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SUSITNA HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

CASE E-VI
ALTERNATIVE FLOW REGIME

VOLUME I - MAIN REPORT

Final Report

February 1985
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HARZA-EBASCO
SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

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SUSITNA HYDROELECTRIC PROJECT

CASE E-VI
ALTERNATIVE FLOW REGIME

VOLUME 1
MAIN REPORT

Report By
Harza-Ebasco Susitna Joint Venture

Prepared for
Alaska Power Authority

Final Report
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1.0 INTRODUCTION

On November 2, 1984, the Alaska Power Authority submitted a report to the Federal Energy Regulatory Commission (FERC) evaluating alternative flow requirements (Harza-Ebasco 1984d). The alternative flow requirements were refinements to the Case C flow requirements contained in the Susitna Hydroelectric Project License Application - Project No. 7114 (Alaska Power Authority 1983). The report incorporated results of additional studies and analyses that have been conducted since submittal of the License Application. These study results allowed development of more detailed and refined environmental flow requirements to meet specific environmental management objectives. As a result of the evaluation, the Power Authority selected one alternative, Case E-VI, as the preferred flow regime case because it produced superior energy benefits and no net loss in habitat value through control of flow releases and other mitigation measures.

On December 3, 1984, FERC requested that the Power Authority formally file the Case E-VI refinement with the Commission. This report responds to that request. It provides information on the development of alternative environmental flow cases, but focuses on information specific to Case E-VI. For further information on alternative regimes, the reader is referred to the Evaluation of Alternative Flow Requirements report submitted on November 2, 1984 (Harza-Ebasco 1984d).

Discussions were held with resource agency personnel on November 20 and 27, 1984 concerning the alternative flow requirements report and the process to be used to arrive at an acceptable flow regime. Those meetings are summarized in Appendix A hereto. Further discussions were held on December 20, 1984 with the regional directors and commissioners of the resource agencies or their representatives. These discussions also focused on the refined flow regime case and the settlement process. The December 20, 1984 minutes are also summarized in Appendix A.

Comments on the "Evaluation of Alternative Flow Requirements" report by various resource agencies are included as Appendix B. These formal comments convey a positive opinion that an acceptable flow regime is achievable. Where appropriate, specific concerns of the resource agencies are addressed in this document.

2.0 DEVELOPMENT OF ALTERNATIVE ENVIRONMENTAL FLOW CASES

2.1 BACKGROUND

The License Application (Exhib. B, Vol. 2, pp. B-2-121 through B-2-130) presented ten alternative flow regimes ranging from the regime which would optimize project economics (Case A) to a regime that would approximate pre-project average, run-of-river conditions (Case G). Seven of the cases (C, C_1, C_2, D, E, F, G) emphasized the use of flow control and planned releases to mitigate potential impacts on downstream aquatic habitats. The major difference among these environmental cases was a gradual, incremental decrease of summer minimum flows from Case G through Case A (Lic. App., Exhib. B, Vol. 2, Table B54). Emphasis was placed on maintaining higher flows (i.e. smaller incremental decreases) during mid-July to mid-September to mitigate impacts on access conditions into side sloughs for spawning adult salmon (Lic. App., Exhib. B, Vol. 2, pp. B-2-127 and B-2-128).

All the flow cases were analyzed to evaluate and compare their economic and environmental consequences. Case C was selected, based on this analysis, as the best compromise between economic and instream flow considerations. Attributes of the flow cases, emphasis on access to sloughs for spawning salmon, evaluation of the consequences of project operation, and mitigation planning were based on information available when the License Application was submitted. However, the Power Authority recognized the potential need to refine the selected case and stated in the Application that,

> "As a more refined assessment of fishery impact, mitigation costs and projected project net benefits becomes available, the project operational flow will be adjusted."
>
> (Lic. App., Exhib. B, Vol. 2, B-2-130).

Results of several studies and other information have become available since the License Application. This accumulated information has provided a more detailed and complete understanding of habitat use by the evaluation species and the importance of certain physical processes in the Susitna system as they relate to the quantity and quality of aquatic habitats. The new information is sufficient to refine Case C to more adequately provide for habitat requirements of the evaluation species. The primary reasons to refine Case C relate to (1) mainstem and side channel rearing habitats, (2) seasonal flow constraints, and (3) maximum flow constraints.

(1) <u>Mainstem and side channel rearing habitats</u>

The use of mainstem associated habitats for rearing is more common than previously perceived. Chinook salmon juveniles use side channel habitats for rearing during the summer (ADF&G 1984b). They are found in the side channels in greatest densities when flow is dominated by turbid water overflow from the mainstem. Conditions in the side channels are directly influenced by mainstem discharge at these times. Chum salmon also use turbid water, low velocity, mainstem sites for short-term rearing during their downstream migration to Cook Inlet.

The rationale used to establish Case C flow requirements did not include consideration of the use of mainstem and side channel habitats for rearing. The primary environmental considerations in the Case C flows were for upstream migration by adult salmon, access conditions into side sloughs for spawning chum and sockeye salmon, and downstream passage of juvenile salmon during migration to Cook Inlet (Lic. App., Exhib. B, Vol. 2, p. B-2-128).

(2) <u>Seasonal flow constraints</u>

Environmental flow constraints for the entire year are necessary to maintain overall aquatic habitat values. The minimum flow constraints included in Case C are a composite of environmental and reservoir operating guidelines. Environmental considerations focused on summer flow, and winter minimum flows were based on reservoir operations for an extreme dry year (1969). There are important uses of the aquatic habitats throughout the year so there is a parallel need to establish appropriate environmental flow requirements for the entire year, rather than focusing only on the summer flow period.

(3) Maximum flow constraints

It is now believed that maximum flow constraints are needed. The flow cases presented in the License Application did not include maximum flow constraints. Maximum constraints are not critical during the summer since the project will be storing flows. However, winter maxima can serve to maintain a desired level of flow stability, protect peripheral habitats, and enhance the feasibility of certain mitigation alternatives, such as artificial berms and other structural modifications in side sloughs.

The first step toward refining Case C was to develop a set of alternative flow cases that preserved the basic qualities of Case C while rectifying its deficiencies and incorporating the new information. The alternative flow cases also had to meet the selection criteria that are discussed in the next section.

2.2 SELECTION CRITERIA

Several criteria were established for selection of alternative flow cases. The criteria were:

1. The flow case had to be goal oriented. That is, the case had to be designed to achieve a specified level of habitat quantity and quality (Section 2.2.1).

2. The flow case had to emphasize critical or sensitive species and habitat combinations (Section 2.2.2).

3. The flow case had to be compatible with mitigation policy. That is, it had to focus on evaluation species, emphasize preservation of habitats in a state of natural production, and integrate with other mitigation efforts (Section 2.2.3).

2.2.1 Management Objectives

The programming of flow regulation to mitigate for potential downstream project impacts requires a clear statement of objectives. A particular objective will dictate the quantity and timing of flow releases and set a standard by which the success of flow regulation can be measured.

The management objectives chosen by the Power Authority emphasized chum salmon spawning in side sloughs and chinook salmon rearing in side channels (the reasons for this emphasis are detailed in sections 2.2.2 and 2.2.3 below). The specific objectives were:

1. To maintain quantity and quality of existing habitats (ie., no net loss in habitat value).

2. To maximize chinook salmon production (rearing) in existing habitats.

3. To maintain 75% of existing side slough spawning habitat for chum salmon.

4. To maintain 75% of existing side channel rearing habitat for chinook salmon.

5. To maintain 75% of existing side slough and side channel habitats for chum salmon spawning and chinook salmon rearing, respectively.

6. To maintain 75% of existing side channel rearing habitat for chinook salmon and provide flows (spikes) for access by spawning chum salmon into side sloughs (minimum structural modification of critical reaches for access).

7. To maintain 75% of existing side channel rearing habitat for chinook rearing and provide flows (spikes) for access by spawning chum salmon into side sloughs by spawning chum salmon (moderate structural modification of critical reaches for access).

The Power Authority applied these objectives and developed eight alternative flow cases for evaluation and comparison (Harza-Ebasco 1984d). This process included an analysis of characteristics of habitat types and identification of project-sensitive habitat use by the evaluation species. These factors are detailed below.

2.2.2 Critical Species And Habitat Combinations

The primary change from natural riverine conditions due to project operations will be altered streamflows in the mainstem Susitna River. The project will change the annual hydrology by storing high summer flows for release during the normally low flow period in winter. This primary change will also alter annual cycles for factors associated with mainstem flow such as water temperature, turbidity and suspended sediment. These changes will not affect all habitats equally. The magnitude of effect will depend on the level of influence that mainstem conditions have on physical characteristics of the various habitat types. In addition, the habitats are not used uniformly by all species at all times. Therefore, some prioritization is necessary for effective allocation of flows. The timing and volume of flow discharge should be planned to produce the greatest possible mitigative effect for the aquatic habitats and evaluation species.

The Power Authority evaluated habitat characteristics and seasonal habitat uses by the evaluation species in order to develop a rationale for establishing environmental flow requirements and to plan project operations. The general approach was to find the most important, based on density, frequency and duration, uses of the aquatic habitats which are most sensitive to mainstem flows. This process and its results were also reviewed to avoid overlooking a critical use of a less sensitive habitat that would be adversely impacted by project operation. No such circumstance was found.

2.2.2.1 Habitat Sensitivity to Mainstem Conditions

Changes due to project operation will be greatest in the Middle River reach (Devil Canyon-Talkeetna; Lic. App., p. E-3-72). The magnitude of discharge changes in the Middle River will be dampened in the Lower River by the dominating influence of inflow from the Chulitna, Talkeetna and Yentna Rivers (Appendix E and F), especially during spring and summer. Therefore, flow regulation intended to mitigate project impacts will have limited effectiveness for Lower River (Talkeetna-Cook Inlet) habitats. Other factors associated with mainstem discharge, such as temperature, turbidity, and suspended sediment, will follow the same trend. The magnitude of change will decrease with distance downstream from the project site (AEIDC 1984b) and the effect of any design or operational measures to mitigate these changes will be "masked" by the influence of inflow from the major tributaries. Therefore, the current analysis focuses on evaluation species and habitats found in the Middle River.

Seven habitat types have been defined in the Middle River Basin (AEIDC 1984a). Each was characterized and compared based on the level of influence mainstem conditions have on particular physical attributes of the habitats (Table 2.2-1).

Table 2.2-1

SUSITNA HYDROELECTRIC PROJECT
INFLUENCE OF MAINSTEM FLOW AND WATER QUALITY ON
CHARACTERISTICS OF AQUATIC HABITAT TYPES

		Physical Characteristics				
Habitat Type	Hydraulic[1/]	Hydrologic	Temp.	Turbidity	Ice	Total
Mainstem (MS)	4	4	4	4	4	20
Side Channel (SC)	3	4	4	3	4	18
Tributary Mouth (TM)	3	3	2	2	3	13
Side Slough (SS)	2	2	2	2	2	10
Upland Slough (US)	1	1	0	0	0	2
Tributary (T)	0	0	0	0	0	0
Lake (L)	0	0	0	0	0	0

0 - no influence
1 - small, limited influence
2 - moderate, occasional influence
3 - moderate, frequent influence
4 - direct, extensive influence

1/ Depth, velocity, wetted area, etc.

Tributary and lake habitat types are isolated from mainstem influence and their physical attributes will not be effected by project operation. Upland sloughs are usually in old overflow channels and oxbows that are presently isolated from the mainstem. They receive mainstem water only during infrequent and high flood events. Mainstem influence is limited to small backwater areas at the slough mouths so project operation will have little effect on upland slough habitats.

Side channels and side sloughs are active overflow channels that differ primarily in the frequency of receiving mainstem flow. Side sloughs are the most lateral channels and receive mainstem flow less often than side channels. Habitat characteristics of the side sloughs are controlled by local climate, runoff and groundwater upwelling during periods of relative isolation from the mainstem. Side channels are more closely associated with the mainstem and some receive mainstem flows through most of the year. Side channels may completely dewater during periods of low mainstem flow or, if groundwater or intragravel flow is sufficient, their habitat characteristics may resemble side sloughs. Both side channel and side slough habitat types are influenced by mainstem flows and several of their physical habitat components are sensitive to changes in mainstem discharge.

Tributary mouth habitat is the area bounded by the uppermost point of mainstem induced backwater effect in a tributary and the area of clearwater plume from tributary flow into the mainstem. The areal extent and physical attributes of this habitat type are controlled by both mainstem and tributary conditions.

The relative influence of mainstem flow on primary characteristics of the major habitat types is summarized in Table 2.2-1. This summary shows that mainstem, side channel, side slough and tributary mouth habitat types are influenced by the mainstem and several of their physical attributes are sensitive to change in mainstem discharge.

2.2.2.2 Habitat Use By The Evaluation Species

The next step in this analysis was to evaluate use of the habitat types by each of the evaluation species (Table 2.2-2). The information used for this step is contained in ADF&G, 1984a and 1984b. Lake habitat was not included due to its isolation from mainstem influence. Tributary habitat, although isolated from mainstem influence, was included because of its dominating role in overall production in the Middle River for most evaluation species.

Habitat use by each evaluation species was separated into major life history and behavioral components: migration, spawning/incubation and rearing. Migration includes both directed movement to particular sites, such as the upstream migration of adult salmon to spawning sites, and more non-directed activity, such as movement by rearing fish from one habitat site to another. Spawning and incubation were combined because they are limited to the same habitat sites and although their specific habitat criteria (needs) may differ, each limits the habitat flexibility of the other. Rearing is used broadly in this analysis to include the relatively active period of feeding and rapid growth during the summer and the less active overwintering period.

The habitat uses noted in Table 2.2-2 are the most important or predominant for each species. For example, chinook salmon juveniles are found in upland slough and tributary mouth habitats. However, their use of these habitats for rearing is much less important than use of side channel, side slough and tributary sites.

Chinook Salmon

Most of the upstream migrant adult chinook enter the Middle River from mid-June to mid-July. They pass through mainstem and tributary mouth habitats to their natal tributary streams to spawn from late July to mid-August. All chinook spawning and incubation occurs in the tributaries.

Table 2.2-2

SUSITNA HYDROELECTRIC PROJECT
USES OF SUSITNA RIVER HABITAT TYPES BY EVALUATION SPECIES

Evaluation Species	Habitat Type					
	MS	SC	TM	SS	US	T
Chinook Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear		X		X		X
Coho Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear					X	X
Chum Salmon						
Migrate	X	X	X	X		X
Spawn-incubate		X		X		X
Rear	X			X		X
Sockeye Salmon						
Migrate	X			X		
Spawn-incubate				X		
Rear				X	X	
Pink Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear						
Arctic Grayling						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Rainbow Trout						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Burbot						
Migrate	X					
Spawn-incubate	X					
Rear	X					
Dolly Varden						
Migrate	X		X			X
Spawn-incubate						X
Rear	X					X

Juvenile chinook salmon (age 0+) begin rearing in their natal tributaries immediately after emergence. This early rearing during May and June is limited almost entirely to tributary sites. Beginning in late June, there is a gradual redistribution of large numbers of juveniles from tributary to side channel and side slough habitats. The major rearing sites during July and August are in tributaries and side channels. The juvenile chinook rearing in side channels begin moving into side sloughs in September and by November, the greatest densitites are found in tributaries and side sloughs, which are the major overwintering habitats. The juvenile chinook (age 1+) move out of their overwintering habitats and migrate to Cook Inlet during the spring and early summer. Downstream migrant chinook are out of the Middle River by mid-July.

Coho Salmon

Adult coho salmon migrate into the Middle River from early August to early September to spawn. Essentially all coho spawning and incubation occurs in tributary habitat sites from late August to early October. Coho juveniles begin rearing in natal tributary habitats immediately after emergence. Many of the juveniles leave the tributaries and redistribute into upland sloughs and side sloughs during late June and early July. The major rearing habitats during July to October are tributaries and upland sloughs. Data regarding overwintering sites suggest that upland sloughs are most important.

Chum Salmon

Adult chum salmon enter the Middle River from mid-July to early September. Most spawn in either tributary or side slough habitats and a few spawn in side channels with suitable upwelling conditions. Major spawning occurs from mid-August through September. Chum salmon juveniles begin rearing in their natal habitats after emergence in the spring. They tend to remain in these sites until they begin a gradual downstream migration to Cook Inlet in June. Juvenile chum will use low velocity, backwater areas in the mainstem for holding and, perhaps, some short term rearing during downstream migration. The chum salmon juveniles move out of the Middle River by mid-July.

Sockeye Salmon

Adult sockeye salmon (second run) move into the Middle River from mid-July through August. They spawn, almost exclusively, in side sloughs from mid-August to early October. Sockeye juveniles begin rearing in their natal side sloughs after emergence in late spring. They are most abundant in side sloughs during May and June and begin moving into upland sloughs in late June. They are most abundant in upland sloughs from July through mid-September. Their densities in the Middle River decline abruptly in all habitats by mid-August. Most of the juveniles apparently move out of the Middle River at this time and the few that remain overwinter in side sloughs.

Pink Salmon

Adult pink salmon migrate into the Middle River from mid-July to mid-August and spawn almost exclusively in tributaries. Pink salmon juveniles begin migrating downstream after emergence and are out of the Middle River by late June.

Arctic Grayling

Arctic grayling are most commonly associated with clearwater habitats. Spawning and major summer rearing occur in tributaries. They also rear in tributary mouth habitat. Some grayling move out of the tributaries into mainstem areas in late summer. Overwintering occurs in both tributary and mainstem habitats.

Rainbow Trout

Rainbow trout are associated with clearwater habitats. Spawning and major rearing occur in tributary habitat. Some rainbow congregate at tributary mouths during late summer. This behavior appears to be in response to food supply (salmon eggs) provided by spawning salmon. Rainbow trout move out of the tributaries to tributary mouths during late summer and early fall and overwinter in the mainstem.

Burbot

Burbot are found in the mainstem throughout the year. They occur mostly in turbid, low velocity, backwater areas directly influenced by mainstem flow. Spawning occurs during January. Although specific spawning sites in the Middle River have not been found, evidence suggests they spawn at slough mouths and in deep, backwater areas influenced by groundwater.

Dolly Varden

The majority of spawning and rearing by Dolly Varden occurs in tributary habitat. They move from the mainstem into tributaries by late June. The Dolly Varden move back out of the tributaries in late fall and overwinter in the mainstem.

Conclusions Regarding Habitat Use

Several general observations can be drawn from the habitat uses summarized in Table 2.2-2. First, tributary habitat is the habitat type used most commonly by the evaluation species. Sockeye salmon and burbot are the only species that do not use tributaries extensively for important life history phases. Secondly, the resident species make little use of side channel, side slough or upland slough habitats, whereas the anadromous species (salmon) frequently use these habitats. The most common use of the mainstem habitat type is for migration and movement although resident species also overwinter in the mainstem.

Habitat requirements associated with migration and movement are less critical and restrictive than for the other life history categories. Suitable depth and velocity conditions exist over a broad range of mainstem flows, and flow requirements to support migration and movement would not be restrictive to project operation. Flow requirements to satisfy the more critical needs of rearing and spawning/incubation will also satisfy the habitat needs for migration. Therefore, habitat requirements for rearing and spawning/incubation were emphasized for the remainder of the analysis.

The four sensitive habitat types from Table 2.2-1 (MS, SC, TM and SS) were selected for comparison based on their use for rearing and spawning/incubation (see Table 2.2-3).

(MS) Mainstem habitat is used mostly for rearing, especially overwintering. Use of the mainstem by chum salmon is transient and short-term during their downstream movement to Cook Inlet. The major use of mainstem habitat by arctic grayling, rainbow trout and Dolly Varden is for overwintering. The total area of mainstem habitat will be greater during the winter under the expected range of project flows than under natural flows. In addition, the populations of all the resident species in the Middle River, including burbot, are characterized as low density.

(TM) Arctic grayling and rainbow trout use tributary mouth habitat for rearing during the ice-free seasons. Use by rainbow is transient, occurring mostly in the late summer and fall. The total area of this habitat will be greater and more stable under the lower and more stable mainstem flows during project operation (Trihey 1984).

(SC) Side channel habitat is used by chinook salmon for rearing and chum salmon for spawning. The chum salmon spawning is limited to sites with sufficient upwelling conditions and accounts for only approximately five percent of the total chum spawning in the Middle River Basin.

Table 2.2-3

SUSITNA HYDROELECTRIC PROJECT
PRIMARY UTILIZATION OF SENSITIVE HABITAT TYPES
BY EVALUATION SPECIES

Evaluation Species	Habitat Types: Mainstem	Side Channel	Side Slough	Tributary Mouth
Chinook Salmon		R	R	
Chum Salmon	R	S	S,R	
Coho Salmon				
Sockeye Salmon			S,R	
Pink Salmon				
Arctic Grayling	R			R
Rainbow Trout	R			R
Dolly Varden	R			
Burbot	S,R			

S - spawning/incubation
R - rearing

Large numbers of chinook juveniles rear in side channels through most of the summer and early fall. The use of this habitat appears to be important to chinook production in the Middle River. Therefore, chinook rearing in side channels was selected as one of the critical uses of a sensitive habitat for primary consideration in developing environmental flow requirements.

(SS) Side sloughs are used by salmon species for both rearing and spawning/incubation. The chinook salmon rearing in side sloughs during the ice-free season is a lesser component of the total population than those rearing in side channels. Flow requirements to maintain side channel habitat would also serve chinook rearing in side sloughs. Environmental flow cases designed to protect chinook rearing in side channels also provide for overwintering in side sloughs since, for the most part, the same fish use both habitats.

Chum and sockeye salmon use side sloughs for both spawning and rearing. Sockeye use of this habitat is so similar to chum, in time and location, that their habitat needs can be provided by concentrating on the more abundant chum salmon. Both species use side sloughs for short term, initial rearing prior to outmigration to Cook Inlet or movement to another habitat type. Chum salmon utilize side sloughs extensively for spawning. This is the most intensive use of a sensitive habitat in the Middle River for spawning. Therefore, chum salmon spawning in side sloughs was selected as another critical use of a sensitive habitat for development of environmental flow cases.

2.2.3 Compatibility with Mitigation Policy

The alternative flow cases had to be compatible with the mitigation policies and procedures presented in the License Application (Exhib. E, Vol. 6A, pp. E-3-3 to E-3-6 and E-3-147 to E-3-150). The flow cases had to function well with other mitigation measures to result in no-net-loss of fish production from the Susitna System. The flow cases also had to provide for habitat of sufficient quality and quantity to maintain natural reproducing populations to the greatest extent possible, consistent with other project objectives.

The environmental flow cases designed and selected for analysis emphasized the habitat needs of the evaluation species which were considered most important and most sensitive to anticipated changes from natural conditions. The flow cases were designed to mitigate potential impacts by using flow releases to maintain natural production in existing habitats.

2.3 CHARACTERISTICS OF THE ALTERNATIVE ENVIRONMENTAL FLOW CASES

Eight alternative flow cases were selected for analysis (Harza-Ebasco 1984d). The eight cases can be combined into three general groups, as follows:

1. cases designed to mitigate impacts on chum salmon spawning in side sloughs,

2. cases designed to mitigate impacts on chinook salmon rearing in side channels,

3. cases designed to mitigate both 1 and 2, above.

Each environmental flow case is made up of a set of weekly minimum and maximum flow constraints within which the project must operate. The project will generally operate by storing the high summer natural flows for release in the winter when energy demand is greatest. Therefore, summer minimum and winter maximum flow constraints are the most important. Summer maximum and winter minimum flow constraints are still necessary to provide guidelines for operation under unusual circumstances.

Figures 2.3-1, 2.3-2, and 2.3-3 are generic illustrations of the three groups of flow cases listed above. The first figure focuses on chum salmon spawning in side sloughs (Figure 2.3.-1). The gradual increase of minimum constraints in May is to assure adequate downstream passage conditions for outmigrant chum juveniles and to establish a higher base flow in preparation for the June spiking flow. The large spiking flow in June is designed to overtop the upstream berms of the major side sloughs and clear them of deposited sediments and debris. This flow spike would be necessary only every three or four years. The relatively low minimum constraint during July is to provide sufficient mainstem passage conditions for upstream migrant adults. The increased minimum constraints from late July to mid-September are to establish a base flow sufficient to provide the chum adults with enhanced access conditions into the side sloughs. The spiking flows in August and September are provided to further improve access conditions. Maximum flow constraints during the winter are established to prevent overtopping of the upstream berms when and where an ice cover is not present, and to establish criteria for construction of artificial berms if they are necessary and feasible.

Flow cases to mitigate potential impacts on chinook salmon rearing in side channels differ markedly from the first group (Figure 2.3-2). The absence of spiking flows is the most obvious difference. Spiking flows are not needed in these cases because local flow in the sloughs would provide adequate access conditions for the small, juvenile chinook. Minimum summer constraints are established to maintain a desired quantity of side channel rearing habitat and increase flow stability to the greatest extent possible. Maximum winter flow constraints are intended to protect overwintering sites in side sloughs used by the chinook juveniles.

Flow cases to mitigate impacts on both chum spawning and chinook rearing are simply combinations of the characteristics of the other two groups (Figure 2.3-3). Flow cases in this group were generally formed by combination of two flow cases, one each from groups one and two, using the maximum and minimum constraints in each week that were most restrictive on project operation. Some refinements, such as the magnitude of spiking flows, were also added for some cases. The combination of attributes from the cases illustrated in Figures 2.3-1 and 2.3-2 would have no significant adverse effects on mitigation for chum spawning. However, there may be some adverse results for chinook rearing due to the temporary loss of habitat stability caused by spiking flows.

