SUSITNA HYDROELECTRIC PROJECT
AQUATIC MITIGATION REPORT SERIES

MIDDLE RIVER FISH MITIGATION PLAN

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Preface

This report represents one volume of a three volume report series on aquatic mitigation planning for the proposed Susitna Hydroelectric Project. These volumes are:

1. Access, Construction and Transmission Aquatic Mitigation Plan

2. Impoundment Area Fish Mitigation Plan

3. Middle River Fish Mitigation Plan

A primary goal of the Alaska Power Authority's mitigation policy is to maintain the productivity of natural reproducing populations, where possible. The planning process follows procedures set forth in the Alaska Power Authority Mitigation Policy for the Susitna Hydroelectric Project (APA 1982), which is based on the U.S. Fish and Wildlife Service and Alaska Department of Fish and Game mitigation policies. Mitigation planning is a continuing process, which evolves with advances in the design of the project, increased understanding of fish populations and habitats in the basin and analysis of potential impacts. An important element of this evolution is frequent consultation with the public and regulatory agencies to evaluate the adequacy of the planning process. Aquatic mitigation planning began during preparation of the Susitna Hydroelectric Project Feasibility Report (1981) and was further developed in the FERC License Application (1983). A detailed presentation of potential mitigation measures to mitigate impacts to chum salmon that spawn in the side sloughs was prepared in November 1984. It is expected that the three reports in the present report series will also continue to evolve as the understanding of project effects is refined.

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1.0 INTRODUCTION

1.1 - Background

The Alaska Power Authority submitted a License Application to the Federal Energy Regulatory Commission for the proposed Susitna Hydroelectric Project in February 1983. The License Application proposed a two-stage project. The first stage would consist of a dam at the Watana site built to an elevation of 2205 feet and the second a dam at the Devil Canyon site built to an elevation of 1465.

In support of the FERC review process a Fish Mitigation Plan (WCC 1984) based on data available at the time was developed for anticipated impacts resulting from the construction and operation of the two stages. In May 1985 the Alaska Power Authority's Board of Directors voted to revise the project that was presented in the License Application. Construction of the project was proposed in three stages rather than the previously proposed two stages. Stage 1 would be a dam constructed at the Watana site to an elevation of 2025 resulting in a full pool elevation of 2000 ft. Stage 2 would be similar to the second stage at Devil Canyon in the License Application. Stage 3 would raise the full pool elevation of Stage 1 to 2185 ft, or the elevation of Watana as proposed in the License Application.

The proposed staging of the project would result in impacts that differ in magnitude as well as time of occurrence from those identified in the License Application. Accordingly, this necessitated development of a revised fish mitigation plan that includes measures that adequately address these changes in impacts.

1.2 - Approach to Mitigation

The Alaska Power Authority's (APA) goal for Susitna Hydroelectric Project fish mitigation is to maintain the productivity of natural reproducing populations (APA 1982). This is consistent with the mitigation goals of the U.S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G) (APA 1982, ADF&G 1982, USFWS 1981). The APA plans to either maintain existing habitat or provide replacement habitat of sufficient quantity and quality to support this productivity. Where it is not feasible to achieve this goal, APA will compensate for the impact with propagation facilities.

The development of the fish mitigation plan will follow a logical step-by-step process. Figure 1 illustrates this process and identifies the major components (APA 1983). The options proposed to mitigate for impacts of the Susitna Hydroelectric Project will be analyzed according to the hierarchical scheme shown in Figure 2.

