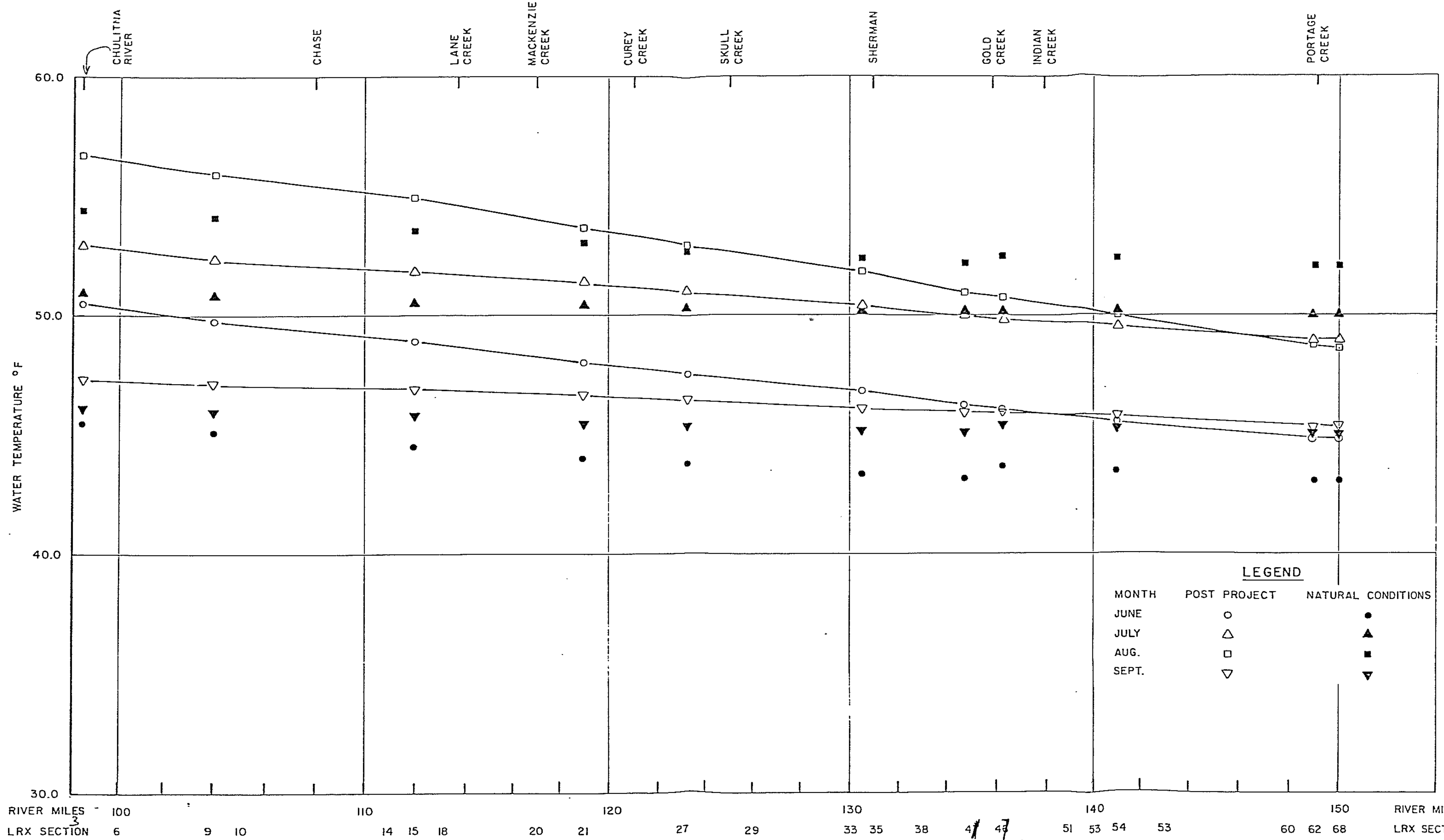
FIGURE



CROSS SECTION LRX 3

NEAR THE CONFLUENCE OF THE CHULITNA AND SUSITNA RIVERS

FIGURE 6



LONGITUDINAL THERMAL PROFILES
POST PROJECT AND NATURAL CONDITIONS

FIGURE

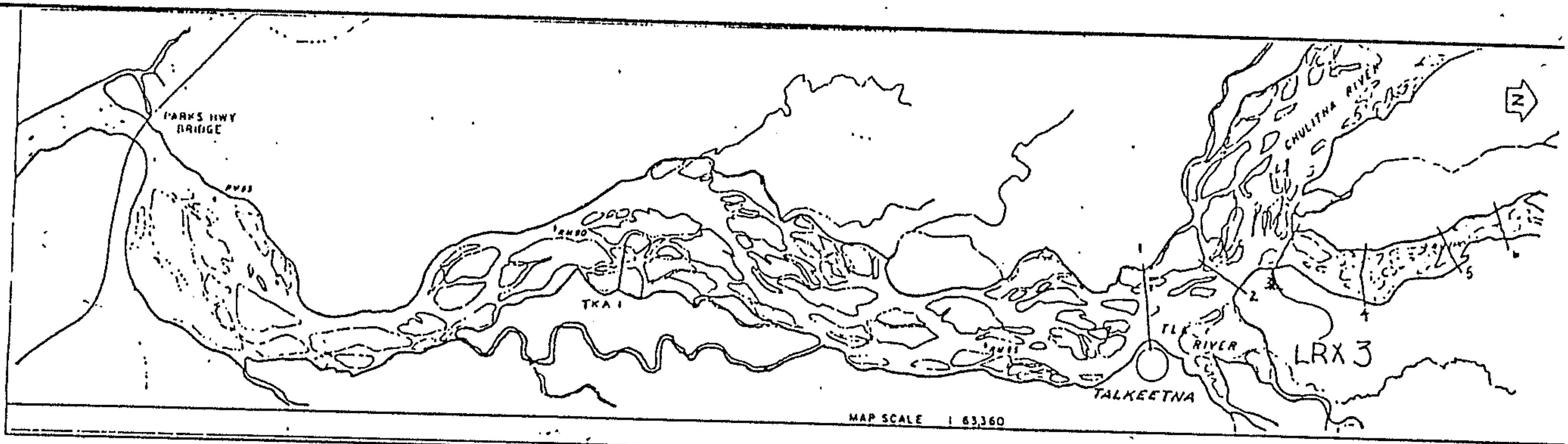
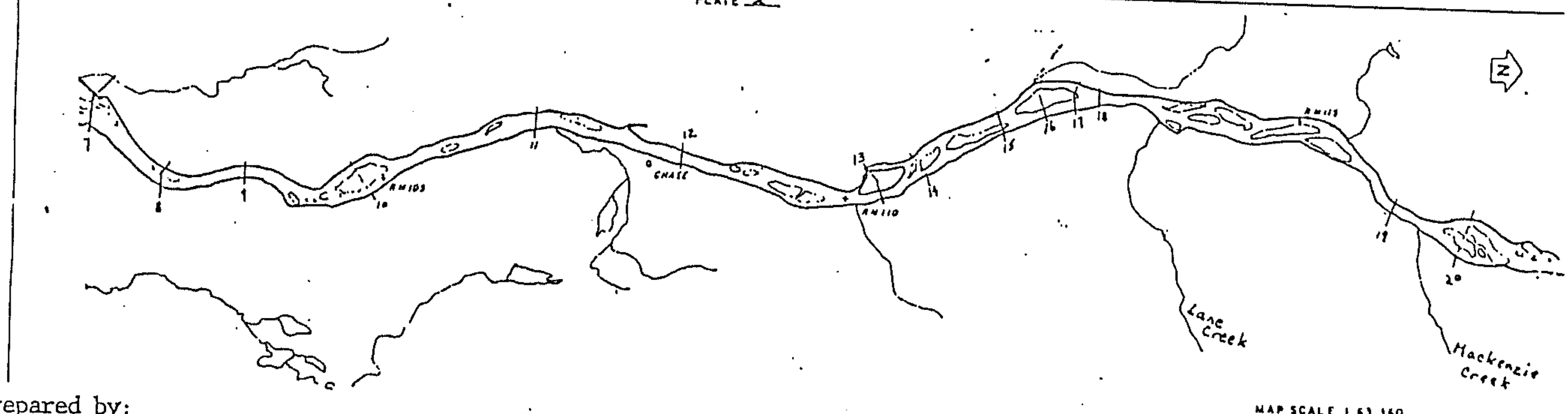


PLATE 2



Prepared by:

R&M CONSULTANTS, INC.

FIGURE 3.1 RIVER CROSS-SECTION LOCATIONS

Figure 8

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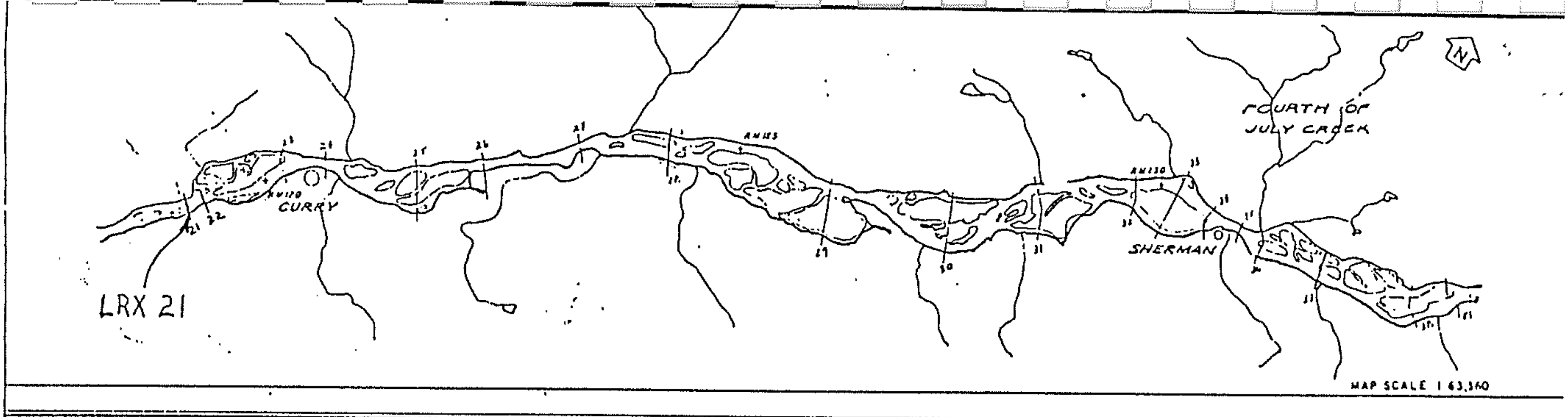

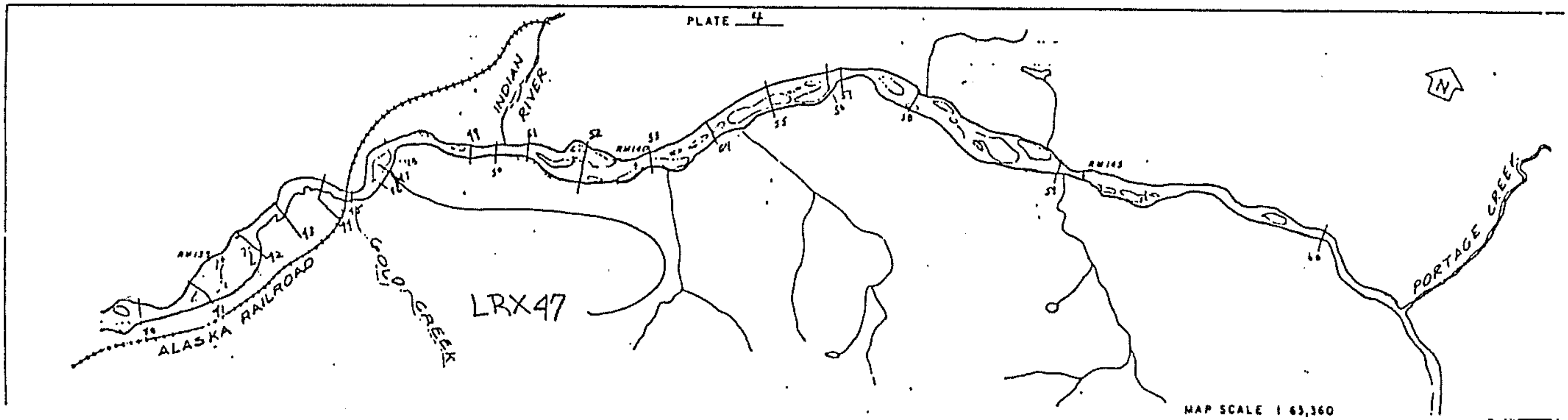

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FIGURE ~~3.1~~ CONTINUED
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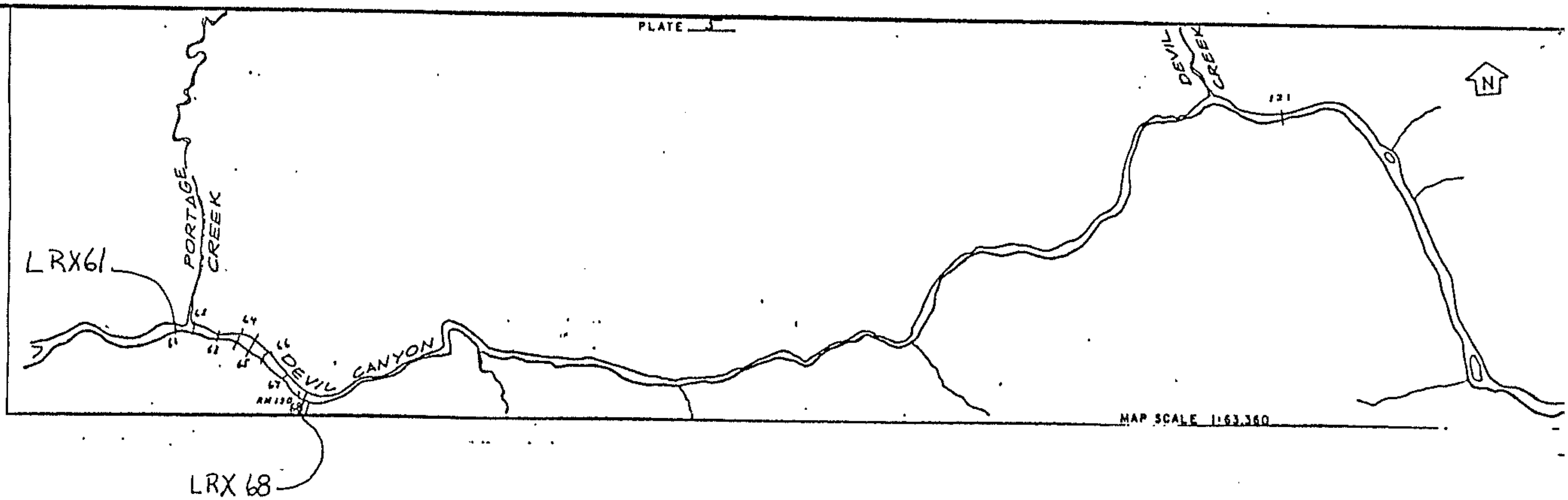

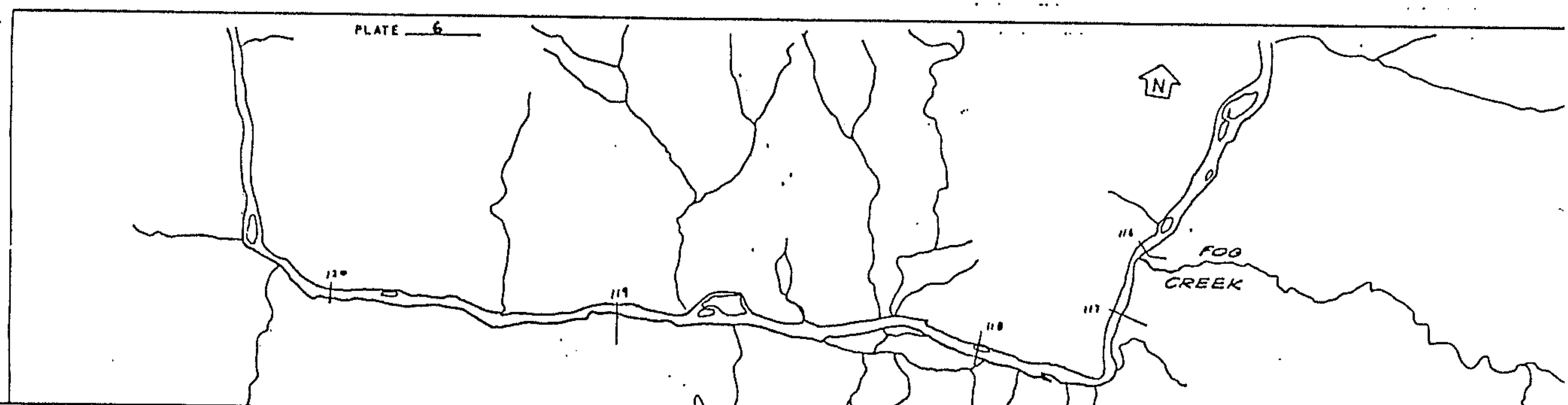

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FIGURE ~~3.1~~ CONTINUED
12-8

ACRES

winter requirement for egg incubation, winter discharges of warmer water may be determined to be desirable. At this time any conclusion regarding winter requirements of downstream temperature for the existing fisheries would appear to be premature.

MITIGATION: To avoid or minimize the impact of shifting of temperature events, adversely affecting winter temperatures, and decreasing summer temperatures, structures that provide for withdrawing water from strata within the reservoir which provides for control of downstream water temperatures are essential. The intake design has been altered many times and various configurations have been examined. Presently, the project design includes a multi-level intake at the Watana development (Figure 9) and a single level intake at the Devil Canyon development (Figure 10).