MITIGATE WITH FLOW FOR CHUM SALMON SIDE SLOUGH SPAWNING HABITAT

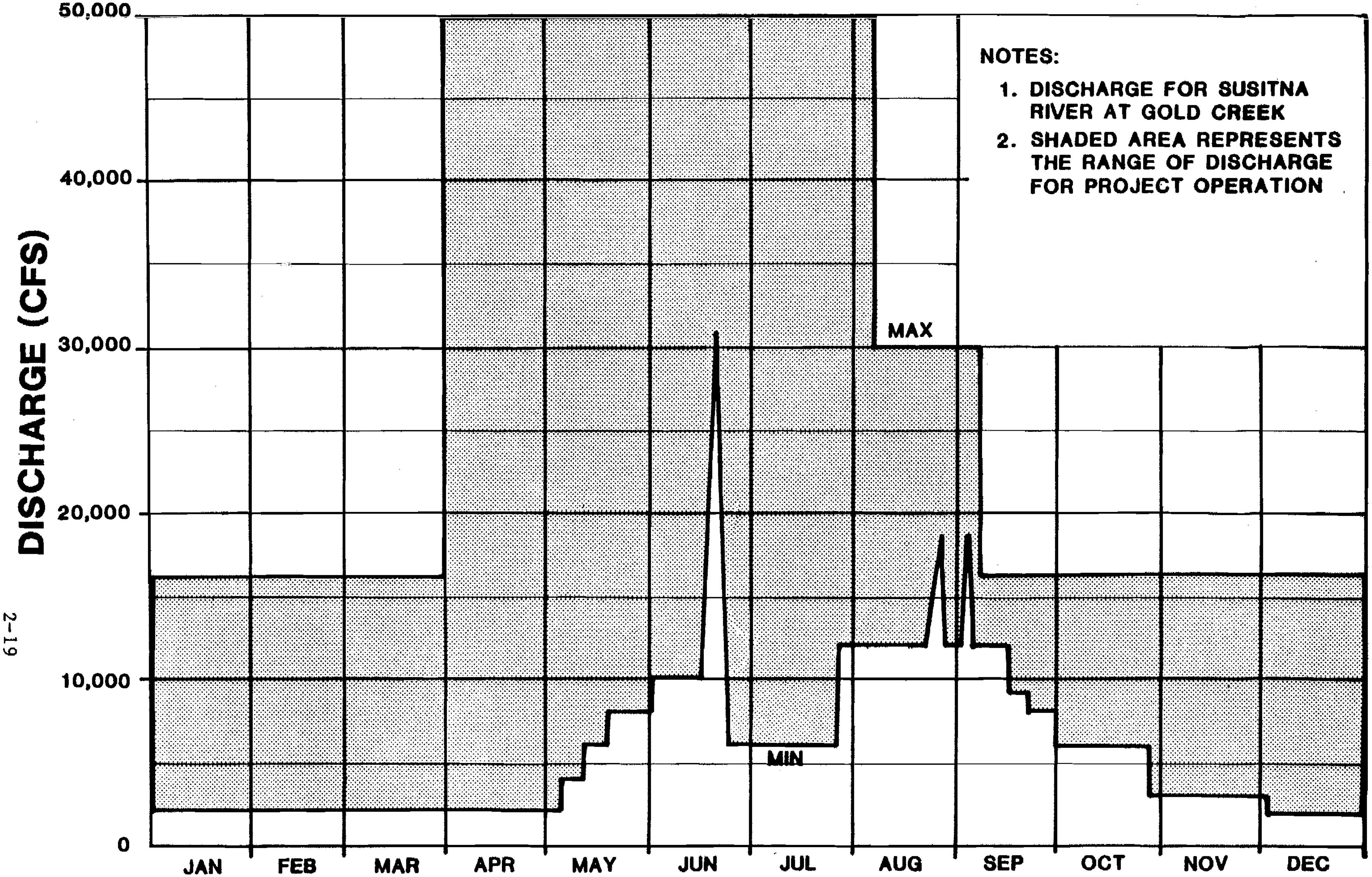

FIGURE 2.3-1

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

MITIGATE WITH FLOW FOR CHINOOK SALMON SIDE CHANNEL REARING HABITAT

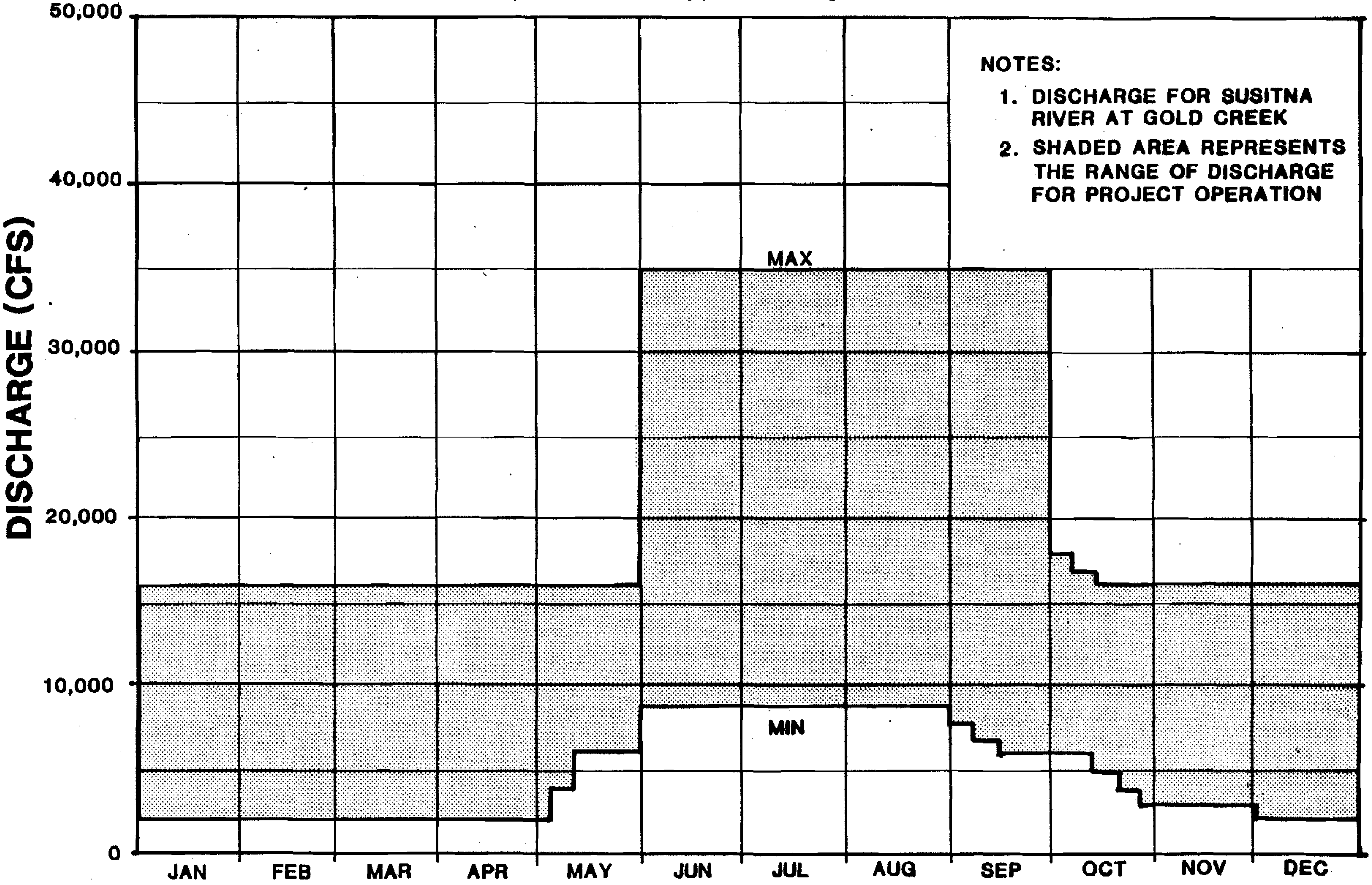

FIGURE 2.3-2

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

MITIGATE WITH FLOW FOR BOTH CHINOOK SALMON SIDE CHANNEL REARING HABITAT AND CHUM SALMON SIDE SLOUGH SPAWNING HABITAT

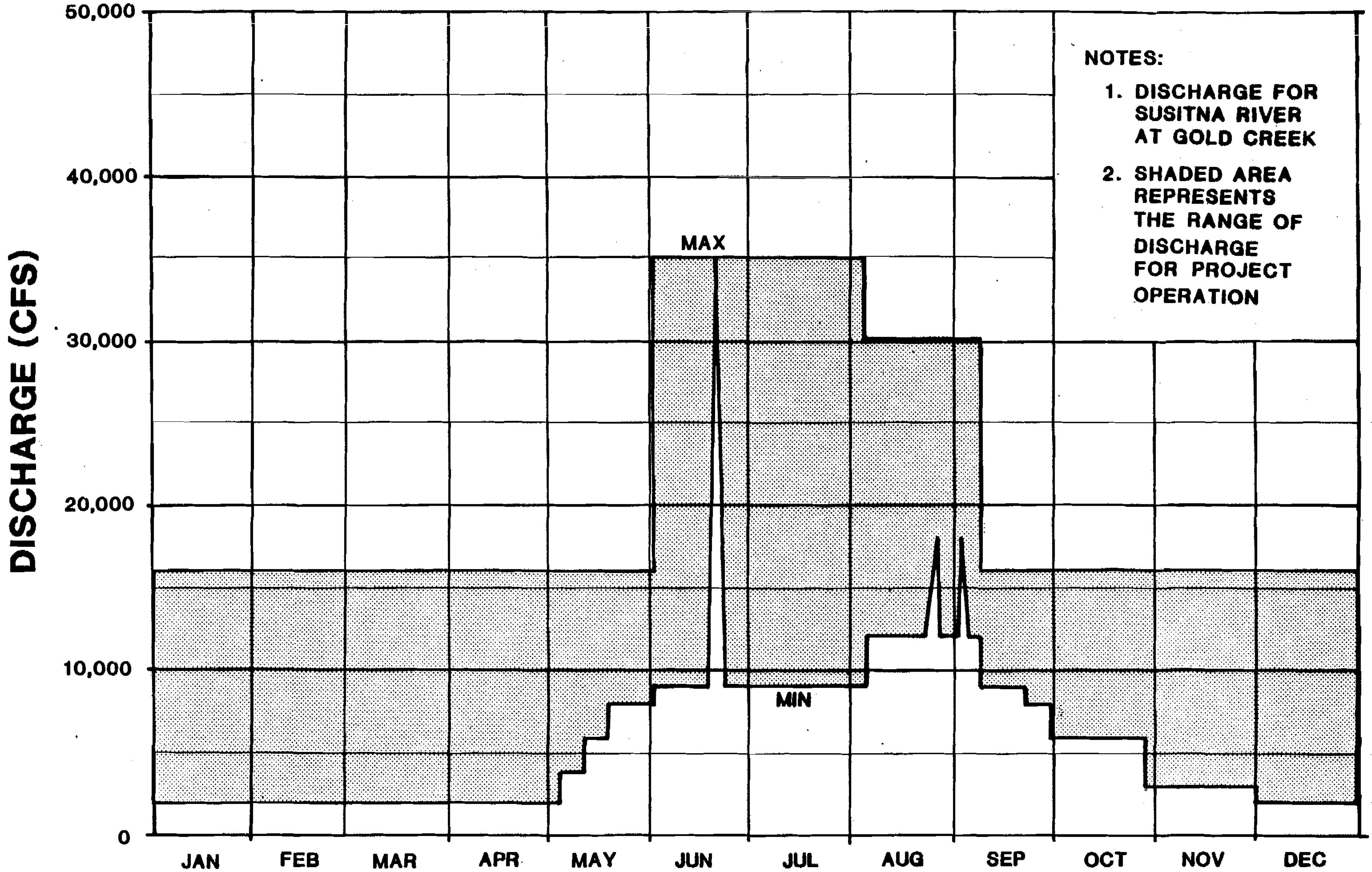

FIGURE 2.3-3

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

3.0 SELECTION OF FLOW CASE E-VI

3.1 FLOW CONSTRAINTS

Maximum and minimum flow constraints for Case E-VI were developed on a weekly basis for each week of the year. This information is presented in Table 3.1-1 and Figure 3.3-1. The flow constraints can be separated into three major divisions: winter flows, summer flows, and transitional flows.

The most important winter flow constraints are maximum flows since normal project operation would produce discharges greater than the naturally occurring flows during the November to April period. The selected winter maximum (October-April) is intended to establish a boundary near the upper range of operational flows that would result in flow stability and provide a reasonable level of protection to over-wintering habitat. Side sloughs are especially important in this context because chinook juveniles utilize this habitat for over-wintering. The 16,000 cfs maximum flow would prevent overtopping of all the major sloughs prior to freeze-up, and stabilize habitat availability during ice-cover periods.

The winter minimum flow is established to prevent dewatering of rearing habitats. The 2,000 cfs minimm is chosen based on natural flows and represents a high mean natural winter flow.

Flow constraints during the winter to summer transition period (mid to late May) are intended to maintain flow stability and prevent rapid drops in discharge due to decreasing power demand in May and to gradually increase flow to summer levels. The minimum flow constraints are most important during this period.

Summer flow constraints (water weeks 36-48) are designed to maintain rearing habitats and provide greater flow stability. Chinook juveniles are acquiring the major portion of their freshwater growth during this period

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Table 3.1-1

SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE E-VI

Water Week	Period	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum	Water Week	Period	Gold Creek Flow (cfs) Minimum	Gold Creek Flow (cfs) Maximum
14	31 Dec. - 06 Jan.	2,000	16,000	40	01 July - 07 July	9,000*	35,000
15	07 Jan. - 13 Jan.	2,000	16,000	41	08 July - 14 July	9,000*	35,000
16	14 Jan. - 20 Jan.	2,000	16,000	42	15 July - 21 July	9,000*	35,000
17	21 Jan. - 27 Jan.	2,000	16,000	43	22 July - 28 July	9,000*	35,000
18	28 Jan. - 03 Feb.	2,000	16,000	44	29 July - 04 Aug.	9,000*	35,000
19	04 Feb. - 10 Feb.	2,000	16,000	45	05 Aug. - 11 Aug.	9,000*	35,000
20	11 Feb. - 17 Feb.	2,000	16,000	46	12 Aug. - 18 Aug.	9,000*	35,000
21	18 Feb. - 24 Feb.	2,000	16,000	47	19 Aug. - 25 Aug.	9,000*	35,000
22	25 Feb. - 03 Mar.	2,000	16,000	48	26 Aug. - 01 Sep.	9,000*	35,000
23	04 Mar. - 10 Mar.	2,000	16,000	49	02 Sep. - 08 Sep.	8,000	35,000
24	11 Mar. - 17 Mar.	2,000	16,000	50	09 Sep. - 15 Sep.	7,000	35,000
25	18 Mar. - 24 Mar.	2,000	16,000	51	16 Sep. - 22 Sep.	6,000	35,000
26	25 Mar. - 31 Mar.	2,000	16,000	52	23 Sep. - 30. Sep.	6,000	35,000
27	01 Apr. - 07 Apr.	2,000	16,000	1	01 Oct. - 07 Oct.	6,000	18,000
28	08 Apr. - 14 Apr.	2,000	16,000	2	08 Oct. - 14 Oct.	6,000	17,000
29	15 Apr. - 21 Apr.	2,000	16,000	3	15 Oct. - 21 Oct.	5,000	16,000
30	22 Apr. - 28 Apr.	2,000	16,000	4	22 Oct. - 28 Oct.	4,000	16,000
31	29 Apr. - 05 May	2,000	16,000	5	29 Oct. - 04 Nov.	3,000	16,000
32	06 May - 12 May	4,000	16,000	6	05 Nov. - 11 Nov.	3,000	16,000
33	13 May - 19 May	6,000	16,000	7	12 Nov. - 18 Nov.	3,000	16,000
34	20 May - 26 May	6,000	16,000	8	19 Nov. - 25 Nov.	3,000	16,000
35	27 May - 02 June	6,000	16,000	9	26 Nov. - 02 Dec.	3,000	16,000
36	03 June - 09 June	9,000*	35,000	10	03 Dec. - 09 Dec.	2,000	16,000
37	10 June - 16 June	9,000*	35,000	11	10 Dec. - 16 Dec.	2,000	16,000
38	17 June - 23 June	9,000*	35,000	12	17 Dec. - 23 Dec.	2,000	16,000
39	24 June - 30 June	9,000*	35,000	13	24 Dec. - 30 Dec.	2,000	16,000

* Minimum summer flows are 9,000 cfs except in dry years when the minimum will be 8,000 cfs. A dry year is defined by the one-in-ten year low flow.

and they utilize side-channel sites that are directly affected by mainstem discharge (ADF&G 1984b). A 9,000 cfs mimimum flow would maintain 75% of the existing habitat quantity at sites presently utilized by chinook and increased flow stability would improve habitat quality over natural conditions.

Flow constraints during the summer to winter transition period (September and October) are intended to maintain flow stability and prevent rapid drops in flow prior to high winter power demands. Minimum flow constraints are not important in this period.

3.1.1 Flow Stability Constraints

Flow stability criteria are required to protect the instream flow uses of the river in addition to weekly average minimum and maximum flow constraints. These constraints would be indexed to Watana discharge when Watana is operating alone, and to Devil Canyon discharge when Devil Canyon is operating with Watana, rather than to discharges measured at the Gold Creek gaging station.

Indexing to powerhouse flows rather than Gold Creek flows is desirable because of:

1. The variability in flow from the intervening area between the powerhouses and Gold Creek, and

2. The time required for changes in powerhouse discharge to be reflected in Gold Creek discharges.

3.1.1.1 Watana Only Operation

Watana operation will follow two guides, one is a long-term operation guide on a weekly basis and the other is a short-term operation guide on an hourly basis.

Long-term operation will use a family of rule curves as a guide for seasonal adjustment of flow for power generation and downstream flow requirements. The expected discharges in 52 weeks of the year from the Watana powerhouse are determined from trial computations. These are the discharges which can most likely produce the required energies by keeping thermal energy generation constant at one value throughout the winter (October to mid-May) and May) and constant at a different value throughout the summer (mid May to September). The expected discharge versus time is a smooth curve with high discharges in winter, low discharges in summer, and gradual changes at transitions. The weekly discharge during operation could be 63, 80, 100, 120, or 140 percent of the expected discharge. The variation of discharge between two consecutive weeks is limitd to 20 percent. However, the limitation can be violated if the discharge has to be increased to maintain the minimum flow requirement at Gold Creek. Thus, the weekly average flow at Gold Creek does not drop below the minimum weekly flow requirement even when the intervening flow between Watana and Gold Creek is very low.

With a given weekly average flow obtained from the long-term operation guide the short-term operation will be fit to the system load demand within a week under the environmental constraints. The largest allowable discharge at Watana during any given week will be 110 percent of the weekly average discharge. The smallest allowable discharge will be 90 percent of the average for the week. If intervening flows between Watana and Gold Creek decrease during the week and the Gold Creek discharge is below the minimum weekly flow constraint Watana discharge will be increased above 110 percent of the weekly Watana average in order to maintain the minimum weekly average flow requirements at Gold Creek. If the average flow for a given week approximates or equals the minimum weekly flow requirements, there may be times during the week when the Gold Creek discharge is less than the minimum weekly flow requirements. This deviation will not exceed 800 cfs.

On an hourly basis, the maximum allowable rate of change of discharge at Watana will be 10 percent per hour of the weekly average Watana discharge under increasing discharge conditions and 500 cfs per hour when discharge is being reduced. When energy production and weekly average flows are being adjusted from one week to the next, the same rates of change of discharge will apply and will be based on the weekly average discharge for the upcoming week. The discharge change will occur during the early morning hours of a Sunday or a Monday. The change will be separate from, and additional to, the 10 percent deviation from the average permitted during the remainder of the week.

3.1.1.2 Watana and Devil Canyon Operation

In long-term operation, Watana will be used for seasonal regulation of flow whereas Devil Canyon will be kept as full as possible. Devil Canyon will not release water unless the release from Watana for power is not enough to satisfy the minimum flow requirement at Gold Creek. Once the Watana release for power is greater than needed to satisfy downstream requirements, Devil Canyon will be refilled immediately.

On an hourly basis, in short-term operation, discharges from Watana can be varied without restriction because Watana will discharge directly into the Devil Canyon reservoir. Devil Canyon will be operated to regulate and stabilize downstream flows.

The largest allowable discharge at Devil Canyon during any given week will be 110 percent of the weekly average Devil Canyon discharge and the smallest allowable discharge will be 90 percent of the average for the week. Since the Devil Canyon powerhouse will be base loaded, flow changes will generally be in response to changes in daily average or weekly average energy demand, not hourly demand. During the early years of Devil Canyon operation the entire Railbelt system energy demand in the summer can be met by Devil Canyon without operating Watana. It is preferable to use the Devil Canyon powerhouse during these periods to avoid cone valve discharges at Devil Canyon and resulting cooler water temperatures (See Section 3.4.2.1). Therefore, flow changes under these conditions will be in response to hourly demand changes.

If intervening flows between Devil Canyon and Gold Creek decrease during the week and the Gold Creek discharge is below the minimum weekly flow constraint, Devil Canyon discharge will be increased above the 110 percent weekly average flow limit in order to maintain the minimum weekly average flow requirements at Gold Creek. During a week when the Gold Creek weekly average flow is being maintained at the minimum flow requirement, there may be times during the week when the Gold Creek discharge is less than the minimum weekly flow requirement. This deviation will not exceed 900 cfs.

The maximum rate of change of the powerhouse discharge at Devil Canyon will be 350 cfs per hour whether discharge is being increased or decreased. At a discharge of 9000 cfs at Gold Creek, a 350 cfs change corresponds to a 0.1 foot difference in stage at Gold Creek.

3.1.2 Dam Safety Criteria

If the Watana reservoir level exceeds elevation 2185.0 feet, dam safety criteria will supersede both weekly flow constraints and flow stability constraints. Environmental considerations are built into the dam safety criteria as discussed herein. Project operation at Watana will be similar for both Watana operating alone and Watana operating with Devil Canyon once the Watana reservoir reaches elevation 2185.0 or higher.

3.1.2.1 Watana Only Operation

If the water level in Watana reservoir reaches elevation 2185.0 and continues to rise, Watana discharge will be increased by releasing water through the outlet works. Because the intake to the outlet works is approximately 150 feet below the water surface, operation of the cone valves results in reduced downstream water temperatures. In order to provide for as gradual a change in water temperature as possible, the following guidelines will apply:

1. Supply as much energy as possible from the Watana powerhouse within the constraints of the system energy demand, other generation and Watana powerhouse capacity.

2. Increase the outlet works discharge at the estimated minimum rate required to prevent the water level from exceeding elevation 2185.5. If the inflow to the reservoir is more than 24,000 cfs greater than the powerhouse can discharge, then the release from the cone valves will be 24,000 cfs when the water level reaches elevation 2185.5.

If the outlet works are not releasing water at full capacity and the water level rises above elevation 2185.5, the outlet works will be opened immediately to full capacity. If the full capacity of the outlet works and powerhouse flow are not sufficient to discharge all the inflow the water level will continue to rise.

If the water level exceeds elevation 2185.5 but does not reach elevation 2193.0 then the Watana discharge will remain relatively constant until the water level decreases to elevation 2185.5. If the water level starts to decrease below elevation 2185.5 then the outlet works will be closed in a gradual manner as they were opened. The rate of closure will be that estimated to cause the water level to reach elevation 2185.0 when the outlet works discharge reaches zero. The outlet works will be completely closed before the water level is allowed to decrease below elevation 2185.0.

It is estimated that there is less than a 1 in 50 chance that in any one year the water level will continue to rise to elevation 2193.0. If the water level reaches elevation 2193.0 and continues to increase, the spillway will be opened. Since it is expected that spillway operation will result in a greater potential for deleterious gas concentrations in the river downstream, the spillway will also be opened up as gradually as possible, consistent with providing sufficient freeboard on the dam to meet safety requirements. The powerhouse and outlet works releases will continue as before, and the spillway will be opened at the estimated minimum rate required to prevent the water level from exceeding elevation 2193.3. If the water level reaches elevation 2193.3 and continues to rise, the spillway gates will be opened as much as needed to prevent the water level from increasing any further. It is estimated that there is less than a 1 in 10,000 chance in any year that the water level would exceed elevation 2193.3 or the spillway would be discharging more than 120,000 cfs.

If the reservoir water level reaches elevation 2193.3 and the spillway, outlet works and powerhouse are insufficient to pass the inflow, the water level will increase. Watana discharge will not be controlled again until the water level decreases to elevation 2193.3. When this occurs, the spillway will be closed gradually in a manner estimated for the water level to reach elevation 2193.0 when the spillway is discharge is zero. The spillway gates will be completely closed before the water level is allowed to decrease below elevation 2193.0.

3.1.2.2 Watana and Devil Canyon Operation

Project operation at Watana with both Watana and Devil Canyon operating will be similar to Watana only operations when the water level in Watana reservoir exceeds elevation 2185.0, in the early years of Devil Canyon operation. However, while Watana reservoir is filling in the spring, and before the water level reaches elevation 2185.0, the Devil Canyon powerhouse will be used to generate system energy demands. Releases would be made from the Watana outlet works to keep Devil Canyon reservoir levels high. This policy was adopted for the purpose of minimizing downstream temperature effects (See Sec. 3.4.2.1). When the Watana water level reaches elevation 2185.0 it is necessary to switch energy generation from Devil Canyon to Watana in order to meet the criteria of passing the 50 year flood without using the spillway. The change from the Devil Canyon to the Watana powerhouse can be made in a gradual manner, but in no case would the Watana water level be allowed to rise above elevation 2185.5 without the Watana powerhouse supplying all available system energy demands and the Watana outlet works releasing at full capacity. After the system load is transferred from Devil Canyon to Watana the operation at Watana would be identical to that for Watana only operation.

When the Watana water level reaches elevation 2185, operation at Devil Canyon will be relatively simple. Devil Canyon reservoir will be allowed to fill while minimum flow requirements are being met. While the Devil Canyon reservoir is filling, the outlet works will be opened up in a gradual manner estimated to prevent the water level from exceeding elevation 1455.0. When the water level reaches elevation 1455.0 the outlet works will be opened as much as necessary to keep the water level stable. In this period, Devil Canyon will operate as essentially a run-of-river project, passing Watana outflows and intervening flows. The rates of change of Devil Canyon discharge will be similar to those for Watana with small modifications resulting from variations in intervening flow.

It is estimated that Devil Canyon can pass all of the Watana outflows and all intervening flows through its outlet works while the Watana water level is at or below elevation 2193.0. If the Devil Canyon water level begins to increase above elevation 1455.0 and the outlet works are functioning at their full capacity of 38,500 cfs, the Devil Canyon spillway must be opened to maintain freeboard on the dam. The spillway will be opened at whatever rate is necessary to keep the pool level at elevation 1455.0. It is estimated that the chance the spillway would be operated in any one year is less than 1 in 50. There is less than a 1 in 10,000 chance that the spillway would be operated at a flow exceeding 123,000 cfs or that the Devil Canyon water level would exceed elevation 1455.0. If the spillway were opened completely and the reservoir level continued to rise, discharge from Devil Canyon would be uncontrolled. Control would not be regained until the water level receded to elevation 1455.0. When the water level decreases to elevation 1455.0 the spillway and outlet works will be closed in a manner to keep the water level at elevation 1455.0.

When system energy demands increase, the releases made from Watana to keep Devil Canyon reservoir levels high can be made from the Watana powerhouse rather than the outlet works. Because of the increased energy demands, filling of Watana reservoir will occur less frequently and later in the year. There will be a much decreased chance that the outlet works at either Watana or Devil Canyon will have to be operated or that the spillways would be opened. The operation to pass floods when the Watana reservoir reaches elevation 2185.0 would differ slightly from the early years of Devil Canyon operation. If the water level at Watana were to rise above elevation 2185.0 it would not be necessary to switch all the energy generation to Watana. Only that load would be switched which would be necessary to keep the Watana water level from exceeding elevation 2193.0 for the 50 year flood. It is estimated that this requires a Watana powerhouse discharge of 7,000 cfs. Additionally, the increased energy demand means that Devil Canyon would have the capacity to discharge some flow from its powerhouse before it becomes necessary to open up the outlet works there.

Overall, operation of the two dams with greater system energy demands will result in more gradual changes in discharge and less chance of outlet works or spillway operation than in the first years of Devil Canyon operation.

3.1.3 Emergency Situations

Under normal circumstances, the minimum flow requirements at Gold Creek will be maintained at all times unless otherwise agreed to by the appropriate State and Federal agencies. In emergency situations, if powerhouse operation is not possible, outlet facilities will be operated to meet the flow requirements. Correspondingly, if another part of the energy generation system is temporarily lost, Watana and Devil Canyon will be operated to make up the deficit. The resulting discharge variation may exceed the maximum variation rate of 10 percent, and discharge may reach the maximum flow constraint. However, the discharge at Gold Creek will not be allowed to exceed the maximum weekly flow requirement and the rate of change of discharge will be constrained by the rates established in Section 3.1.1.

3.2 POWER AND ENERGY CONSIDERATIONS

3.2.1 Reservoir Operations Program

In refining the flow requirements from the Case C to the Case E-VI flow regime, the energy analysis was conducted using the reservoir operations program described in the License Application (Exhibit E, Chapter 2, Section 3.2 pp. E-2-55 to E-2-57). A number of modifications were made to the input data and the reservoir operations program itself to incorporate additional and revised data, to eliminate possible inconsistencies in the analysis and to improve the estimate of project benefits. The revisions, modifications, and additional data are described below.

First, since submitting the License Application, two additional years of discharge data have become available. These have been incorporated in the data base, increasing the number of years of energy simulation for each electrical demand level from 32 to 34 years.

Second, the flow data have also been revised. Because of the rare occurrence of the low flows during water year 1969, water year 1969 was modified in the License Application (p. E-2-57). Water year 1969 flows were adjusted to provide an annual flow which had a probability of occurrence in any one year of one in thirty. Reservoir operations planning was then based on this low flow event. The current Case E-VI refinement studies do not include these modifications but utilize the unmodified natural hydrology to determine the annual energy benefits and environmental impacts (See Appendix D).

Third, reservoir generation studies were based on a weekly time step. Reservoir generation studies used to determine the project economics presented in the License Application were based on a monthly time step. Since this was considered to be too large a time step to adequately assess the aquatic impacts, a weekly reservoir operations analysis was conducted to provide a weekly time series of flows. The derivation of monthly and weekly average in flows to Watana and Devil Canyon reservoirs is described in Appendix D.

For Case E-VI, the weekly reservoir operations program was used for both economic and environmental studies to ensure consistency. Monthly energy data were generated by summing weekly energy data for appropriate weeks and fractions of weeks corresponding to the various months. This monthly energy information was then utilized in the General Electric Optimized Generation Planning (OGP) program to determine project economics.

Fourth, the reservoir operations program was modified by developing a family of rule curves. These improved the estimated project economic benefits by minimizing weekly changes in energy production and at the same time stabilizing flow from week to week. Large changes in weekly inflow to the Watana reservoir did not result in a high energy output during a week when flows were high, and then decrease the following week when flows were lower.

Fifth, another change from the License Application is the operational strategy for dispatching project energy on a monthly or weekly basis. In the License Application, it was assumed that the Susitna project would be operated to generate monthly energies that maintained an approximately constant proportionality to the monthly system electrical demand. If the annual energy from the project represented one half of the annual system demand, approximately one half of the monthly system electrical demand would be provided each month by the Susitna project. Because the monthly electrical demand is greater in winter than summer, maintaining project energy generation at a rate proportional to demand would result in correspondingly greater energy generation from the project in winter than summer. If the resulting flows were less than the flow requirements, energy generation was increased until the flow requirements were met. This had the effect of reducing the energy available for generation in other months.

Current operational strategy has been adjusted to capture additional economic benefits through what is termed "constant thermal generation." The reservoirs are almost full at the end of September while they are at the lowest levels in mid-May. Energy distribution within summer, mid-May to September, and that within winter, October to mid-May, can be varied as a function of water surface variation without reducing total energy production. Therefore, the turbine discharges are so adjusted that the energy distribution will keep thermal energy generation constant as much as possible. By providing the same amount of thermal energy each week within the winter and summer periods, advantage can be taken of the most fuel efficient thermal units in the system. Cost savings occur because it is more economical to provide the annual thermal energy by running the least-cost thermal units throughout the season rather than running them for part of a season along with other less efficient units.

In constant thermal generation, the seasonal energy available from the project is subtracted from the system seasonal electrical energy demand to yield the amount of energy to be produced by thermal generation. The weekly thermal energy is distributed evenly throughout each week of the season. The thermal energy is subtracted from the weekly system electrical energy demand to yield the energy to be provided by the project. Since winter system electrical energy demand is higher than summer demand, this operational strategy results in more energy being produced by the project in winter. If flows of the Susitna River at Gold Creek are ever less than the flow requirements, energy production is increased until the flow requirements are satisfied. Energy generation from the Susitna project is correspondingly reduced in the remainder of the year. Energy generation between October and May may also be constrained by the available reservoir storage volume and local winter reservoir inflow.

A key parameter in the reservoir operation studies is the electrical energy demand forecast. In the original License Application, economic and environmental studies were based on a preliminary medium-load forecast prepared by Battelle Northwest. In the revised License Application, submitted in July 1983, the energy forecast and economic studies were updated on the basis of oil price forecasts by Sherman H. Clark Associates. The resulting electrical forecast has been termed the S.H. Clark NSD forecast and is the APA Reference Case forecast. At the time of the revised license submittal, Exhibit E of the original application was not revised. However, subsequent information provided to the FERC was based on the S.H. Clark NSD forecast. This report uses the S.H. Clark NSD forecast.

3.2.2 Watana Operation - 1996 and 2001

Watana operation studies were conducted using the APA Reference Case electrical energy demand forecasts for 1996 and 2001, and the flow constraints discussed in Section 3.1. Reservoir operation in the year 1996 is representative of the early years of Watana only operation and 2001 is the last year of Watana only operation. The energy produced in each year is similar. Mean annual energy production is 3400 GWH in 1996 and 3440 GWH in 2001.

In the 34 years of energy simulations, annual energy production varies from a low of 2320 GWH for both the 1996 and 2001 demands, to highs of 3930 GWH for the 1996 demand and 3980 GWH for the 2001 demand. Firm annual energy was assumed to be based on the third lowest energy generation (94% probability of exceedance) because of the high return period of the minimum flow year (water year 1969). This resulted in a firm annual energy of 2860 GWH.

With the 1996 demand of 4670 GWH, energy generation from the Watana project and other existing hydro-projects is sufficient to meet the entire system load during the week containing the annual peak demand, without the assistance of thermal generation, 26 percent of the time. However, by 2001, the Railbelt electrical load will have increased sufficiently that the system hydro-generation must be supplemented with thermal energy during the week containing the annual peak demand, based on the 34 years of simulation.

3.2.3 Watana and Devil Canyon Operation - 2002 and 2020

Watana and Devil Canyon operation studies were conducted using the APA Reference Case electrical energy demand forecasts for 2002 and 2020, and the flow constraints discussed in Section 3.1 In 2002, after allowing for existing hydro-generation, the Watana and Devil Canyon projects can meet the entire Railbelt electrical load based on the 34 years of simulation. Even in an extreme dry year such as water year 1969, the annual electrical energy needs of the Railbelt can be met by hydroelectric generation.

By the year 2020, system energy requirements will have increased to 8312 GWH. Even in the wettest years of the study period, the available hydroelectric energy will be insufficient to meet the annual energy needs of the Railbelt area. Average annual energy production from the Susitna projects will be 6850 GWH. Watana and Devil Canyon will each contribute approximately half the project energy. During the extreme dry sequence, such as occurred in water years 1969 and 1970, Watana and Devil Canyon together could produce 5090 GWH of annual energy. Firm annual energy was determined to be 5770 GWH based on the year with the third lowest annual energy production in the 34 years of simulation.

There is a 35 percent probability that system hydro-generation in 2020 will be capable of meeting the entire system energy demand during the week containing the annual peak demand. During other times of the year some thermal energy would be required. The maximum annual energy production from both Watana and Devil Canyon would be 7720 GWH.

3.3 PROJECT FLOWS AND RESERVOIR ELEVATIONS

3.3.1 Watana Operation - 1996 and 2001

3.3.1.1 1996 Electrical Energy Damand Forecast

Weekly discharge and reservoir elevations based on the reservoir operations studies for a 1996 electrical energy demand forecast of 4670 GWH, are presented in Appendix E hereto (Table E-5).

The maximum weekly average Watana turbine discharge during the 34 year simulation is 12,600 cfs. After accounting for other existing system hydroelectric energy, the energy associated with this discharge is sufficient to meet the maximum system energy demand during the week containing the peak annual demand. The minimum weekly average Watana turbine discharge is 3700 cfs.

The mean average turbine discharge during the period of peak winter demand is approximately 10,000 to 11,000 cfs. The mean weekly average turbine discharge in summer is in the range of 6,000 to 7,000 cfs.

Turbine discharges at Watana will normally vary gradually from one week to the next. In the 34 years of simulation, the maximum change in weekly turbine discharge was 2,700 cfs. Cone valve releases at Watana are required in 25 of the 34 years of simulated project operation as presented in Table 3.3-1 and 3.4-1. In 18 of these years the release is required because the reservoir is full. There is approximately a 53 percent chance, annually, that Watana reservoir will fill to elevation 2185 feet, thereby necessitating a cone valve release. Only in the simulation of water year 1967 did the cone valves operate at their full capacity of 24,000 cfs. The volume of water released through the cone valves is approximately 3 percent of the total inflow to Watana reservoir.

Cone valve releases occurred between mid June and early October with the highest releases occurring between mid July and late September.