Proposed mitigation options are grouped into two broad categories based on different approaches:

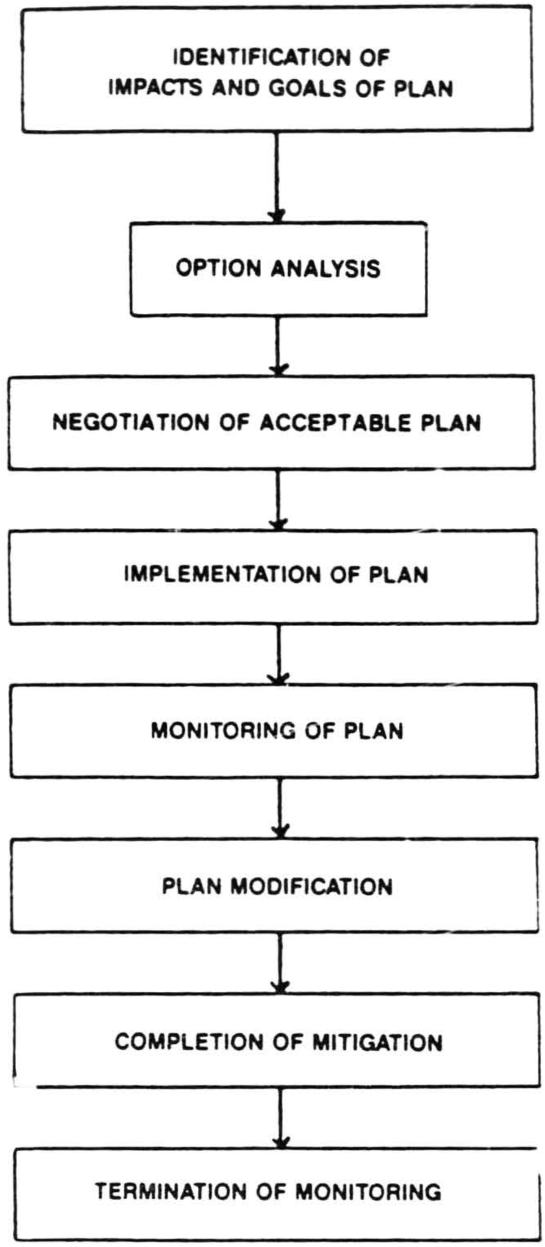
- Modifications to design, construction, or operation of the project

- Resource management strategies

The first approach is project specific and emphasizes measures that avoid or minimize adverse impacts according to the Fish and Wildlife Mitigation Policy established by the APA (1982) and coordinating agencies (ADF&G 1982, USFWS 1981). These measures involve adjusting or adding project features during design and planning so that mitigation becomes a built-in component of project actions.

If impacts cannot be mitigated by the first approach, rectification, reduction or compensation measures will be implemented. This type of mitigation will involve management of the resource rather than adjustments to the project, and will require concurrence of resource management boards or agencies with jurisdiction over resources within the project area.

Mitigation planning for the Susitna Hydroelectric Project has emphasized both approaches. The sequence of option analysis from avoidance through compensation has been applied to each impact issue. If full mitigation can be achieved at a high priority option, lower options may not be considered. In the development of mitigation plans, measures to avoid, minimize, or rectify potential impacts are treated in greatest detail.