The impact of low water temperatures during the critical summer spawning months has not been alleviated by the adoption of a "multilevel" turbine intake system. By proper control, water can be drawn from the surface layers of the reservoirs in the summer. This water will average between 9.8 C and 11.8 C. This is with the normal summer time temperature variability of the system.

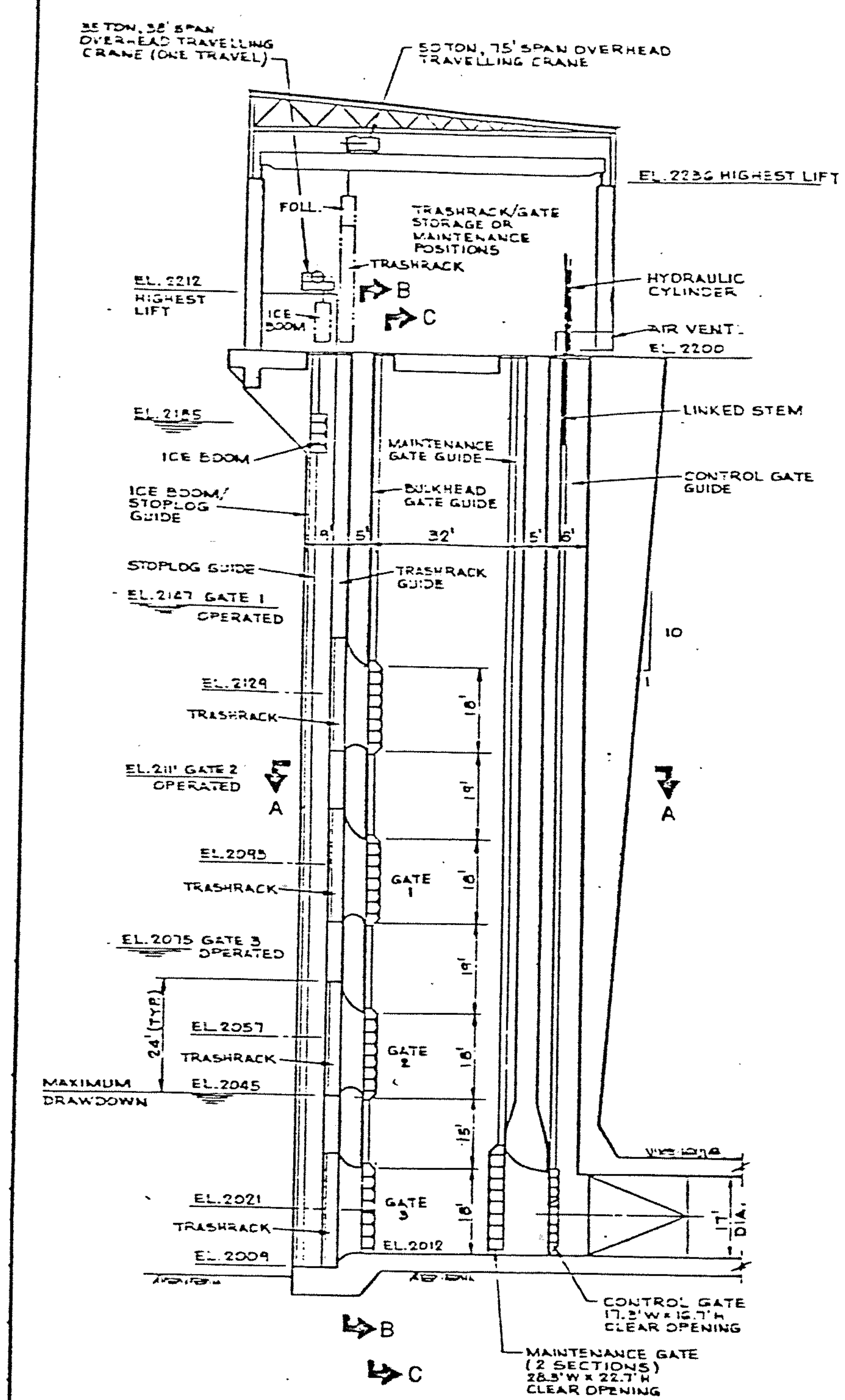
The impact of altered water temperatures during the winter months (i.e., from 0.0 C. - 1.0 C. to 3.9 C.) on fisheries has not been established.

The effects of altered temperatures during the winter period could potentially benefit downstream fisheries as well as create adverse conditions. If the existing stock of salmon in the river below Devil Canyon are dependent on groundwater temperatures in the range of the project temperature water discharge, the release of warmer water from the reservoirs during the winter period could provide a large source of warm water that meets the thermal requirements of the incubating eggs and developing alevins. If other conditions are met for successful spawning and incubation, significant enhancement of the fisheries resource may occur.

Alternatively, if the cold water of the mainstem is needed to provide the proper development rate of the eggs and juveniles, similar warming of the downstream discharges could provide earlier development of the immature fish and the resultant early downstream migrants could be subjected to adverse conditions that would decrease their survival rates. The studies of these thermal phenomena and the development rates of eggs incubating in the spawning gravel should help resolve this question.

The outlets of the Watana reservoir are currently designed with multiple level intakes. During the summer period, these are predicted to selectively withdraw water from the proper thermal strata of the upper layers of the reservoir water column to provide downstream water acceptable to migrating anadromous fish and the resident species. These temperatures are also well within the tolerance levels of the early incubation period for the chum and sockeye eggs. During actual operation of both reservoirs, this warm water layer will be stored in Devil Canyon reservoir and discharged through a single outlet 70 feet below the full pool level of the reservoir. During the summer months, the water level of Devil Canyon reservoir can be maintained below full pool so that the water temperature discharged downstream of Devil Canyon is drawn from near the surface of this reservoir. The projected downstream temperatures from this operation scheme are depicted in Figures 2 through 8. The establishment of an inverted thermal strata during the winter period for both reservoirs is a possibility with significant layers of water cooler than the maximum density layers of 4 C. The extent that this layer develops will determine the downstream water temperature discharged in the winter months. Data from the Corps of Engineers studies of Bradley Lake, indicate that in December, this layer may extend to 70 meters. However, since a precise prediction of the thermal strata of the reservoirs is not available at this time, the worst case assumption has been used for winter discharges in projecting downstream temperatures; that is continuous winter discharge of 4 C water. This value most significantly departs from the natural thermal regime. Using these discharge temperatures from Devil Canyon reservoir, the downstream temperatures during the winter months do not decrease to the normal stream winter temperature of 0 C. until near the Chulitna-Susitna confluence (Figure 11).

Further evaluation of the fisheries studies currently ongoing will be required to determine whether this condition is beneficial or adverse to the fishery



SECTION THRU
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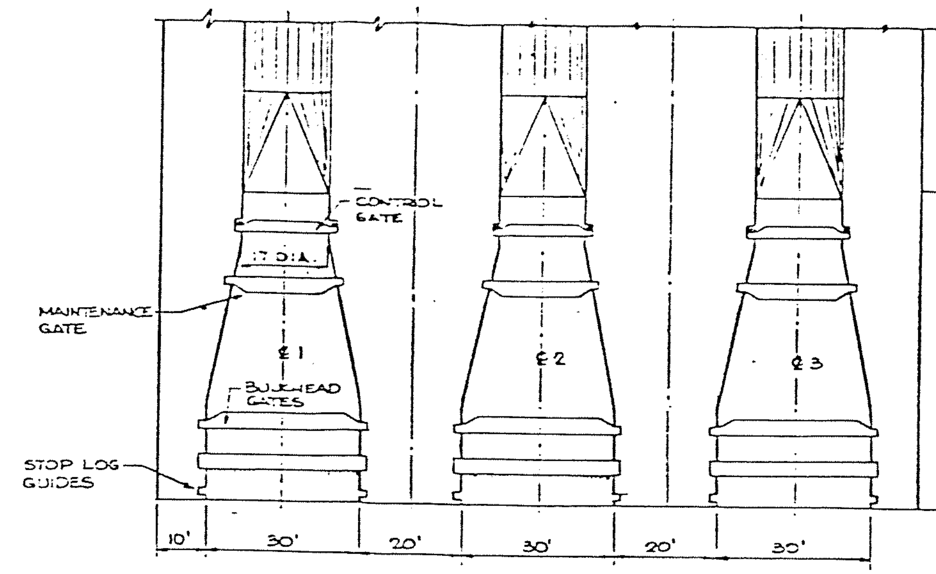

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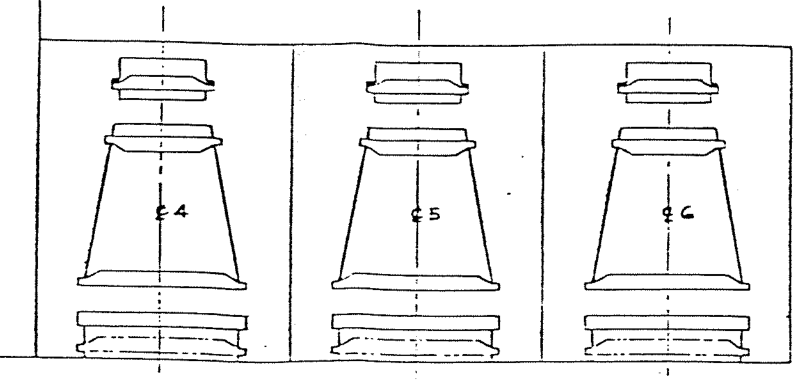
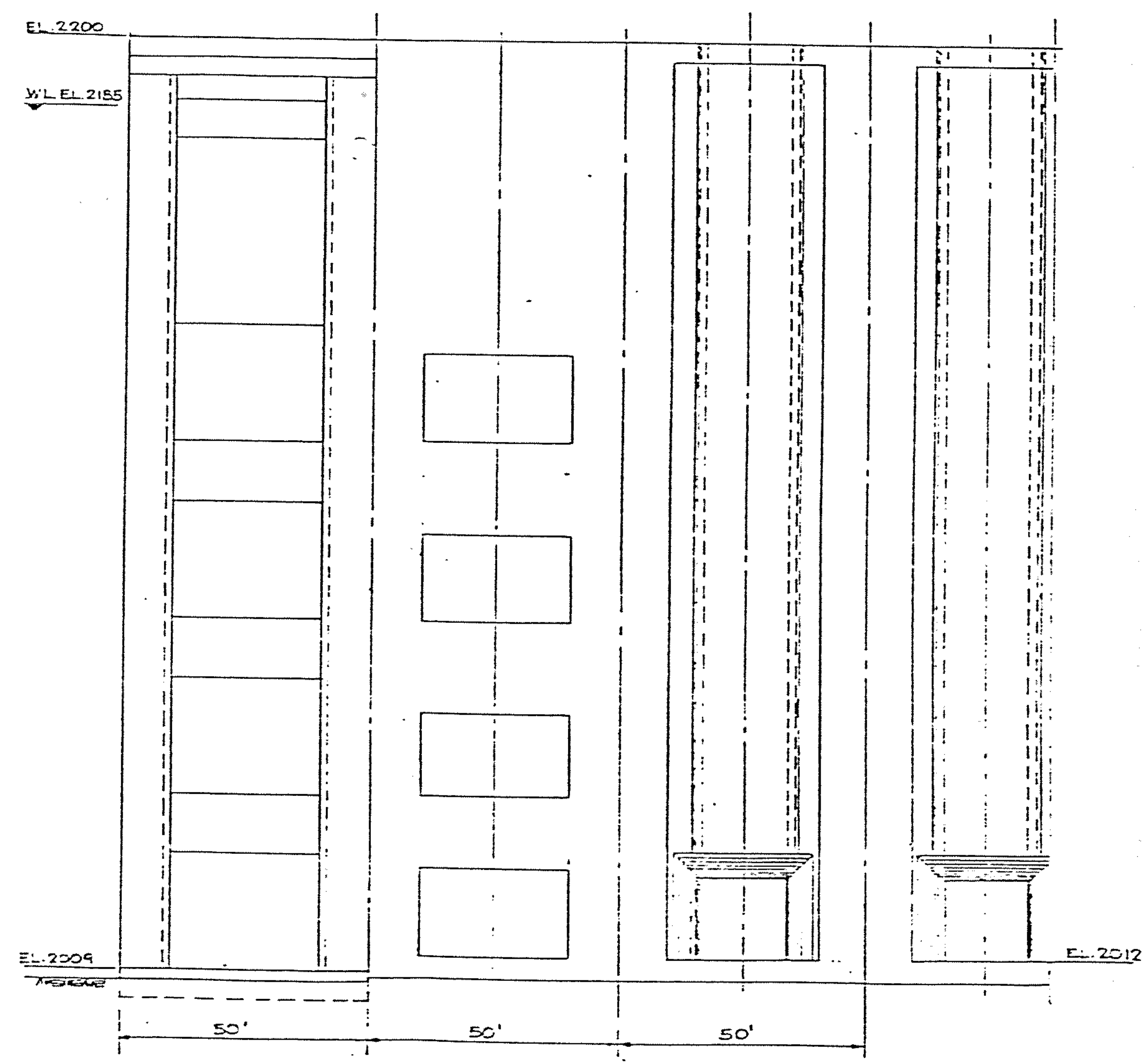


SECTION A-A



FRONT ELEVATION

SECTION B-B

SECTION C-C
(GATES OMITTED FOR CLARITY)