Table 3.3-1

WATANA CONE VALVE OPERATION
1996 ENERGY DEMANDS

WEEK BEGINNING

	JUNE		JULY					AUGUST				SEPTEMBER				OCTOBER
YEAR	17	24	1	8	15	22	29	5	12	19	26	2	9	16	23	1
1951	248														4252	
1955							375	593	477	53	12187	10611	6219	3490	1006	
1956									12923	9312	6712	4151	8568	7988	2253	
1957													1546	7361	6643	
1958											204					
1959											1611	13636	3359	502		222
1960															689	1558
1961											38					
1962				15	415	507	15409	12846	12733	12619	12750	11649	4504	2064	2002	
1963								51	283	10955	10600	5825	4269	1751	570	
1964						466			52	5832	4528	1613				
1965													1785	8195	10546	2724
1967									24000	18805	9469	16188	6402	2452		
1968												1731	1655			
1969			67			192										
1971											5665	11857	4764	1618	273	
1972						83	345	227	321	182	1065	4303	8380	4047		
1973				172	734	644	141		186							
1975											3196	2070	8372	7200	4745	
1976							531	683	980	1135	1087					
1977									28		1012	1356	4766	4097	2116	
1979	3															
1980														3638	2481	316
1981									3537	23911	13551	7855	4751	2561	544	
1983					225	93										

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The with-project flows at Gold Creek, based on the 34 years of simulation, are provided in Table E-5. Table E-16 and Exhibit E-2 show the percent of time that discharges at Gold Creek would be equalled or exceeded for each week of the year. Figure 3.3-1 illustrates the discharges for each of the 52 weeks that would be exceeded 6,50 and 97 percent of the time. Minimum weekly flow requirements are met or exceeded 100 percent of the time. Normally, discharge during low flow periods (97 percent exceedance) is well above the minimum flow requirements in winter, but at the minimum flow requirements in summer.

During periods of high intervening flow between Watana and Gold Creek or during periods when Watana reservoir is at or above elevation 2,185, flows at Gold Creek may approach or exceed the maximum weekly flow requirements between May and September. There is no way to avoid this except by shutting off the turbines at Watana during periods of very high local inflow or releasing water prior to Watana reservoir reaching elevation 2,185. The latter could lead to a less than full reservoir at the end of the high flow period and thus a reduction in available energy.

During normal operation in the winter, Gold Creek discharge remains well below the 16,000 cfs maximum flow requirement, even during the highest flow years.

Because of the potential variations in local inflow between Watana and Gold Creek and because of a potential 20 percent variation in Watana turbine discharge, some flow variability in discharge at Gold Creek during a given week should be expected. The maximum variability would likely occur in the summer because of the higher and more variable intervening flows during that period.

Weekly average discharges at Sunshine and Susitna Station are presented in Appendix E Tables E-6 and E-7, respectively. Flow duration data at these stations is presented in Tables E-17 and E-18 and Figures E-4 and E-5. The change in discharge at these gaging stations from the Case C flow regime is not significant.

Watana reservoir elevations at the end of each week are presented in Table E-5. Probability distributions of Watana reservoir surface elevations for the first week of October, January, April and July are presented in Figures 3.3-2 through 3.3-5 respectively. Figure 3.3-2 indicates the generally filled condition of the reservoir at the beginning of October (i.e. 62 percent of the time the reservoir is filled above elevation 2,180 feet). In lower flow years, the reservoir does not completely fill. Thirty-five percent of the time the reservoir elevation is between 2,155 and 2,180. In the extreme low flow year the reservoir is at elevation 2,134 feet by October 1, thus demonstrating the severity of 1969 when compared to other years. By January 1, (Figure 3.3-3) the reservoirs draw down to between 2,130 to 2,155 except for the extreme low flow year. By early April (Figure 3.3-4). Watana water levels are between 2,095 and 2,110 feet 91 percent of the time. By July (Figure 3.3-5), there is wide range of possible reservoir water surface elevations because of the large variation in runoff in May and June.

3.3.1.2 2001 Electrical Energy Demand Forecast

Weekly discharge and reservoir elevations based on the reservoir operation studies for a 2002 electrical energy demand forecast of 5117 GWH are presented in Appendix E hereto (Table E-8).

As system electrical energy demand grows from 1996 to 2001, minor changes in weekly turbine dischrges at Watana will take place in years with high annual discharge. The maximum weekly average powerhouse discharge, based upon the 34 years of simulation, will increase from 12,600 cfs in 1996 to 13,200 cfs in 2001. The minimum weekly average turbine discharge would be 3,700 cfs if the annual flow were similar to the low flow year which occurred in water year 1969. During average and low flow conditions, project operation and hence turbine discharge would not be affected by demand during the period 1996 to 2001.

Watana reservoir water levels for maximum, mean, and minimum conditions are shown in Figure 3.3-6. Reservoir inflow, outflow and water levels for the 34 years of simulation are depicted in Figures 3.3-7 to 3.3-9. Cone valve releases are required in 15 of the 34 years simulated. In 13 of these years the release is because the reservoir is full. There is a 38 percent chance that the reservoir will fill to elevation 2,185 feet. No situation arose where the cone valves were operated at maximum capacity. Table 3.4-2 summarizes the cone valve releases which were simulated to occur in 2001.

Increased power demands in 2001 result in changes in turbine discharges and cone valve releases which are manifest in discharges at Gold Creek and locations further downstream. The with-project flows at Gold Creek for the 2001 demand are provided in Table E-8. Table E-20 and Figure E-7 show the percent of time that discharges at Gold Creek would be equalled or exceeded for each week of the year and Figure 3.3-10 illustrates the discharges for each of the 52 weeks that would be exceeded 6,50 and 97 percent of the time.

Weekly average discharges at Sunshine and Susitna Station are also presented in Tables E-9 and E-10, respectively. Flow duration data for these stations are presented in Tables E-21 and E-22 and Figures E-8 and E-9.

End of week Watana reservoir elevations are presented in Table E-8. Probability distributions of Watana reservoir surface elevations for the first weeks of October, January, April and July are presented in Figures 3.3-11 through Figure 3.3-14, respectively. The figures are similar to those presented for the 1996 level of demand.

3.3.2 Watana and Devil Canyon Operation

3.3.2.1 2002 Electrical Energy Demand Forecast

Weekly discharge and reservoir levels based on reservoir operations studies for a 2002 electrical energy demand forecast of 5238 Gwh are presented in Appendix F hereto (Tables F-6 and F-7).

When Devil Canyon comes on line in 2002, there is more energy available from Watana and Devil Canyon than can be used in the system, as discussed in Section 3.2.3. In each of the 34 years simulated, streamflows were adequate to provide system energy demands. For each powerhouse and for any week between early November and early May, turbine discharge is similar for all 34 years simulated. For the period between early May and late October, year to year differences in turbine discharge result from variations in intervening flows, a policy designed to minimize temperature impacts (See Sec. 3.4.2.1) and operation of the outlet works and powerhouse during floods.

Appendix F, Table 6 provides Watana turbine discharge information for the 34 years of simulation. Table F-17 presents the Watana turbine discharge data in the form of a flow duration table. From early November to late April there is a difference of only a few hundred cubic feet per second (cfs) between the maximum and minimum flows for each week. From early May to late October, differences are greater. There is greater than a 94 percent chance that operation of the cone valves at Watana will be required because Watana reservoir has filled to elevation 2,185. Based on the historic record there is a 59 percent chance that the cone valves will be operated at full capacity sometime during the year. Tables 3.3-2 and 3.4-3 illustrate the high frequency of cone valve discharges at the Watana reservoir. Cone valve releases occurred as early as mid June in the simulation and last until early October.

Turbine discharge at Devil Canyon follows a pattern similar to that at Watana as indicated in Table F-7 and Table F-18. From early November to

Table 3.3-2

DEVIL CANYON CONE VALVE OPERATION
2002 ENERGY DEMANDS

WEEK BEGINNING

YEAR	JUNE 17	JUNE 24	JULY 1	JULY 8	JULY 15	JULY 22	JULY 29	AUGUST 5	AUGUST 12	AUGUST 19	AUGUST 26	SEPTEMBER 2	SEPTEMBER 9	SEPTEMBER 16	SEPTEMBER 23	OCTOBER 1
1950								2807	10898	7209	2818					
1951								5941	7926	7406	13905	18816	7281	7626	4677	
1952					4876	17202	33443	13404	8418	4015	6040	8053	1992	102	1993	
1953			5693	8430	9980	10709	14846	11414	7187	7518	10431	7013	5270	2473		
1954						7971	20574	14451	14298	14146	12583	4264	2038	986		
1955				10759	12342	16454	12951	11272	11650	16051	34184	10567	3965	1085		
1956			18222	24067	24721	23207	20657	17328	14630	9637	6560	4315	9823	9081	1895	
1957				11367	13850	15756	10625	10612	10352	8573	10194	7200	8540	7790	6890	
1958				2356	11448	11041	35626	20393	10736	6799	1518					
1959					1478	11434	12791	8038	12745	38000	38000	22045	3099			
1960							10565	14233	11367	10519	9470	6788	16283	8339	3451	321
1961		11141	12412	13508	14341	15161	15431	15884	12082	10844	5313	1254	2531	1695	1605	
1962	17077	31794	18053	16776	13452	18126	15453	12633	12481	12328	12442	11954	3647	788	686	
1963			17425	35660	35399	28504	18633	15554	12138	13217	9366	4294	2557			
1964		24763	15373	16152	14790	7396	9588	8584	5009	5799	3150	485				
1965				4530	17909	14360	11724	9431	20871	9785	974	5802	9176	7301	9902	2352
1966					315	10806	16923	12181	8248	11797	7268	1791	1222	862		
1967				3642	19490	28939	16013	14234	38000	35808	15524	16962	5692	1126		
1968		8376	19787	16467	15634	14801	11676	9661	6356	4702	2811	449	237			
1969																
1970																
1971							5568	35688	35364	33824	8903	11407	3442			
1972	27681	15296	15377	15406	12819	8829	10424	11790	9910	10401	3558	2574	6945	2209		
1973								9816	6856	11550	12493	2061				
1974											933	5556			971	
1975			8802	21320	18293	15834	13634	9088	8123	5931	3521	852	8114	6725	3852	
1976								19324	11172	6286	1358					
1977		6547	11546	13866	15193	11163	12222	11533	9627	9681	2375		3499	2711	455	
1978						5605	9793	8765	7358	4460	295	511				
1979				414	25583	26961	15705	14155	9530	6592	4496			2187		
1980			15211	24268	27733	21070	27256	12238	10917	8887	3681		231	7092	845	
1981				10948	36106	33034	35511	32820	37737	36610	23332	6858	3369	897		
1982				7234	14711	17555	13150	6242	4101	2253	3305	2533	5451	14185	2962	
1983				4202	8632	9995	10799	16210	14196	11310	15506	7653	709		441	

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late April, the difference between the maximum and minimum flows for a given week is less than a few hundred cfs. From early May to late October, differences in flow are greater.

There is an almost certain probability that cone valve releases will occur during the initial years of Devil Canyon operation. Depending on the inflow cone valve releases may range from only a few thousand cfs to 38,000 cfs. The duration may be as short as a few weeks to as long as 15 weeks. This is presented in Table 3.4-3.

Figure 3.3-15 illustrates the discharges at Gold Creek for each of the 52 weeks that would be exceeded 6,50 and 97 percent of the time. There is little variability in weekly average flow for any given week between October and April. The week to week variation during this period is small and results from the gradually varying energy demand. In summer there is a substantial flow variation caused by the variation in flow. In dry years, Watana reservoir does not fill until late summer. Therefore, flow remains close to the minimum flow requirements during the summer months. Under high flow and average flow conditions, Watana reservoir fills much earlier. Once filled to elevation 2,185, Watana and Devil Canyon are operated essentially so that inflow equals outflow. Therefore, flow at Gold Creek will be similar to that occurring under natural conditions once Watana reservoir is filled to its normal maximum operating level of 2,185 feet. However, inflows in excess of approximately 31,000 cfs will be limited to discharges less than or equal to that amount by the capacity of the cone valves and powerhouse.

Weekly average discharges at Sunshine and Susitna Station for the 2002 demand are provided in Table F-8. Weekly reservoir elevations for both Watana and Devil Canyon are provided in Table F-6 and F-7. Figures 3.3-16 through 3.3-19, present probability distributions of Watana water surface elevations for the first week of October, January, April and July. The figures show that in the early years of Watana and Devil Canyon operation, Watana reservoir will rarely be drawn below elevation 2,120 feet and will almost always be filled annually. Devil Canyon reservoir will normally be between elevation 1445 and 1,455 feet to minimize temperature impacts. Figures 3.3-20 and 3.3-21 show maximum, minimum and mean water levels at Watana and Devil Canyon reservoirs.

3.3.2.2 2020 Electrical Energy Demand Forecast

Weekly discharge and reservoir levels based on reservoir operations studies for a 2020 electrical energy demand forecast of 8312 Gwh are presented in Appendix F hereto (Tables F-9 and F-10).

As the energy demand grows the usable energy from the project will likewise increase and result in greater discharges through the turbines at both Watana and Devil Canyon. By the year 2020, the available energy from the project can be absorbed in the system. With-project flows in 2020 would therefore be indicative of project flows a few years before 2020 and after 2020.

Watana turbine discharges and flow duration data for the 34 years of simulation are presented in Tables F-9 and F-22, respectively. Maximum weekly average Watana turbine discharge is 12,600 cfs and the minimum weekly average discharge is 4,000 cfs.

The cone valve releases at Watana are much reduced in frequency, magnitude and duration when compared to the releases which could occur in the early years of both Watana and Devil Canyon operation. There is a 40 percent chance that there will be a cone valve release from Watana in any given year. Releases will occur in August and September. Not only will the cone valves at Watana not be used to capacity, there is a 40 percent probability that if there is a cone valve release, the peak discharge during the release will be less than 6,000 cfs. A summary of cone valve releases at Watana is provided in Table 3.4-4.

Maximum weekly average turbine discharge at Devil Canyon, as presented in Table F-10, will be 12,900 cfs. Minimum weekly turbine discharge will be 1,900 cfs. This minimum discharge would occur only during a low flow event such as took place in 1969. The average turbine discharge during the November to February period will be about 10,000 to 11,300 cfs. Cone valve releases would occur in about 44 percent of the years as indicated in Table 3.4-4. Since Devil Canyon will normally be operated at a constant reservoir elevation of 1455, outflow is approximately equal to inflow. Therefore, when cone valve releases are required at Watana they are usually required at Devil Canyon. Cone valve releases will occur in August and September.

With-project flows at Gold Creek are listed in Table F-10. Table F-24 shows the percent of time that discharges at Gold Creek would be equalled or exceeded for each week of the year. Figure 3.3-22 illustrates the discharges for each of the 52 weeks that would be exceeded 6,50, and 97 percent of the time. In the winter period, flow is generally a few thousand cfs above the minimum flow requirements and a few thousand cfs below the maximum flow requirements for the entire historic record. In summer, during low flow years, discharge at Gold Creek is maintained at the minimum flow requirements. During average years, with-project flow at Gold Creek is about 1,000 cfs higher than the minimum requirements. During high flow conditions, with-project flow can approach 40,000 cfs.

Because the drainage area between Devil Canyon and Gold Creek is about 36 percent of the drainage area between Watana and Gold Creek, the flow variations at Gold Creek caused by variations in intervening flow between Devil Canyon and Gold Creek will be much reduced from that which could occur when Watana operates alone.

Discharge data at Sunshine and Susitna Station for the 2020 demand are given in Table F-11.

Weekly reservoir elevations for both Watana and Devil Canyon are provided in Tables F-9 and F-10, respectively. Figures 3.3-23 and 3.3-24 show maximum, mean and minimum reservoir levels for Watana and Devil Canyon, respectively. Figures 3.3-25 through 3.3-29 show Watana and Devil Canyon flows and water levels for the 34 years of simulation. Figures 3.3-30 through 3.3-33, present probability distributions of Watana water surface elevations for the first weeks of October, January, April and July. With a mature system, Watana reservoir will normally be drawn down to between elevation 2070 and 2085 feet 88 percent of the time. Annually, there is a 62 percent chance that the reservoir will be filled to between elevation 2,180 feet and 2,185 feet.

Devil Canyon reservoir will normally be maintained at 1,455 feet, but in low flow years may be drawn down to provide the minimum weekly flow requirement at Gold Creek.

3.4 WATER QUALITY

The License Application discusses the effects of construction and operation of the project on the water quality of the Susitna River. The following parameters were evaluated: water temperature, ice, bedload and suspended sediment, turbidity, vertical illumination, dissolved gases, nutrients, total dissolved solids, specific conductance, significant ions, total hardness, pH, total alkalinity, free carbon dioxide, total organic carbon, chemical oxygen demand, true color, metals, chlorophyll-a, bacteria and miscellaneous parameters such as pesticides, herbicides, uranium and gross alpha radioactivity. Only the water temperature, ice, and dissolved gas parameters would be affected by the Case E-VI refinement to Case C.

The Alaska Power Authority, at FERC's request, has made simulations of the reservoir and river temperature and ice conditions for Watana operating alone and for Watana and Devil Canyon operating together. These simulations considered several levels of projected energy demands and various hydrological and meteorological conditions using Case C flow requirements. The simulations were transmitted to FERC with the Power Authority's comments on the DEIS (Alaska Power Authority 1984a, 1984b, 1984c) and in a separate transmittal in October 1984 (Harza-Ebasco, 1984).

The Case C simulations refined and expanded the information presented in the License Application (Figures E.2.171 - E.2.185 and E.2.213 - E.2.222). Also, the Power Authority had previously presented a calibration of the DYRESM model (Harza-Ebasco, 1984a) which refined and expanded the analysis in the License Application (Figures E.2.165 - E.2.171). [See Appendix C (this report) for current status of License Application Tables and Figures relative to Case E-VI.]

The Power Authority has now made further simulations of reservoir and river temperatures and ice conditions to determine the effect(s) of the Case E-VI refinement to Case C. The new simulations provide nearly identical results as the simulations developed for Case C (see comparisons in Appendix G and Appendix H).

Because of the similarities in the results of the new simulations for Case E-VI, the Power Authority believes that its comments on the DEIS regarding the impact of construction and operation remain valid for Case E-VI flow conditions and that the simulations for Case C may be used to evaluate effects of Case E-VI.

Additionally, the Power Authority has checked the reservoir operations for Case E-VI and has determined that the potential for developing detrimental levels of gas concentration in excess of naturally occurring levels due to project operation is less than or equal to the potential with Case C.

The remainder of this section presents discussions of the results of the analyses, first for Watana operating alone, and then for Watana and Devil Canyon operating together.

3.4.1 Watana Operating Alone

3.4.1.1 Reservoir Temperature and Ice

Reservoir temperatures and ice cover were simulated for Case E-VI using DYRESM. The projected energy demands are for the year 2001 and the hydrological and meteorological data are from the period November 1980 to September 1982. This period represents a high flow year (1981) followed by an average flow year (1982). These simulations provided the upstream boundary conditions for all river temperature and ice simulations described below.

Simulations for both Case C and E-VI (see Appendix G, Exhibits 1 and 2) used the policy of releasing water having temperatures as close to natural as possible, as set out in the License Application (p. E-2-119). The simulations for both cases result in similar outflow temperatures, similar ice thicknesses and similar freezeup and melt-out dates. Outflow temperatures are generally within a few tenths of a degree except for a few short periods where the difference is as much as one degree.

The most significant difference occurs in early July of the 1982 simulation. The Case E-VI simulation results in about 5°C cooler outflows for about one week. This difference results from somewhat lower reservoir water levels due to higher releases early in the summer with Case E-VI compared to Case C. The reduced reservoir levels cause the third level of the multi-level intake to be used for Case E-VI rather than the second level for Case C. Water at the third level is somewhat colder than at the higher level.

For the summer period after the first week in July, the release temperatures with E-VI are approximately 0.5°C warmer than for Case C. The effects of these differences are reduced downstream.

3.4.1.2 River Temperatures, Open Water

River temperatures were simulated for Case E-VI using SNTEMP. Again, the projected energy demands are for the year 2001; and the hydrological and meteorological data are for the period May 1981 to September 1982. The simulation for the period November 1981 to April 1982 was used to define the upstream boundary of the river ice run. The results of the simulations are shown in Appendix G, Exhibit 3. The results of a similar simulation using Case C flow requirements are shown in Appendix G, Exhibit 4. Comparisons of simulated temperatures for these two runs at river miles 100, 130 and 150 are shown in Appendix G, Exhibit 5.

As can be seen from the comparisons of the two runs the temperature differences are larger at river mile 150 and diminish with distance downstream. The temperature differences between Case C and Case E-VI are generally within a few tenths of a degree (°C) except for a one week period in 1982 in which there is a difference of 5°C at the dam. Note, that even for this large a difference in reservoir outflow temperatures, the difference at river mile 130 is only about 1°C. This indicates the importance of climate conditions to river temperatures. Although the Case E-VI temperature is slightly colder for this one week, it is slightly warmer for the next few weeks.

3.4.1.3 River Ice

River ice conditions were simulated for Case E-VI using ICECAL. The projected energy demands are for the year 2001 and hydrological and meteorological data are for the period November 1981 to April 1982. The results are shown in Appendix G, Exhibit 6. The Power Authority's transmittals to the FERC (Alaska Power Authority 1984c and Harza-Ebasco 1984b) did not contain a similar simulation for Case C flow requirements. Therefore, for this transmittal, a river ice simulation for Case C flow requirements has also been made and is presented in Appendix G, Exhibit 7. A comparison of the two runs is shown in Appendix G, Exhibit 8.

As can be seen from the comparison of the runs, the Case E-VI flow requirements do not significantly affect the results. The progression of the ice front, its location versus time, and the maximum water levels are all similar. The simulation for Case E-VI shows generally lower water levels (one to four feet) downstream of river mile 123. Upstream of river mile 123, however, water levels are generally one to two feet higher. This is not considered significant since it does not result in a significant difference in the number of side sloughs which might be affected by overtopping due to staging. The differences appear to be the result of slightly different reservoir outflow temperatures and discharges for Case E-VI than for Case C, which causes some differences in ice accumulation and staging. With Case E-VI the river ice cover is simulated to melt out approximately 10 days earlier than with Case C.

3.4.1.4 Dissolved Gases

As discussed in the License Application (p. E-2-132 and Table E.2.50), the design for the Watana Dam includes cone valves which will be used to release all floods with return periods of 50 years or less. The use of cone valves to pass flows in excess of energy and minimum flow requirements will minimize the potential for gas concentrations to exceed naturally occurring levels downstream of the project. As can be noted from Appendix E, Tables 5 and 8, and Tables 3.4-1 and 3.4-2, the cone valve capacity of 24,000 cfs is never exceeded. Therefore, the spillway would not be operated and detrimental levels of gas concentration would not be expected to exceed naturally occurring levels as a result of project operation.

Flood routing studies have also confirmed that the 50 year flood for the period July-September can be stored and released without operating the spillway.

3.4.2 Watana And Devil Canyon Operating

3.4.2.1 Reservoir Temperature And Ice

Reservoir temperatures and ice cover were simulated for Case E-VI using DYRESM. The projected energy demands are for the year 2002 with hydrological and meteorological data from the period November 1980 to September 1982. This period represents a high flow year (1981) followed by an average flow year (1982). These simulations provided the upstream boundary conditions for all river temperature and ice simulations described below.

Simulations for both Case C and E-VI (see Appendix H, Exhibits H-1 and H-2) used the policy of releasing water having temperatures as close to natural as possible, as set out in the License Application (p. E-2-119). The simulations for both cases again result in similar outflow temperatures, similar ice thicknesses and similar freezeup and melt-out dates. Outflow temperatures are generally within a few tenths of a degree except for a few short periods.

June 1981 E-VI outflow temperatures are approximately 1°C cooler than Case C. Early to mid-July 1982 outflow temperatures are similar to 1981 temperatures but average 2°C cooler than Case C. The E-VI temperature in the second week of July 1982 is 4.5°C cooler than for Case C. The drop in outflow temperatures in mid-July which is common to both Case C and Case E-

Table 3.4-1

SUSITNA HYDROELECTRIC PROJECT
WATANA FIXED CONE VALVE OPERATION
1996 SIMULATION

Year	Week of First Release	Week of Maximum Release	Duration of Release	Maximum Release	Powerhouse Flow	Total Release
			Weeks	cfs	cfs	ac-ft
1950	—	—	—	—	—	—
1951	June 17	Sept 23	2	4,252	7,769	70,900
1952	—	—	—	—	—	—
1953	—	—	—	—	—	—
1954	—	—	—	—	—	—
1955	July 29	Aug 26	9	12,187	7,118	488,000
1956	Aug 12	Aug 12	7	12,923	6,756	725,000
1957	Sept 9	Sept 16	3	7,361	7,647	229,000
1958	Aug 26	Aug 26	1	204	7,203	2,830
1959	Aug 26	Sept 2	5	13,636	7,317	268,000
1960	Sept 23	Oct 1	2	1,558	8,220	32,600
1961	Aug 26	Aug 26	1	38	7,147	528
1962	July 8	July 29	12	15,409	6,642	1,220,000
1963	Aug 5	Aug 19	8	10,955	6,870	477,000
1964	July 22	Aug 19	5	5,832	6,855	173,000
1965	Sept 9	Sept 23	4	10,546	7,782	344,000
1966	—	—	—	—	—	—
1967	Aug 12	Aug 12	6	24,000	6,797	1,070,000
1968	Sept 2	Sept 2	2	1,731	7,288	47,000
1969	July 1	July 22	2	192	6,853	3,600
1970	—	—	—	—	—	—
1971	Aug 26	Sept 2	5	11,857	7,313	336,000
1972	July 22	Sept 9	9	8,380	7,477	263,000
1973	July 8	July 15	5	734	6,765	26,100
1974	—	—	—	—	—	—
1975	Aug 26	Sept 9	5	8,372	7,477	365,000
1976	July 29	Aug 19	5	1,135	7,069	61,300
1977	Aug 12	Sept 9	6	4,766	7,469	190,000
1978	—	—	—	—	—	—
1979	June 17	June 17	1	3	7,470	40
1980	Sept 16	Sept 16	3	3,638	7,646	94,300
1981	Aug 12	Aug 19	7	23,911	6,892	788,000
1982	—	—	—	—	—	—
1983	July 15	July 15	2	225	6,684	4,420

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Table 3.4-2

SUSITNA HYDROELECTRIC PROJECT
WATANA FIXED CONE VALVE OPERATION
2001 SIMULATION

Year	Week of First Release	Week of Maximum Release	Duration of Release	Maximum Release	Powerhouse Flow	Total Release
			Weeks	cfs	cfs	ac-ft
1950	—	—	—	—	—	—
1951	—	—	—	—	—	—
1952	—	—	—	—	—	—
1953	—	—	—	—	—	—
1954	—	—	—	—	—	—
1955	Aug 26	Sept 2	5	9,795	8,126	299,000
1956	Aug 12	Aug 19	7	8,526	7,647	563,000
1957	Sep 16	Sept 23	2	5,780	8,635	108,000
1958	—	—	—	—	—	—
1959	—	—	—	—	—	—
1960	Oct 1	Oct 1	1	628	9,128	8,720
1961	—	—	—	—	—	—
1962	July 22	July 29	10	14,648	7,403	1,110,000
1963	Aug 19	Aug 26	5	9,798	7,891	350,000
1964	Aug 26	Aug 26	2	2,013	7,874	39,000
1965	Sept 16	Sept 23	3	9,682	8,646	207,000
1966	—	—	—	—	—	—
1967	Aug 19	Sept 2	5	15,370	8,141	641,000
1968	—	—	—	—	—	—
1969	—	—	—	—	—	—
1970	—	—	—	—	—	—
1971	Aug 26	Sept 2	4	11,040	8,130	291,000
1972	Sept 9	Sept 16	2	3,201	8,485	47,600
1973	—	—	—	—	—	—
1974	—	—	—	—	—	—
1975	Sept 9	Sept 16	3	6,353	8,494	205,000
1976	Aug 12	Aug 19	3	326	7,878	10,600
1977	Sept 16	Sept 23	2	1,254	8,623	34,400
1978	—	—	—	—	—	—
1979	—	—	—	—	—	—
1980	—	—	—	—	—	—
1981	Aug 12	Aug 19	6	23,121	7,682	720,000
1982	—	—	—	—	—	—
1983	—	—	—	—	—	—

VI is a result of the filling of the reservoirs and the need to release excess flows through the outlet works. Water temperatures at the outlet works intake are cooler than at the power intakes.

The differences between the Case E-VI and Case C temperatures are a result of the higher minimum flow requirements for Case E-VI in June and July. These requirements are met by a combination of powerhouse discharges and outlet works releases from Devil Canyon Dam. During this period Watana Reservoir is generally being filled. The two reservoirs can meet the flow requirements by being operated in different manners:

1. While Watana reservoir is being filled; meet the minimum flow requirements as much as possible from Devil Canyon reservoir storage. This will result in lowered Devil Canyon water levels. Release only as much water from Watana as needed to keep Devil Canyon water level at the minimum operating level (elevation 1405).

    a. Meet energy requirements by generating power from required Watana flows. Remaining energy requirements to be supplied by Devil Canyon flows, or

    b. Meet energy requirements by generating power from required Devil Canyon flows. Remaining energy requirements to be supplied by Watana flows.

2. Meet the minimum flow requirements from Watana storage and operate Devil Canyon in a "run of river" mode, keeping Devil Canyon reservoir water level above the upper intake.

    a. Meet energy requirements by generating power from required Watana flows. Remaining energy requirements to be supplied by Devil Canyon flows, or

b. Meet energy requirements by generating power from required Devil Canyon flows. Remaining energy requirements to be supplied by Watana flows.

Policy 1 is more energy conservative than Policy 2 since Policy 2 results in releases from Watana prior to Watana reservoir being filled. Policies 1a and 2a are also more energy conservative than 1b and 2b since 1b and 2b result in releases from Watana which do not generate power. Policy 2 results in higher outflow temperatures than Policy 1. With Policy 1 there is a two to three week period, as Devil Canyon water levels are being reduced, when the lower level of the Devil Canyon power intake must be used. Water temperatures at this level are approximately 1°C cooler than would be available if the water level were kept higher. Policy 1a would result in a Devil Canyon water level below El. 1445 and operation of the lower level intake approximately every other year. Policy 2b would force Devil Canyon water level to be above El. 1445 at all times.

Policy 2b results in the warmest possible outflow temperatures and was used in reservoir operation simulations and reservoir temperature simulations for 2002 energy demands.

As system energy requirements increase, Watana reservoir will be drawn down further in winter and will fill later in the summer. Less water will be released through the outlet works, and more water through the powerhouses. Thus, outflow temperatures would increase for all the policies discussed above. Additionally, with the increase in energy demands, Case E-VI flow requirements will be met by powerhouse releases at Devil Canyon. Additional energy will be generated at Watana, and this water will tend to keep the Devil Canyon water level above the upper level intake. Temperature differences between the policies will be reduced. In the 2020 Simulation Policy 1a results in June-July Devil Canyon water levels below El. 1,445 in only 4 of the 34 years simulated. Therefore, for 2020 energy demands, Policy 1a was adopted for reservoir operation simulations.

3.4.2.2 River Temperatures, Open Water

River temperatures were simulated for Case E-VI using SNTEMP. The projected energy demands are for the year 2002, and hydrological and meteorological data are for the period May 1982 to September 1982. The simulation for the period November 1981 to April 1982 was used to define the upstream boundary of the river ice run. The results of the simulation are shown in Appendix H, Exhibit H-3. The results of a similar simulation using Case C flow requirements are shown in Appendix H, Exhibit H-4. Comparisons of simulated temperatures for these two runs at river miles 100, 130 and 150 are shown in Appendix H, Exhibit H-5.

As can be seen from the comparisons of the two runs the temperature differences are larger at river mile 150 and diminish with distance downstream. The temperature differences between Case C and Case E-VI are generally within a few tenths of a degree (°C) except for the periods noted in Section 3.4.2.1.

3.4.2.3 River Ice

ICECAL was used to simulate river ice conditions for Case E-VI flow requirements. The projected energy demands are for the year 2002, and data are for the period November 1981 to April 1982. The results are shown in Appendix H, Exhibit H-6. A river ice simulation for the same conditions but using Case C flow requirements is presented in Appendix H, Exhibit H-7. A comparison of the two runs is shown in Appendix H, Exhibit H-8.

As can be seen from the comparison of the runs, the Case E-VI flow requirements do not significantly change the results. The progression of the ice front, its location versus time, and the maximum water levels are all similar. The number of side sloughs which might be affected by overtopping due to staging is similar. Slough 8 would be overtopped for Case C but not for Case E-VI. The differences appear to be the result of slightly different reservoir outflow temperatures and discharges for Case E-VI than for Case C, which causes some differences in ice accumulation and staging.