MITIGATION PLAN DEVELOPMENT AND IMPLEMENTATION

Figure 1

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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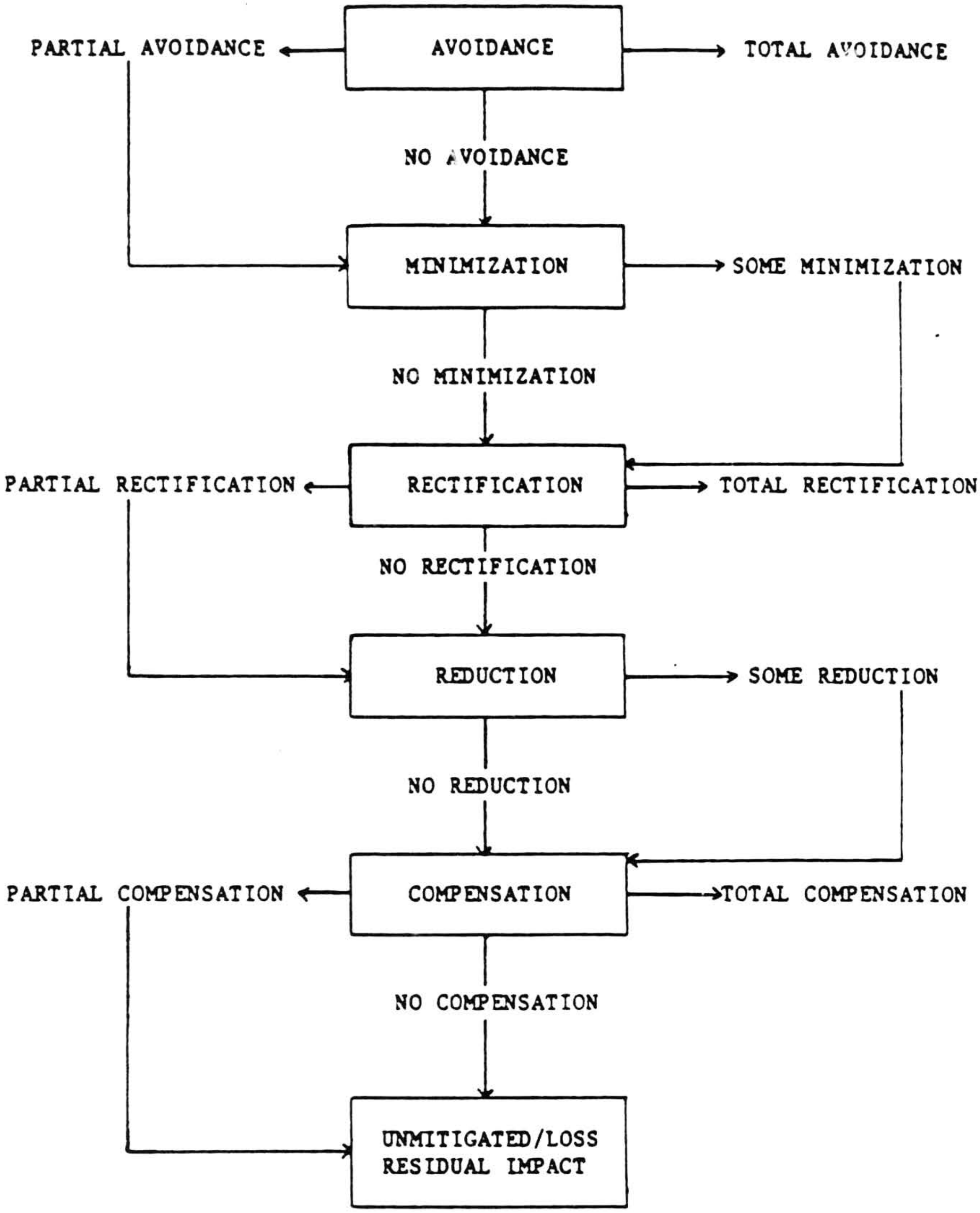
HARZA-EBASCO
SUSITNA JOINT VENTURE



OPTION ANALYSIS

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Figure 2

Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Monitoring and maintenance of mitigation features to reduce impacts over time are recognized as integral parts of the mitigation process. The monitoring program is being developed and will be applied to fishery resources and their habitat.

1.3 - Scope

This report presents analyses of mitigation options that can be used in developing an acceptable mitigation plan for impacts resulting from each stage of the proposed three-stage construction and operation of the Susitna Hydroelectric Project. Options are presented for impacts on fish resources and habitats between Devil Canyon and Talkeetna.

Primary consideration is given to mitigation measures for impacts to sensitive habitats supporting chum salmon spawning and incubation and juvenile chinook salmon rearing and overwintering. Project flow releases are the primary means of mitigating for chinook juveniles and serve as partial mitigation for chum spawning. Additional chum salmon spawning and juvenile chinook rearing mitigation is accomplished by structural modification of presently utilized side sloughs to maintain productive spawning, incubation and rearing habitat. The most heavily used sloughs and side channels for spawning by chum salmon during the 1981-1984 study period were selected for detailed analysis; these include sloughs 8A, 9, 9B, 9A, 11, and 21, and Upper Side Channel 11 and Side Channel 21 (Barrett et al. 1985). However, the analyses are applicable to other sloughs in the middle Susitna River where physical impacts are expected to be similar. Artificial propagation with stream-side incubation pits is proposed to compensate for losses should the above measures prove unsuccessful.