SCALE 0 16 32 FEET

Figure 9

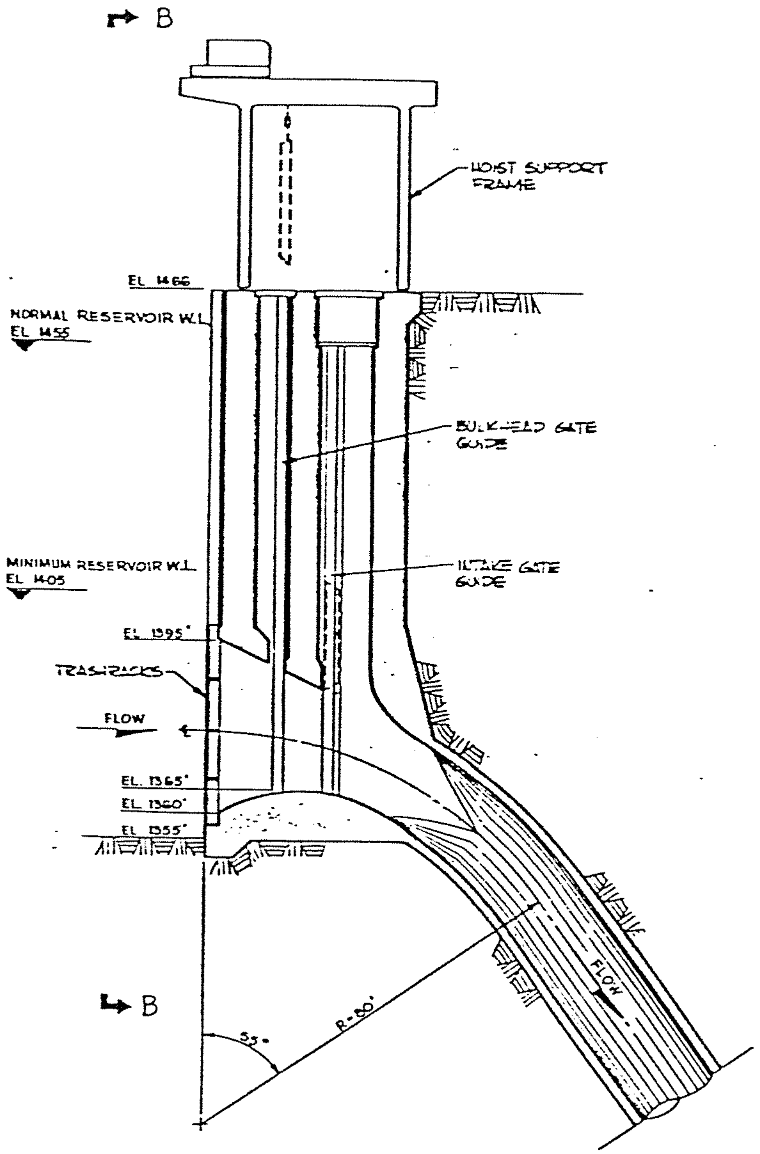
ACRES

ALASKA POWER AUTHORI

SUSITNA HYDROELECTRIC PROJECT

WATANA
POWER INTAKE
PLANS, SECTIONS & ELEVATIO

MARCH 1982



SECTION A-A
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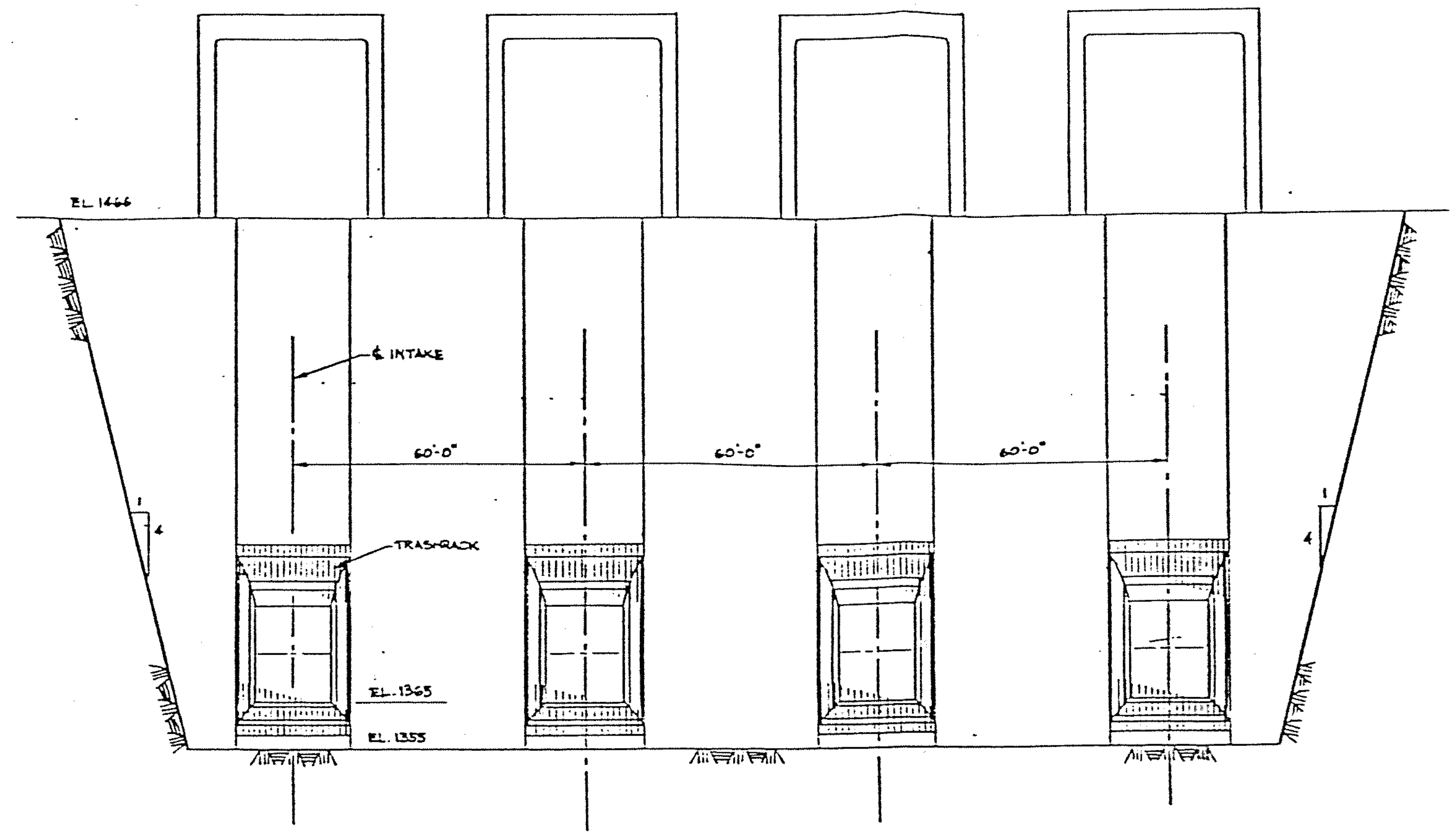
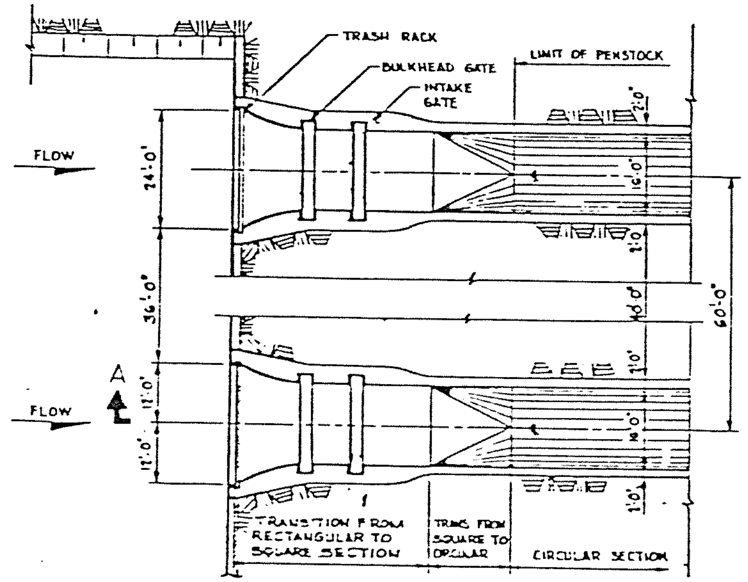


SECTION B-B
SCALE A



SECTIONAL PLAN
SCALE: A

SCALE A 0 16 32 FEET

Figure 4.10

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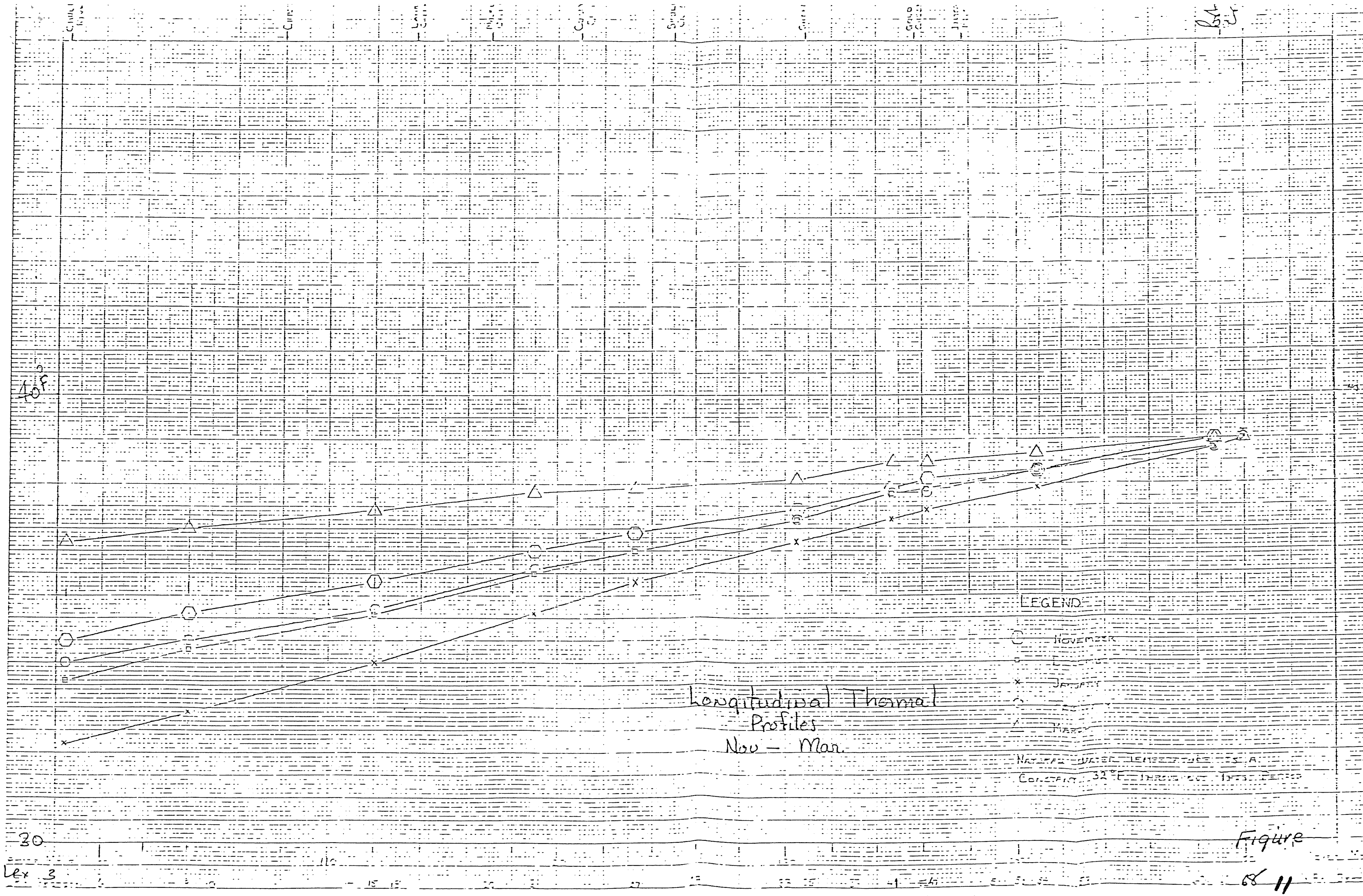
ALASKA POWER AUTHORI

SUSITNA HYDROELECTRIC PROJECT

DEVIL CANYON
POWER INTAKE STRUCTURE
PLAN AND SECTIONS

MARCH 1982


40°F
30
LEGEND
NOVEMBER
Longitudinal Thermal
Profiles
Nov – Mar
Figure 11
Lex 3

B.10.13

resource of the river. If adverse impacts are predicted, an altered operation scheme and multiple level discharge structure at the Devil Canyon reservoir will have to be explored to determine if this would alleviate any adverse impacts. If determined to be beneficial, discharge from the 4 C. thermal layer of the Devil Canyon could be accomplished by maintaining sufficient depth in this reservoir during the winter or routing warmer water from the Watana reservoir lower outlets during the winter periods.

During both the summer and winter periods, the use of multiple level outlet structures of proper design and operated in a manner to provide the required downstream temperatures will probably be adequate to meet the water temperature requirements of downstream fisheries.

IMPACT: Altered flow regime in the Devil Canyon to Chulitna confluence and it's effect on the fisheries resources.

The fisheries in this reach of the river use portions of the wetted portion of the system during different times in their life cycle. Resident fish are found overwintering in the mainstem of the river and are usually concentrated in the mouth areas of the tributaries during the summer. The mainstem is also a migratory corridor for these species in the spring and fall.

Sockeye salmon adults migrate during the summer months of July and August through the mainstem and spawn exclusively in the slough habitat. Little information is available on the rearing of this species, but they apparently rear in this type of habitat also.

Chum salmon behave similarly to sockeye salmon in that they migrate into the system in early August and spawn primarily in the slough habitat with minor use of the tributaries. There is also use of side channels of the mainstem for spawning by this species. Chum salmon will outmigrate in a relatively short period of time after emerging from the gravel to the Cook Inlet estuary.

The odd year pink salmon which run in this area primarily use the clear water tributaries for spawning with very little use of the slough habitats. This species immediately outmigrates upon emergence with very little fresh water rearing. No information is available on habitat use during the large even year runs.

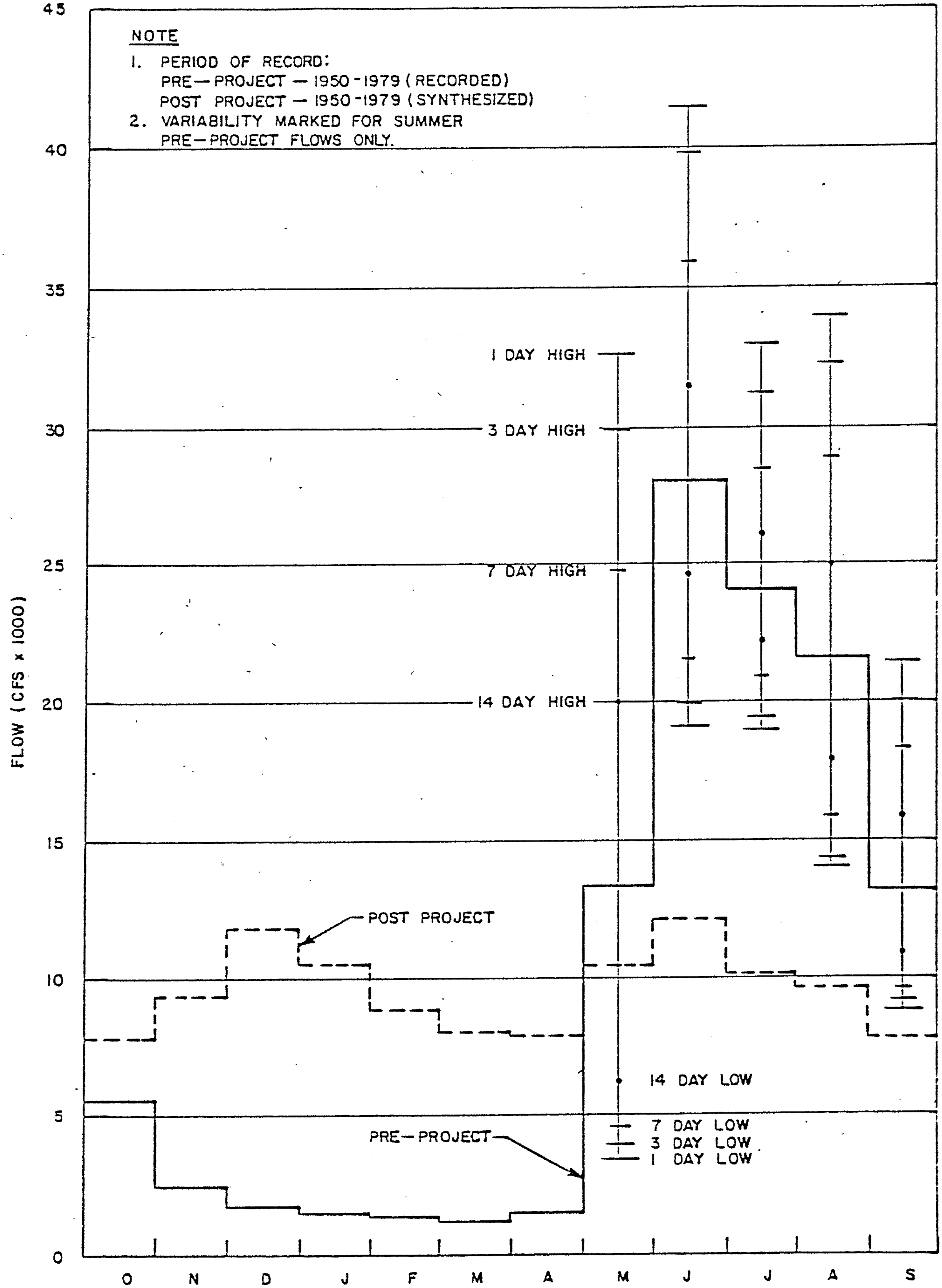
The coho salmon adults migrate into the system during August and September with these individuals primarily using clear water tributaries for spawning. Limited use of side channel or peripheral portions of the mainstem was observed. The juveniles of this species, upon emergence, rear for one to two years in the associated riverine habitat. This rearing occurs in the clear water tributaries and in the mainstem of the Susitna with the main concentrations associated with the slough habitats.

Chinook salmon in this reach of the river were observed to spawn only in the clear water tributaries. The juveniles rear in habitat similar to the coho juveniles, primarily concentrated in the slough habitats. Both coho and chinook juveniles were observed in the mainstem and some of the sloughs during the winter months.

The alteration of the natural flow regime of the Susitna River will be a requirement of the storage facility operation of the proposed project in order to meet the seasonal load demands for electricity. The overall effect of this process is to substantially increase the winter flows and decrease the summer flows in this reach of the Susitna River. Figure 12 depicts the pre- and post-project monthly average flows under the proposed operation scheme with both Watana and Devil Canyon on line. The flow variability of the pre-project conditions are also shown in this illustration.

The proposed flow regime for the project will sufficiently decrease the stage of the Susitna River so that access of adults to the slough habitat and possibly to the side channel of peripheral mainstem habitats will not be possible. This will effectively eliminate the spawning populations of the species using this habitat in this reach of the river, the chum and sockeye salmon. Approximately 15% of the Susitna chum and 1% of the Susitna sockeye use this section of the river. The effects on the odd year pink salmon run will be minimal, in that access into the clear water tributaries should not be affected. These streams have sufficient gradient to establish a new channel adequate for fish passage between the tributaries and the lower stage Susitna. Likewise, coho and chinook spawning should not be significantly affected although the present rearing habitat will be reduced. It is not known whether rearing habitat will be sufficiently limited for these species to adversely affect the populations currently using the system.

MITIGATION: The postproject flow regime associated with the previously described impacts has been developed to maximize power production. Many alternatives are available for mitigation of these impacts. However, mitigation activities within the Devil Canyon to Chulitna confluence reach of the river will require that flood and flow control be maintained at some flow above the power production level. Mitigation options that have been identified including the flow control options are described in the following



PRE AND POST PROJECT FLOWS
SUSITNA RIVER AT GOLD CREEK

FIGURE

ACRE

sections. The technology to mitigate by using any or all of the techniques is available. Detailed investigations, aimed at determining which method would be the most suitable would be implemented before a final program could be instituted.

One option is to maintain or improve conditions in side sloughs utilized by salmon. Upwelling water in the channels or sloughs provides the necessary flow to hatch the eggs and to maintain aquatic food organisms during the winter freeze-up period. Such groundwater flow is not sufficient to provide the necessary depth and velocity required by spawning adults. This flow is either supplied by the river flowing through the slough or by backwater entering the slough from the downstream end. A river flow level near 19,000 cfs at Gold Creek is presently required to provide the upper end flow in the sloughs. This level of flow is above the summer power requirements and must be spilled during critical times. The reservation of a quantity of water as acre feet can be established and used for this extra spill. Sufficient water could be provided during the late summer to allow access of spawning chum and sockeye salmon to the side slough habitat currently used by these species. In addition, flows could be manipulated over a short period of time to provide adequate water to run through the sloughs to clean the spawning gravel. The exact time of the spill and the duration, while generally known, requires additional refinement before a flow regime can be worked out and submitted for inclusion in the operating schedule or for rule curve operation. Although significantly different from the natural flow regime, flows sufficient to avoid adverse impacts to the fisheries of the river are possible if they can be regulated on a short term basis during the summer months.

The flow from upwelling groundwater may or may not be available as the recharge water source for the aquifers has not been established. This requires that a program be developed and executed to establish both source and quantity of the ground water supply and the resultant temperatures. The techniques for developing this type of survey and assessing the findings are known and may be applied to the problems associated with the sloughs.

To insure an upwelling flow, it may be necessary to recharge an aquifer. If the aquifer is supplied from river flows and stored in the island(s) between a channel and the main river, an upper river flow sufficient to recharge the aquifer may be required.