3.4.2.4 Dissolved Gases

As discussed in the License Application (p. E-2-132 and Table E.2.58) the design for Watana and Devil Canyon Dams includes cone valves which will be used to release all floods with return periods of 50 years or less. The use of cone valves to pass flows in excess of energy and minimum flow requirements will minimize the potential for gas concentrations to exceed naturally occurring levels downstream of the project. As can be noted from Appendix F, Tables 5 and 8, and Tables 3.4-3 and 3.4-4, the Watana and Devil Canyon cone valve capacities of 24,000 cfs and 38,500 cfs are never exceeded. Therefore, the project spillways would not be operated and detrimental levels of gas concentrations would not be expected to exceed naturally occurring levels as a result of project operation.

Flood routing studies have also confirmed that the 50-year flood for the period July-September can be stored and released from the project reservoirs without operating the spillways.

3.4.3 Refinement to Reservoir and River Temperature and Ice Studies

The reservoir and river temperature and ice simulations transmitted to the Federal Energy Regulatory Commission (FERC) with the Alaska Power Authority's comments on the Draft Environmental Impact Statement (DEIS) contained simulations for the winter period October 1976 to May 1977. Reservoir simulations for this period utilized climatological data from the Federal Aviation Administration Weather Station at Talkeetna because the National Weather Service station at Summit, used for simulations in the period November 1970 to October 1976, was closed in October 1976. After the initial simulations were made, an examination showed that the wind speeds recorded for Talkeetna for this period were not similar to typical wind speeds at Summit and Watana. A sensitivity run of the model showed that the use of the Talkeetna wind speeds resulted in somewhat colder reservoir outflow temperatures and thus a more extensive downstream river ice cover than if more accurate wind speeds had been used.

Table 3.4-3

SUSITNA HYDROELECTRIC PROJECT
DEVIL CANYON CONE VALVE OPERATION
2002 SIMULATION

Year	Week of First Release	Week of Maximum Release	Duration of Release	Maximum Release	Powerhouse Flow	Total Release	Maximun Watana Release During Period
			Weeks	cfs	cfs	ac-ft	cfs
1950	Aug 05	Aug 12	4	10,898	9,313	330,000	18,160
1951	Aug 05	Sep 02	8	18,816	9,438	1,024,000	24,000
1952	Jul 15	Jul 29	11	33,443	1,087	1,385,000	24,000
1953	Jul 01	Jul 29	12	14,846	9,159	1,406,000	20,931
1954	Jul 22	Jul 29	9	20,574	8,436	1,271,000	24,000
1955	Jul 08	Aug 26	11	34,184	0	1,967,000	24,000
1956	Jul 01	Jul 15	13	24,721	5,460	2,564,000	24,000
1957	Jul 08	Jul 22	12	15,756	8,825	1,695,000	22,198
1958	Jul 08	Jul 29	8	35,626	0	1,391,000	24,000
1959	Jul 15	Aug 19	9	38,000	0	2,055,000	24,000
1960	Jul 29	Sep 09	10	16,283	10,303	1,271,000	22,570
1961	Jun 24	Aug 05	14	15,884	9,177	1,855,000	23,083
1962	Jun 17	Jun 24	15	31,794	2,108	2,753,000	24,000
1963	Jul 01	Jul 08	11	35,660	0	2,684,000	24,000
1964	Jun 24	Jun 24	11	24,763	4,843	1,546,000	24,000
1965	Jul 08	Aug 12	13	20,871	7,840	1,728,000	24,000
1966	Jul 15	Jul 29	10	16,923	9,166	994,000	22,511
1967	Jul 08	Aug 12	11	38,000	0	2,721,000	24,000
1968	Jun 24	Jul 01	12	19,787	8,036	1,545,000	24,000
1969	--	--	--	--	--	--	6,123
1970	--	--	--	--	--	--	3,390
1971	Jul 29	Aug 05	7	35,689	0	1,869,000	24,000
1972	Jun 17	Jun 17	14	27,681	3,698	2,134,000	24,000
1973	Aug 05	Aug 26	5	12,493	9,767	596,000	20,593
1974	Aug 26	Sep 02	3	5,556	10,030	104,000	13,996
1975	Jul 01	Jul 08	13	21,320	7,116	1,727,000	24,000
1976	Aug 05	Aug 05	4	19,324	6,406	531,000	24,000
1977	Jun 24	Jul 15	13	15,193	8,812	1,537,000	21,740
1978	Jul 22	Jul 29	7	9,793	9,142	512,000	17,979
1979	Jul 08	Jul 22	9	26,961	3,907	1,470,000	24,000
1980	Jul 01	Jul 15	12	27,733	3,852	2,220,000	24,000
1981	Jul 08	Aug 12	11	37,737	0	3,581,000	24,000
1982	Jul 08	Jul 22	12	17,555	8,831	1,305,000	23,533
1983	Jul 08	Aug 05	11	16,210	9,178	1,387,000	22,829

Table 3.4-4

SUSITNA HYDROELECTRIC PROJECT
DEVIL CANYON CONE VALVE OPERATION
2020 SIMULATION

Year	Week of First Release	Week of Maximum Release	Duration of Release	Maximum Release	Powerhouse Flow	Total Release	Maximun Watana Release During Period
			Weeks	cfs	cfs	ac-ft	cfs
1950	—	—	—	—	—	—	—
1951	—	—	—	—	—	—	—
1952	—	—	—	—	—	—	—
1953	—	—	—	—	—	—	—
1954	—	—	—	—	—	—	—
1955	Aug 26	Sept 2	5	11,857	5,653	420,000	8,653
1956	Aug 5	Aug 12	8	17,910	6,046	1,210,000	12,222
1957	—	—	—	—	—	—	—
1958	—	—	—	—	—	—	—
1959	Sept 2	Sept 9	5	6,411	6,938	195,000	2,362
1960	—	—	—	—	—	—	—
1961	—	—	—	—	—	—	—
1962	Aug 5	Aug 26	8	16,449	5,760	1,210,000	11,424
1963	Aug 12	Aug 19	7	15,820	5,905	728,000	12,613
1964	Aug 26	Sept 9	3	4,455	6,034	114,000	1,238
1965	Sept 23	Sept 23	2	11,276	7,213	230,000	7,403
1966	—	—	—	—	—	—	—
1967	Aug 12	Aug 19	7	22,674	5,925	1,103,000	16,270
1968	Sept 2	Sept 9	2	4,335	6,136	121,000	—
1969	—	—	—	—	—	—	—
1970	—	—	—	—	—	—	—
1971	Aug 26	Sept 2	5	15,801	5,658	508,000	9,902
1972	May 27	Sept 9	6	11,943	5,269	422,000	5,984
1973	—	—	—	—	—	—	—
1974	—	—	—	—	—	—	—
1975	Aug 26	Sept 9	5	13,114	5,272	572,000	5,976
1976	—	—	—	—	—	—	—
1977	Sept 9	Sept 16	3	7,984	5,206	254,000	1,533
1978	—	—	—	—	—	—	—
1979	—	—	—	—	—	—	—
1980	Sept 16	Sept 16	3	4,933	6,962	142,000	1,419
1981	Aug 12	Aug 19	7	29,582	5,959	1,244,000	22,420
1982	—	—	—	—	—	—	—
1983	—	—	—	—	—	—	—

For this reason the reservoir and river temperature and ice simulations for the period October 1976 to May 1977 have been refined. Typical wind speeds from the Summit station were used to replace the Talkeetna data.

The refined reservoir and river temperature and river ice runs are included in Appendix I.

3.5 IMPACT ASSESSMENT

Case E-VI is designed to reduce environmental impacts of project operation as compared to flow cases designed specifically for power generation. Case E-VI can not, however, mitigate all impacts by flow release alone, so further impact evaluations and mitigation planning are necessary. Section 3.5.1 addresses the principal potential impacts of Case E-VI flow requirements on each life stage of the five Pacific salmon species. The resident evaluation species are treated separately in Section 3.5.2.

3.5.1 Life Stage Impacts - Pacific Salmon

Upstream migration

Adult salmon migrate up the Susitna River toward spawning areas throughout the summer. The 9,000 cfs summer minimum flows will provide sufficient conditions for upstream migration of adults.

Spawning

Less than 15 percent of the salmon using the Susitna River System actually spawn in Middle River habitats (ADF&G 1984a). Most the the salmon that spawn in the Middle River Basin use tributary habitats outside the influence of mainstem discharge. The major spawning habitat most sensitive to changes in mainstem discharge are the side sloughs used by chum and sockeye salmon. Mainstem flows affect spawning success in side sloughs by influencing total usable area within the sloughs, groundwater discharge, and access past critical reaches of the stream.

Access into the major spawning sloughs (8A, 9, 9A, 11 and 21) would be restricted under Case E-VI flows. Analysis based on observed spawning use provides an estimated reduction of approximately 50% of side-slough spawning due to access restriction at 9,000 cfs (see Power Authority Comment on DEIS No. AQR072). However, considering the restricted access together with reduced area and flow within the sloughs, a worst case assumption of 100% loss of side-slough spawning habitat without further mitigation is used for this evaluation.

Juvenile Rearing

Chinook salmon juveniles rear in both clear and turbid water habitats. Substantial rearing occurs in both tributaries and side channels (ADF&G 1984b). Through the summer, densities generally decrease in tributaries and increase in side channel habitats. Population densities in side sloughs are relatively low during the summer but increase markedly during September and October. Tributary habitat would not be impacted by the altered mainstem flows. Case E-VI flows would, however, reduce the quantity of available existing rearing habitat at side channel sites presently used by chinook by approximately 25%.

Chum salmon rearing is essentially limited to tributaries and side sloughs during the early summer (May to early June). Highest population densities during late June and July occur in upland sloughs and tributaries. Essentially all the juvenile chum have moved downstream, out of the Middle River, by the end of July. Case E-VI flows would not impact rearing habitat in tributaries and upland sloughs. Chum salmon use mainstem sites mostly for short-term holding and rearing during downstream migration. Case E-VI flows would not decrease the availability of the low velocity, mainstem backwater sites as presently used by chum. There would, however, be a decrease of chum rearing habitat in side sloughs. Most of the decrease would be due to a reduction or elimination of overtopped conditions in side sloughs during May and June. Decrease of habitat could be as great as 50% at the sites utilized under natural flow conditions.

Sockeye juveniles rear predominantly in natal side sloughs during the early summer and then move mostly to upland sloughs by July. With-project flows are not expected to affect upland slough habitats. The responses of weighted usable area for sockeye and chum are similar for side slough rearing habitat. Therefore, reduction of sockeye rearing habitat would also be approximately 50%.

Coho salmon rear mostly in tributaries and upland sloughs. Impacts due to project operation are not expected in these habitats.

Pink salmon juveniles move rapidly from their natal tributaries to Cook Inlet. The mainstem and associated habitats are apparently used only for migration corridors so project flows would not impact pink salmon rearing.

Downstream Migration

Downstream movement of salmon juveniles occurs throughout the summer (ADF&G 1984b). Chum, pink and age 1+ chinook salmon migrate toward Cook Inlet during the early summer and are out of the Middle River reach by July. Sockeye, coho and age 0+ chinook move gradually downstream throughout the summer. Most of this movement is associated with rearing and gradual relocation into available rearing and overwintering habitat.

Some of this downstream movement is influenced by mainstem discharge (ADF&G 1984b). Increasing discharge during flood flows can act as a stimulus to initiate seaward migration, especially during the early summer. Flood flows later in the summer, when juveniles are rearing or seeking alternative habitat sites, can cause dislocation from preferred rearing areas. Project operation will reduce the frequency and amplitude of flood events in the Middle River. This impact is not expected to significantly affect seaward migration. Factors other than flow, such as increasing day length, water temperature and physiological condition also trigger migration. In addition, increased turbidity, and local run-off could also serve to stimulate migration.

3.5.2 Life Stage Impacts - Resident Evaluation Species

Arctic Grayling

The major uses of sensitive habitats by arctic grayling are overwintering in mainstem habitat and rearing at tributary mouths. With-project conditions will increase the availability of clearwater habitats in general, including tributary mouth habitat (Trihey 1984). More stable with-project flows under Case E-VI will also improve the quality of tributary mouth habitat. Therefore, no adverse impact during the ice-free period is expected.

Arctic grayling overwinter in mainstem areas. Major movement out of the tributaries occurs in September and the fish then move downstream to locations where they remain for the rest of the winter (ADF&G 1983). Habitat requirements for overwintering are not entirely understood but the grayling probably seek stable, deep, low velocity sites relatively free from radical changes due to ice processes. With-project flows will be greater during the winter than natural flows. Therefore, the total area of mainstem, side channel and side slough habitat types will be greater under with-project winter flows and the availability of deep, low velocity sites should also increase. The upstream progression and duration of an ice cover in the Middle River will be reduced under project operation (Harza-Ebasco 1984a). This should further improve overwintering conditions for grayling.

Turbidity levels will be higher during the winter under project operation. This may limit the use of mainstem sites since grayling show a preference for clearwater habitats. With-project winter turbidity was estimated to be approximately 10-20 NTU's which is at the lower end of the range experienced annually under natural conditions (0-1,000 NTU's; Lic. App., Exhibit E, Vol. 5A, pp. E-2-30 and E-2-131). The expected turbidity is within the range that grayling experience in the mainstem and tributaries during the early summer when snowmelt is a large contributor to surface runoff. Therefore, grayling may be able to successfully tolerate the expected with-project turbidity. In addition, the quantity of clearwater habitat in secondary channels (side sloughs and side channels) will be greater under with-project flows. This results from increased head due to higher flows and ice staging in the mainstem which increases groundwater and intragravel flow to peripheral habitats.

Thus, it is expected that Case E-VI flow constraints will provide habitat of sufficient quantity and quality (stability) to maintain existing grayling production.

Rainbow Trout

The major uses of sensitive habitats by rainbow trout are similar to those of Arctic grayling (Table 2.2-3). Rainbow also appear to be less dependent on clearwater habitats and are found more frequently in side sloughs than grayling (ADF&G 1984b). Therefore, rainbow trout should be more tolerant of with-project winter turbidity levels and are more likely than grayling to utilize available clearwater sites to overwinter.

The general increase of clearwater habitat (especially tributary mouth) during the summer and the maintenance of sufficient conditions for overwintering under Case E-VI flow constraints should result in maintenance of rainbow production at levels equal to or higher than natural levels.

Dolly Varden

The primary use of sensitive habitats by Dolly Varden is overwintering in the mainstem. Details regarding their habitat preferences are not well known but they probably seek sites similar to arctic grayling and rainbow trout. Dolly Varden are found in turbid river systems (McPhail and Linsey 1970) so with-project winter turbidity should not limit their use of mainstem and peripheral habitats. Project operation under Case E-VI flow constraints will provide sufficient habitat to maintain production of Dolly Varden at present levels.

Burbot

Burbot use mainstem habitat throughout the year and for all life history stages. They seem to prefer turbid water during the ice-free season since they are rarely captured in the clearwater habitats (ADF&G 1984b). They also show a preference for backwater sites in the mainstem and at slough mouths. Spawning occurs in January although sampling results indicate that little spawning occurs in the Middle River (ADF&G 1984b).

Project operation under Case E-VI constraints will result in lower, more stable summer flows than natural conditions. Summer flows of approximately 9,000 cfs will produce an increase in habitat with side slough and associated slough mouth characteristics (Trihey 1984). The lower summer flows will also increase the number of sites characterized as low velocity, backwater areas. Therefore, with-project summer conditions should provide sufficient habitat to maintain production of burbot at present levels.

Higher water surface elevations caused by increased flows and ice staging during the winter will increase the number of secondary channels that receive flow (Harza-Ebasco 1984a). The increased complexity of wetted channels will increase the number and areal extent of backwater sites in the mainstem and at slough mouths. Therefore, a sufficient quantity of habitat will be available for burbot during the winter.

Habitat quality will be most affected by increased winter turbidity. Burbot are very tolerant of high turbidity levels so the relatively low levels expected with project operation will not affect their survival. Increased turbidity might be expected to affect spawning by limiting visual cues and orientation for spawning behavior; however, burbot are nocturnal spawners and typically spawn under an ice cover (Scott and Crossman, 1973). Vision must be of little or no importance to burbot spawning. Thus project operation under Case E-VI constraints will not affect burbot production.

3.6 MITIGATION

Project impacts would be minimized largely through timing and control of flow releases by adopting the environmental flow requirements in Case E-VI. Without environmental restrictions ("P-1 flows", Harza-Ebasco 1984d, p.4.) flows could fall below 9,000 cfs during June through August in approximately 75% of the years of operation. Mean monthly summer flows could be as low as 4,500 cfs in some years. This would result in total loss of most of the mainstem and side channel rearing habitat presently used by chinook and chum salmon juveniles. Case E-VI flows would minimize this impact by maintaining 75% of the existing side channel rearing habitat. The residual 25% loss of side channel habitat and the loss of chum and sockeye rearing habitat in side sloughs would be rectified by habitat replacement at the more stable, lower flows (relative to natural flows) under Case E-VI.

The impact assessments discussed above (section 3.5) are based on impacts to habitat sites that are now available and used under natural flow conditions. The assessments did not consider the addition of new habitat sites with appropriate characteristics and qualities that would become available at the lower, more stable flows resulting from Case E-VI operation. A case in point is the increase in side channel rearing areas for chinook salmon. The quantity of side channel rearing habitat depends largely on channel complexity, and there is relatively little of this habitat available at bank full flows. The habitat quantity increases as flows decrease, and the flow channels become more complex until a point is reached when flow is reduced to a single thalweg channel. Channel complexity favorable for side channel rearing is much greater at the lower, summer operational flows (Case E-VI) of 9,000 to 12,000 cfs, than at mean summer natural flows of approximately 23,000 cfs.

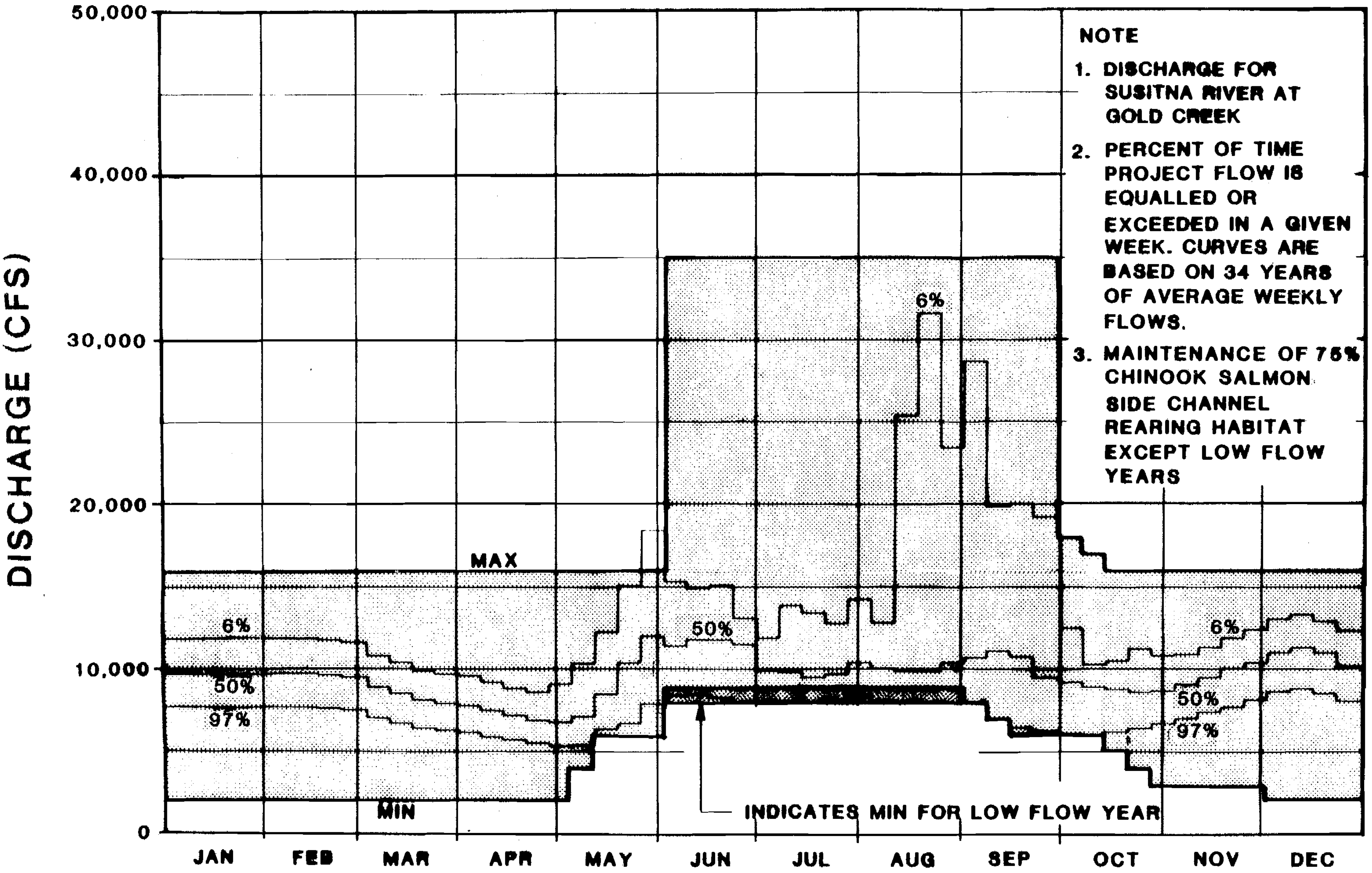
Overall, the quantity of side channel as well as mainstem rearing habitat for both chinook and chum salmon is expected to increase over natural conditions during project operation using Case E-VI flow requirements. Increased flow stability and decreased turbidity are expected to improve habitat quality and augment rearing potential in the Middle River.

Case E-VI minimum flow constraints during late August and early September will minimize impacts of the project on chum and sockeye spawning. However, the loss of side slough habitat for chum and sockeye salmon spawning will need to be rectified by structural modification of existing sloughs. Details of these activities are given in a report entitled "Interim Mitigation Plan for Chum Spawning Habitat in Side Sloughs of the Middle Susitna River" (Woodward Clyde 1984).

The results of the Case E-VI mitigation measures are compatible with mitigation policies and objectives presented in the License Application (Ex. E, Chpt. 3, p. E-3-147). The measures provide habitat quantity and quality sufficient to maintain naturally reproducing populations. All significant impacts are minimized or rectified.

ENVIRONMENTAL FLOW REQUIREMENTS CASE E VI

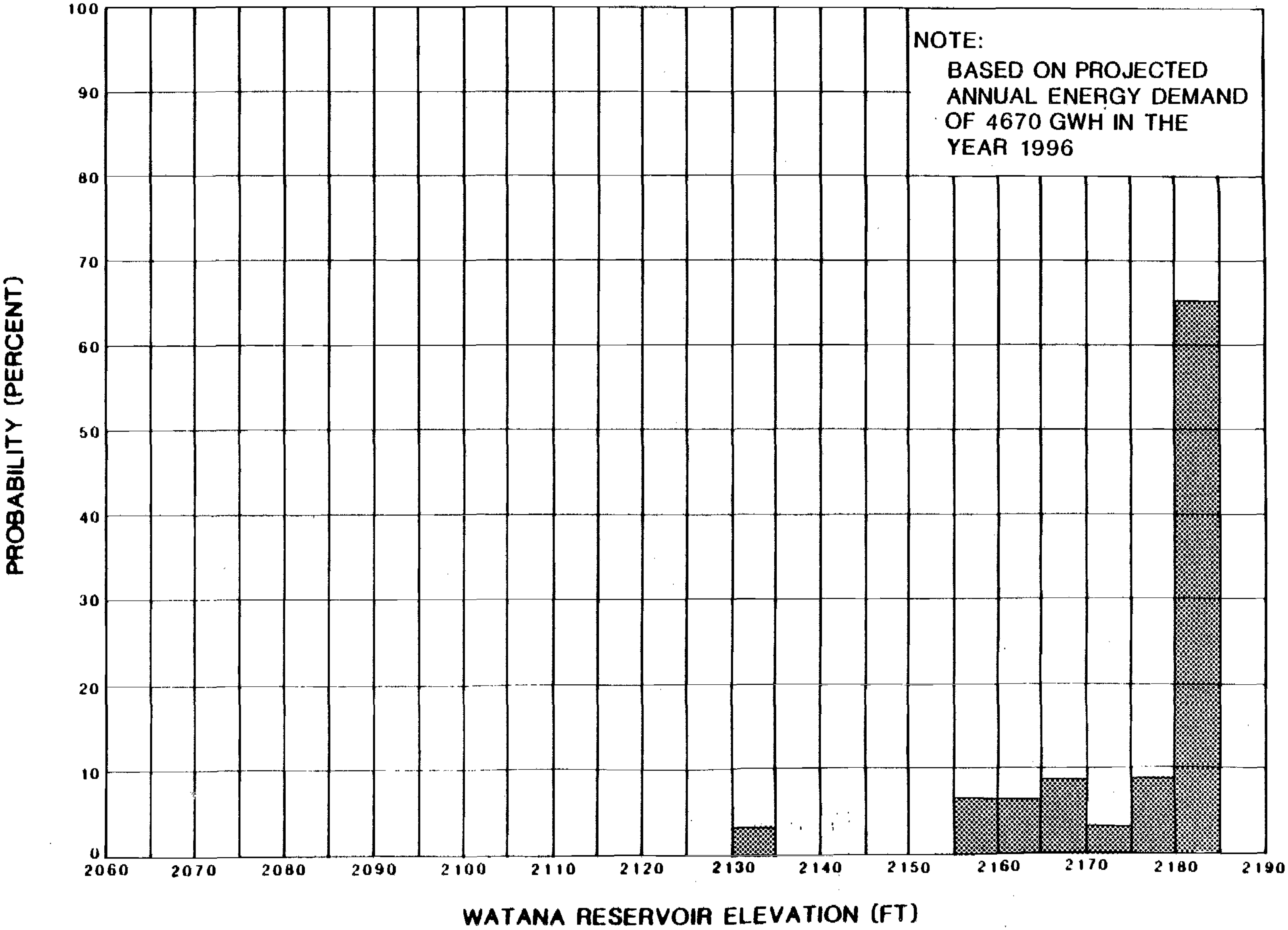
WATANA OPERATION--1996 DEMAND 4670GWH



3-49

FIG. 3.3-1

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON OCTOBER 1
WATANA OPERATION

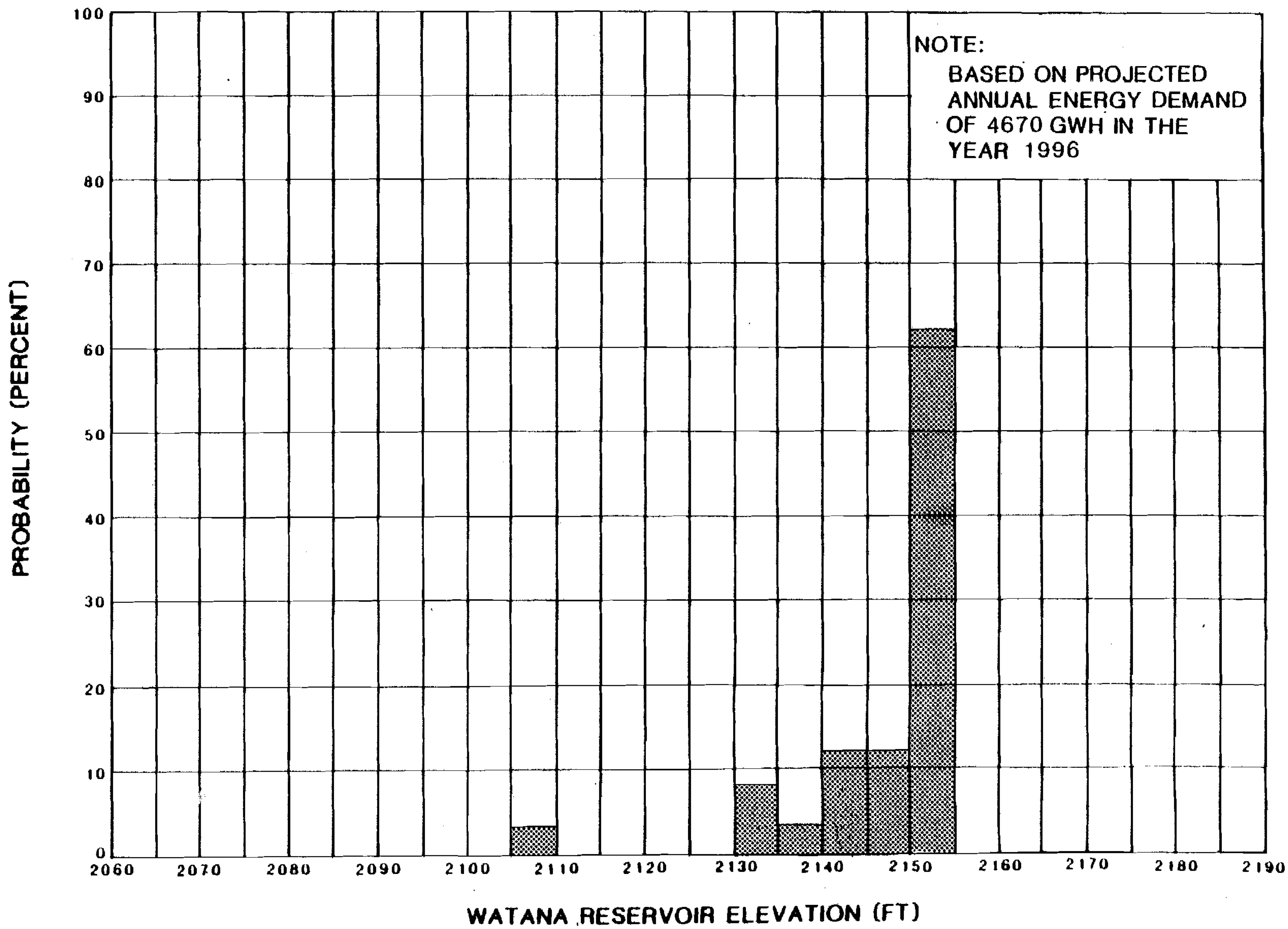


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-2

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON JANUARY 1 WATANA OPERATION