Impacts to species given secondary consideration (coho, sockeye and pink salmon and rainbow trout, Arctic grayling, burbot, and Dolly Varden) are also examined. Mitigation measures proposed for the primary species are evaluated as to their effectiveness in offsetting impacts to the secondary species.

2.0 GENERAL IMPACT ASSESSMENT

Construction and operation of the Susitna Hydroelectric Project would alter the natural physical processes of the Susitna watershed that determine the seasonal and annual variations in water supply, and sediment and chemical yields to the middle Susitna River. These physical processes, in turn, exert a controlling influence on the principal physical habitat components (streamflow, channel structure, water temperature and water quality) that ultimately determine the availability of fish habitat in this reach. The physical changes effected by the project would be qualitatively similar for all stages of the project, however, the magnitude of these changes and corresponding impacts on fish resources and habitats would vary with each stage of development and energy demand level.

The impact assessments presented in this section link the major predicted physical changes with habitat utilization to provide a qualitative statement of impacts likely to result from the Susitna Hydroelectric Project. This linkage is facilitated by assessing the degree of influence the project would have on the morphologic, hydrologic, and hydraulic characteristics of each of the five major aquatic habitat types of the riverine environment identified in the middle Susitna River. The response of fish habitat and species utilization patterns to those physical changes are then predicted.

The process of assessing impacts to habitat types and species/life stages associated with those habitat types also allows identification of evaluation species for which mitigation measures need to be implemented to maintain their productivity. Impacts specific to evaluation species during each of the three stages of project development and intra-stage energy demands and associated mitigation measures for these impacts are addressed quantitatively in Section 4.0.

2.1 - Utilization Within Habitat Types

A detailed discussion of the seasonal physical characteristics and utilization patterns of the various habitat types is found in Jennings (1985). Utilization of these habitats by salmon and resident species is briefly summarized in this section.

2.1.1 Mainstem and Side Channel Habitats

(A) Salmon Species

The mainstem in the middle Susitna river is used by each of the five species of salmon for one or more of the principal life stage activities: migration, spawning, overwintering, and rearing. The upstream migration of adult salmon occurs during the summer high flow season (June to September). Based on 1981 through 1984 escapement estimates less than 5 percent of the total Susitna River salmon escapement migrated within the Talkeetna-to-Devil Canyon reach.

Spawning by coho, chum, and sockeye in middle river mainstem and side channel habitats amounts to only about 5 percent of the total salmon spawning in this reach of the river.

Juvenile salmon use mainstem and side channels for movement and outmigration, rearing, and overwintering. Side channels in particular are important areas for chinook rearing.

(B) Resident Species

Most resident species use the mainstem and side channels as migrational corridors. Some species, such as burbot and round whitefish, also spawn in these habitats.

Rainbow trout, Arctic grayling and burbot appear to make extensive use of the mainstem during winter. Other species, such as Dolly Varden, whitefish and longnose sucker, likely overwinter in the mainstem. However, overwintering areas have not been identified for these species.

Juvenile burbot, round whitefish and longnose sucker rear primarily in mainstem and side channel habitats. Some Arctic grayling and rainbow trout juveniles also use these habitats.

2.1.2 Side Slough and Upland Slough Habitats

(A) Salmon Species

Slough habitat in the middle Susitna River supports spawning for sockeye, coho, pink and chum salmon. Results of escapement and spawning surveys from 1981 through 1984 indicate that chum and sockeye are substantially more numerous in sloughs than pink and coho. In 1984, about 25 percent of all salmon spawning in the middle Susitna River occurred in slough habitats.

Sloughs also function as important rearing and overwintering areas for juvenile salmon. Sockeye juveniles rear primarily in natal side sloughs in the early summer and move into upland sloughs by mid-summer. Some overwintering occurs in the sloughs. The sloughs provide temporary rearing habitat for chum salmon of 1-3 months prior to their outmigration from the middle reach by mid-July.