Besides establishing a level of river flow to provide the necessary supportive depth and velocity required by spawning fish in the sloughs, there is the possibility of altering the water level control of a slough. This may require excavation at one or both ends of the slough and a physical structure at the upper end. The useful spawning area of many of the sloughs is not at either end. The upper end may serve primarily as a channel for high water flows to enter through and it may be severely scoured. The lower end may be an area of deposition for suspended material that settles out as the water flowing through the slough slows down. It may be possible to alter the water control level without disturbing the useful area.

If the control is lowered below the stage of the high winter power flow, the introduction of river water at that time in the sloughs may produce undesired results by this water freezing, ice blocks, by anchor ice, or frazil ice formation. Thus, the control should not be lowered below the stage of the winter high flow unless a physical structure that can be closed is placed at the upper end of the slough.

The river cross section profiles produced an indication that either flow or bed level adjustments are practical. To establish precisely the appropriate flow or bed level or combination requires that a detailed survey of the upper and lower ends of the sloughs be made to define the type of control needed at such points. Water can be introduced either through a culvert or through the bed with shape adjustments to give the necessary supportive depth and velocity. Except for the required field survey, the technology necessary to undertake this type of mitigation is established and available. The requirements for spawning are established for these species in other regions, as are flows needed to keep deposited eggs alive. Data is scheduled for collection that will be stock specific for this region.

The necessary excavation varies for the sloughs under study. The exact quantities must await a detailed field survey and the choice of flow control. There are 32 sloughs at the present time that are used by spawning and rearing salmon. The annual cost of maintenance of the proper conditions within the slough will depend on the level of flood control achieved. With proper flood control this would be expected to be minimal.

Construction materials such as culverts, gates, and gabions may be considered as shelf items. Their use depends upon the control needed for the individual slough.

Major floods have altered the sloughs and side channels. Destruction is generally caused by deposits of gravel, the scouring of the slough bed, or the isolation of the slough from the main river. To insure stabilization in the sloughs that are used by the salmon for spawning or rearing it is necessary that the level of a major flood with a return period of approximately 20 years be reduced to about 28,000 cfs at Gold Creek. This requires the allocation of storage room in the reservoirs and the development of a release pattern to maintain the desired flow level at Gold Creek. Without flood control, mitigation by altering the occupied sloughs may be found to be impractical. The final levels of flow regulation must await the development and completion of the surveys of the sloughs to find their levels and slopes.

Improving conditions in sloughs now not available to spawning salmon is possible under the same scenario as mentioned above. There are a number of sloughs now not used by spawning salmon either because of the lack of water to supply the needed supportive depth and velocity required by spawning salmon, lack of suitable substrate, or because the upwelling flow required to maintain the eggs and fry is not present. The existing transect surveys are not adequate to determine the precise bed levels in the main Susitna. A field survey of the most promising non-used sloughs could result in channel alterations similar to the approach suggested for slough now used by salmon to bring such sloughs into useful production. Until additional field surveys can be made these sloughs must remain as potential for production.

It has been suggested that the existing sloughs now used by salmon could be augmented by additional flow from the mainstem by maintaining water levels that permit greater wetting of the slough beds. There is a preferred temperature for spawning salmon. Through control of the water temperature by the use of a multi-level intake it may be possible to maintain the slough temperature levels as near as possible to the preferred levels, thus resulting in maximum production. These levels are established but they need further site verification, for Susitna stock, in order that a temperature regulating schedule for water releases, primarily through the hydroelectric turbines may be suggested. It has been mentioned previously that it may be undesirable to have a small amount of river water passing through the slough area during the cold water period. This requires a further examination to determine whether such water would be useful or harmful. If useful, it would expand the productive area of the slough; if harmful, it should be excluded.

Maintaining areas in the main river where salmon presently spawn can be helped in part by increasing the water clarity. If the level of clarity of the water can be improved after it has passed through the reservoirs, it is possible that the main river may become more productive and the suspected areas where salmon may now spawn will be improved by the removal of silt. It is assumed that there is little use of the river by chinook salmon. In other large streams chinook salmon are known to spawn in the mainstem. With most of the silt removed and with flow control spawning adults may utilize new areas for the production of large chinook salmon. It is not recommended at this time that additional gravel be placed in the mainstem for spawning purposes. If spawning areas develop, they will develop under the new flow conditions as the river is freed from scouring floods and entrapped silt.

It is believed that there is a limited use of the main river by coho for spawning. With water that is relatively silt free, and with river discharge control, river areas may become more productive or additional areas in which the coho salmon will expand their activities into may be developed naturally. Additional stocking of these habitats may also be desirable to more rapidly develop new populations. The value of this approach requires additional study to evaluate.

Increased food production may be expected in the main river areas as the stream becomes clearer. Additional studies should be made of this to predict a possible increase in rearing area for both coho and chinook fry, fingerlings and yearlings.

Man-made spawning beds could be constructed and operated in suitable areas, in or out of the Susitna basin. Man-made, or artificial spawning beds have been successfully built and operated for sockeye salmon in cold areas. At this time there is no location picked for such spawning channels, but it remains as a potential for mitigation or augmentation, as the mechanics of their construction are known and the potential resulting efficiencies established. Chum salmon are known to spawn in upwelling spring areas and it would be expected that they would respond to conditions in an upwelling artificial spawning bed. It is possible that coho, chinook, and sockeye salmon may use such an area also.

The operation of artificial spawning areas under freezing conditions requires a carefully designed system. Such spawning beds would have to be protected from scouring flood flows. Sufficient numbers of channels have been constructed so that a general overall cost may be established, subject to site specific conditions, particularly the water source. In addition development costs and annual maintenance costs must be added.

Hatchery facilities could be located in or out of the Susitna basin to mitigate for fish losses as a result of the project. Hatcheries have long been used for salmon production. Hatchery conditions vary, but production techniques are well established. Hatcheries have been built and operated in cold areas where there are salmon runs. The costs will vary depending upon the climatic conditions and the species of salmon to be hatched and reared.

The species found in the upper Susitna have been cultured elsewhere in hatcheries, but require details for site specific conditions. A volume of pure, well oxygenated water of proper temperature is required. The cost of supplying one or all of such requirements at a given site may be prohibitive. Temperature control may be a very costly factor. While 4 C. water may be desirable in the winter time, it would be undesirable during other periods.

The resulting production from a successful artificial spawning channel or hatchery operation calls for additional management techniques to protect the natural runs which co-mingle in a mixed fishery. Hatcheries, as an in lieu mitigation, might have to be located outside of the Susitna basin. The technology of construction and operation is established and such a facility remains as a potential for mitigation or augmentation.

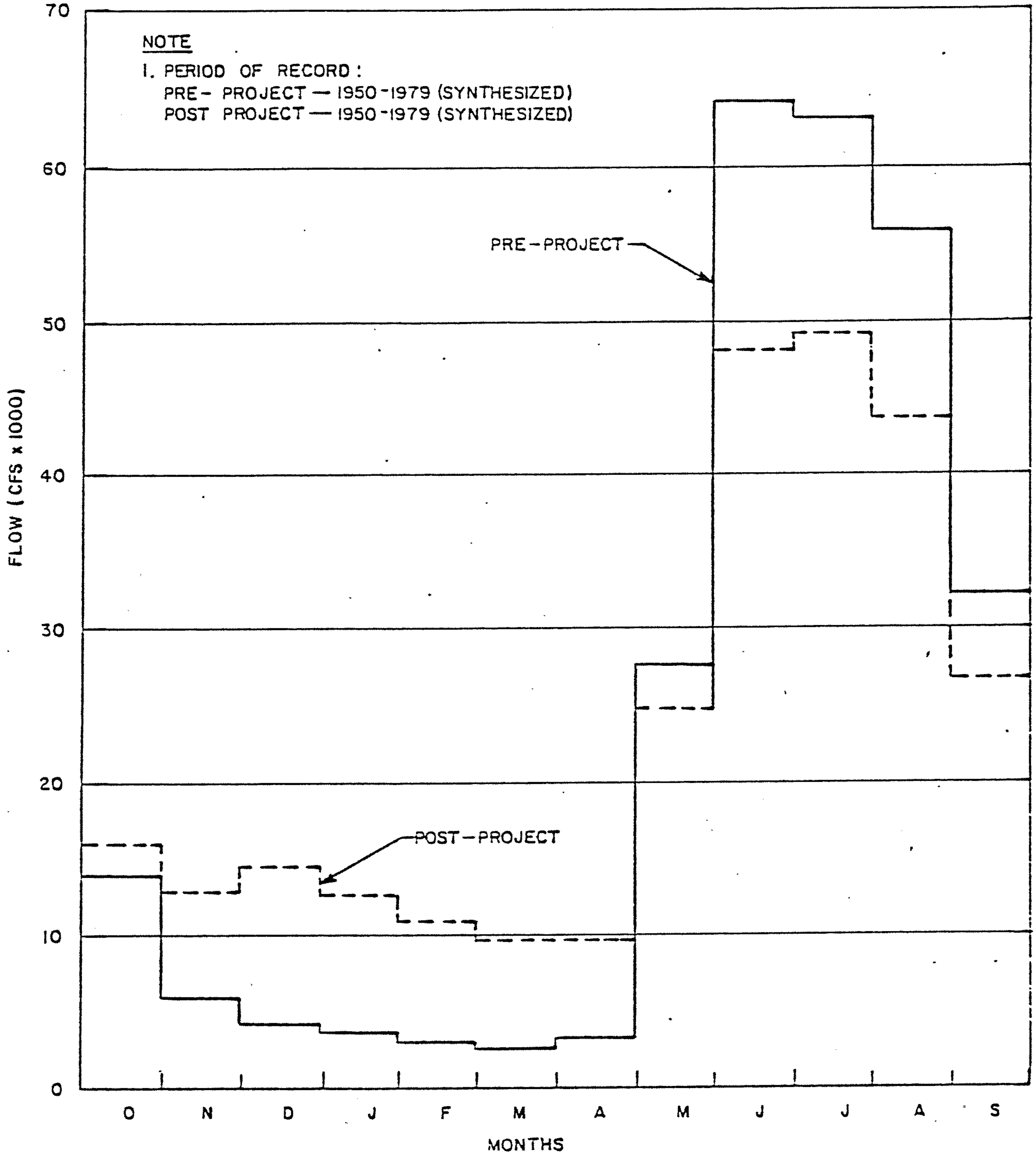
IMPACT: Downstream impacts on the fisheries resources of the Susitna River below the confluence of the Talkeetna and Chulitna rivers.

The installation and operation of the proposed hydroelectric project has the potential of altering the natural flow regime, temperature, water quality, river morphology, and ice processes in this reach. All of these changes have the potential for adversely impacting or benefiting the fisheries resources of this reach of river.

Preliminary baseline measurements and data analyses have been conducted for these parameters for the river reach below Talkeetna. The Sunshine Station at the Parks Highway Bridge has provided the basis for evaluation of this river reach along with supportive data from the Alaska Department of Fish and Game fisheries investigations. These data have provided information on the distribution of resident and anadromous fisheries resources within this reach and the variability of the other physical and chemical parameters of the pre-project river system.

The operation of the project is projected to estimate changes in the monthly average flows in this reach (Figure 13 and 14). Fish will experience post-project discharges that are within the range of natural variability but generally lower by some 20% of average natural discharges during the months of August and September at Sunshine Station and around 10% lower at Susitna Station. As these months are associated with the majority of spawning activity of the anadromous species, little effect of the project on these species within this reach is anticipated.

The winter months will create conditions substantially different from the normal variation of the system, with significant increases in the discharge. During this period of time, the mainstem is used for overwintering habitat for anadromous juveniles and resident species with very little incubation of salmon redds occurring. Although the increase in winter flows is substantial, it is still a small amount compared to the capacity of the channel and there is presently no data available that suggests the flows will cause adverse effects on the fisheries. The increase in discharge during this period may improve winter conditions on the river, but there is also no data suggesting



PRE AND POST PROJECT FLOWS
SUSITNA RIVER AT SUNSHINE STATION

FIGURE 13

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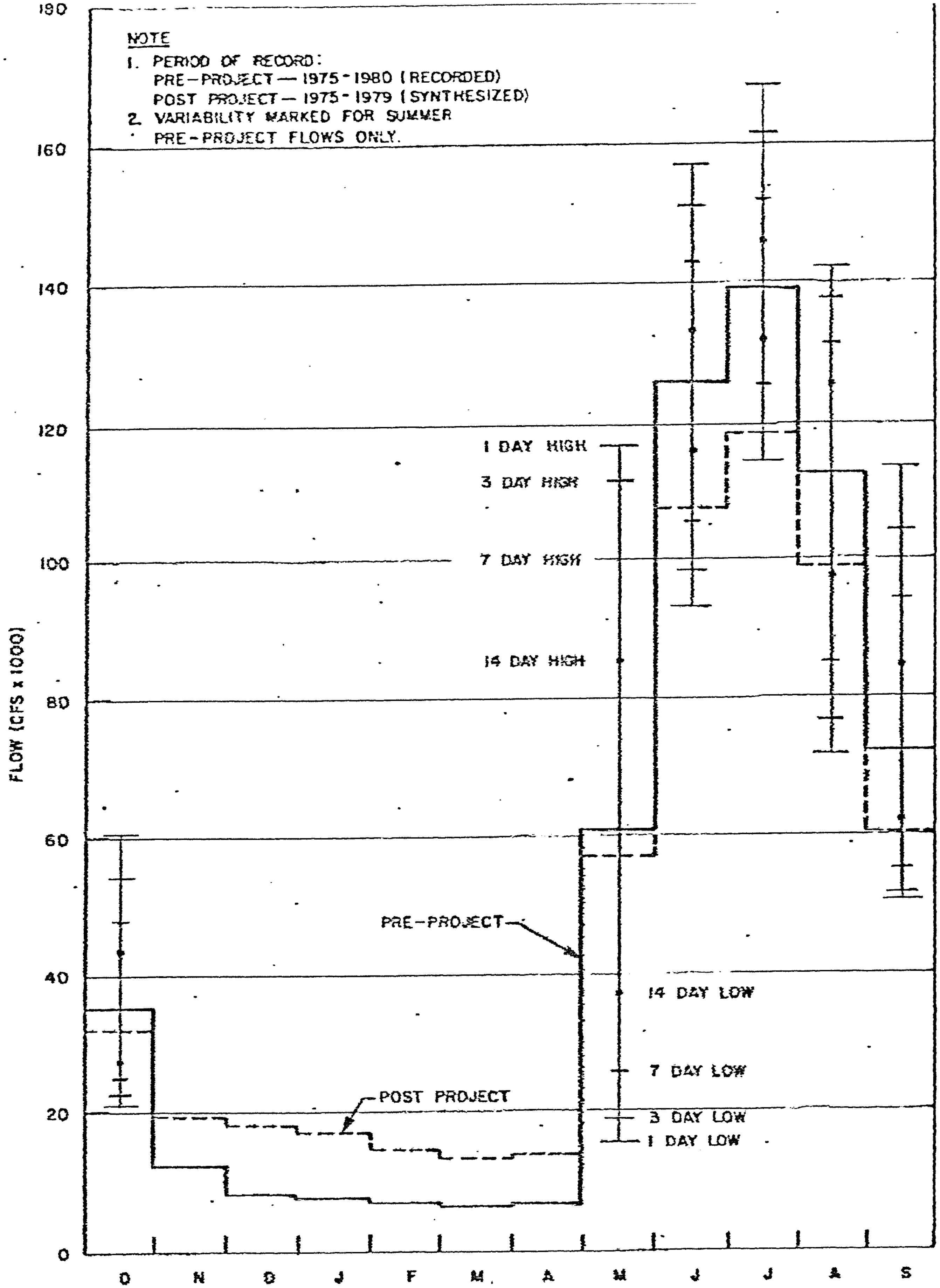


PRE AND POST PROJECT FLOWS
SUSITNA RIVER AT SUSITNA STATION

FIGURE 14

that overwintering habitat limits the abundance of the species in this portion of the river. Additional data collected which will more clearly define the changes in stage with respect to the cross sections in this reach of the river are planned for this coming field season.

Examination of discharge data at Susitna Station indicates that the months of May through October are well within the natural variability of the system, but as at Sunshine Station, the winter months provide for significant discharge increases (Figure 14). These changes are not predicted to have significant effects on the fisheries resources of this system.

The water temperature changes induced by the project versus preproject conditions at the Susitna River confluence with the Chulitna River have been provided by ACRES American (Figure 11-LRX-3). As this water will mix with the other two tributaries in this vicinity, the temperature effects during both the summer and winter periods should be well within the natural variability of the water temperatures during these periods, and not significantly different from the actual preproject conditions. Therefore, the downstream postproject temperature potential impacts will not be affected in this reach of the river.

The water quality parameters measured during the 1981 summer at the Sunshine Station sampling site have been used as the basis for evaluation of the postproject effects on water quality. Postproject water quality conditions have not been clearly established, but evaluation of the parameters by R&M Consultants indicates that no hazardous concentrations of any chemical constituents are expected.

Although decreases in the summer suspended sediment concentrations and associated turbidity are predicted for the river upstream of the Chulitna confluence, the effects of the Chulitna River sediment load on the system should be sufficiently high to mask any benefit that could be expected below this reach. This is caused by a reduction in volume and a subsequent lesser contribution of the total water volume by the mainstem Susitna as well as the Chulitna being the major contributor of sediment per unit volume. Additionally, analyses of the water quality parameters variability during 1981 indicates that the variability between sampling periods is of sufficient magnitude that any decrease should not be distinguishable in this reach of the river. This relationship also holds for other chemical parameters as well. Winter turbidity may have minor increases over the normal conditions. There is no data available to suggest these changes will be adverse to the existing fisheries.