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-3

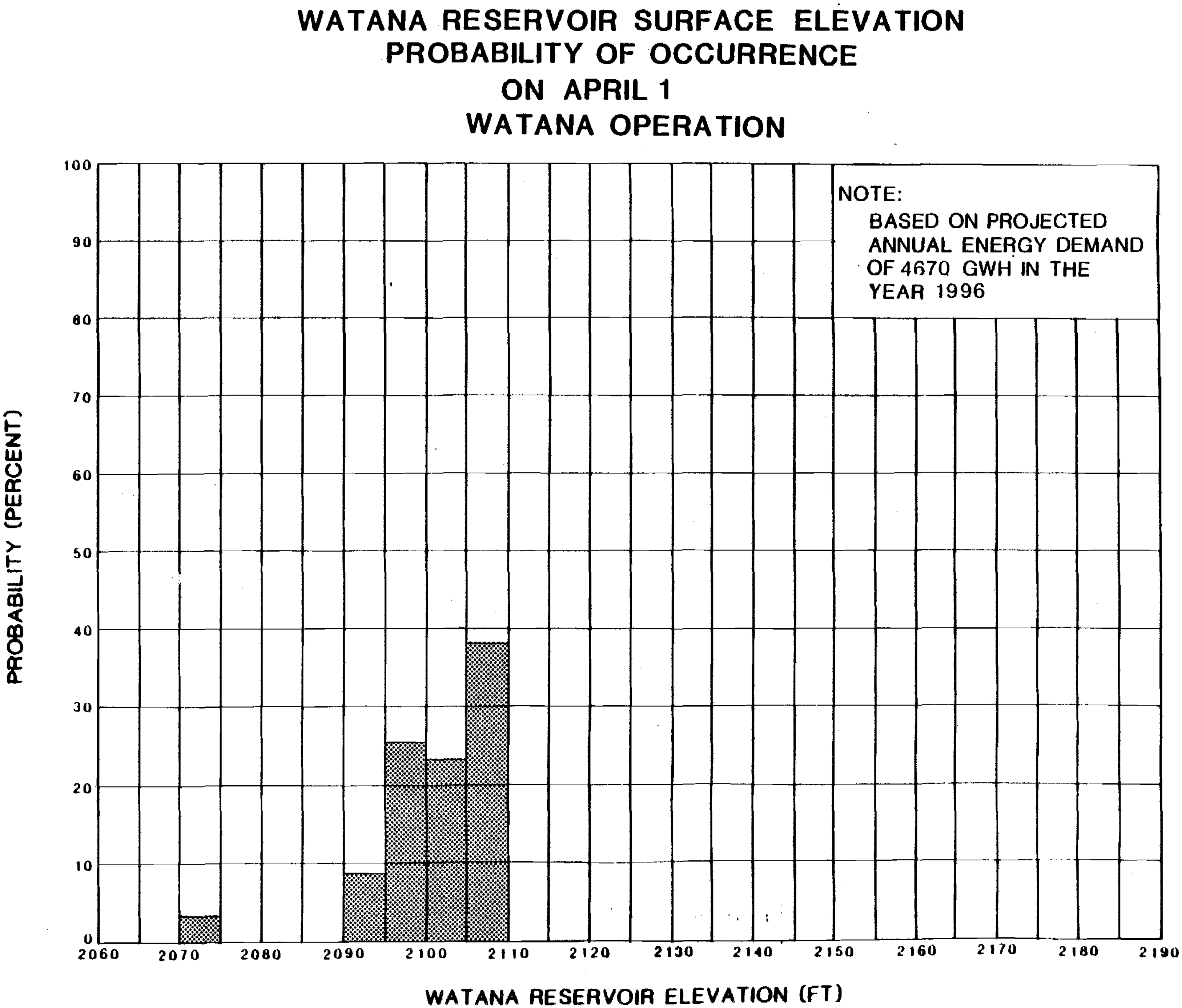
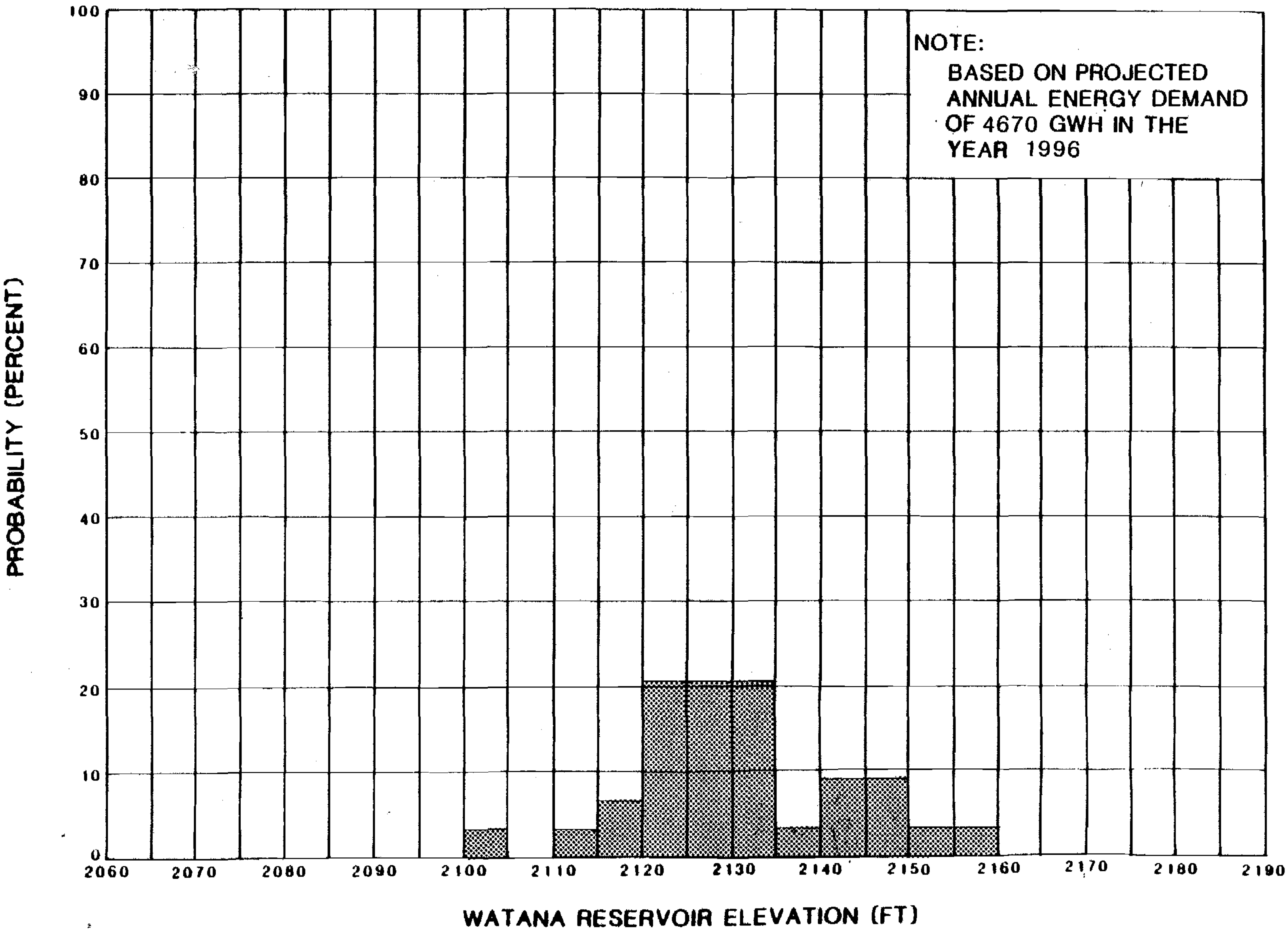


FIG. 3.3-4

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON JULY 1 WATANA OPERATION

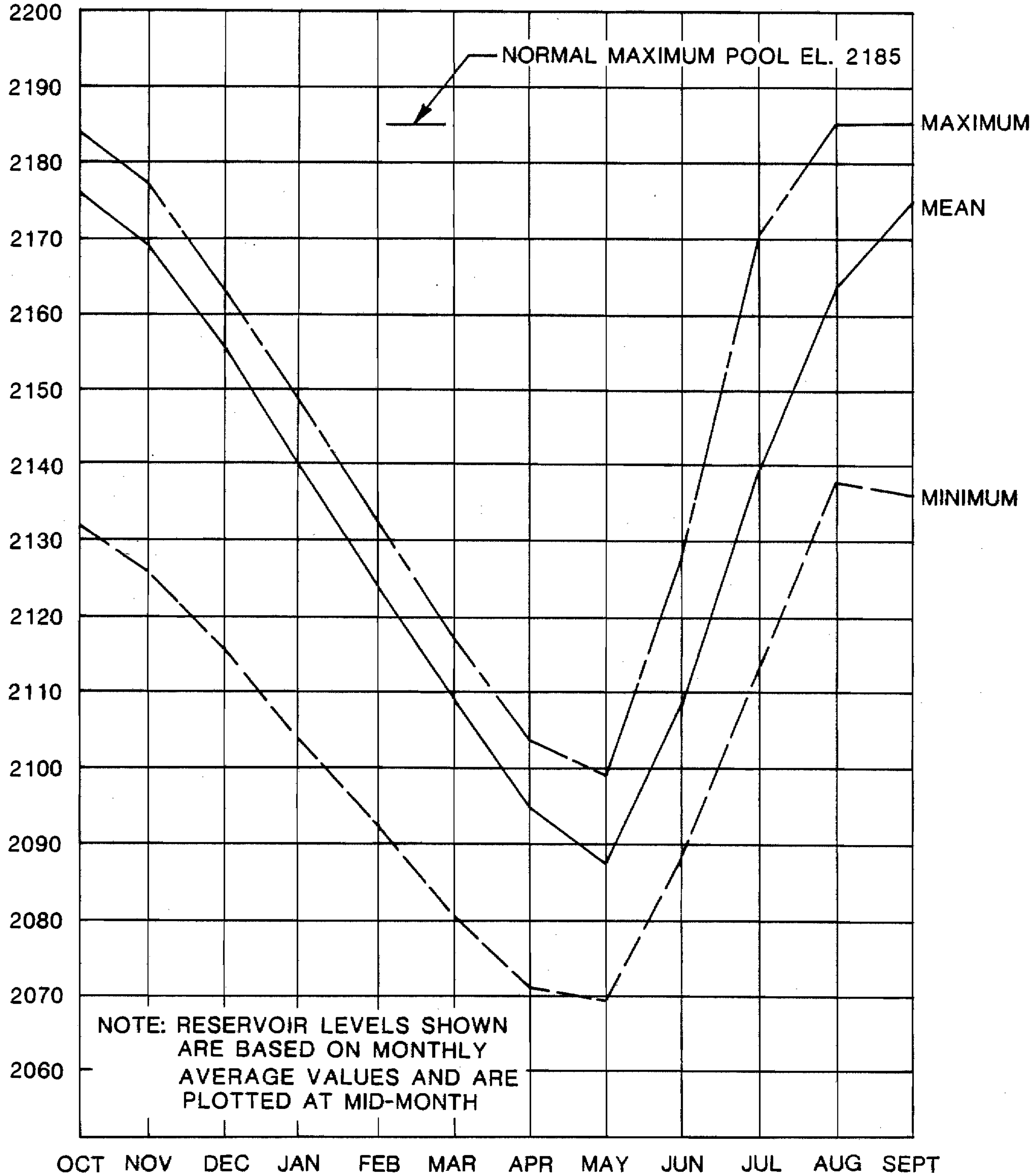


HARZA-EBASCO SUSITNA JOINT VENTURE

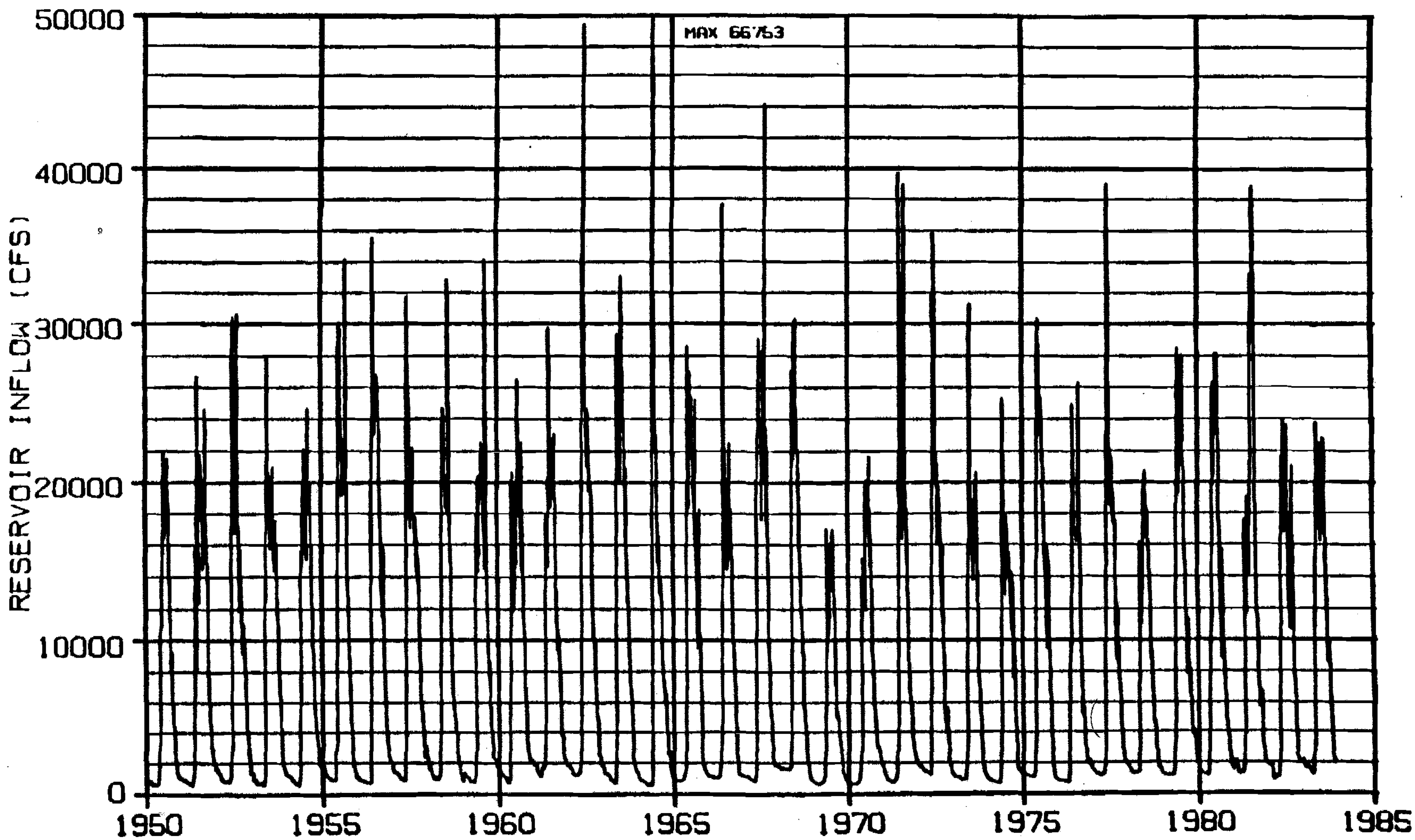
ALASKA POWER AUTHORITY

FIG. 3.3-5

WATANA RESEREVOIR WATER LEVELS
WATANA ONLY OPERATING
2001 SIMULATION CASE E-VI



WATANA
RESERVOIR INFLOW

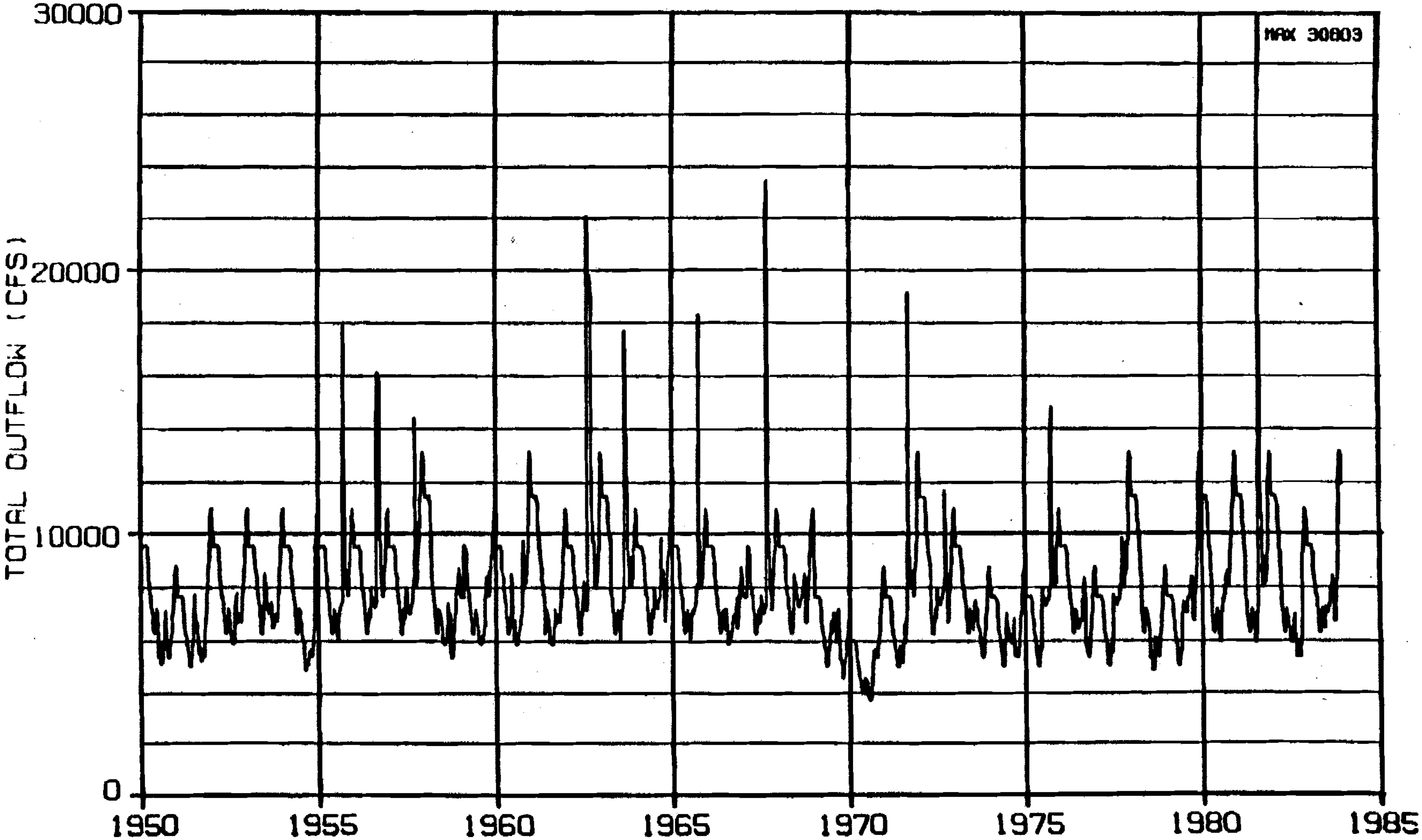


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-7

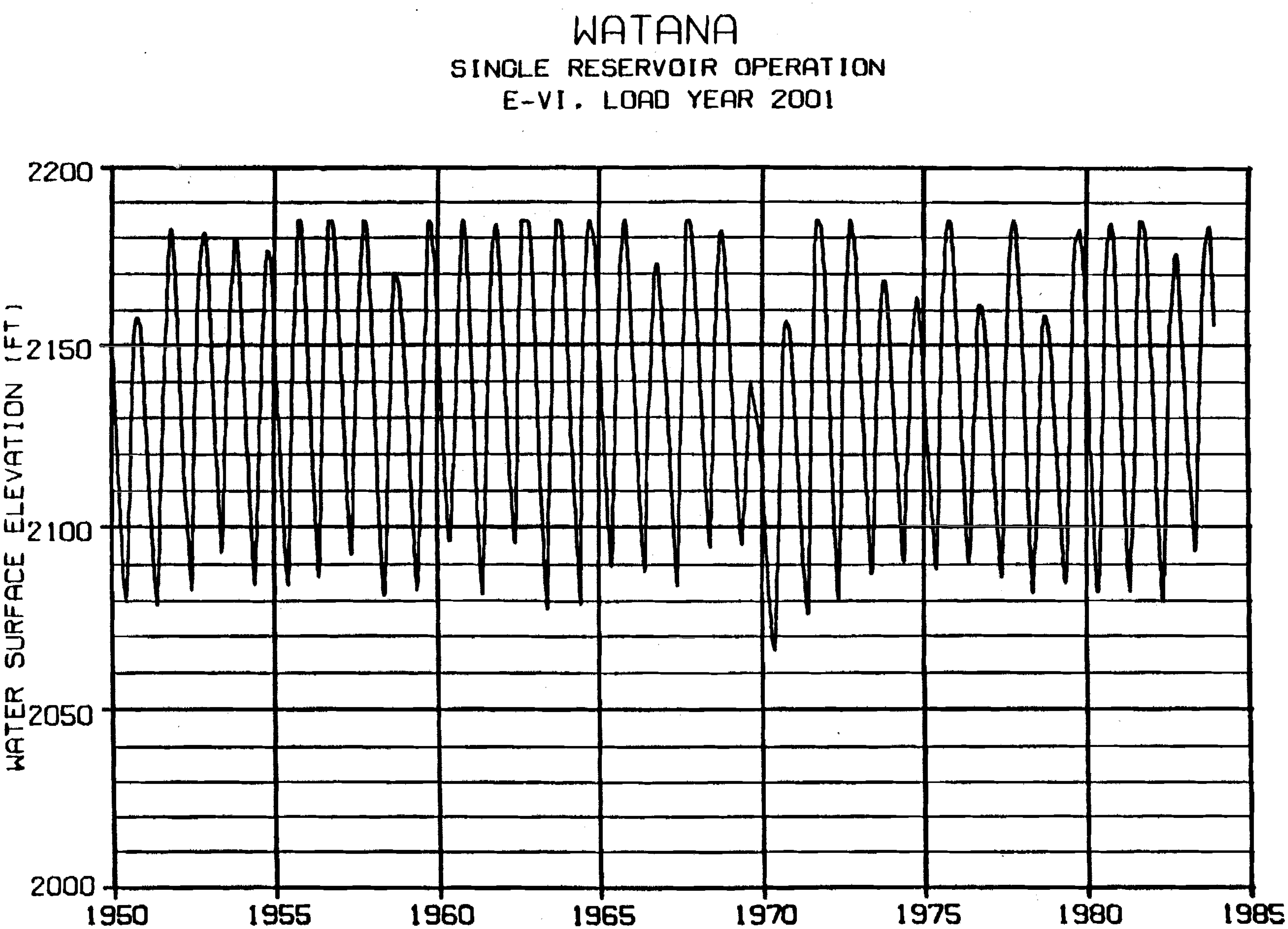
WATANA
SINGLE RESERVOIR OPERATION
E-VI. LOAD YEAR 2001



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-8



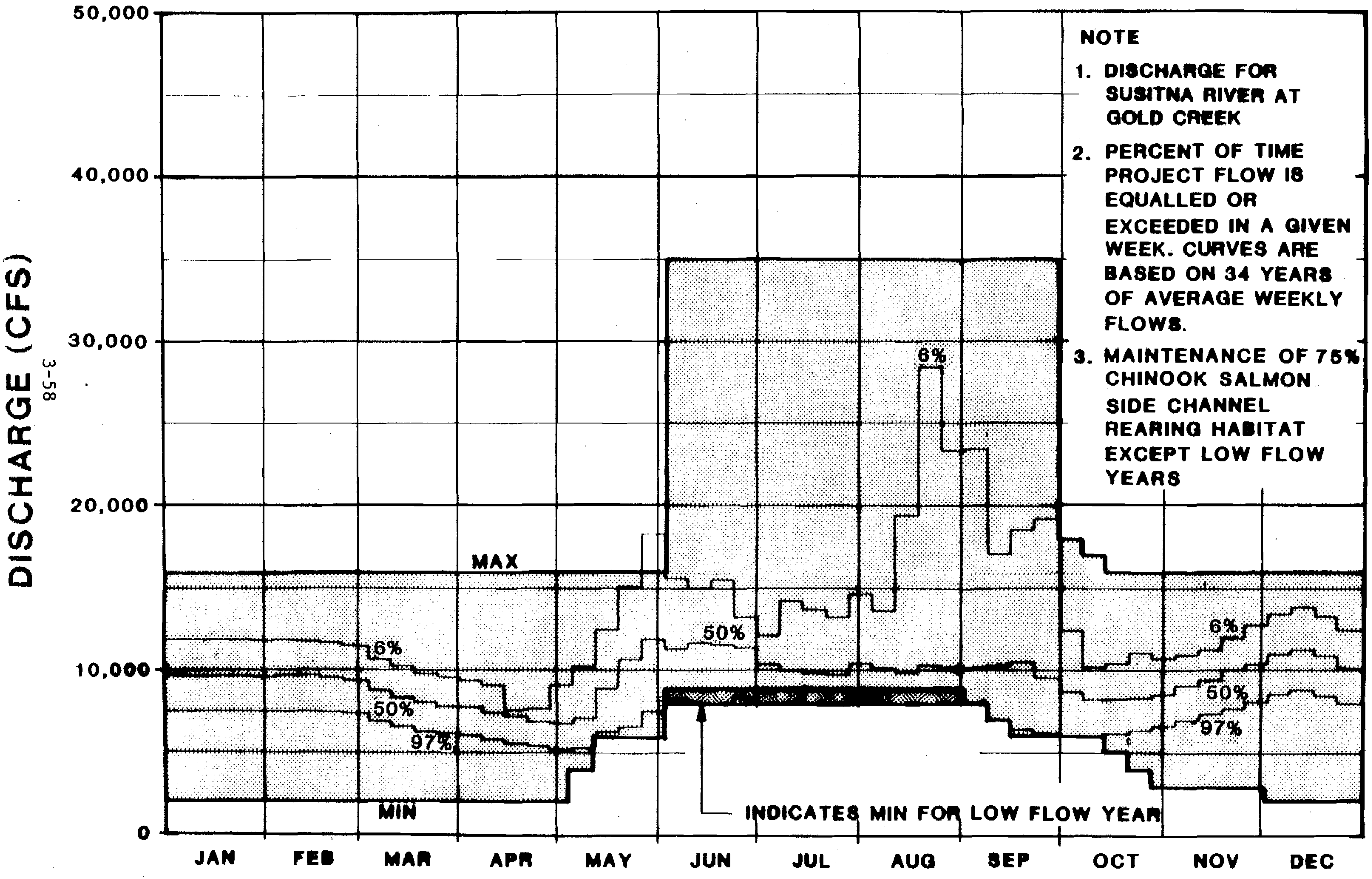
HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-9

ENVIRONMENTAL FLOW REQUIREMENTS CASE E VI

WATANA OPERATION-2001 DEMAND 5117GWH

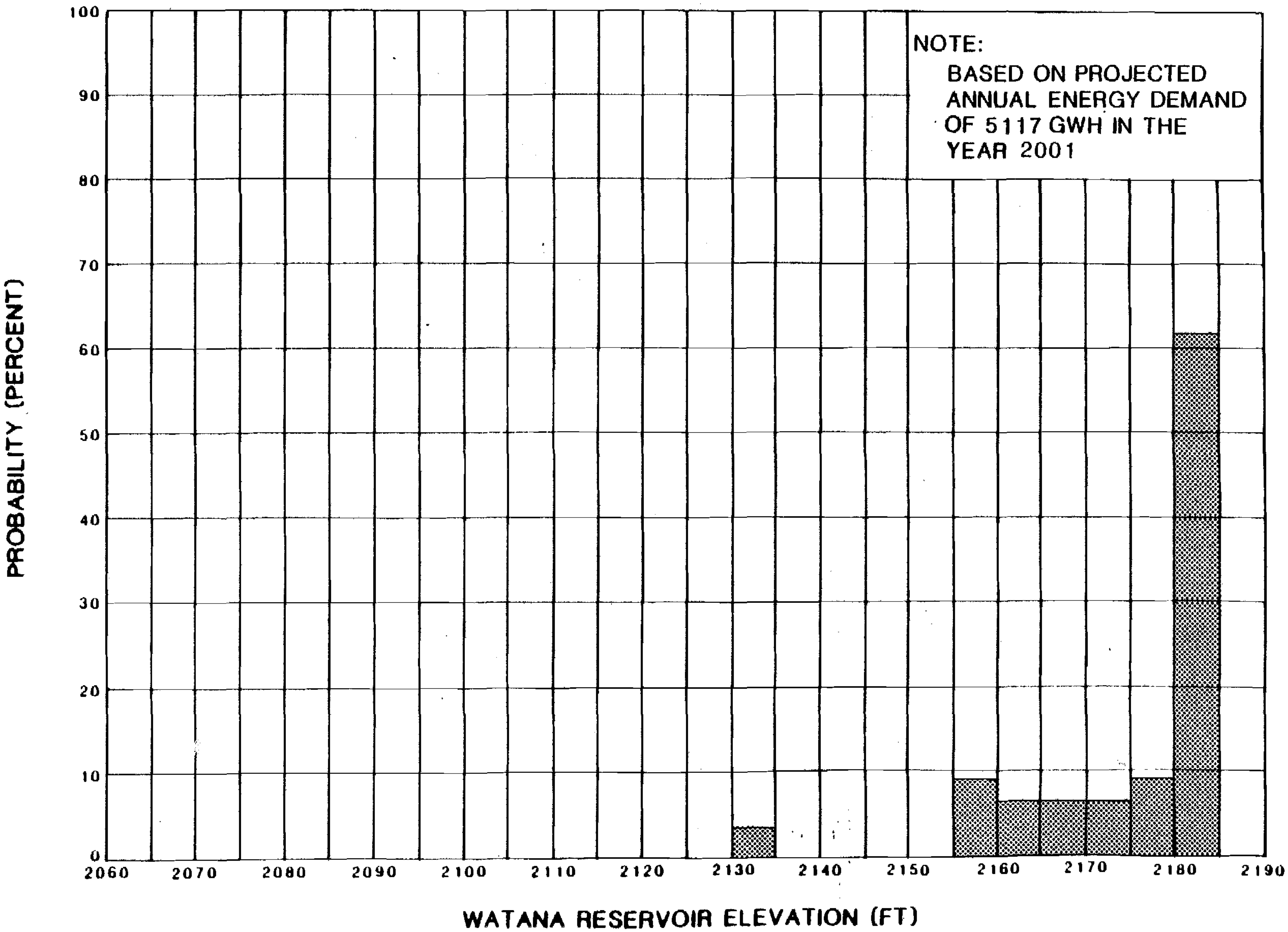


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-10

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON OCTOBER 1 WATANA OPERATION

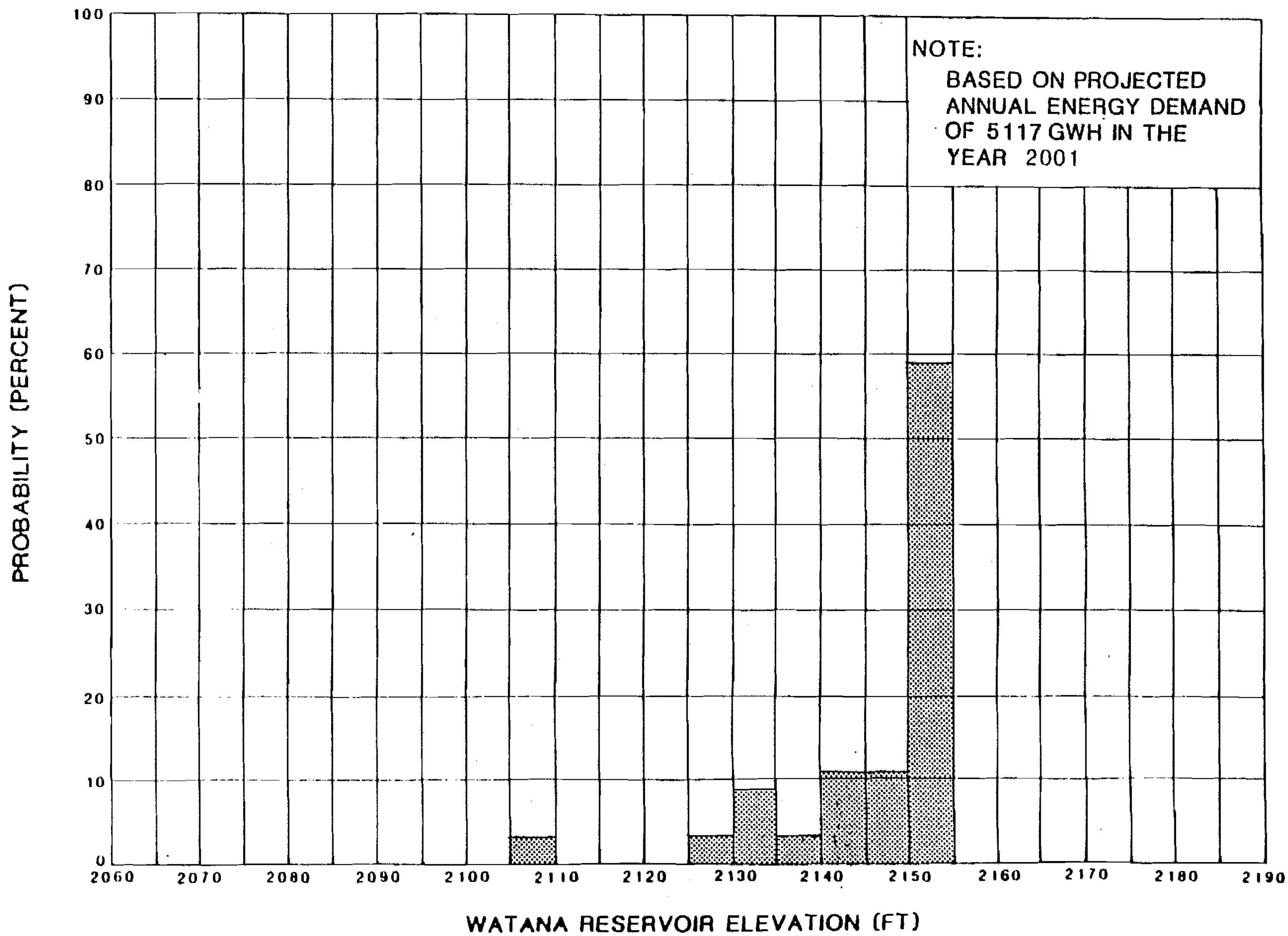


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-11

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON JANUARY 1
WATANA OPERATION