The extent of slough utilization by juvenile pink is limited by their short term residency in freshwater (ADF&G 1983a, Schmidt et al. 1984).

Some juvenile coho move from natal tributaries to rear in upland and side sloughs. Juvenile coho apparently prefer clear water and lower velocities (Schmidt et al. 1984). These conditions usually occur in upland sloughs more frequently than in side sloughs. Some juvenile coho also use sloughs for overwintering.

Juvenile chinook used side sloughs and upland sloughs for rearing in relatively low densities in 1983 (Schmidt et al. 1984). However, sloughs apparently provide important feeding areas during the fall, salmon-spawning period when juvenile chinook move into sloughs to feed on salmon eggs (Schmidt et al. 1984). Sloughs may also be important overwintering habitat for juvenile chinook.

(B) Resident Species

Sloughs are rearing areas for some resident fish. Rainbow trout, Arctic grayling and round whitefish use sloughs and slough mouths for rearing, while some burbot rear in slough mouths (Schmidt et al. 1984). These fish apparently feed on salmon eggs in sloughs during the salmon-spawning period. Spawning in sloughs by resident fish appears to be limited. Burbot and longnose sucker may spawn in slough mouths (Schmidt et al. 1984). The extent of overwintering in sloughs by resident fish is unknown.

2.1.3 Tributary and Tributary Mouth Habitats

(A) Salmon Species

Tributaries serve as the primary spawning habitat for chinook, coho and pink salmon (Barrett et al. 1984, 1985). In 1984, about 70 percent of all salmon spawning upstream of RM 98.6 (68,700 fish) occurred in tributaries (Barrett et al. 1985). About one-third of the chum salmon escapement upstream of Talkeetna spawned in tributaries during 1984 (Barrett et al. 1985). Tributaries are rarely used by adult sockeye salmon (Barrett et al. 1984, 1985).

Chinook, pink, chum and coho salmon frequently spawn at tributary mouths while sockeye salmon spawning appears limited in this habitat type (Barrett et al. 1985). Index counts of spawning salmon in tributary mouth habitats are unavailable, as counts are included in tributary counts. It appears that more spawning occurs in tributaries than in tributary mouths (Barrett et al. 1985). Water depth and velocity may limit spawning in tributary mouths (Sandone et al. 1984).

Juvenile sockeye utilize tributary habitat incidentally (Schmidt et al. 1984). In 1983, few juvenile sockeye were captured in tributary habitat.

Tributaries likely provide rearing habitat for chum salmon for about one to three months (Schmidt et al. 1984).

Tributaries serve as the primary coho natal areas upstream of RM 98.6. Some juvenile coho use tributaries for rearing throughout the summer, while others redistribute downstream to other rearing habitats, including tributary mouths (Schmidt et al. 1984). This redistribution occurs throughout the summer as fish become more mobile. Tributary mouths apparently provide important rearing areas for age-0+ coho (ADF&G 1983a). Some of the larger tributaries may provide overwintering habitat.

Tributaries upstream of RM 98.6 are the primary natal areas for pink salmon (Barrett et al. 1984, 1985). However, tributary utilization by juvenile pink is limited because they move downstream to the ocean shortly after emergence (Schmidt et al. 1984).

Tributaries are important rearing areas for chinook in the spring and early summer (Schmidt et al. 1984). The redistribution of some juveniles from tributaries to other rearing habitat, including the mainstem, sloughs and tributary mouths, occurs throughout the summer as fish become more mobile (Schmidt et al. 1984). Tributary mouths apparently are important rearing areas for juvenile chinook. Juvenile chinook apparently use tributaries for overwintering.

(B) Resident Species

In the Talkeetna-to-Devil Canyon reach, tributaries are the primary spawning and rearing areas for rainbow trout and Arctic grayling (Schmidt et al. 1984). The larger tributaries in this reach, such as Portage Creek, may provide overwintering habitat for some rainbow trout and Arctic grayling (Schmidt et al. 1984). However, it appears that overwintering in tributaries is limited (Schmidt et al. 1984).