River morphology changes may occur in this reach of river because of the decreases in volume and subsequent bedload transport by the mainstem Susitna in the confluence area near Talkeetna. A long term aggradation of materials may occur in this reach and thus cause an increase in stage at any particular discharge in this reach. The flood frequency of the lower river will be decreased. This may produce a long term change in flood pattern and provide more channel stability. The magnitude of these changes do not appear to be sufficient to project any changes in the fish habitat in this area.

The ice formation processes are predicted to change because of winter temperature effects on the river above Talkeetna. On average year conditions, an ice cover is not projected to form above the confluence of the Chulitna River. As a consequence, the ice formation processes will occur in the vicinity of this confluence. ACRES American has provided a detailed analysis of the ice formation process. There is currently no information that suggests these changes will adversely affect the fishery resource.

MITIGATION: Based on the current level of information available, postproject planned operation of the reservoirs should provide conditions in the river sufficiently close to preproject conditions that significant changes in the existing fishery are not predicted. Therefore, impacts in this reach may be avoided by operation of the project in the currently planned framework. This includes downstream temperature control and dissolved gas control in the spilled water and a flow regime that is within the minimums currently projected.

ADF&G. 1975. Pre-authorization of the Susitna Hydroelectric Project: Preliminary Investigations of Water Quality and Species Composition. Alaska Department of Fish and Game, Anchorage, Alaska.

ADF&G. 1977. Pre-authorization of the Susitna Hydroelectric Project: Preliminary investigations of the Water Quality and Aquatic Species Composition. Alaska Department of Fish and Game, Anchorage, Alaska.

ADF&G. 1981. Susitna Hydroelectric Project Environmental Studies Report Subtask 7.10 - Adult Anadromous Fisheries Investigations, Chinook Salmon Species Report. Prepared by Alaska Department of Fish and Game for the Alaska Power Authority, Anchorage, Alaska.

ADF&G. 1981. Susitna Hydroelectric Project Environmental Studies Report Subtask 7.10 - Adult Anadromous Fisheries Project. Phase I Final Draft Report. Prepared by Alaska Department of Fish and Game for the Alaska Power Authority, Anchorage, Alaska.

ADF&G. 1981. Susitna Hydroelectric Project Environmental Studies Report Subtask 7.10 - Species Reports, Juvenile Anadromous Fish. Prepared by the Alaska Department of Fish and Game for the Alaska Power Authority.

ADF&G. 1981. Susitna Hydroelectric Project Environmental Studies Report Subtask 7.10 - Resident Fish Investigations, Upper Susitna River Species/Subject Report. Prepared by the Alaska Department of Fish and Game for the Alaska Power Authority.

APA. 1981. Susitna Hydroelectric Project Environmental Studies Report Subtask 7.10: Fish Ecology Studies. Submitted by Terrestrial Environmental Specialists, Inc. to Acres American, Inc. for the Alaska Power Authority, Anchorage, Alaska.

Peterson, L. and R&M Consultants, Incorporated. 1981. Susitna Hydroelectric Project Hydrology Studies Draft Final Report. Impoundment Effects on Water Quality. Acres American, Inc. Buffalo, New York.

R&M Consultants, Incorporated. 1981. Susitna Hydroelectric Project Preliminary Report Subtask 3.10: Lower Susitna Studies - Preliminary Open Water Calculations. Submitted to Acres American, Inc., Buffalo, New York.

R&M Consultants, Incorporated. 1981. Susitna Hydroelectric Project Interim Report Subtask 3.07: Sediment Yield and River Morphology Studies - Reservoir Sedimentation. Submitted to Acres American, Inc., Buffalo, New York.

DRAFT ANALYSIS

<u>Draft Analysis of Fisheries Mitigation Options</u>

The various stages of Susitna hydroelectric development (cofferdam construction, dam construction, reservoir filling, and reservoir operation) are expected to cause various impacts on the fishery of the Susitna River.

Many potential impacts associated with hydroelectric projects have been examined and, where possible, techniques to minimize these impacts have been incorporated into the design of the dams and ancilliary facilities. These potential impacts include supersaturation of gases in the water, changes in water temperature, loss of habitat, and interference with anadramous fish migration.

Information attached describes the proposed operation of the Susitna hydroelectric development including reservoir drawdown, downstream flows, and temperature.

Supersaturation of gas, particularly nitrogen, can be lethal to fish. This condition can result from plunging flows from the dam spillways. Design for the Watana and Devil Canyon dams have been modified so that cone type valves will be used for the spillway mechanism thereby virtually eliminating the potential supersaturation problem.

Changes in water temperatures downstream could result in potential impacts. This problem has also been examined and designs modified to reduce the potential for impacts. A multiple level intake structure has been incorporated and should result in a minimization of temperature changes from those that naturally occur.

Operation of the two dams also has the potential to create impacts to fisheries. These impacts will vary for each segment of the river depending upon the distance from the dams, changes in stream conditions, and fisheries resources present. These segments of the river can be classified as: the impoundment areas, Devil Canyon to the confluence of the Talkeetna and Chulitna rivers, and from the confluence of the Susitna, Chulitna, and Talkeetna rivers to Cook Inlet.

In the impoundment area, the greatest impacts will occur due to loss of habitat. Tributary streams utilized by grayling will be inundated. Although the mainstem river of the Susitna is not considered a productive area, this area will be lost as riverine fish habitat. Other changes occuring in the reservoir area will be settling out of sediment load and an increase in productivity.

The section of the river from Devil Canyon to Talkeetna will be subject to the largest potential impacts. This area includes natural spawning areas, primarily sloughs outside of the main stem of the river. Reduction of flows during reservoir filling will result in flows of 900 cfs in the winter and 6000 cfs in summer. These winter flows approximate ambient conditions while the summer flows are substantially reduced from natural conditions. The reduction of these flows will likely result in the elimination of access to sloughs used for spawning by chum, pink and sockeye salmon. Following reservoir filling, power production flows in the summer will also prohibit access to the sloughs. In contrast to these impacts, reduction of flood flows and elimination of most of the suspended sediment load could improve existing mainstream conditions. Additional enhancement of mainstream conditions is being actively considered as a means of mitigating the loss of side slough habitat in this Talkeetna to Devil Canyon reach.

The least impacts will occur in the river downstream of the confluence with the Chulitna and Talkeetna rivers. Flow and temperature variations will be dampered greatly downstream from this confluence as flows from major tributaries will compensate for much of the changes. Operation of the reservoir will, however, result in a reduction in flood flows and an increase in winter flows.

Many mitigation alternatives are presently under consideration. The TES annual 1980 report more completely outlines the potential impacts associated with hydroelectric development. These impacts will be addressed in the feasibility report. Possible mitigation measures are presented in generic form inthe following table.

MITIGATION OPTIONS FOR OPERATION FLOW - DOWNSTREAM FISHERIES

A) Avoidance	- no change in natural flows - no project option - provide adequate downstream flow on diel basis throughout year - possible no project option
B) Minimization	- alternative flow regime to minimize impacts on fisheries resource
C) Rectify Impact	- mechanical alteration to provide access to spawning areas at newly created flows, transporting of gravels to suitably maintain spawning areas.
D) Reduce or Eliminate Impact Over Time	- basically monitoring of resource as impacts develop, and also monitoring of planned mitigation measures. This may include the following examples: repair stream alterations due to flooding, proper operation and maintenance of any artifical propogation facilities
E) Compensate	- lake fertilization for sockeye enhancement - fish hatchery - artificial spawning channels - creation of new habitat sites not currently utilized - fish passage structures - lake and or stream stocking management

MITIGATION OPTIONS FOR IMPACT OF IMPOUNDMENT CREATION

A) Avoidance	No impoundment creation; meaning no project option.
B) Minimization	1. Lowering height of reservoir pools, therefore reducing the number of tributary miles inundated by the impoundments. 2. Eliminate Watana Reservoir - opting for single dam site at Devil Canyon. Proposed Watana impoundment has most of the productive tributaries. 3. Move dams to sites where a smaller number of streams would be inundated. 4. Provide for enhancement of other species such as salmon or resident salmonids. Flow regulation downstream may provide this opportunity. 5. Development, if possible, of a fisheries in the impoundments.
C) Rectify	Possible stocking of portions of tributaries, including areas that will not be inundated.
D) Reduce or Eliminate Impact	Monitoring of tributary stream systems to determine impoundment effects upon fisheries.
E) Compensate	Intensify management efforts in existing habitats to enhance populations. Also stocking of lakes, other drainage systems, removal of fish barriers and other habitat improvement measures.

MITIGATION OPTIONS FOR DOWNSTREAM TEMPERATURE REGIME ALTERATIONS

A. Avoidance	1. Multi-level discharges that effectively provide controlled temperatures during summer months. 2. Consideration of floating intake structure to allow colder winter intake water to be discharged. Improved multi-level discharge schemes could also accomplish this. 3. During filling time, consideration of feasible options for discharging water with a temperature closely following the existing temperature regime.
B. Minimize	1. Multi-level discharge structure should at least reduce any significant impact on summer rearing and adult behavior. Proper operation, design, and control of water releases at both dams are necessary. 2. During filling, possible variation in flow releases to allow water temperatures downstream of the dam to obtain temperatures as close to the present regime as possible.
C. Rectify	Importing artifically reared stock to the affected area.
D. Reduce or Eliminate	Monitoring water temperature regime and fish population response to the altered temperatures.
E. Compensate	Introduction of other species or stocks more adaptable to altered temperature regimes. Replacement of lost population in other geographic areas. Artificial propogation in suitable portions of the Susitna through spawning channels or hatcheries, if losses confined to the reproductive cycle of the salmon.

Reservoir Operations and Temperature Modeling

1. Pre and post-project average monthly flows at Gold Creek, Sunshine, and Susitna stations for 30 year hydrology record utilizing Case A (proposed operation scenario).

2. Pre and post-project average monthly stream temperatures for Case A for average, wettest, and driest flow year of record in the reach from Devil Canyon to Talkeetna.

3. Post-project stream flows during Watana reservoir filling sequence.

4. Reservoir temperature profiles for average year conditions.

5. Post-project stream temperatures during Watana reservoir filling sequence.

GOLD CREEK UPDATED PRE-PROJECT FLOWS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
6335.	2583.	1439.	1027.	788.	726.	870.	11510.	19600.	22600.	19880.	8301.	7972.
3848.	1300.	1100.	960.	820.	740.	1617.	14090.	20790.	22570.	19670.	21240.	9062.
5571.	2744.	1900.	1600.	1000.	880.	920.	5419.	32370.	26390.	20920.	14480.	9516.
8202.	3497.	1700.	1100.	820.	820.	1615.	19270.	27320.	20200.	20610.	15270.	10035.
5604.	2100.	1500.	1300.	1000.	780.	1235.	17280.	25250.	20360.	26100.	12920.	9619.
5370.	2760.	2045.	1794.	1400.	1100.	1200.	9319.	29860.	27560.	25750.	14290.	10204.
4951.	1900.	1300.	980.	970.	940.	950.	17660.	33340.	31090.	24530.	18330.	11412.
5806.	3050.	2142.	1700.	1500.	1200.	1200.	13750.	30160.	23310.	20540.	19800.	10347.
8212.	3954.	3264.	1965.	1307.	1148.	1533.	12900.	25700.	22880.	22540.	7550.	9413.
4811.	2150.	1513.	1448.	1307.	980.	1250.	15990.	23320.	25000.	31180.	16920.	10489.
6558.	2850.	2200.	1845.	1452.	1197.	1300.	15780.	15530.	22980.	23590.	20510.	9649.
7794.	3000.	2694.	2452.	1754.	1810.	2650.	17360.	29450.	24570.	22100.	13370.	10750.
5916.	2700.	2100.	1900.	1500.	1400.	1700.	12590.	43270.	25850.	23550.	15890.	11531.
6723.	2800.	2000.	1600.	1500.	1000.	830.	19030.	26000.	34400.	23670.	12320.	10989.
6449.	2250.	1494.	1048.	966.	713.	745.	4307.	50580.	22950.	16440.	9571.	9793.
6291.	2799.	1211.	960.	860.	900.	1360.	12990.	25720.	27840.	21120.	19350.	10117.
7205.	2098.	1631.	1400.	1300.	1300.	1775.	9645.	32950.	19860.	21830.	11750.	9395.
4163.	1600.	1500.	1500.	1400.	1200.	1167.	15480.	29510.	26800.	32620.	16870.	11151.
4900.	2353.	2055.	1981.	1900.	1900.	1910.	16180.	31550.	26420.	17170.	8816.	9761.
3822.	1630.	882.	724.	723.	816.	1510.	11050.	15500.	16100.	8879.	5093.	5561.
3124.	1215.	866.	824.	768.	776.	1080.	11380.	18630.	22660.	19980.	9121.	7535.
5288.	3407.	2290.	1442.	1036.	950.	1082.	3745.	32930.	23950.	31910.	14440.	10206.
5847.	3093.	2510.	2239.	2028.	1823.	1710.	21890.	34430.	22770.	19290.	12400.	10836.
4826.	2253.	1465.	1200.	1200.	1000.	1027.	8235.	27800.	18250.	20290.	9074.	8052.
3733.	1523.	1034.	874.	777.	724.	992.	16180.	17870.	18800.	16220.	12250.	7581.
3739.	1700.	1603.	1516.	1471.	1400.	1593.	15350.	32310.	27720.	18090.	16310.	10234.
7739.	1993.	1081.	974.	950.	900.	1373.	12620.	24380.	18940.	19800.	6881.	8136.
3874.	2650.	2403.	1829.	1618.	1500.	1680.	12680.	37970.	22870.	19240.	12640.	10080.
7571.	3525.	2589.	2029.	1668.	1605.	1702.	11950.	19050.	21020.	16390.	8607.	8142.
4907.	2535.	1681.	1397.	1286.	1200.	1450.	13870.	24690.	28680.	20460.	10770.	9427.
5639.	2467.	1773.	1454.	1236.	1114.	1368.	13317.	27928.	23853.	21479.	13171.	

SUNSHINE STATION UPDATED PRE-PROJECT FLOWS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
14003.	5639.	3611.	2748.	2276.	2033.	2311.	22418.	45613.	59179.	54849.	27734.	20201.
12226.	4712.	3804.	2930.	2435.	2144.	3563.	42196.	58971.	69474.	58354.	51069.	25982.
13713.	5702.	3782.	3470.	2511.	2282.	2357.	11258.	68738.	64937.	53363.	32057.	22014.
17394.	7199.	4080.	2818.	2343.	2317.	4292.	50302.	64075.	54231.	49954.	33737.	24395.
13227.	5092.	3977.	3667.	2889.	2423.	3204.	32595.	54605.	53386.	57701.	28376.	21779.
12188.	6340.	4313.	3927.	3189.	2577.	2608.	21758.	69686.	70891.	77692.	35385.	25884.
11011.	4367.	3161.	2612.	2286.	2209.	2214.	33157.	73741.	80569.	69034.	44195.	27424.
15232.	7029.	4907.	4006.	3471.	2844.	2907.	34140.	79153.	62302.	53243.	48121.	26448.
18399.	9032.	6139.	4067.	2996.	2643.	3499.	27759.	60752.	59850.	56702.	20098.	22670.
11578.	5331.	3592.	3387.	3059.	2280.	2895.	29460.	61286.	67591.	71948.	36915.	25188.
15131.	6415.	4823.	4059.	3201.	2675.	2928.	34802.	39311.	58224.	55315.	43086.	22498.
16976.	6109.	5504.	4739.	3478.	3490.	5109.	32438.	60886.	63619.	60616.	36071.	24922.
14579.	6657.	4820.	4222.	3342.	2975.	3581.	24520.	87537.	67756.	61181.	36711.	26657.
13956.	6052.	4690.	4074.	3621.	2399.	2025.	35245.	56629.	78219.	52938.	29182.	24086.
16555.	5707.	3533.	2797.	2447.	2013.	2381.	8645.	111073.	58836.	46374.	23267.	23817.
15473.	7472.	4536.	3373.	2962.	2818.	3435.	24597.	58488.	65042.	56375.	53703.	24856.
18208.	5321.	3965.	3404.	3007.	2875.	3598.	16179.	69569.	55213.	62007.	30156.	22820.
11551.	4295.	3856.	3698.	3294.	2793.	2639.	39912.	66162.	77125.	82747.	37379.	27371.
10796.	5113.	4563.	4181.	3986.	3898.	4359.	36961.	76770.	69735.	46730.	20885.	24016.
8573.	1048.	2650.	2218.	2092.	2077.	3458.	21509.	40404.	45267.	24656.	14268.	11269.
9416.	3978.	2848.	2600.	2448.	2382.	3150.	25687.	47602.	60771.	54926.	27191.	20250.
12264.	7467.	4930.	3325.	2514.	2551.	2640.	10652.	76206.	64787.	74549.	32402.	21505.
14313.	6715.	4922.	4257.	3801.	3335.	3210.	36180.	66856.	62292.	51251.	34156.	24277.
13588.	6018.	4030.	3312.	2984.	2646.	2821.	18215.	59933.	51711.	51085.	25236.	20132.
11294.	4699.	3524.	2882.	2519.	2220.	2916.	31486.	43713.	51267.	43222.	29114.	19071.
12302.	4938.	3777.	3546.	2990.	2810.	3160.	29380.	72835.	73692.	51678.	35567.	24890.
12565.	4238.	2734.	2507.	2355.	2281.	3294.	27875.	56366.	55506.	52155.	18502.	19865.
10620.	5888.	5285.	4231.	3640.	3171.	3537.	27292.	87773.	62194.	55157.	32719.	25126.
17397.	7130.	5313.	4213.	3227.	3002.	3542.	22707.	48041.	57930.	42118.	22742.	19781.
11223.	5648.	4308.	3674.	3206.	2963.	3704.	33876.	59849.	71774.	48897.	26790.	22973.
13690.	5825.	4199.	3498.	2952.	2631.	3177.	27717.	64198.	63178.	55900.	32304.	