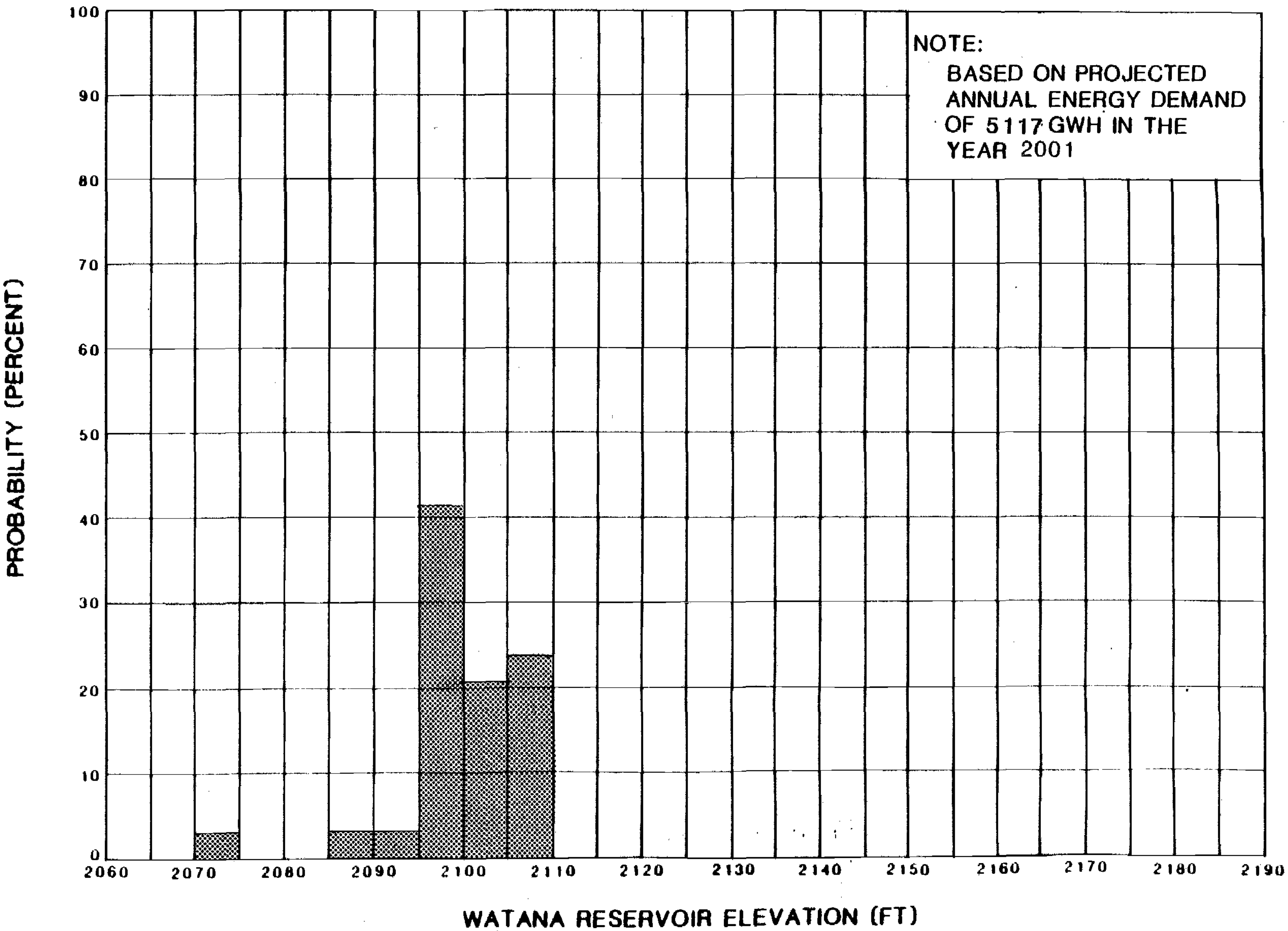


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-12

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON APRIL 1
WATANA OPERATION

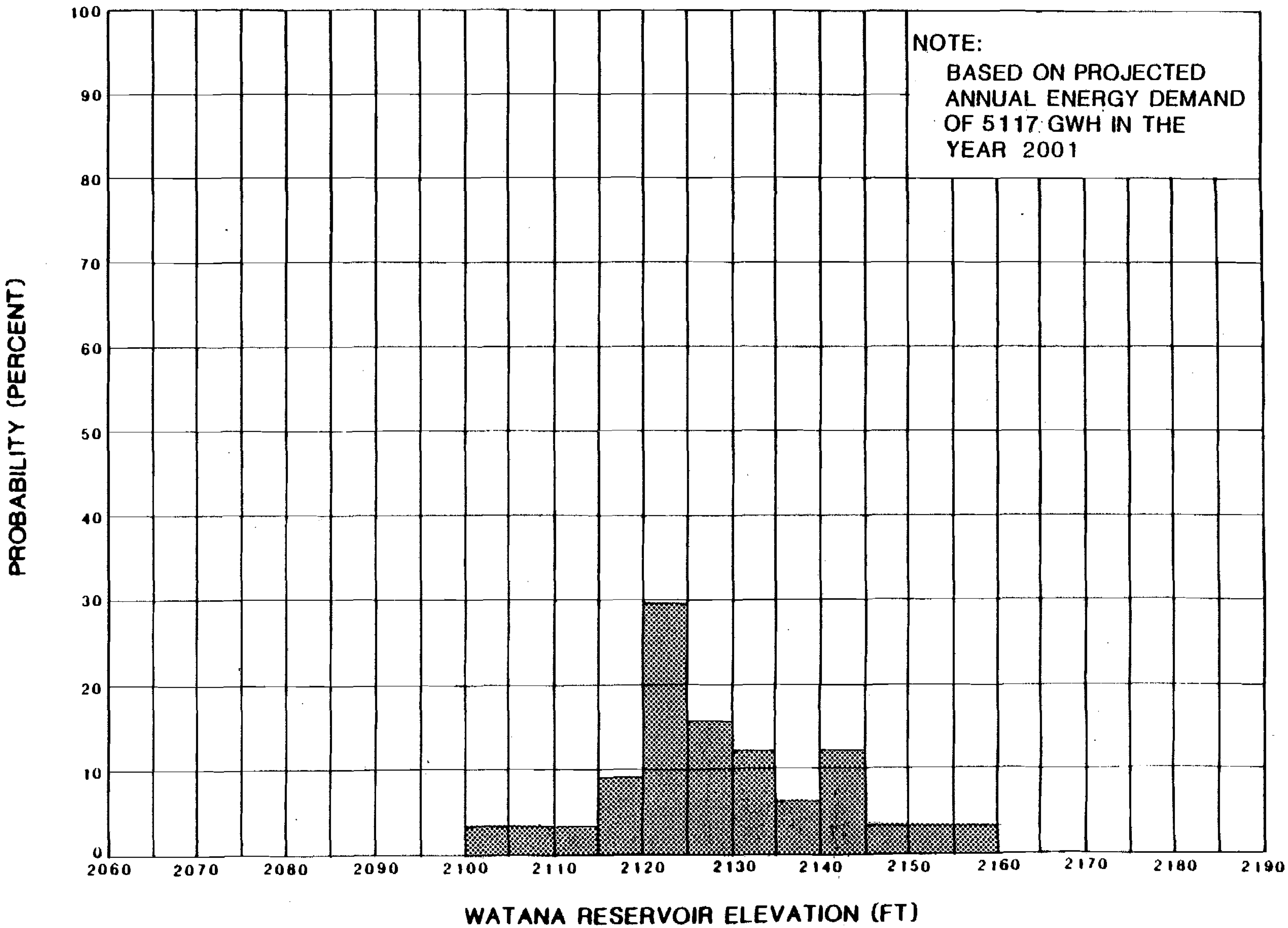


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-13

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON JULY 1
WATANA OPERATION



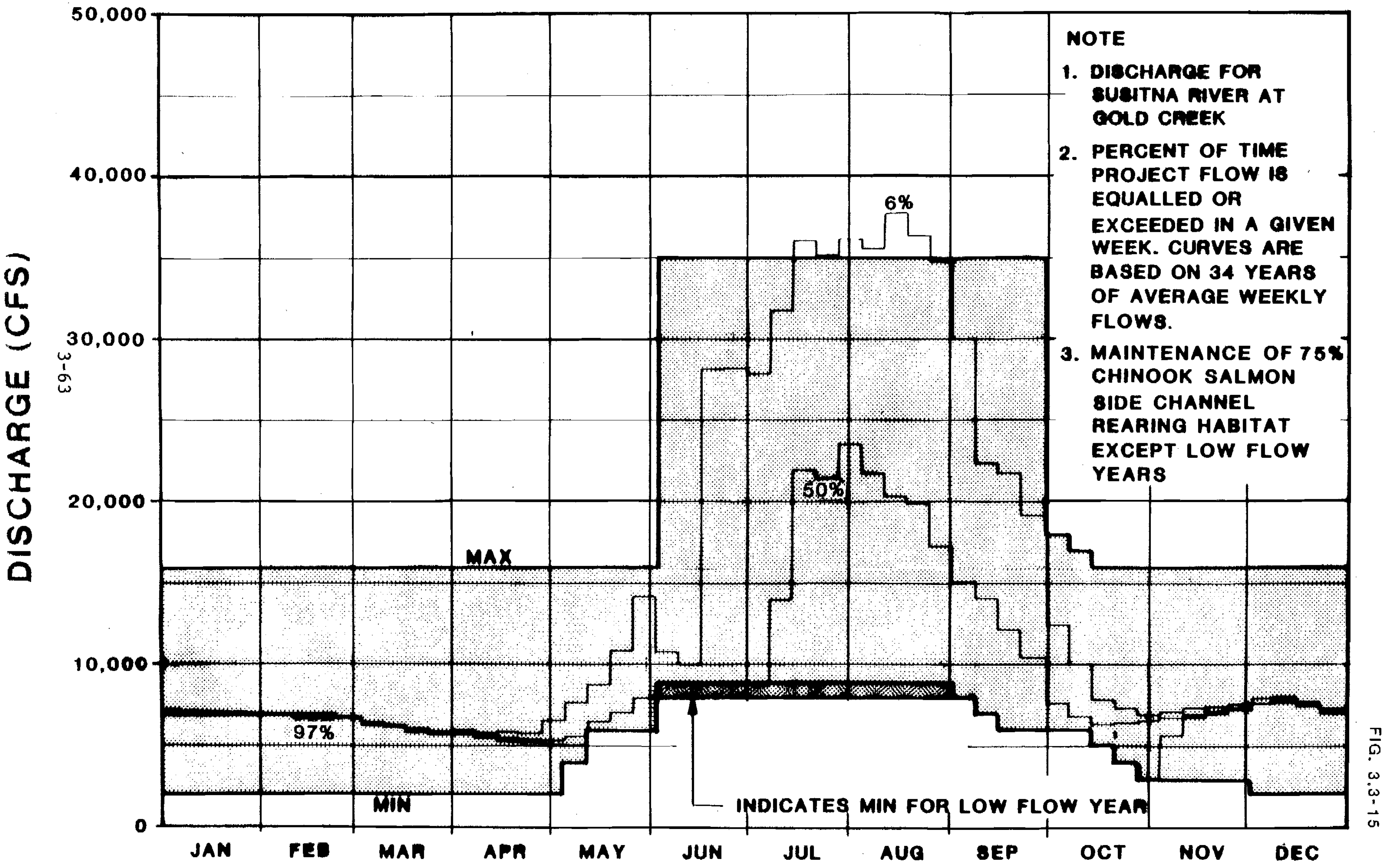
HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-14

ENVIRONMENTAL FLOW REQUIREMENTS CASE E VI

WATANA/DEVIL CANYON OPERATION-2002 DEMAND 5238GWH



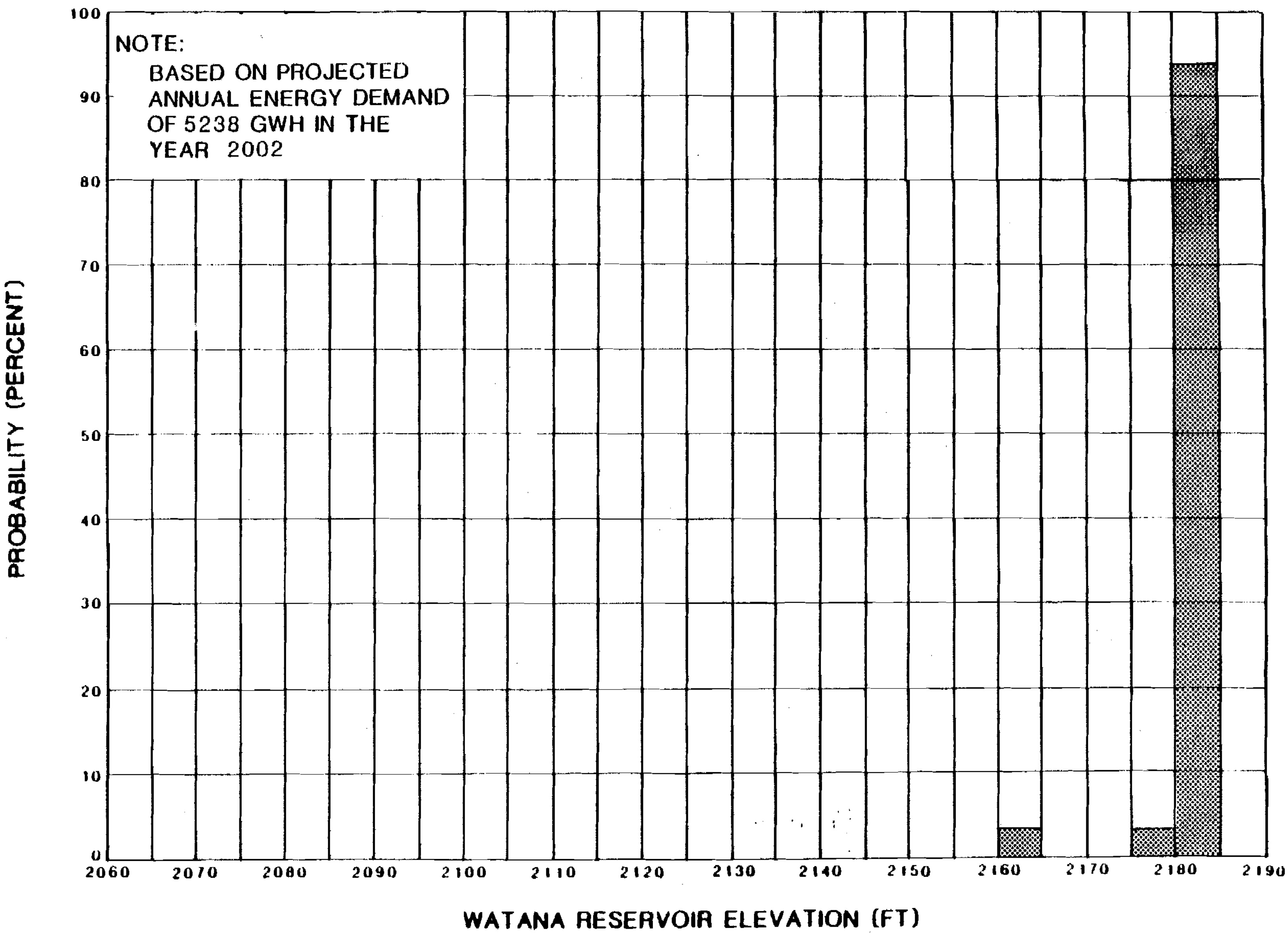
3-63

FIG. 3.3-15

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON OCTOBER 1
WATANA AND DEVIL CANYON OPERATION



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-16

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON JANUARY 1 WATANA AND DEVIL CANYON OPERATION

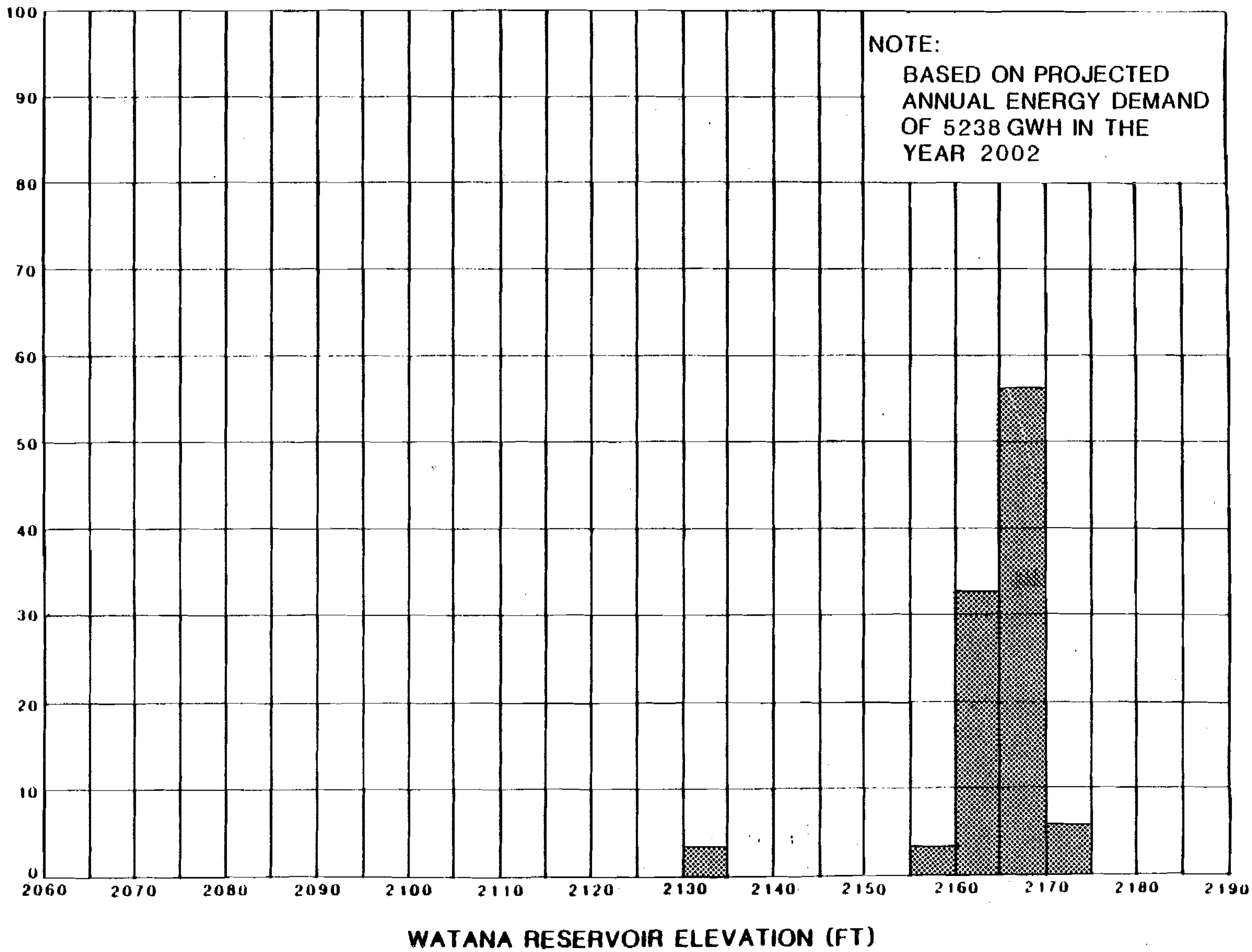
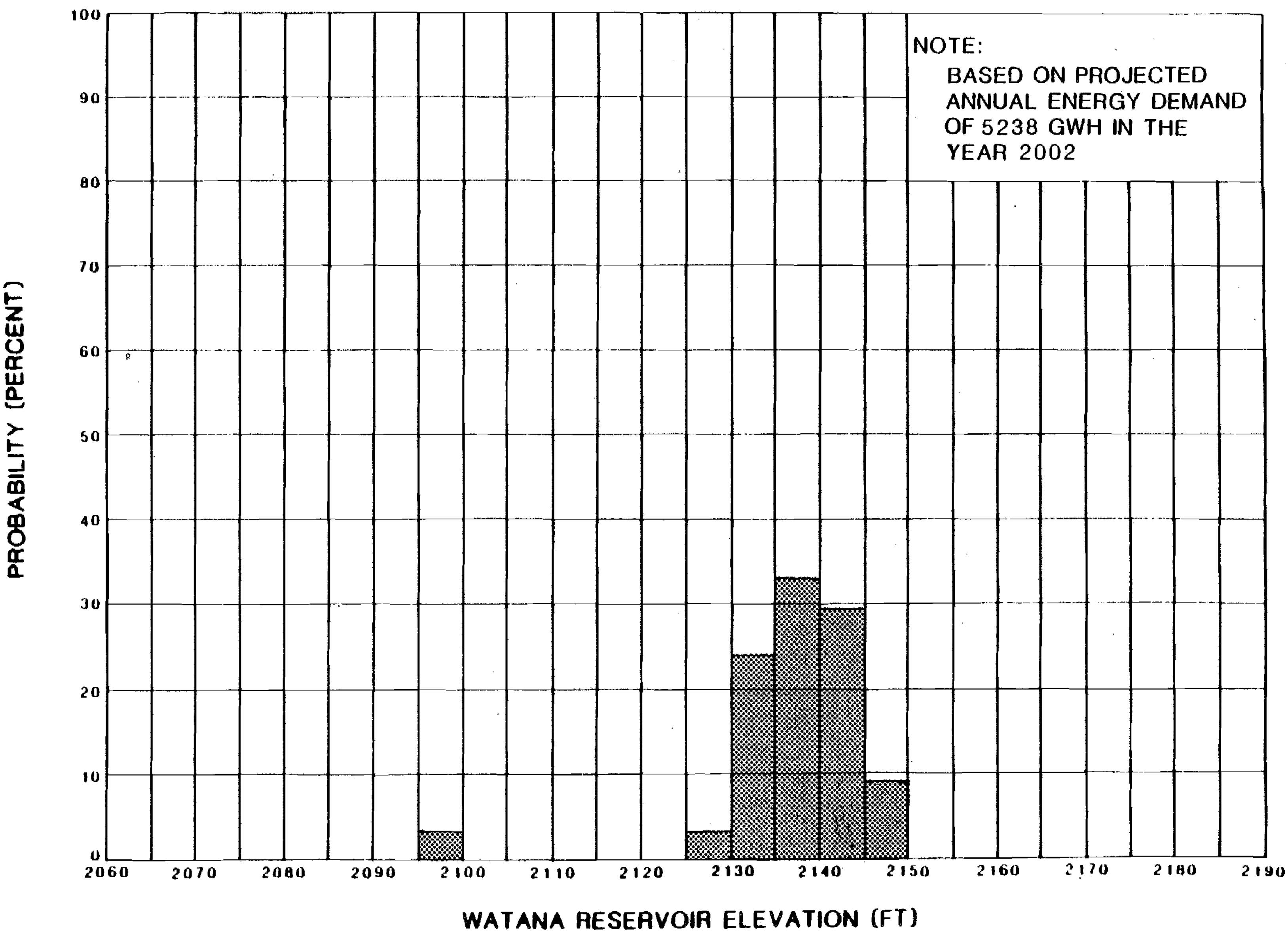