Round whitefish, humpback whitefish, Dolly Varden and longnose sucker likely spawn in tributary or tributary mouth habitats (ADF&G

1983a, Schmidt et al. 1984). Juvenile Dolly Varden are thought to rear in the upper reaches of tributaries. Tributary mouths are important rearing and feeding areas for many resident species, such as rainbow trout, Arctic grayling and whitefish (ADF&G 1981, 1983b, Schmidt et al., 1984).

2.2 - Relationship Between Physical Changes and Habitat Utilization

Of the physical habitat components that determine the availability of fish habitat, streamflow is the most important because of its direct relationship to all physical processes influencing fish habitat in the middle river. Under natural conditions, mainstem discharges are high from late May through early September and decrease during September and October to reach low flow levels which continue throughout the winter. Under project operation, flow would be more uniform throughout the year with higher than natural flows in winter and lower than natural in summer.

Project operation would alter the natural temperature regime by delaying the temperature rise during early summer and extending warm water temperatures into fall. The warmer water temperatures during the fall are expected to delay development of the ice front from two to seven weeks (Harza-Ebasco 1985). In addition, the warmer water temperatures released during the winter would result in open water conditions for a variable distance below the dams. The upstream progression of the ice front would vary with volume and temperature of release water and year-specific climatic conditions.

The proposed impoundment area is expected to entrap nearly all the suspended sediment currently being transported to the middle Susitna River. Reduced mid-summer turbidities would likely result from such a reduction in suspended sediment. Winter mainstem turbidities, however, are expected to be higher than natural.

The degree of impact these changes in physical processes would exert on each of the habitat types would depend on the level of influence mainstem conditions have on the physical characteristics of the various habitat types.

2.2.1 Mainstem and Side Channel Habitat Types

Mainstem habitat type is comprised of those portions of the Susitna River that normally carry water throughout the year whereas side channels convey flow during the open water season except during periods of low flow. Therefore, mainstem and to a lesser extent side channel habitat types would be directly affected by changes in mainstem flow conditions. In contrast to natural flows, regulated summer flows would provide relatively stable habitat conditions in these two habitat types; however, the amount of habitat available may be less than that available under natural conditions for some life stages. Mainstem and side channel habitats would also be directly affected by temperatures and seasonal changes in turbidity levels and associated project released flows.

2.2.2 Side Sloughs and Upland Sloughs

The project flow regime would cause one or more of the following physical changes in side sloughs and upland sloughs of the middle Susitna River:

- Reduced backwaters in spring, early summer and in winter upstream of the ice-covered areas.

- Increased backwaters in fall and in winter in areas downstream of the ice-front.

- Reduced frequency of breaching in spring and early summer.

- Increased frequency of breaching in winter in ice-covered areas.

- Reduced groundwater upwelling during spring and summer and in winter upstream of the ice cover.

Each of the above physical changes is discussed in relation to current and potential utilization of these habitat types by salmon and resident species.

(A) Reduced Backwater

Backwaters at slough mouths under natural conditions provide greater depths in the affected zone than would be provided by local slough flow. Project flows would substantially reduce the backwater zone in some sloughs during spring and early summer resulting in a decrease in the surface area. Depths would likely remain suitable for rearing and outmigration of juvenile salmon. The degree of loss would be dependent on the relative spatial distribution of available habitat under natural and project conditions. During fall and winter in areas downstream of the ice front, increased backwaters resulting from increased project flows and ice staging would sustain incubating salmon embryos that otherwise might be dewatered under natural conditions. The increased backwaters would also provide additional rearing and outmigrating habitat, assuming no deleterious effects due to overtopping in winter.

(B) Breaching Flows

Breaching flows in side sloughs provide habitat in addition to that provided by local flow by increasing the amount of area with suitable depths for various life stage activities. Project flows would substantially reduce the frequency of breaching flows in spring and early summer. This may result in difficulties in the movements and outmigration of juvenile salmonids. The low utilization of these habitat types by resident species would result in little or no impacts. During winter, the higher than natural flows and associated staging in the ice-covered areas would result in breaching or overtopping of sloughs and the influx of near-zero degree water. This may retard the development of embryos and reduce the quality of overwintering habitat.