SUSITNA STATION UPDATED PRE PROJECT FLOWS

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
26869.	11367.	6197.	6072.	5256.	5377.	5657.	66294.	101616.	124890.	106432.	39331.	42113.
18026.	6933.	5961.	7074.	7295.	6382.	7354.	59273.	82255.	123164.	100947.	73471.	41513.
31936.	16364.	6989.	8274.	7036.	5853.	5783.	45294.	132517.	137322.	116186.	62076.	49582.
41952.	16299.	9746.	8049.	6775.	6350.	7993.	88840.	130561.	125919.	97610.	44168.	48942.
20169.	11829.	5272.	7202.	4993.	4980.	6306.	58516.	108881.	116732.	128587.	66275.	44976.
23896.	9168.	6183.	7255.	5815.	5316.	6112.	38161.	169045.	148877.	120120.	53504.	51149.
19925.	10522.	7295.	6179.	6831.	6374.	7182.	82486.	161346.	168815.	131620.	104218.	57395.
41622.	21548.	14146.	10600.	8356.	7353.	7705.	63204.	176219.	140318.	124613.	87825.	58657.
52636.	19857.	10633.	7553.	6387.	6679.	8097.	70321.	112897.	122780.	99609.	53053.	47503.
30543.	9508.	4763.	7795.	6564.	5666.	6448.	56601.	110402.	146217.	138334.	67904.	49249.
25754.	10165.	7095.	6716.	6310.	5651.	5830.	30062.	84134.	127403.	113972.	61565.	43881.
33782.	12911.	13768.	12669.	10034.	9193.	9803.	83457.	151715.	138969.	116697.	62504.	54792.
29029.	13013.	8977.	9050.	6183.	5951.	4635.	54554.	163049.	143441.	121221.	74806.	52995.
27716.	10755.	8865.	6671.	7854.	6058.	5565.	53903.	85648.	146420.	106707.	70782.	44912.
37846.	11702.	5626.	6351.	5762.	4910.	5531.	35536.	153126.	124806.	92280.	46110.	44132.
28747.	10458.	5127.	6952.	6196.	6170.	7120.	49485.	110075.	138407.	111646.	89744.	47627.
36553.	12313.	9159.	8031.	7489.	7091.	8048.	52311.	125183.	117607.	118729.	63687.	47200.
26373.	12963.	8322.	8029.	7726.	6683.	7281.	58107.	134881.	136306.	137318.	89527.	52793.
37725.	15873.	15081.	11604.	11532.	8772.	8763.	94143.	137867.	130514.	86675.	42385.	50094.
15940.	6606.	4279.	5033.	5137.	5172.	6152.	41317.	83226.	102121.	62368.	34085.	31228.
22683.	6799.	5016.	6074.	5581.	5732.	5769.	53036.	94612.	132985.	117728.	80585.	44717.
32817.	16607.	8633.	6509.	6254.	5883.	5788.	29809.	122258.	139183.	133310.	69021.	48006.
32763.	14922.	8791.	9380.	8158.	6646.	6895.	74062.	176024.	142787.	107597.	60220.	54045.
26782.	14853.	8147.	7609.	7477.	6313.	7688.	64534.	122797.	123362.	107261.	45227.	45171.
20974.	10113.	6081.	7402.	6717.	6294.	6963.	61458.	67838.	102184.	80252.	56124.	36036.
19520.	10400.	9419.	8597.	7804.	7048.	6867.	47540.	126800.	135700.	91360.	77740.	45900.
31550.	9933.	6000.	6529.	5614.	5368.	7253.	70460.	107000.	115200.	99650.	48910.	42789.
30140.	16270.	13100.	10100.	8911.	6774.	6233.	56180.	165900.	143900.	125500.	83810.	55735.
38230.	12630.	7527.	6974.	6771.	6590.	7033.	48670.	90930.	117600.	102100.	55500.	41713.
36810.	15000.	9306.	8823.	7946.	7032.	8683.	81260.	119900.	142500.	128200.	74340.	53317.
30055.	12658.	8215.	7906.	7037.	6320.	6979.	60463.	123698.	131932.	110641.	65963.	

GOLD CREEK POST-PROJECT FLOWS (CASE A) DEC.23,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
7736.	9073.	12669.	10814.	8961.	7877.	7931.	10434.	10176.	8338.	5773.	4906.	8724.
6967.	7875.	9414.	8340.	6614.	6604.	6355.	10016.	9362.	7650.	6111.	12518.	8152.
7464.	10635.	13130.	11386.	9173.	8031.	7856.	8838.	13752.	9211.	8027.	6692.	9516.
10094.	11388.	12930.	10886.	8992.	7971.	8195.	11809.	12915.	7642.	9453.	8148.	10035.
7496.	9991.	12729.	11087.	9173.	7932.	8031.	13161.	12866.	8060.	9628.	6109.	9689.
7006.	10074.	13274.	11581.	9573.	8251.	7998.	10179.	12109.	8858.	14554.	8159.	10135.
6843.	9791.	12529.	10766.	9143.	8092.	7972.	12287.	13255.	15641.	16005.	14617.	11412.
7698.	10941.	13371.	11487.	9673.	8352.	7993.	11151.	11989.	8472.	10243.	12789.	10347.
10104.	11845.	14487.	11759.	9480.	8299.	8114.	10518.	10704.	7992.	9257.	4995.	9796.
6972.	7686.	10229.	11234.	9480.	8131.	8103.	13428.	12095.	9401.	14602.	9909.	10106.
8451.	10741.	13430.	11632.	9625.	8348.	7967.	10312.	9259.	8359.	6411.	11258.	9649.
9686.	10891.	13923.	12239.	9926.	8961.	9231.	11297.	13741.	10718.	12031.	6466.	10759.
7700.	10591.	13329.	11687.	9673.	8552.	8281.	8832.	16353.	14623.	16462.	12177.	11522.
8616.	10691.	13229.	11387.	9673.	8152.	7793.	11310.	12406.	15775.	14713.	8131.	10990.
8341.	10141.	12723.	10835.	9139.	7864.	7878.	8373.	16524.	14787.	8482.	5156.	10020.
7082.	9062.	12440.	10747.	9033.	8051.	7941.	9600.	11602.	9908.	10868.	12339.	9889.
9097.	9989.	12861.	11186.	9473.	8452.	8356.	10127.	14134.	8370.	7412.	5355.	9568.
6876.	7599.	11735.	11286.	9573.	8351.	8056.	10504.	11886.	12937.	17240.	14905.	10912.
7589.	10244.	13284.	11768.	10073.	9051.	8491.	10929.	12927.	13800.	8329.	5032.	10126.
6793.	7664.	9304.	10510.	8896.	7967.	8091.	9312.	8547.	6053.	5164.	4957.	7772.
7172.	8004.	9519.	8420.	6801.	6968.	5875.	6737.	11552.	9506.	6034.	5151.	7645.
7144.	7780.	8987.	8222.	7128.	7462.	8403.	8918.	12834.	8086.	6732.	5270.	8081.
6900.	7758.	11879.	12026.	10201.	8974.	8291.	13492.	14059.	14508.	10628.	5634.	10363.
6630.	9987.	12694.	10986.	9372.	8151.	7851.	8526.	11066.	6587.	5581.	4932.	8530.
7060.	7922.	9300.	7844.	8798.	7876.	7859.	10869.	10046.	7560.	5682.	5413.	8019.
6916.	7775.	9304.	8227.	6515.	7573.	8173.	11254.	12710.	14690.	9124.	5298.	9297.
9631.	9884.	12310.	10760.	9123.	8051.	8050.	11258.	11496.	6634.	5271.	5070.	8962.
7194.	8175.	9717.	8191.	8160.	8651.	8260.	11686.	13729.	11817.	9834.	5861.	9273.
9231.	11416.	13819.	11815.	9841.	8756.	8283.	8295.	8865.	7516.	5777.	5071.	9057.
7141.	7951.	9349.	8126.	6998.	8351.	8030.	9076.	8870.	13091.	11171.	5024.	8598.
7788.	9452.	11930.	10574.	8943.	8137.	7990.	10418.	12061.	10220.	9553.	7711.	

TY GCCPST.DAT

SUNSHINE STA. POST PROJECT FLOWS (CASE A) DEC.23,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
15404.	12129.	14841.	12535.	10449.	9184.	9372.	21342.	36189.	44917.	40742.	24339.	20954.
15345.	11287.	12118.	10310.	8229.	8008.	8301.	38122.	47444.	54554.	44797.	42347.	25072.
15606.	13593.	15012.	13256.	10684.	9433.	9293.	14677.	50120.	47758.	40470.	24269.	22014.
19286.	15090.	15310.	12604.	10515.	9468.	10872.	42841.	49670.	41673.	38797.	26615.	24395.
15119.	12983.	15206.	13454.	11062.	9575.	10000.	28476.	42421.	41086.	41229.	21565.	21848.
13824.	13654.	15542.	13714.	11362.	9728.	9456.	22618.	51935.	52192.	66496.	29254.	25815.
12903.	12258.	14390.	12398.	10459.	9361.	9266.	27784.	53856.	65120.	60509.	40782.	27424.
17144.	14920.	16136.	13793.	11644.	9996.	9700.	31541.	60982.	47464.	42946.	41110.	26448.
20291.	16923.	17362.	13861.	11169.	9794.	9980.	25377.	45756.	44962.	43619.	17543.	23053.
13739.	10867.	12308.	13173.	11232.	9431.	9748.	26898.	53061.	61922.	55370.	29904.	24804.
17024.	14306.	16053.	13846.	11374.	9826.	9595.	29334.	33040.	43603.	38136.	33834.	22498.
18888.	14000.	16733.	14526.	11650.	10631.	11690.	26375.	45177.	49788.	50547.	29167.	24931.
16363.	14548.	16049.	14009.	11515.	10127.	10162.	20762.	60620.	56529.	54093.	34998.	26648.
15849.	13943.	15919.	13861.	11794.	9551.	8988.	27525.	43035.	59594.	43981.	24993.	24086.
20447.	13798.	14762.	12584.	10620.	9164.	9514.	12711.	77017.	50673.	38416.	18852.	24047.
16264.	13735.	15765.	13160.	11135.	9969.	10016.	21207.	44370.	47110.	46123.	46692.	24629.
20100.	13212.	15195.	13190.	11182.	10027.	10179.	16961.	50753.	43753.	47589.	23761.	22992.
14264.	10294.	14091.	13484.	11467.	9944.	9528.	27936.	48538.	63262.	67367.	35414.	27132.
13395.	13304.	15792.	13968.	12159.	11049.	10940.	31710.	58147.	57115.	37889.	17101.	24381.
11564.	10082.	11072.	12004.	10255.	9228.	10039.	19771.	33451.	35220.	20941.	14132.	16480.
13464.	10767.	11501.	10196.	8481.	8574.	7945.	21044.	40524.	47617.	40980.	23221.	20360.
14120.	11840.	11627.	10105.	8606.	8863.	9961.	15825.	56112.	48923.	49341.	23232.	22380.
15366.	11410.	14291.	14044.	11974.	10486.	9791.	27782.	46485.	54030.	42592.	27390.	23803.
15392.	13752.	15259.	13098.	11156.	9797.	9645.	18506.	43199.	40048.	36376.	21096.	20610.
14611.	11098.	11790.	9852.	10540.	9372.	9783.	26175.	35889.	40027.	32684.	22277.	19508.
15479.	11013.	11478.	10257.	8034.	8983.	9740.	25284.	53236.	62662.	42712.	28555.	23953.
17457.	12129.	13963.	12293.	10528.	9432.	9971.	21513.	43482.	43200.	37626.	16691.	20690.
13940.	11413.	12599.	10593.	10182.	10322.	10117.	26298.	63532.	51141.	45751.	25940.	24319.
19059.	15021.	16543.	13999.	11400.	10153.	10123.	19052.	37859.	44426.	31505.	19206.	20696.
13457.	11064.	11976.	10403.	8918.	10114.	10284.	29082.	44029.	55985.	39608.	21044.	22164.
15839.	12814.	14356.	12619.	10659.	9653.	9800.	24818.	48331.	49545.	43974.	26844.	

TY SHNCPST.OUT

SUSITNA STATION POST PROJECT FLOWS (CASE A) DEC.23,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
28270.	17857.	17427.	15859.	13429.	12528.	12718.	65218.	92192.	110628.	92325.	35936.	42865.
21145.	13508.	14295.	14454.	13089.	12246.	12092.	55199.	70827.	108244.	87388.	64749.	40603.
32946.	24255.	18219.	18060.	15209.	13004.	12921.	48713.	113929.	120143.	103293.	74288.	49582.
46844.	24180.	20976.	17855.	14947.	13501.	14573.	81379.	116156.	113391.	86453.	37046.	48942.
22061.	19720.	16501.	16989.	13166.	12132.	13102.	54397.	96497.	104432.	112115.	59464.	45048.
25532.	16482.	17412.	17042.	14018.	12467.	13210.	59024.	151294.	130175.	108924.	47373.	51079.
21815.	18413.	18524.	15965.	15004.	13476.	14204.	77113.	141261.	153366.	123095.	100505.	59395.
43714.	29439.	25375.	20387.	16529.	14505.	14498.	60605.	158048.	125480.	114516.	80814.	58659.
54528.	27778.	21858.	17347.	14560.	13830.	14680.	67939.	97901.	107392.	86326.	50498.	47886.
32704.	15064.	13479.	17581.	14737.	12817.	13321.	54039.	99377.	130618.	121756.	60893.	48866.
27647.	18056.	18235.	16503.	14483.	12802.	12497.	44594.	77863.	114782.	96793.	72313.	43881.
35674.	20805.	24997.	22456.	18206.	16344.	16384.	79394.	136006.	125112.	106628.	55600.	54801.
30813.	20934.	20206.	18837.	14356.	13103.	13216.	50796.	136132.	132814.	114133.	71093.	52986.
29609.	18646.	20094.	18458.	16027.	13210.	12528.	46183.	72054.	127795.	97750.	66593.	44912.
39738.	19593.	16855.	16138.	13935.	12061.	12664.	39602.	119070.	116643.	84322.	41695.	44360.
29538.	16721.	17356.	16739.	14369.	13321.	13701.	46095.	95957.	120475.	101594.	82933.	47400.
38445.	20204.	20389.	17817.	15662.	14243.	14629.	52793.	106367.	106117.	104311.	57492.	47373.
29109.	18962.	18557.	17815.	15899.	13834.	14170.	53131.	117257.	122443.	121938.	87562.	52556.
40414.	23764.	26310.	21391.	19705.	15923.	15344.	88892.	119244.	117894.	78034.	38601.	50460.
18911.	12640.	12701.	14819.	13310.	12323.	13033.	42579.	76273.	92074.	58653.	33949.	33439.
26731.	13588.	13669.	13670.	11614.	11924.	10564.	48393.	87534.	119831.	103782.	76615.	44826.
34673.	20980.	15330.	13289.	12346.	12395.	13109.	34982.	102162.	123319.	108132.	59851.	45881.
33816.	19587.	18160.	19167.	16631.	13797.	13476.	65664.	155653.	134525.	98935.	53454.	53572.
28586.	22587.	19376.	17395.	15649.	13464.	14512.	64825.	106063.	111699.	92552.	41085.	45649.
24303.	16512.	14347.	14372.	14768.	13446.	13830.	56147.	60014.	90944.	69714.	49287.	36474.
22697.	16475.	17120.	15308.	12848.	13221.	13447.	43444.	109200.	122670.	82394.	70728.	44963.
33442.	17824.	17229.	16315.	13787.	12519.	13930.	69098.	94116.	102894.	85121.	47099.	43615.
33460.	23795.	20414.	16462.	15453.	13925.	12813.	55186.	141659.	132847.	116094.	77031.	54928.
39890.	20521.	18759.	16760.	14944.	13741.	13614.	45015.	80745.	104096.	91487.	51964.	42628.
39044.	20416.	16974.	15552.	13658.	14183.	15263.	76466.	104080.	126711.	118911.	68594.	52488.
32203.	19643.	18371.	17027.	14748.	13343.	13601.	57564.	107831.	118299.	98915.	60504.	

ACRES

Calculations

SUBJECT: Susitna Hydroelectric Project

JOB NUMBER
FILE NUMBER
SHEET OF
BY RLR DATE 22 Dec 81
APP DATE

Stream Water Temperature for Average Year Case A (°C)

"Floating" intake at Watana and single level intake at 70 ft. at Devil Canyon

Cross Section	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
* LRX 68 Below Devil Canyon Dam.	39	3.9	3.9	3.9	5.7	7.1	9.8	9.6	7.6	4.3	3.9	3.9
LRX 61 Portage Creek.	3.8	3.8	3.9	3.9	5.8	7.1	9.8	9.7	7.6	4.3	3.9	3.8
LRX 54	3.3	3.5	3.7	4.0	6.1	7.5	10.1	10.1	7.7	4.2	3.5	3.5
* LRX 47 Gold Creek	3.0	3.2	3.6	4.1	6.2	7.8	10.2	10.3	7.8	4.2	3.4	3.3
LRX 41	2.9	3.2	3.6	4.1	6.3	7.9	10.3	10.4	7.8	4.2	3.3	3.2
LRX 34	2.6	2.9	3.4	4.2	6.5	8.2	10.6	10.7	7.9	4.1	3.0	2.9
LRX 27	2.1	2.5	3.3	4.3	6.8	8.6	10.7	11.0	8.0	4.1	2.7	2.5
LRX 21	1.7	2.3	3.2	4.4	7.0	8.9	10.9	11.3	8.1	4.0	2.5	2.2
LRX 15	1.1	1.8	3.0	4.5	7.3	9.4	11.2	11.8	8.2	3.9	2.1	1.7
LRX 9	0.5	1.4	2.8	4.7	7.7	9.9	11.5	12.2	8.3	3.8	1.7	1.3
* LRX 3 Confluence	0.1	1.1	2.6	4.8	7.9	10.3	11.7	12.6	8.4	3.8	1.4	0.9
Discharge Below DC (CFS)	10514	8883	8072	7903	9344	10288	9070	8665	6972	7403	9425	11824

FORM NO. 152 REV. 1

STREAM WATER TEMPERATURE FOR WET YEAR CASE A (°C)
"FLOATING" INTAKE AT WATANA AND SINGLE LEVEL INTAKE AT 70 FT AT DEVIL CANYON.