FIG. 3.3-17

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON APRIL 1 WATANA AND DEVIL CANYON OPERATION

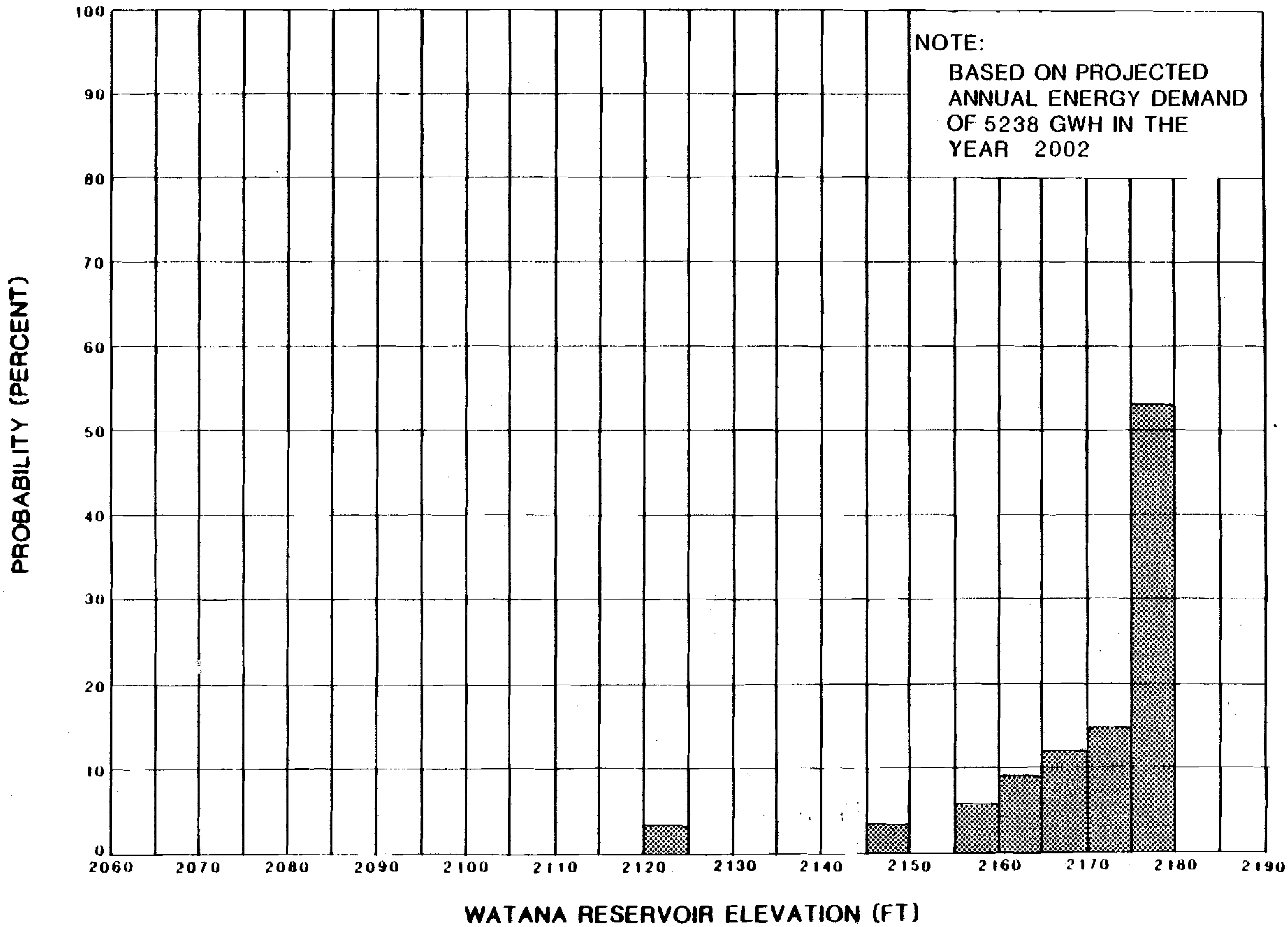


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-18

WATANA RESERVOIR SURFACE ELEVATION
PROBABILITY OF OCCURRENCE
ON JULY 1
WATANA AND DEVIL CANYON OPERATION

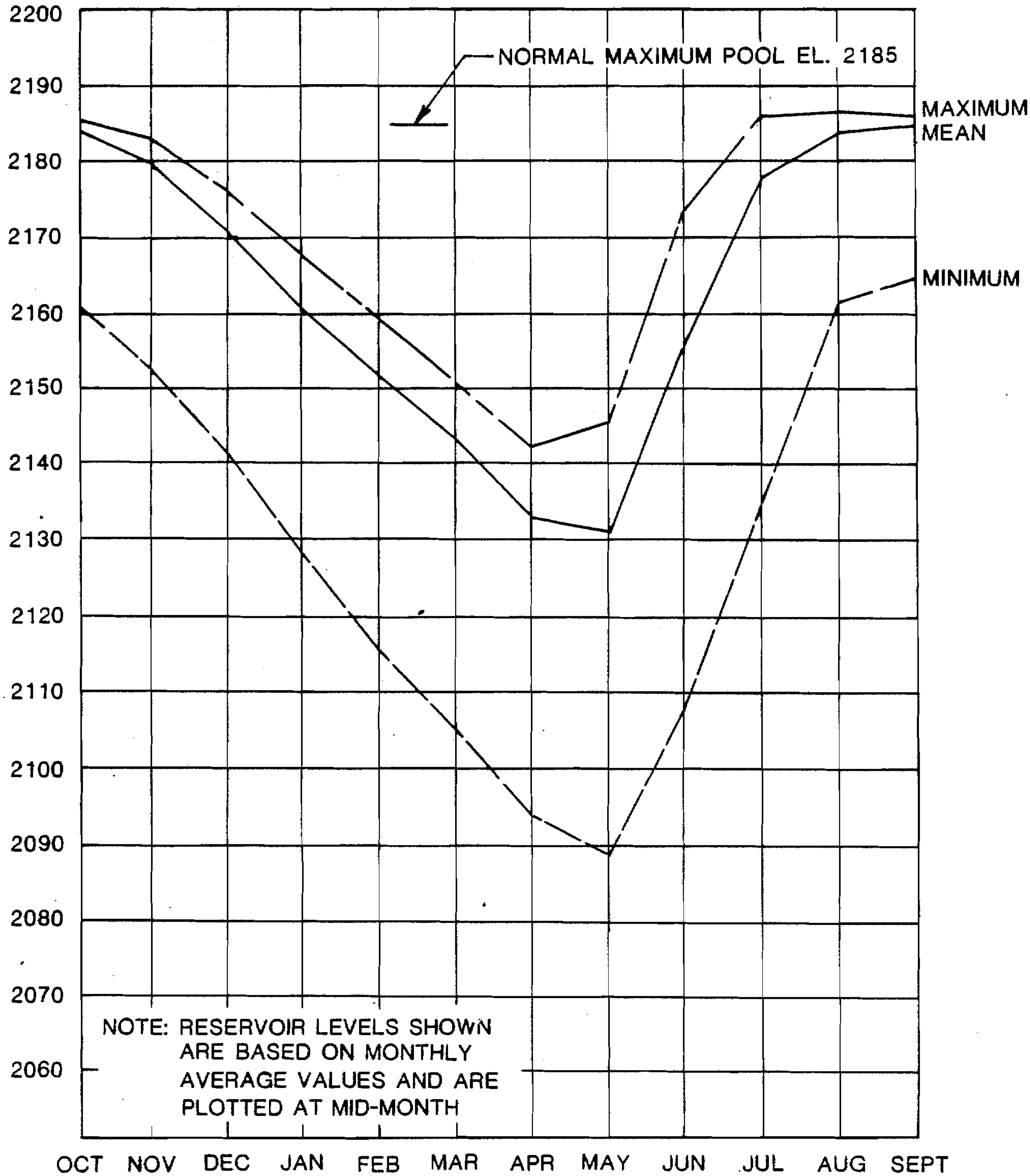


HARZA-EBASCO SUSITNA JOINT VENTURE

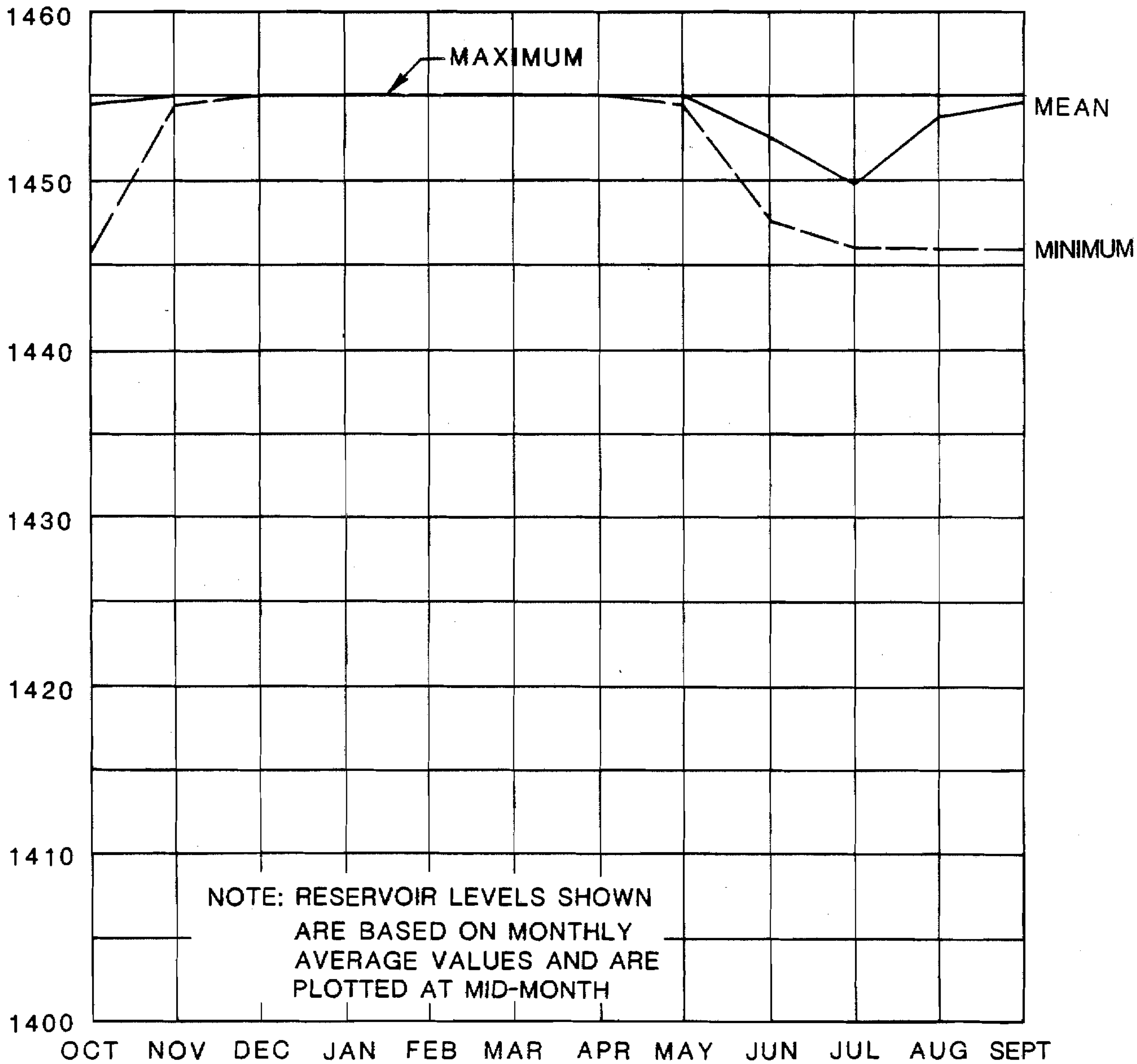
ALASKA POWER AUTHORITY

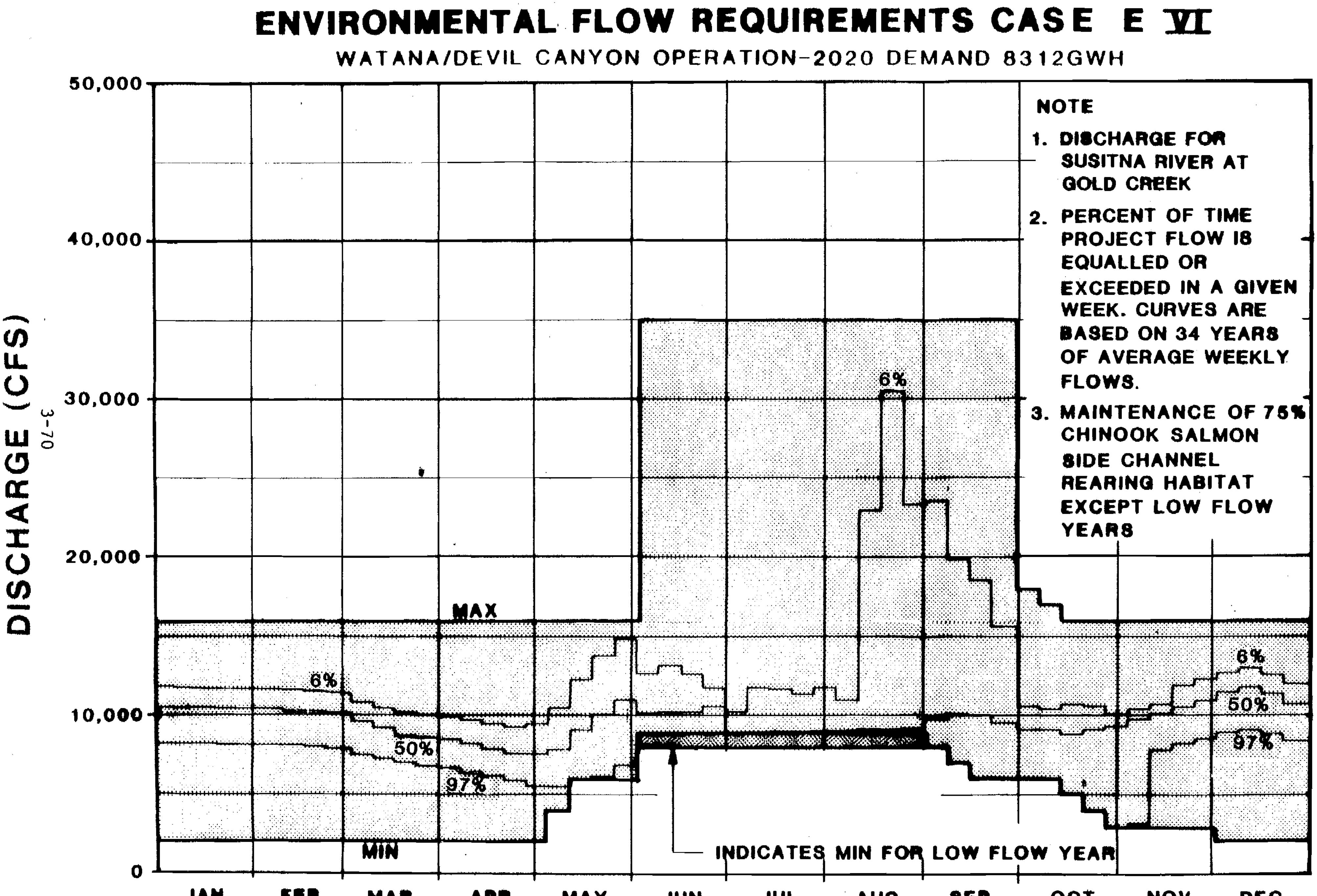
FIG. 3.3-19

WATANA RESERVOIR WATER LEVELS
WATANA AND DEVIL CANYON OPERATING
2002 SIMULATION CASE E-VI



DEVIL CANYON WATER LEVELS
2002 SIMULATION CASE E-VI



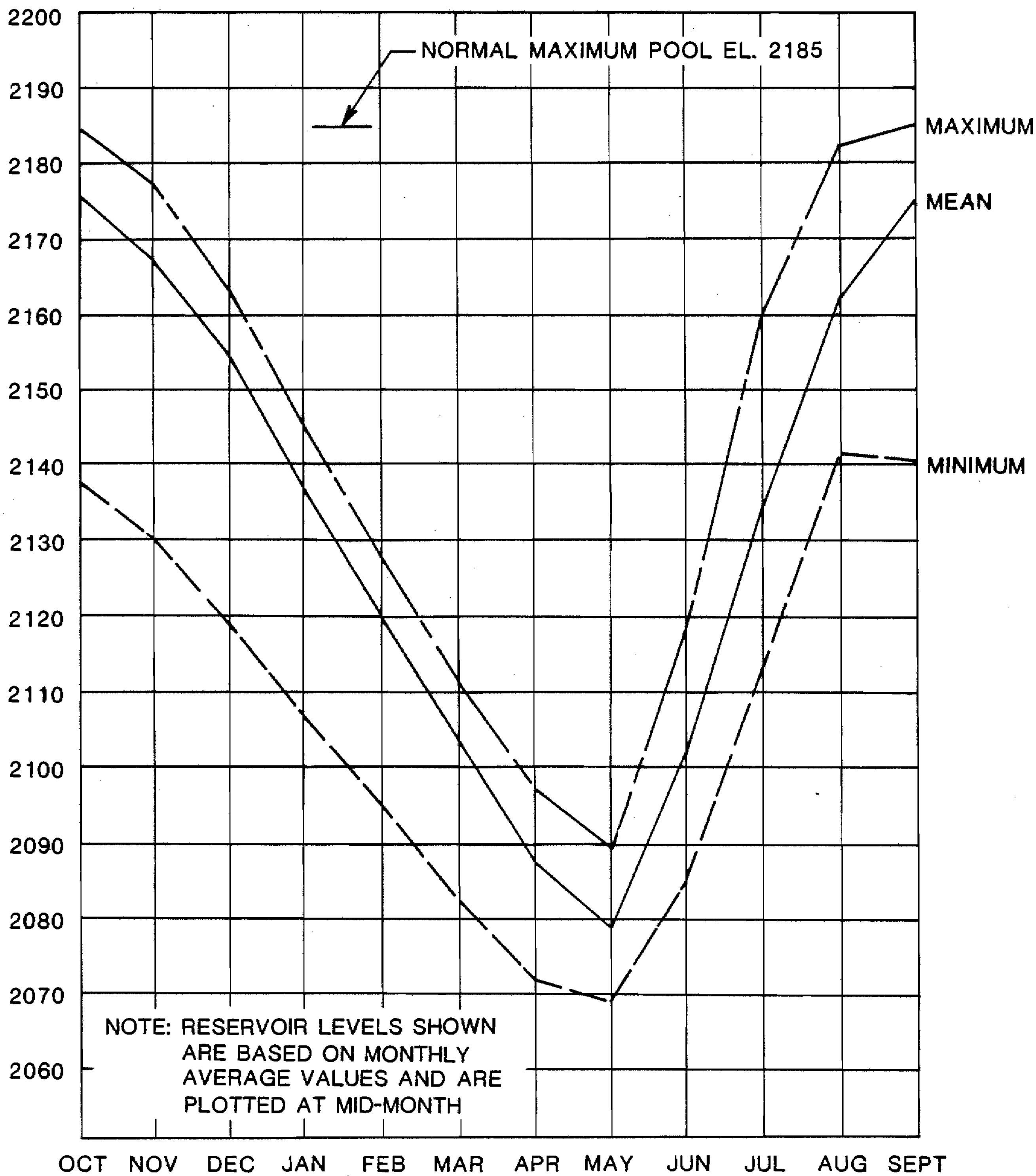


HARZA-EBASCO SUSITNA JOINT VENTURE

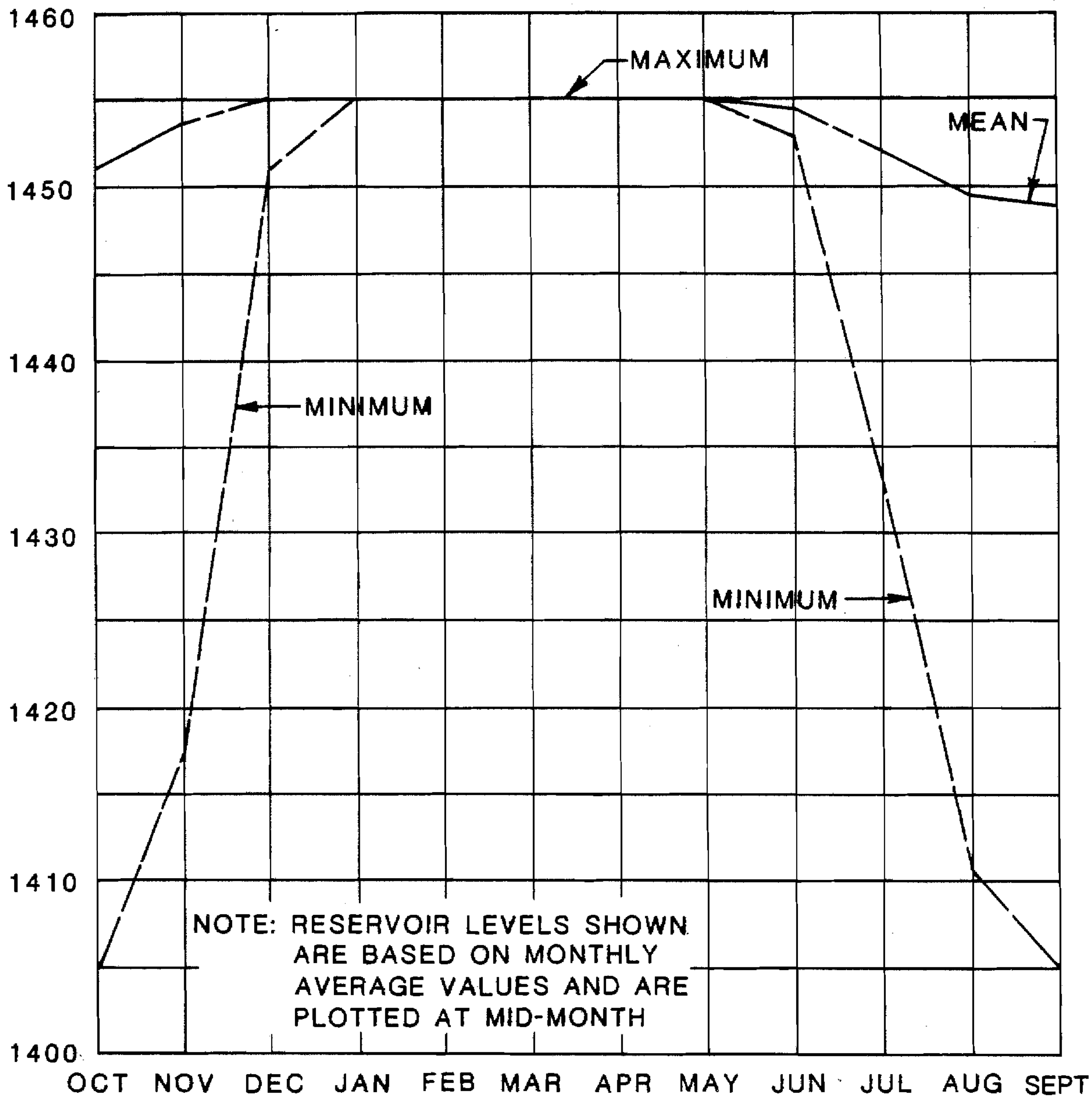
ALASKA POWER AUTHORITY

FIG. 3.3-22

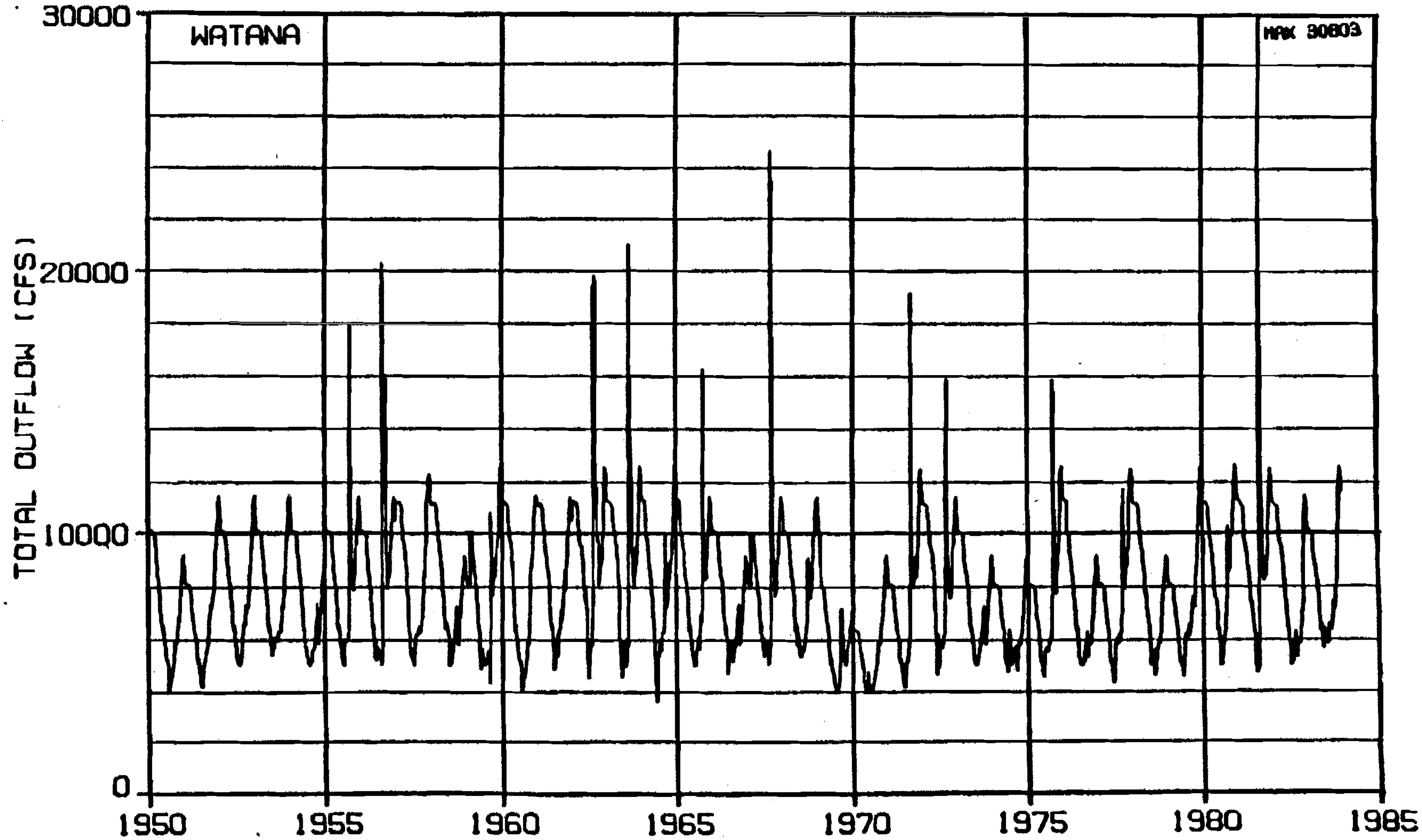
WATANA RESERVOIR WATER LEVELS
WATANA AND DEVIL CANYON OPERATING
2020 SIMULATION CASE E-VI



DEVIL CANYON WATER LEVELS
2020 SIMULATION CASE E-VI



WATANA & DEVIL CANYON
DOUBLE RESERVOIR OPERATION
E-VI, LOAD YR. 2020



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-25

WATANA & DEVIL CANYON
DOUBLE RESERVOIR OPERATION
E-VI. LOAD YR. 2020

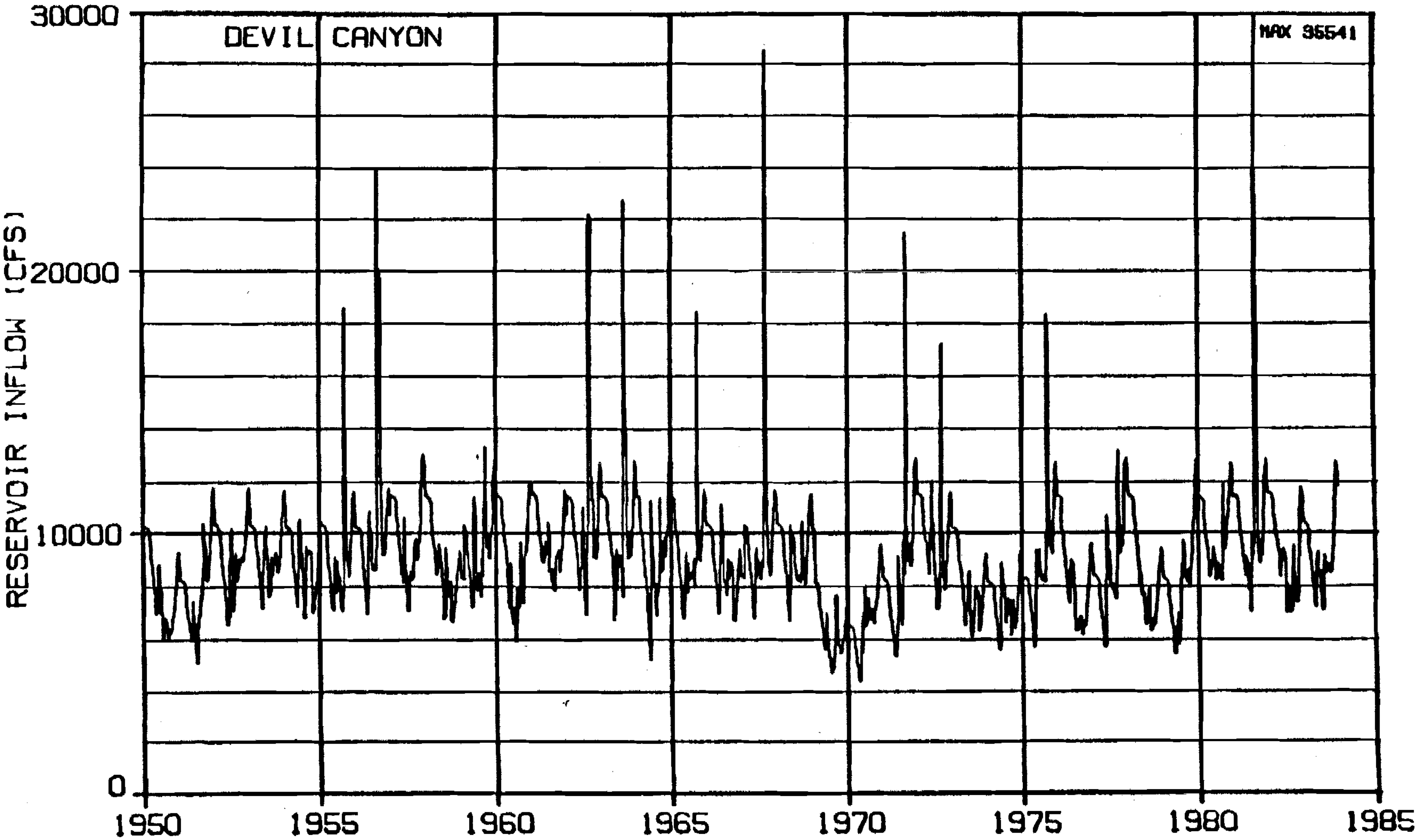
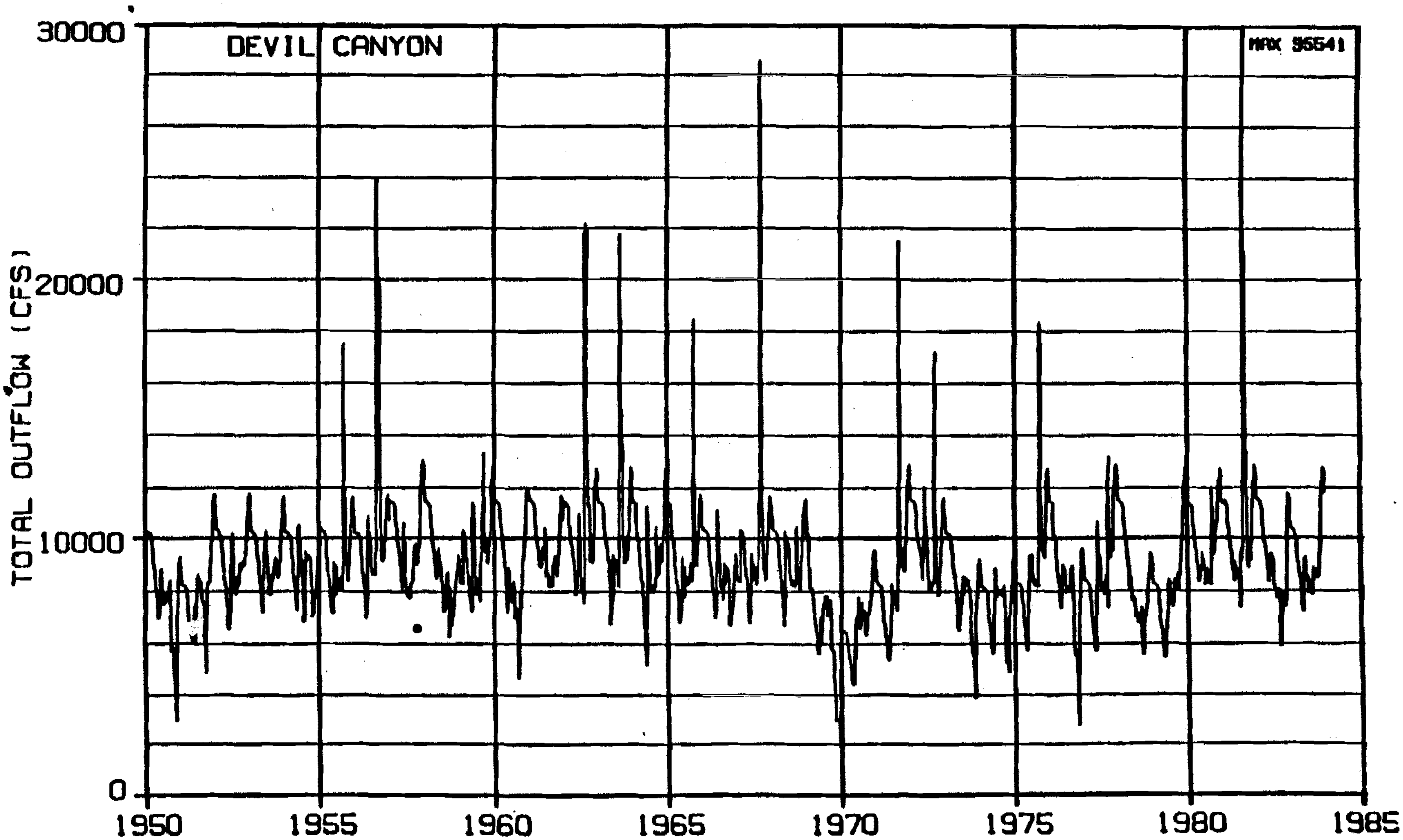


FIG. 3.3-26

WATANA & DEVIL CANYON
DOUBLE RESERVOIR OPERATION
E-VI. LOAD YR. 2020



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-27

WATANA & DEVIL CANYON
DOUBLE RESERVOIR OPERATION
E-VI. LOAD YR. 2020

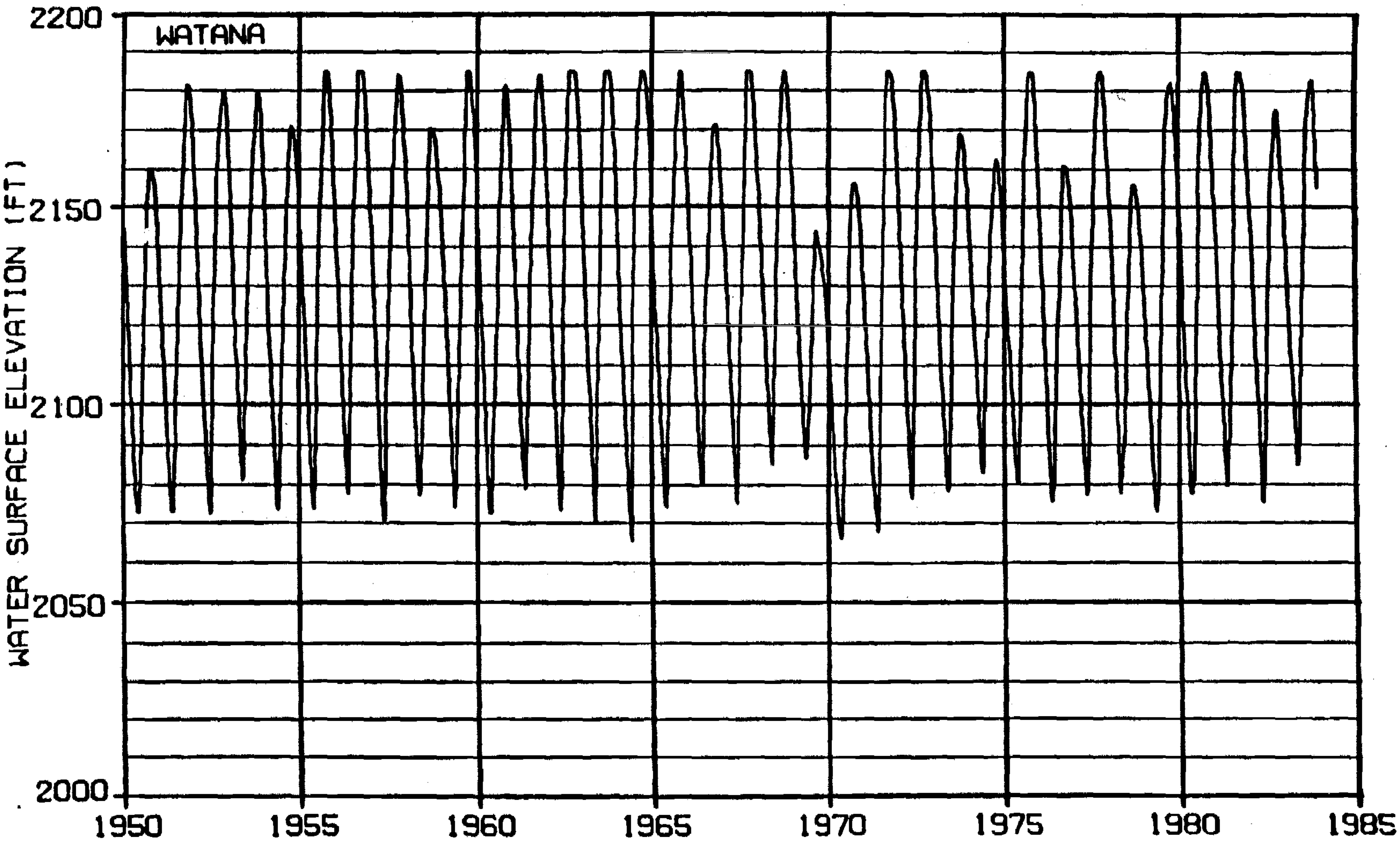
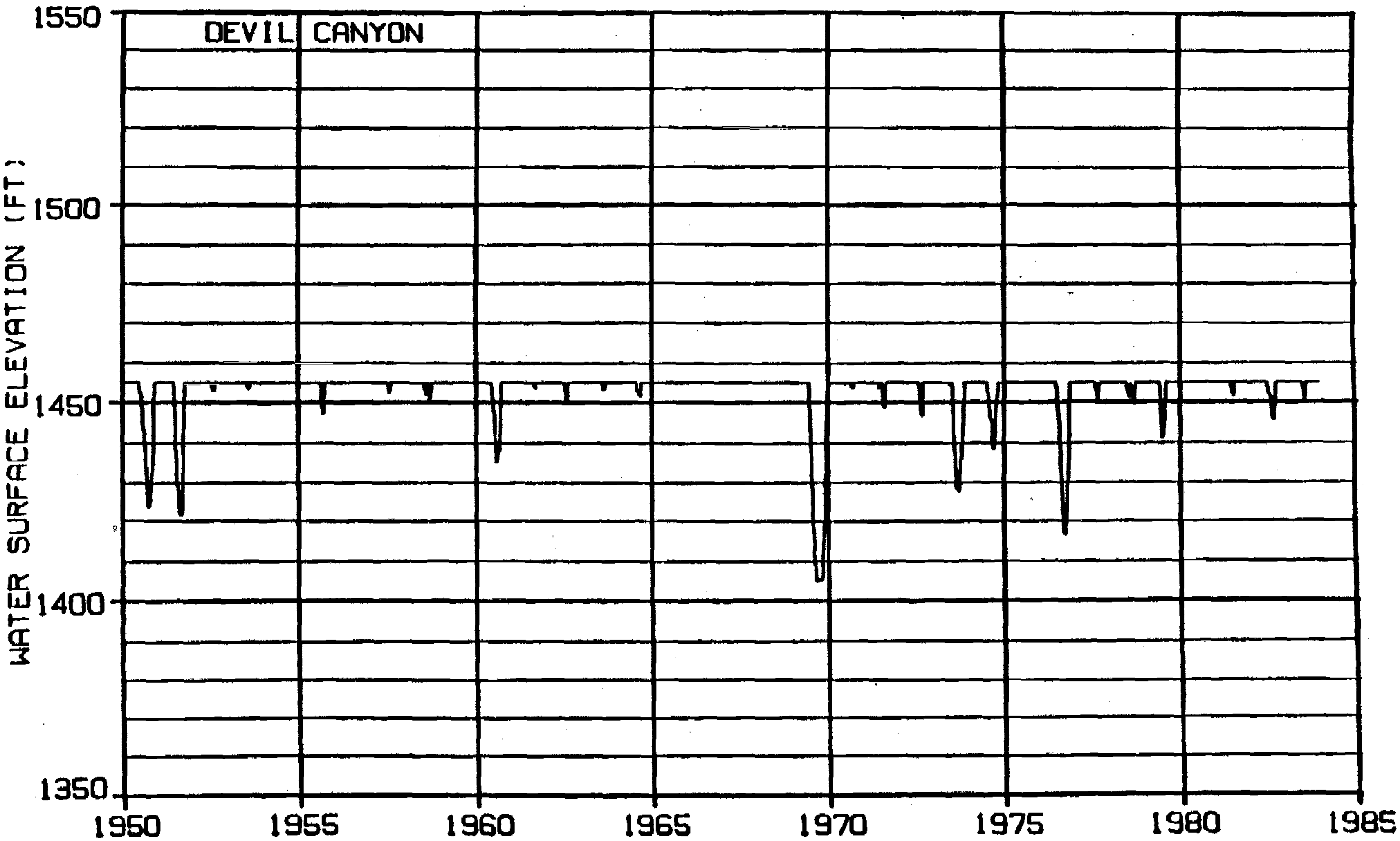