(C) Upwelling

Reductions in the rate of upwelling during winter would decrease the quality and quantity of habitat for life stages that prefer these areas.

Chum salmon embryos, for example, appear to depend on the relatively warmer temperatures associated with groundwater upwelling for successful incubation. In the fall, many chinook salmon juveniles move into areas with a groundwater source to overwinter (Roth and Stratton 1985). Reduction in upwelling in the early summer may be of little significance. Increases in the rate of upwelling over natural conditions would occur with the high flows in fall (October and November) and winter in areas downstream of the ice front.

2.2.3 Tributary and Tributary Mouth Habitats

Tributary habitat would be unaffected by alteration of mainstem flows. Under project operational flows access into tributaries is not anticipated to be a problem for returning adult salmon (Trihey 1982).

Tributary mouth habitat is the area bounded by the uppermost point of mainstem backwater effect in a tributary and the area of clearwater plume from tributary flows into the mainstem. The areal extent and physical characteristics of this habitat type are a function of mainstem and tributary conditions. The total area of tributary mouth habitat will be greater and more stable under lower regulated mainstem flows during project operation (Klinger and Trihey 1984). Salmon and resident species utilizing this habitat type would benefit from these changes.

2.3 - Selection of Evaluation Species

All three mitigation policies (APA, ADF&G and USFWS) imply that project impacts on the habitats of certain sensitive fish species will be of greater concern than changes in distribution and abundance of less sensitive species. Sensitivity can be related to high human use value as well as susceptibility to change because of project impacts. Statewide policies and management approaches of resource agencies suggest that concern for fish and wildlife species with commercial, subsistence, or other consumptive uses is greater than for species without such value. These species are often numerous, and utilize a wide range of habitats, as well as having high human use value. Such characteristics often result in these species being selected for careful evaluation when their habitats are subjected to alternative uses. By avoiding or minimizing alterations to habitats utilized by these species, the impacts to other less sensitive species that utilize similar habitats may also be avoided or reduced.

The evaluation species were selected after initial baseline studies and impact assessments had identified the important species and potential impacts on available habitats throughout the year.

Since the greatest changes in downstream habitats are expected in the reach between Devil Canyon and Talkeetna, fish using that portion of the river were considered to be the most sensitive to project effects. Because of differences in their seasonal habitat requirements, not all species would be equally affected by the proposed project. Of the species in the middle Susitna River, chum and sockeye salmon appear to be the most vulnerable because of their dependence on slough habitats for spawning, incubation and early rearing. Of these two, chum salmon are the dominant species. Chinook and coho salmon are less likely to be impacted by the project because two critical life stages, spawning and incubation, occur in habitats that are not likely to be altered by the project. Similarly, while some pink salmon spawn in slough habitats in the reach between Devil Canyon and Talkeetna, most of these fish utilize tributary habitats. The mitigation measures proposed to maintain chum salmon productivity should allow sockeye and pink salmon to be maintained as well. Project effects on the rearing life stage of juvenile salmon, particularly chinook salmon, are also of concern. The chinook juveniles rear in the river up to two years and coho salmon juveniles up to 3 years prior to out-migration. Much of the coho rearing apparently occurs in clear water areas, such as in sloughs and tributary mouths, with the more abundant chinook rearing in turbid side channels as well as clear water areas. Maintenance of chinook rearing habitat should provide sufficient habitat for less numerous resident species with similar life stage requirements.