CROSS SECTION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LRX 68	3.9	3.9	3.9	3.9	5.7	7.1	10.1	9.7	7.3	4.2	3.9	3.9
LRX 61	3.8	3.8	3.9	3.9	5.8	7.2	10.1	9.8	7.3	4.2	3.9	3.8
LRX 54	3.3	3.5	3.7	4.0	6.0	7.5	10.3	10.0	7.4	4.1	3.5	3.5
LRX 47	3.0	3.3	3.6	4.1	6.2	7.8	10.4	10.2	7.5	4.1	3.3	3.3
LRX 41	2.9	3.2	3.6	4.1	6.2	7.9	10.5	10.2	7.5	4.1	3.3	3.2
LRX 34	2.6	2.9	3.4	4.2	6.4	8.1	10.6	10.4	7.5	4.0	3.1	2.9
LRX 27	2.1	2.6	3.3	4.3	6.7	8.5	10.8	10.7	7.6	3.9	2.7	2.6
LRX 21	1.8	2.3	3.2	4.4	6.9	8.8	10.9	10.9	7.7	3.9	2.5	2.3
LRX 15	1.1	1.9	3.0	4.5	7.2	9.3	11.1	11.2	7.8	3.8	2.1	1.8
LRX 9	0.6	1.5	2.8	4.7	7.5	9.8	11.3	11.6	7.9	3.7	1.7	1.4
LRX 3	0.1	1.2	2.6	4.8	7.8	10.2	11.5	11.8	7.9	3.6	1.5	1.0
DISCHARGE BELOW D.C. (CFS)	10708.	9066.	8004.	7889.	10606.	11052.	13763.	14085.	12783.	6540.	9680.	12436.

ACRES

Calculations

SUBJECT: SUSITNA HYDROELECTRIC PROJECT

JOB NUMBER
FILE NUMBER
SHEET OF
BY RWR DATE 22 Dec 8[illegible]
APP DATE

FORM NO. 152 REV. 1

ACRES

Calculations

SUBJECT: SUSITNA HYDROELECTRIC PROJECT
PROJECTED WATER TEMPERATURES

JOB NUMBER
FILE NUMBER
SHEET ___ OF ___
BY RWR DATE 22 Dec 81
APP ___ DATE ___

STREAM WATER TEMPERATURE FOR DRY YEAR CASE A "FLOATING" INTAKE AT WATANA AND INTAKE AT 70 FT AT D.C.
(°C)

CROSS SECTION	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
LRX 68	3.9	3.9	3.9	3.9	5.7	6.9	9.4	9.2	7.4	4.3	3.9	3.9
LRX 61	3.8	3.8	3.9	3.9	5.8	6.9	9.4	9.3	7.4	4.3	3.8	3.8
LRX54	3.2	3.3	3.7	4.1	6.2	7.4	9.7	10.0	7.6	4.2	3.5	3.4
LRX47	2.8	3.1	3.5	4.2	6.5	7.6	9.9	10.4	7.7	4.1	3.2	3.1
LRX41	2.7	3.0	3.5	4.2	6.6	7.7	10.0	10.5	7.7	4.1	3.1	3.0
LRX34	2.3	2.6	3.4	4.3	6.8	8.0	10.2	11.0	7.8	4.1	2.9	2.7
LRX27	1.7	2.2	3.2	4.4	7.2	8.5	10.5	11.6	8.0	4.0	2.5	2.2
LRX21	1.3	1.9	3.1	4.5	7.5	8.7	10.7	12.0	8.1	3.9	2.3	1.9
LRX15	0.6	1.4	2.8	4.7	8.0	9.3	11.0	12.7	8.3	3.8	1.8	1.3
LRX9	0.0	0.9	2.6	4.8	8.4	9.8	11.3	13.3	8.4	3.7	1.4	0.8
LRX 3	0.0	0.6	2.5	5.0	8.7	10.2	11.6	13.7	8.5	3.7	1.1	0.4
DISCHARGE BELOW D.C. (CFS)	8353.	6742.	6914.	5842.	6079.	10041.	7988.	4707.	4474.	6914.	7934.	9463.

GOLD CREEK 'POST' PROJECT FLOWS (WATANA RES. FILLING) DEC.21,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
3665.	1399.	1170.	1112.	1046.	1057.	1090.	6854.	7168.	9407.	8966.	5581.	4043.
2599.	1093.	1094.	1052.	1047.	1020.	1215.	6440.	6272.	8783.	9192.	8634.	4037.
3028.	1474.	1299.	1225.	1059.	1045.	1016.	5202.	10597.	10229.	9564.	7509.	4441.
3766.	1640.	1319.	1181.	1108.	1049.	1133.	8233.	9850.	8845.	9928.	8356.	4717.
3435.	1400.	1216.	1112.	1097.	1042.	1192.	9583.	9773.	9376.	11679.	8354.	4738.
3561.	1609.	1395.	1306.	1249.	1114.	1159.	6601.	8979.	9772.	8213.	5442.	4200.
2899.	1212.	1161.	1063.	1115.	1146.	1132.	8707.	10168.	11259.	11377.	9736.	5081.
3648.	1673.	1335.	1227.	1211.	1165.	1155.	7574.	8885.	9361.	9222.	9559.	4668.
4227.	1918.	1905.	1384.	1165.	1074.	1168.	6942.	7602.	9127.	9697.	6171.	4365.
3193.	1320.	1298.	1267.	1258.	1186.	1264.	9849.	8990.	10507.	13240.	9053.	5202.
3442.	1536.	1428.	1345.	1213.	1136.	1130.	6736.	6297.	9474.	10267.	9024.	4419.
3795.	1572.	1621.	1572.	1349.	1379.	1585.	7722.	10666.	10730.	8620.	7824.	4870.
3328.	1337.	1240.	1191.	1143.	1123.	1143.	5256.	11253.	8406.	7663.	7744.	4402.
3213.	1191.	1191.	1191.	1215.	1016.	953.	7731.	9337.	11633.	8659.	6120.	4454.
3312.	1361.	1199.	1096.	1084.	1038.	1036.	4728.	11738.	8867.	8392.	6647.	4208.
3582.	1331.	1041.	997.	987.	993.	1028.	6024.	8507.	10604.	9726.	7724.	4379.
4034.	1433.	1327.	1240.	1215.	1215.	1337.	6551.	11010.	9706.	10439.	7136.	4720.
2943.	1298.	1278.	1298.	1269.	1211.	1217.	6924.	8798.	10813.	12515.	7797.	4780.
2931.	1319.	1251.	1263.	1240.	1240.	1233.	7353.	9846.	10337.	9022.	6252.	4441.
2737.	1175.	1028.	1005.	1016.	1030.	1148.	5736.	5538.	7256.	7107.	5433.	3351.
2771.	1094.	1057.	1088.	1066.	1052.	994.	5844.	8231.	10250.	9716.	6497.	4138.
3570.	1811.	1503.	1245.	1159.	1133.	1168.	4888.	9317.	8824.	10463.	6851.	4328.
2918.	1406.	1453.	1468.	1437.	1357.	1305.	9917.	11001.	8950.	7780.	6044.	4586.
2575.	1175.	1118.	1068.	1100.	1026.	1013.	4948.	7941.	7899.	8273.	5574.	3643.
2726.	1068.	1002.	988.	987.	997.	1020.	7391.	7089.	8828.	8696.	7064.	3980.
2700.	1126.	1226.	1200.	1261.	1259.	1282.	7678.	9621.	10290.	8963.	7835.	4537.
4110.	1292.	1105.	1116.	1107.	1109.	1213.	7681.	8386.	7925.	7406.	5769.	4018.
2950.	1623.	1615.	1380.	1315.	1289.	1377.	8111.	10617.	9163.	8433.	6627.	4542.
3827.	1780.	1509.	1351.	1300.	1248.	1194.	4718.	5773.	8635.	8978.	6074.	3866.
3183.	1490.	1268.	1160.	1131.	999.	1032.	5501.	5785.	9968.	9789.	6273.	3965.
3296.	1405.	1288.	1206.	1165.	1125.	1164.	6911.	8835.	9509.	9466.	7157.	

Watana Outflows:

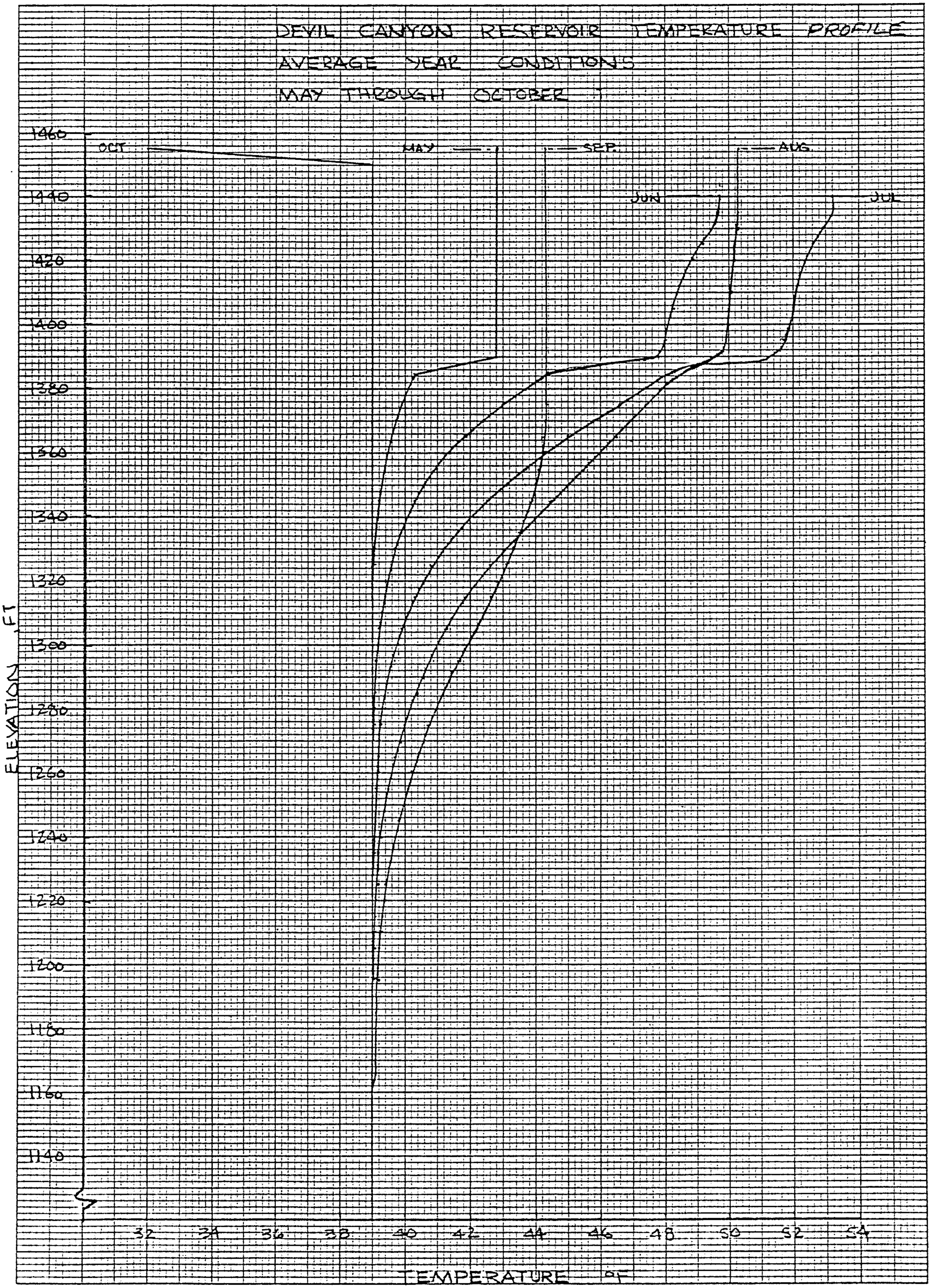
2050 900 900 900 900 900 900 4000 4000 6000 6000 3200.

SUNSHINE STA. 'POST' PROJECT FLOWS (WATANA RES. FILLING) DEC.21,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
11333.	4435.	3342.	2833.	2534.	2364.	2331.	17762.	33181.	45786.	43735.	25014.	16273.
10777.	4505.	3778.	3022.	2662.	2424.	3161.	34546.	44354.	55687.	47878.	38463.	20756.
11170.	4432.	3181.	3095.	2570.	2447.	2453.	11041.	46965.	48826.	42007.	25086.	16537.
13158.	5342.	3699.	2899.	2631.	2546.	3810.	39265.	46605.	42876.	39272.	26823.	17077.
11058.	4372.	3693.	3479.	2986.	2685.	3161.	24698.	39378.	42402.	43280.	23810.	17076.
10379.	5189.	3663.	3439.	3038.	2591.	2617.	19040.	48805.	53106.	60155.	26537.	19880.
8759.	3679.	3022.	2695.	2431.	2415.	2426.	24204.	50769.	60738.	55881.	35591.	21093.
13094.	5652.	4100.	3533.	3182.	2809.	2862.	27964.	57878.	48353.	41925.	37880.	20769.
14414.	6996.	4780.	3486.	2854.	2569.	3034.	21801.	42654.	46097.	44059.	18719.	17623.
9960.	4501.	3377.	3206.	3010.	2484.	2907.	23317.	49956.	53028.	54098.	29048.	19901.
12015.	5101.	4051.	3559.	2962.	2614.	2758.	25758.	30078.	44718.	41992.	31600.	17267.
12997.	4681.	4431.	3959.	3073.	3049.	4044.	22900.	42102.	49800.	47136.	30525.	19041.
11991.	5294.	3960.	3513.	2985.	2698.	3024.	17186.	55520.	50312.	47294.	30565.	19529.
10446.	4443.	3881.	3665.	3336.	2415.	2148.	23946.	39966.	55452.	37927.	22982.	17551.
15418.	5018.	3238.	2845.	2565.	2338.	2672.	9066.	72231.	44753.	38326.	20343.	18234.
12764.	6004.	4366.	3410.	3089.	2911.	3103.	17631.	41275.	47806.	44981.	42077.	19118.
15037.	4656.	3661.	3244.	2924.	2790.	3160.	13385.	47629.	45089.	50616.	25542.	18144.
10331.	3993.	3634.	3496.	3163.	2804.	2689.	24356.	45450.	61138.	62642.	28306.	21000.
8737.	4379.	3759.	3463.	3326.	3238.	3682.	28134.	53066.	53632.	38582.	18321.	18695.
7508.	3593.	2796.	2499.	2375.	2291.	3096.	16195.	30442.	36423.	22884.	14608.	12059.
9063.	3857.	3039.	2864.	2746.	2658.	3064.	20151.	37203.	48361.	44662.	24567.	16853.
10546.	5871.	4143.	3128.	2637.	2534.	2726.	11795.	52595.	49661.	53072.	24813.	18627.
11384.	5058.	3865.	3486.	3210.	2869.	2905.	24207.	43427.	48472.	39744.	27800.	18027.
11337.	4940.	3683.	3180.	2884.	2672.	2807.	14928.	40074.	41360.	39068.	21738.	15723.
10277.	4244.	3492.	2996.	2729.	2493.	2744.	22597.	32932.	41295.	35698.	23928.	15469.
11263.	4364.	3400.	3230.	2780.	2669.	2849.	21708.	50147.	58262.	42551.	27092.	19193.
11936.	3537.	2758.	2649.	2512.	2490.	3134.	17936.	40372.	44491.	39761.	17390.	15747.
9696.	4861.	4497.	3782.	3337.	2960.	3234.	22723.	60420.	48487.	44350.	26706.	19588.
13655.	5385.	4233.	3535.	2859.	2645.	4034.	15475.	34767.	45545.	31706.	20209.	15504.
9499.	4603.	3895.	3437.	3051.	2762.	3286.	25507.	40944.	57862.	38226.	22293.	17530.
11347.	4768.	3715.	3251.	2881.	2641.	2974.	21311.	45105.	48835.	43887.	26290.	