FIG. 3.3-28

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

WATANA & DEVIL CANYON
DOUBLE RESERVOIR OPERATION
E-VI, LOAD YR. 2020

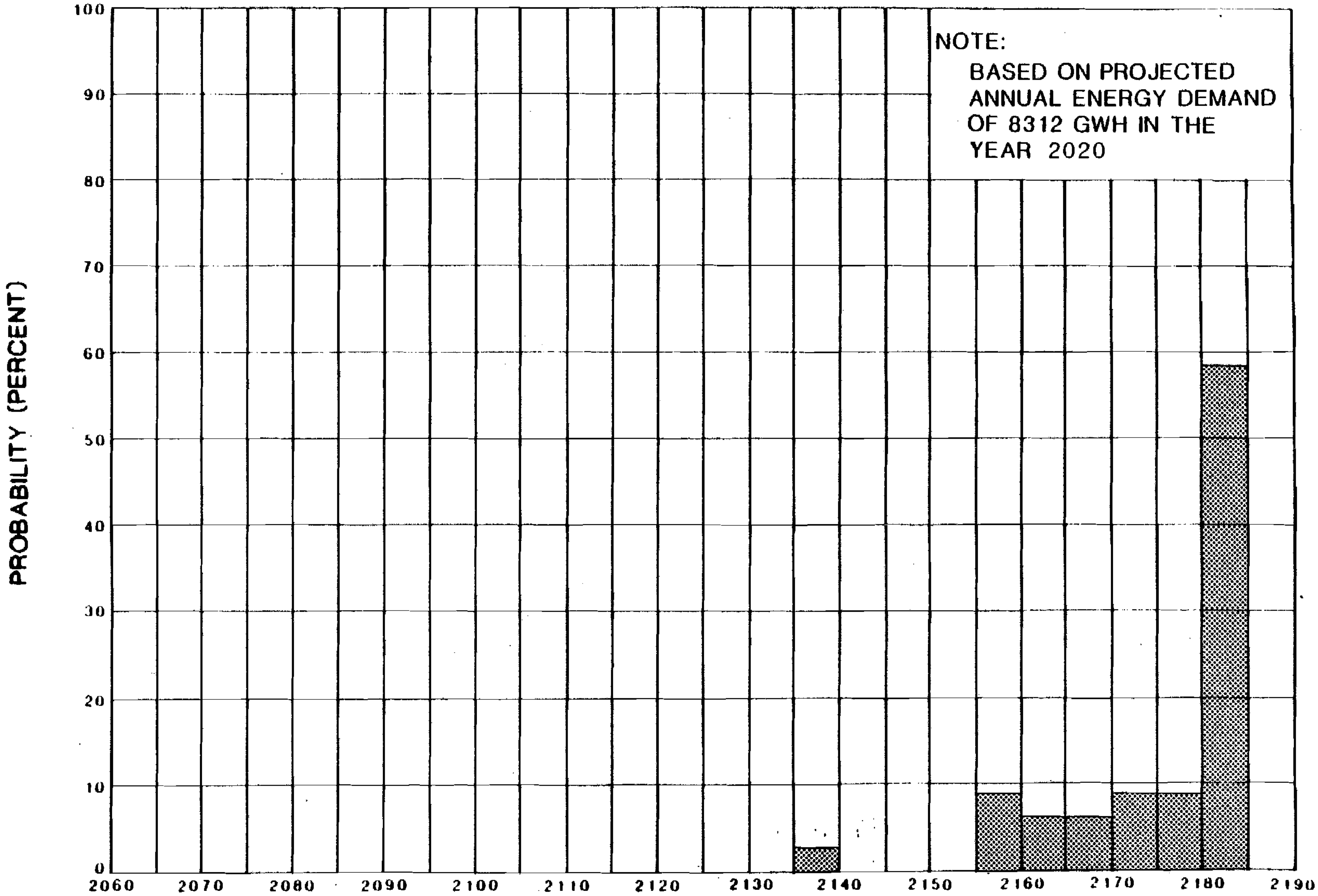


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-29

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON OCTOBER 1 WATANA AND DEVIL CANYON OPERATION



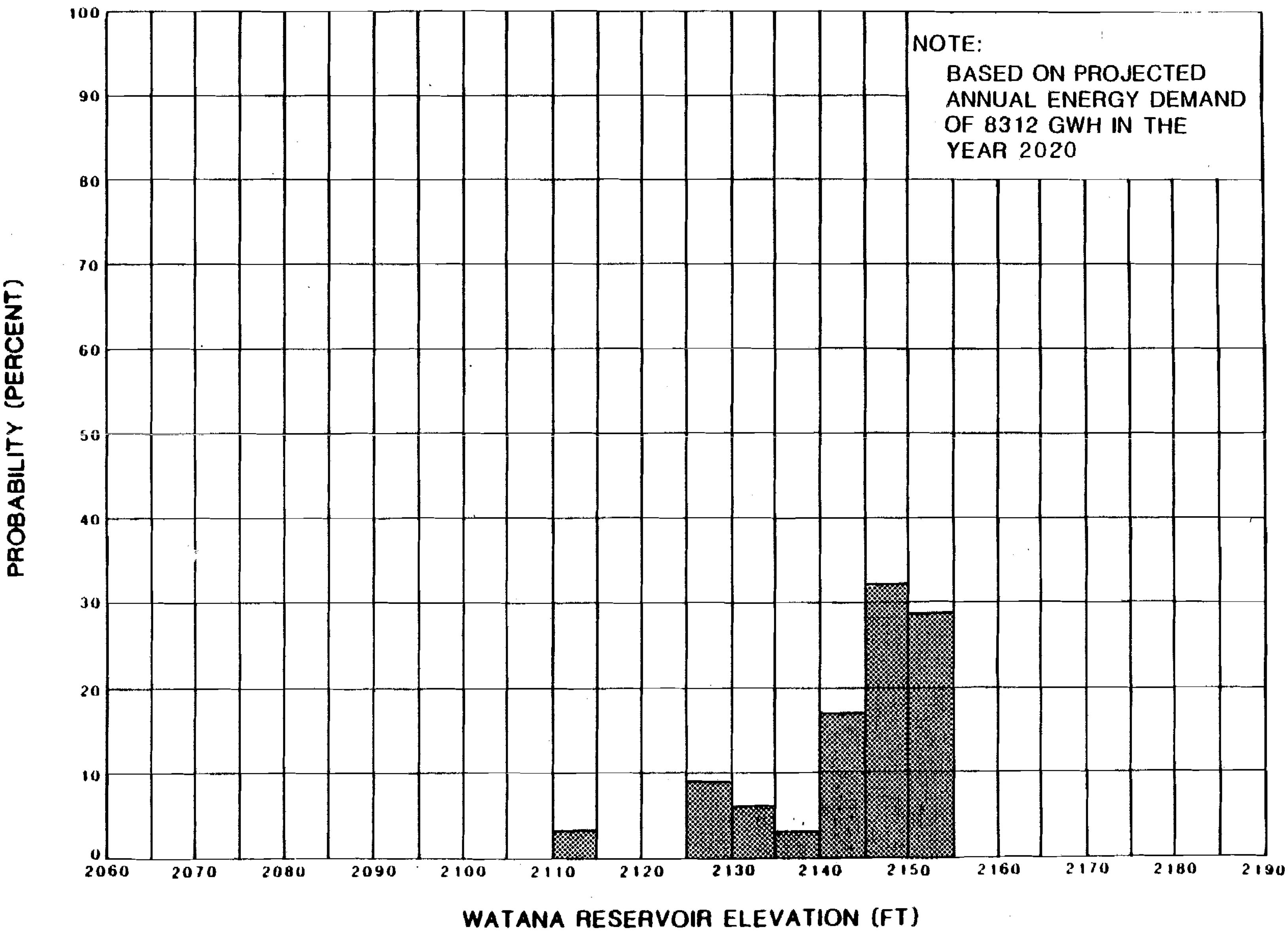
NOTE:
BASED ON PROJECTED ANNUAL ENERGY DEMAND OF 8312 GWH IN THE YEAR 2020

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-30

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON JANUARY 1 WATANA AND DEVIL CANYON OPERATION

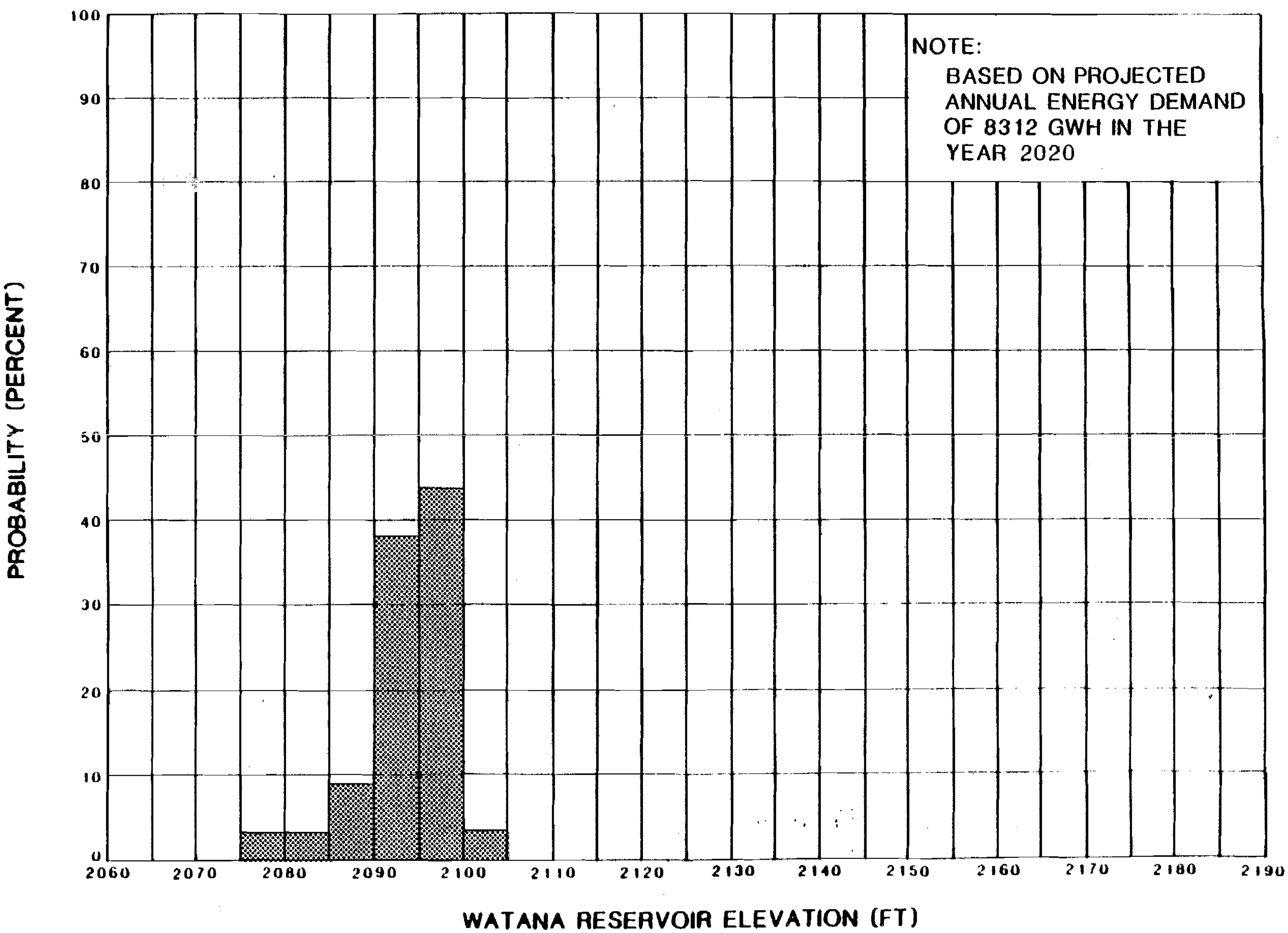


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-31

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON APRIL 1 WATANA AND DEVIL CANYON OPERATION

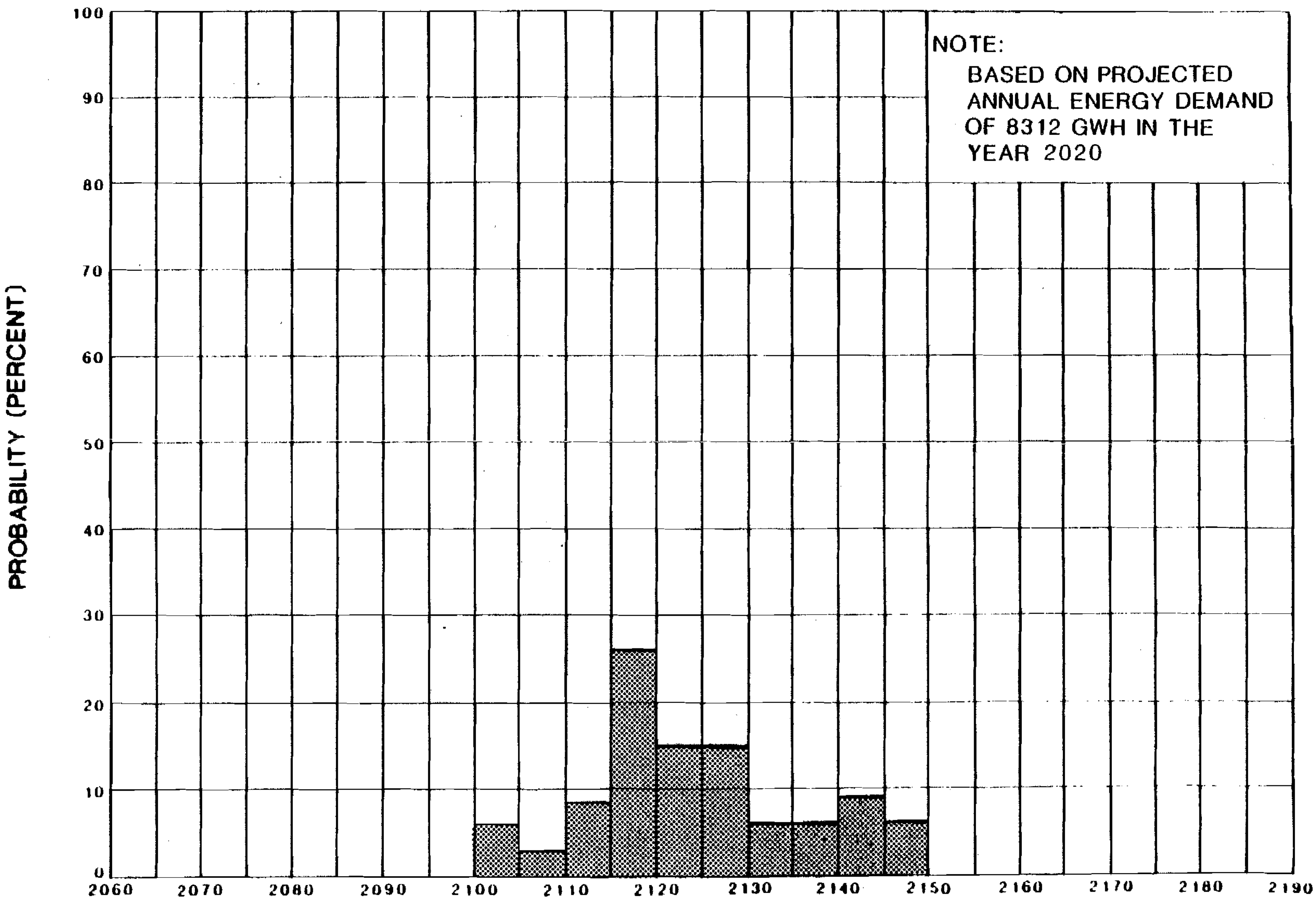


HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-32

WATANA RESERVOIR SURFACE ELEVATION PROBABILITY OF OCCURRENCE ON JULY 1 WATANA AND DEVIL CANYON OPERATION



HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

FIG. 3.3-33

4.0 FLOW REQUIREMENTS DURING DAM CONSTRUCTION AND RESERVOIR IMPOUNDMENT

4.1 WATANA DAM

During construction of the Watana Dam, prior to impoundment of the reservoir, the river flows will be unaffected and impacts will be as described in the License Application (p. E-2-65 to E-2-77).

When impoundment of the Watana Reservoir begins, the flow requirements will be the same as Case E-VI for the period of May through October (water weeks 31 through 5). From November through April, the policy will be to release the inflow and hold the reservoir level constant. The rationale for this is explained in the License Application (p. E-2-78). In dry years, defined in the same manner as for project operation, the minimum flow requirements at Gold Creek would be reduced by 1,000 cfs from the flow requirements in other years. This reduction would apply from May through October only.

An additional constraint during filling is the requirement to provide freeboard in the reservoir to contain the 250-year flood (License Application p. E-2-79). This prevents the imposition of maximum flow requirements at Gold Creek during filling. Such requirements would limit the ability to discharge floods and cause water levels to infringe on freeboard requirements. The filling flow requirements are given on Table 4.1-1.

The filling of Watana Reservoir has been simulated in a manner similar to that given in the License Application (p. E-2-79). Wet, dry and average three-year streamflow sequences given in the License Application (p. E-2-80 and Table E.2.37) were routed through the reservoir. The same construction sequence, including dam elevations, was used. The sequences of pre-filling streamflows at the Watana Dam Site and at Gold Creek are shown on Table 4.2-2. The sequences of flows at Watana and Gold Creek during filling are shown on Tables 4.1-3 and 4.1-4 respectively. Figure 4.1-1 shows the progression of the dam crest elevation during construction, the impounded water surface elevation, and the sequences of flows at Gold Creek.

The simulation of filling, using the 90% exceedance flow sequence, was used to develop target reservoir elevations which could be used to determine whether flow requirements at Gold Creek should be reduced by 1,000 cfs for the next month. These target elevations represent the water levels attained at the ends of the months with the dry flow sequence. The Watana reservoir volume and surface area plot in the License Application (Fig. E.2.128) was used in the routing. Target elevations are shown on Table 4.1-1.

The computations indicate that the Watana Reservoir could be filled to its normal maximum water level (El. 2185) for wet and average sequences in about the same time using either Case C or Case E-VI. By August of the third summer of filling, the reservoir would be full. In a dry sequence, however, the reservoir water level would reach El. 2175 at the end of the third summer of filling. This is 10 feet above a dry sequence filling with Case C.

Table 4.1-1
SUSITNA HYDROELECTRIC PROJECT
E-VI FLOW REQUIREMENTS
DURING FILLING OF WATANA RESERVOIR

Water Week	Date	Watana Target Res. Elev.[1]		Minimum Flow Requirements at Gold Creek[2]	
		Second Summer	Third Summer	If WSEL[3] Meets or Exceeds Target	If WSEL Is Below Target
1	Oct 1-Oct 7			6,000	5,000
2	Oct 8-Oct 14			6,000	5,000
3	Oct 15-Oct 21			5,000	4,000
4	Oct 22-Oct 28			4,000	3,000
5	Oct 29-Nov 4	2,055		3,000	2,000
6	Nov 5			Natural	Natural
through					
30	Apr 28			Natural	Natural
31	Apr 29-May 5		2,055	2,000	2,000
32	May 6-May 12			4,000	3,000
33	May 13-May 19			6,000	5,000
34	May 20-May 26			6,000	5,000
35	May 27-June 2	1,908	2,074	6,000	5,000
36	June 3-June 9			9,000	8,000
37	June 10-June 16			9,000	8,000
38	June 17-June 23			9,000	8,000
39	June 24-June 30	1,965	2,110	9,000	8,000
40	July 1-July 7			9,000	8,000
41	July 8-July 14			9,000	8,000
42	July 15-July 21			9,000	8,000
43	July 22-July 28			9,000	8,000
44	July 29-Aug 4	2,006	2,140	9,000	8,000
45	Aug 5-Aug 11			9,000	8,000
46	Aug 12-Aug 18			9,000	8,000
47	Aug 19-Aug 25			9,000	8,000
48	Aug 26-Sept 1	2,037	2,162	9,000	8,000
49	Sept 2-Sept 8			8,000	7,000
50	Sept 9-Sept 15			7,000	6,000
51	Sept 16-Sept 22			6,000	5,000
52	Sept 23-Sept 30	2,052	2,173	6,000	5,000

1/ Surface elevations measured on last day of month ending in given water week

2/ There are no maximum flow constraints during filling

3/ WSEL = water surface elevation

Table 4.1-2
SUSITNA HYDROELECTRIC PROJECT
PRE-PROJECT
STREAMFLOW SEQUENCES USED
IN FILLING SIMULATION[1/]

Month	Dry 90% Exceedence		Average 50% Exceedence		Wet 10% Exceedence	
	Watana	Gold Creek	Watana	Gold Creek	Watana	Gold Creek
October	4,213	5,073	4,713	5,732	5,272	6,453
November	1,879	2,263	2,102	2,557	2,352	2,879
December	1,312	1,580	1,468	1,785	1,642	2,010
January	1,071	1,290	1,198	1,457	1,340	1,640
February	910	1,096	1,018	1,238	1,138	1,393
March	822	990	919	1,118	1,028	1,258
April	1,008	1,214	1,127	1,371	1,261	1,544
May	9,715	11,699	10,870	13,221	12,158	14,882
June	20,238	24,371	22,644	27,541	25,326	31,001
July	17,842	21,486	19,963	24,280	22,327	27,330
August	16,095	19,382	18,008	21,903	20,142	24,655
September	9,641	11,610	10,787	13,120	12,064	14,767

1/ See Table E.2.37 of License Application

Table 4.1-3
SUSITNA HYDROELECTRIC PROJECT
SUSITNA RIVER DISCHARGES (cfs)
MEASURED AT WATANA
DURING WATANA FILLING
CASE E-VI FLOW REQUIREMENTS

Water Year	Wet Sequence 10% Exceedence	Avg Sequence 50% Exceedence	Dry Sequence 90% Exceedence
1991 Apr	1,261	1,127	1,008
May	8,690	7,402	6,247
June	20,005	17,323	14,917
July	5,309	4,683	5,356
Aug	14,993	11,121	6,414
Sept	6,743	5,466	4,831
1992 Oct	5,272	4,713	4,172
Nov	2,352	2,102	1,879
Dec	1,642	1,468	1,312
Jan	1,340	1,198	1,071
Feb	1,138	1,018	910
Mar	1,028	919	812
Apr	1,261	1,127	1,008
May	2,179	2,552	2,919
June	3,125	3,903	3,667
July	7,797	4,683	14,356
Aug	8,649	5,105	4,713
Sept	4,097	4,467	3,831
1993 Oct	3,851	4,013	3,172
Nov	2,352	2,102	1,879
Dec	1,642	1,468	1,312
Jan	1,340	1,198	1,071
Feb	1,138	1,018	910
Mar	1,028	919	822
Apr	1,261	1,127	1,008
May	2,179	2,552	1,919
June	8,958	3,903	3,667
July	3,997	4,683	4,356
Aug	12,862	5,105	4,713
Sept		8,766	3,831
Oct			3,172

Table 4.1-4

SUSITNA HYDROELECTRIC PROJECT
SUSITNA RIVER DISCHARGES (cfs)
MEASURED AT GOLD CREEK
DURING WATANA FILLING
CASE E-VI FLOW REQUIREMENTS

Year	Month	Wet Sequence 10% Exceedance	Avg. Sequence 50% Exceedance	Dry Sequence 90% Exceedance
1991	April	1,544	1,371	1,214
	May	11,414	9,753	8,231
	June	25,680	22,220	19,050
	July	10,312	9,000	9,000
	August	19,506	15,016	9,701
	Sept	9,446	7,799	6,800
1992	Oct	6,453	5,732	5,032
	Nov	2,879	2,557	2,263
	Dec	2,010	1,785	1,580
	Jan	1,640	1,457	1,290
	Feb	1,393	1,238	1,096
	Mar	1,258	1,118	990
	Apr	1,544	1,371	1,214
	May	4,903	4,903	4,903
	June	8,800	8,800	7,800
	July	12,800	9,000	8,000
	Aug	13,162	9,000	8,000
	Sept	6,800	6,800	5,800
1993	Oct	5,032	5,032	4,032
	Nov	2,879	2,557	2,263
	Dec	2,010	1,785	1,580
	Jan	1,640	1,457	1,290
	Feb	1,393	1,238	1,096
	Mar	1,258	1,118	990
	Apr	1,544	1,371	1,214
	May	4,903	4,903	3,903
	June	14,633	8,800	7,800
	July	9,000	9,000	8,000
	Aug	17,375	9,000	8,000
	Sept		11,099	5,800

4.2 DEVIL CANYON DAM

During the construction of Devil Canyon Dam, before the impounding of any water in the reservoir, the Case E-VI flow requirements at Gold Creek will be maintained. No significant change in water quality parameters is expected as a result of using Case E-VI rather than Case C during Devil Canyon construction.

Devil Canyon Reservoir would be filled in the same two-phase manner as described in the License Application (pp. E-2-148 to E-2-150). During the first phase of filling, the water level will be raised from near El. 850 to El. 1135. This will require impounding approximately 76,000 acre feet of water. The Case E-VI operational flow requirements will be maintained during this period. The second phase of filling will require impounding about 1,000,000 acre feet of water and will raise the water level to its normal operating level, El. 1455. Case E-VI operational flow requirements will be maintained during this period.

Case E-VI flow requirements are generally lower than Case C for the period August through May and higher for June and July. Therefore, the time required to fill Devil Canyon for each phase would depend on the time of year, but would not be significantly different than stated in the License Application. The discussion of water quality impacts, presented in the License Application, remains valid.

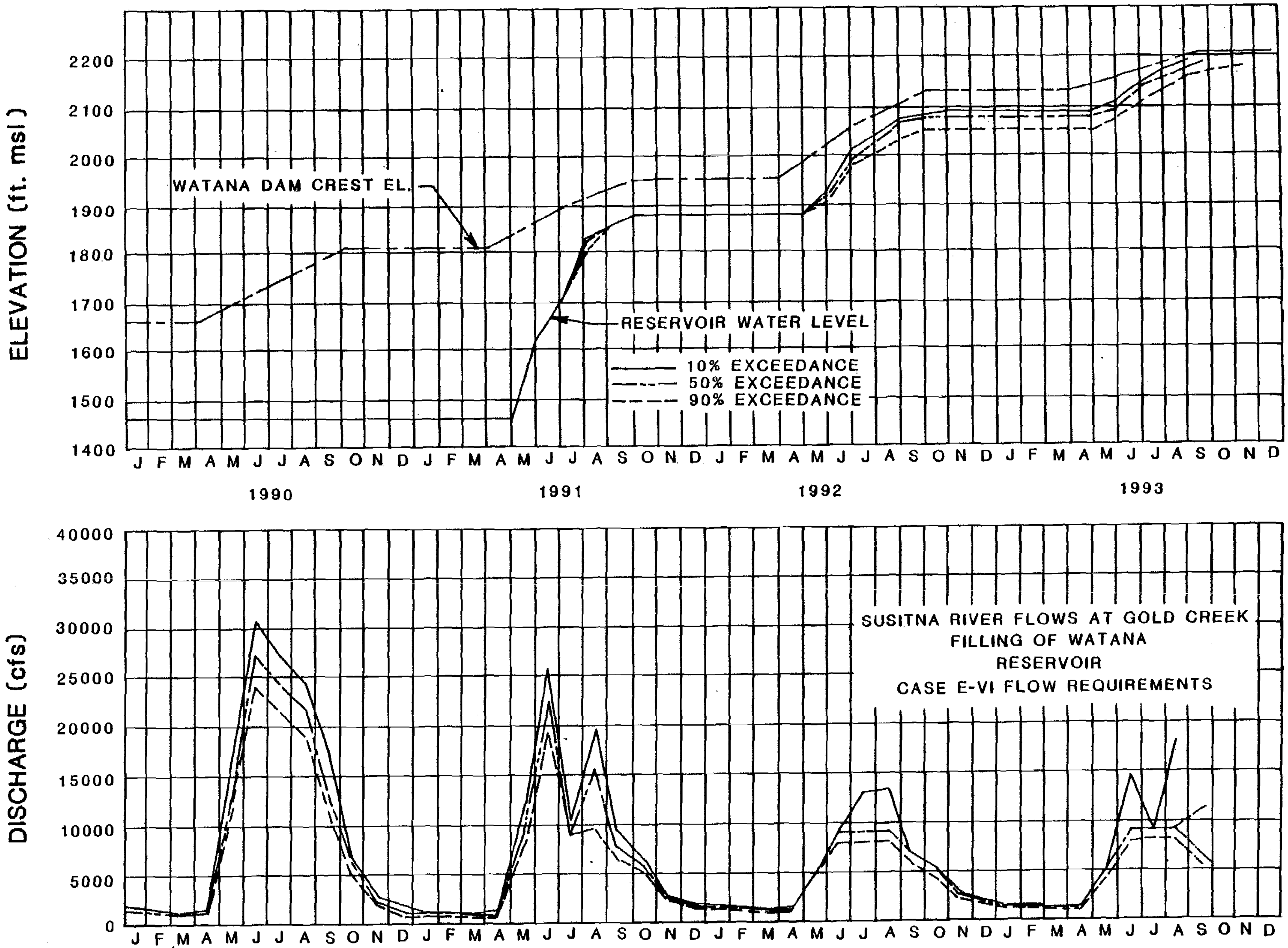


FIGURE 4.1-1

HARZA-EBASCO SUSITNA JOINT VENTURE

ALASKA POWER AUTHORITY

REFERENCES

5.0 REFERENCES

REFERENCES

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