SUSITNA STATION "POST" PROJECT FLOWS (WATANA RES. FILLING) DEC.21,1981

OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	YR AVG
24199.	10183.	5728.	6157.	5514.	5708.	5877.	61638.	87184.	111697.	95516.	36611.	38184.
16777.	6726.	5975.	7166.	7522.	6662.	6952.	51623.	67737.	109377.	90467.	60865.	36487.
28510.	15074.	6388.	7899.	7095.	6018.	6061.	45077.	110774.	121211.	104630.	75105.	44507.
40716.	14432.	9365.	8150.	7063.	6579.	7511.	77803.	113091.	114574.	86928.	37254.	43624.
18000.	11129.	1988.	7014.	5090.	5242.	6263.	50819.	93404.	105748.	114166.	61709.	40298.
22087.	8017.	5533.	6767.	5694.	5330.	6371.	55446.	148164.	131089.	102583.	44656.	45145.
17871.	9834.	7156.	6262.	6976.	6530.	7364.	73533.	138174.	148984.	118467.	95624.	53065.
39664.	20171.	13339.	10127.	8067.	7318.	7660.	57028.	154944.	126369.	113495.	77584.	52981.
48651.	17851.	9276.	6972.	6215.	6605.	7734.	61363.	94799.	108527.	86766.	51674.	42455.
28925.	8678.	4518.	7614.	6515.	5872.	6487.	50460.	96272.	131724.	120394.	60037.	43962.
22638.	8851.	6233.	6216.	6071.	5590.	5660.	41018.	74901.	115897.	100619.	70079.	38650.
29783.	11486.	12695.	11789.	9629.	8762.	8738.	75819.	132931.	125129.	103217.	56958.	48911.
26441.	11680.	8117.	8341.	5826.	5674.	6078.	47220.	131032.	125997.	107334.	66660.	45867.
24206.	9146.	8056.	8262.	7569.	6074.	5688.	42604.	68785.	123653.	91676.	64582.	38377.
34709.	10813.	5331.	6399.	5880.	5235.	5822.	35757.	114284.	110723.	84232.	43186.	39546.
26038.	8990.	5757.	6989.	6323.	6263.	6788.	42519.	92862.	121171.	100452.	78318.	41889.
33382.	11618.	8855.	7871.	7104.	7006.	7610.	49217.	103243.	107433.	107338.	59273.	42525.
25176.	12661.	8100.	7827.	7595.	6694.	7341.	49551.	114169.	120319.	117213.	80454.	46424.
35756.	14839.	14277.	10886.	10872.	8112.	8086.	85316.	116163.	114431.	78727.	39821.	44774.
14855.	6151.	1425.	5314.	5430.	5386.	6090.	39003.	73264.	93277.	60596.	34425.	29018.
22330.	6678.	5207.	6338.	5879.	6008.	5683.	47500.	84213.	120575.	107464.	77961.	41320.
31095.	15011.	7846.	6312.	6377.	6066.	5674.	30952.	98645.	124057.	111864.	61432.	42128.
29834.	13235.	7731.	9609.	7867.	6180.	6190.	62089.	152595.	128967.	96087.	53864.	47796.
24531.	13775.	7800.	7477.	7377.	6339.	7674.	61247.	102938.	113011.	95244.	41727.	40762.
19969.	9658.	6049.	7516.	6957.	6567.	6991.	52569.	57057.	92212.	72728.	50938.	32434.
18481.	9826.	9042.	8281.	7594.	6907.	6556.	39868.	106111.	118270.	82233.	69265.	40203.
27921.	9232.	6024.	6671.	5771.	5577.	7093.	65521.	91006.	104185.	87256.	47778.	38671.
29216.	17243.	12312.	9651.	8608.	6563.	5930.	51611.	138547.	130193.	114693.	77797.	50197.
34486.	10885.	6419.	6294.	6403.	6233.	6525.	41139.	77653.	105215.	94688.	52967.	37437.
35086.	13955.	8893.	8586.	7791.	6831.	8265.	72891.	100995.	123588.	117529.	69843.	47854.
27711.	11597.	7730.	7659.	6967.	6331.	6774.	54057.	104605.	117588.	98829.	59949.	

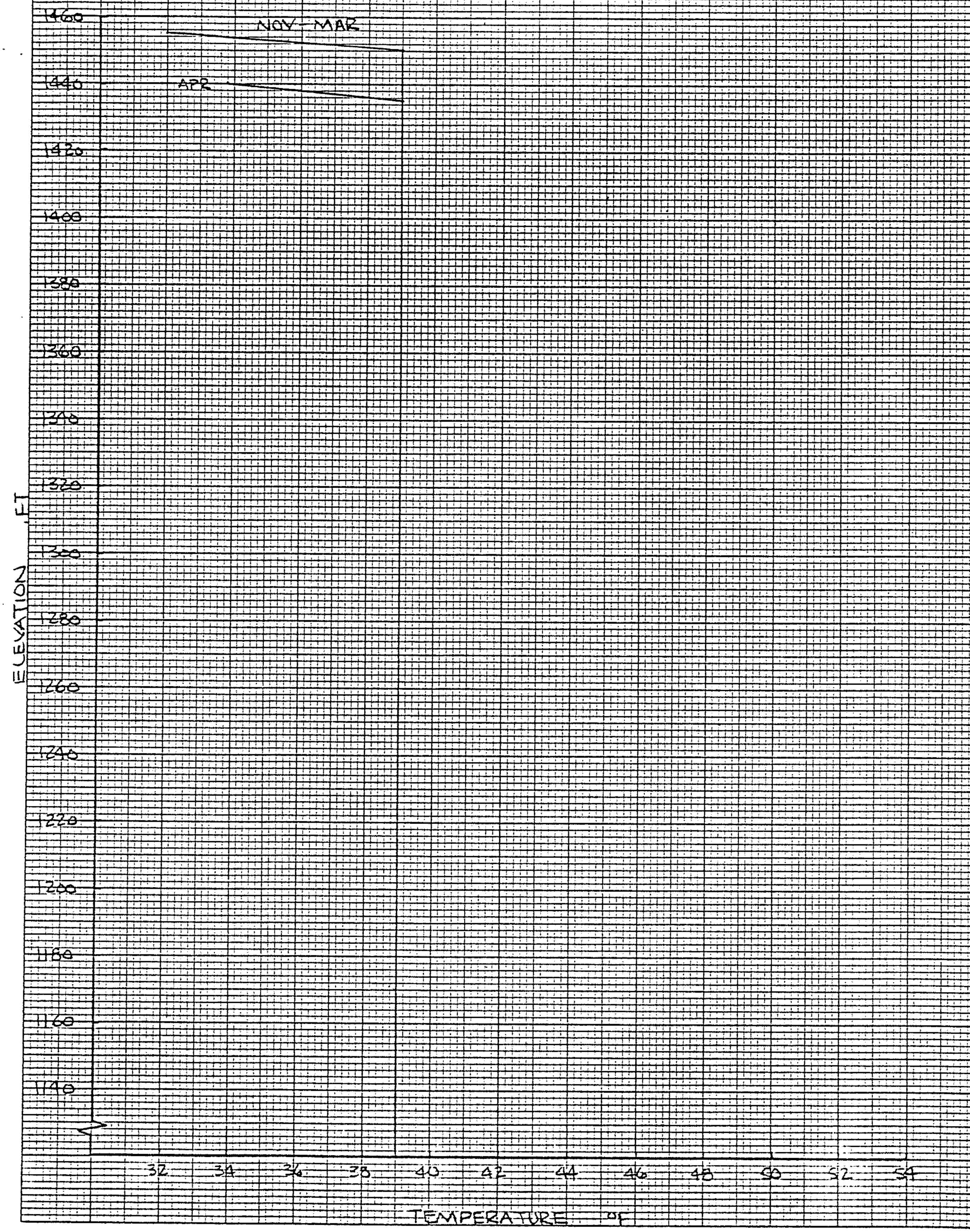


46 1320

K•E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

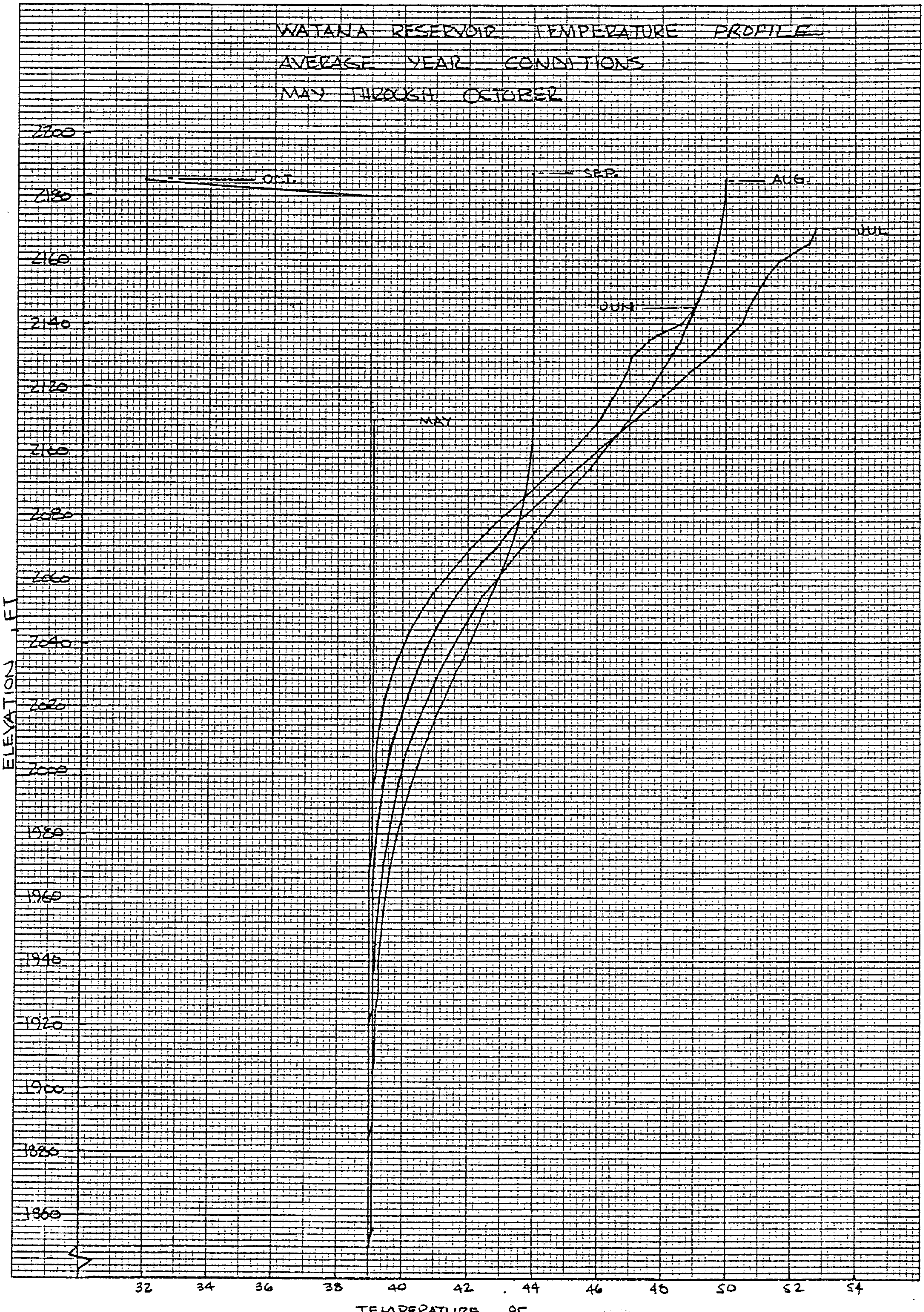
RJS 300RC.

DEVIL CANYON RESERVOIR TEMPERATURE PROFILE
AVERAGE YEAR CONDITIONS
NOVEMBER THROUGH APRIL

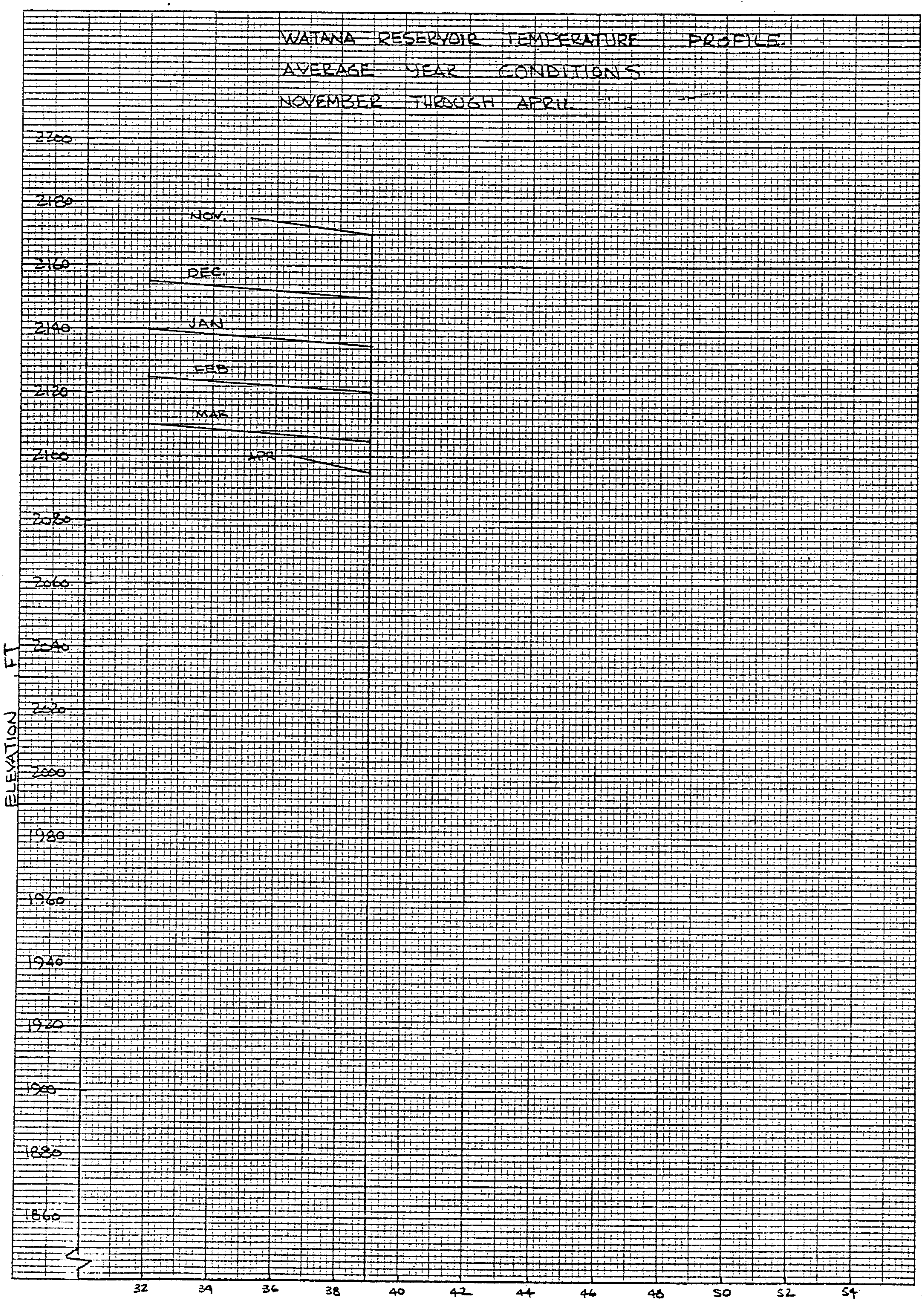


K+E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A. 46 1320

RJS 31 DEC. 8



WATANA RESERVOIR TEMPERATURE PROFILE
AVERAGE YEAR CONDITIONS
MAY THROUGH OCTOBER
OCT.
SEP.
AUG.
JUL
JUN
MAY
ELEVATION, FT
2200
2180
2160
2140
2120
2100
2080
2060
2040
2020
2000
1980
1960
1940
1920
1900
1880
1860
32
34
36
38
40
42
44
46
48
50
52
54
TEMPERATURE °F



46 1320

K&E 10 X 10 TO ½ INCH 7 X 10 INCHES KEUFFEL & ESSER CO. MADE IN U.S.A.

22

RJS 30DEC81

Average Monthly Stream Temperatures (C°) for Filling odd years (low flow)
Watana Reservoir

	January	February	March	April	May	June	July	August	Sept	Oct	Nov	Dec
Watana Flow →	900	900	900	900	4000	4000	6000	6000	6000/3200 avg = 4600	3200/900 avg = 2050	900	900
Watana outflow Temp	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9	3.9
LRX 68 Below Devil Canyon Dam	0.0	0.0	0.0	5.6	6.7	8.6	6.3	7.1	4.9	2.8	0.0	0.0
LRX 61 Flow	1100	1070	1045	1070	5870	7108	8256	8228	7644	4000	1225	1150
Temp	0.0	0.0	0.0	5.6	6.7	8.6	7.5	7.1	4.9	2.5	0.0	0.0
LRX 54	0.0	0.0	0.0	6.1	7.1	9.2	7.8	7.6	5.1	2.4	0.0	0.0
LRX 47 Gold Creek	0.0	0.0	0.0	6.3	7.4	9.5	8.0	7.9	5.2	2.4	0.0	0.0
LRX 41	0.0	0.0	0.0	6.4	7.5	9.6	8.1	8.0	5.3	2.4	0.0	0.0
LRX 34	0.0	0.0	0.0	6.6	7.7	9.9	8.4	8.3	5.4	2.4	0.0	0.0
LRX 27	0.0	0.0	0.0	6.8	8.1	10.4	8.7	8.8	5.5	2.3	0.0	0.0
LRX 21	0.0	0.0	0.0	6.9	8.3	10.8	8.9	9.1	5.7	2.3	0.0	0.0
LRX 15	0.0	0.0	0.0	7.2	8.8	11.4	9.3	9.7	5.9	2.2	0.0	0.0
LRX 9	0.0	0.0	0.0	7.3	9.2	11.9	9.7	10.2	6.1	2.2	0.0	0.0
LRX 3 Confluence	0.0	0.0	0.0	7.4	10.7	12.3	10.0	10.6	6.2	2.2	0.0	0.0
Alternative Watana Flows	900	900	900	900	4000	4000	16000	16000	6000/3700	3700/900	900	900
Temp at LRX 68	0.0	0.0	0.0	4.3	6.5	8.4	4.9	5.2	4.7	2.5	0.0	0.0