In summary, the primary and secondary evaluation species and life stages selected for the Susitna Hydroelectric Project in the Devil Canyon to Talkeetna Reach are:

PRIMARY

Chum Salmon

- Spawning adults
- Embryos and pre-emergent fry

Chinook Salmon

- Rearing juveniles

SECONDARY

Chum Salmon

- Returning adults
- Rearing juveniles
- Out-migrant juveniles

Chinook Salmon

- Returning adults
- Out-migrant juveniles

Sockeye Salmon

- Returning adults
- Spawning adults
- Embryos and pre-emergent fry
- Rearing juveniles
- Out-migrant juveniles

Coho Salmon

- Returning adults
- Rearing juveniles
- Out-migrant juveniles

Pink Salmon

- Returning adults
- Spawning adults
- Embryos and pre-emergent fry
- Out-migrant juveniles

Arctic Grayling

- Adults
- Juveniles

Rainbow Trout

- Adults
- Juveniles

Dolly Varden

- Adults

Burbot

- Adults
- Juveniles

3.0 MITIGATION OPTIONS

A Fish Mitigation Plan was prepared and distributed to agency personnel in November 1984. This was followed by a workshop on the subject document in December 1984. At the request of APA, participating resource agencies and interveners submitted comments on the three principal mitigation options proposed in the document: flow release, habitat modification and artificial propagation.

In general, the Alaska Department of Fish and Game, National Marine Fisheries Service and the Fish and Wildlife Service concurred that flow release combined with habitat modification is a feasible approach in achieving APA's goal of no net loss of habitat value. Concerns, however, were expressed by all three agencies on the lack of emphasis placed on flow release and the effectiveness of habitat modifications in Southcentral Alaska. Artificial propagation was viewed by the agencies as a mitigation option of last resort should the preferred mitigation options fail.

Rational for development of the APA's selected flow regime and agency comments on this and the other mitigation options are addressed below where appropriate.

3.1 - Flow Release

The aquisition of additional information on the relationships between physical processes and habitat utilization in the middle river subsequent to submittal of the License Application has permitted refinement of the original Case C flow regime. This resulted in the development of eight environmental flow cases, each designed to achieve specific environmental goals (Harza-Ebasco 1984). These environmental flow cases can be grouped into three broad categories of which Case C, Case EV, and Case EVI are representative. These three flow regimes were evaluated and compared in the Fish Mitigation Plan (WCC 1984). Case C emphasized providing flows that allowed access into sloughs for spawning. Case EVI, the APA's preferred regime, was designed to minimize impacts to chinook rearing while Case EV was designed to minimize impacts to chum salmon spawning and chinook salmon rearing.

An evaluation of CASE EVI indicated that although the flows under Case EV were established to minimize impacts to chum spawning, habitat modification measures would be necessary to rectify the residual impacts. Furthermore, the effort expended on habitat modification measures necessary to offset the residual impacts to spawning habitat under the Case EV regime would not be substantially greater than these for Case EVI. The primary difference between the two regimes, therefore, would be the degree to which impacts to chinook juvenile habitat are minimized or avoided. Analyses are currently underway to forecast the mainstem flows that would provide the optimum summer rearing flows for juveniles. The availability of the results of these analyses will provide the opportunity to direct attention to the priority mitigation option, flow release. The lack of progress on this option has been a concern expressed by the resource agencies.

3.2 - Habitat Modification

A number of habitat modification measures were presented in the Fish Mitigation Plan for review and comment by the resource agencies. The measures within this option focus primarily on rectifying impacts to chum salmon spawning habitat although secondary benefits would accrue to rearing and overwintering habitat of juvenile chinook salmon as well as life stages of other salmon and resident species. Those measures considered by APA and the resource agencies to have the greatest likelihood of success are described below in order of priority and will be incorporated into the updated mitigation plan presented in Section 4.0.

3.2.1 Slough Excavation

Mechanical excavation of certain reaches of sloughs would improve fish passage and fish habitat within the sloughs. At slough mouths, excavation would provide fish access when backwaters are negligible during low mainstem discharges. Mechanical excavation can be used to facilitate passage within sloughs by channelizing the flow or deepening the thalweg profile at the passage reach.

On a larger scale, mechanical excavation to lower the profile of the entire slough could increase the amount of upwelling in the slough. A greater head between the mainstem and the slough bed would result in additional local flow in the slough.

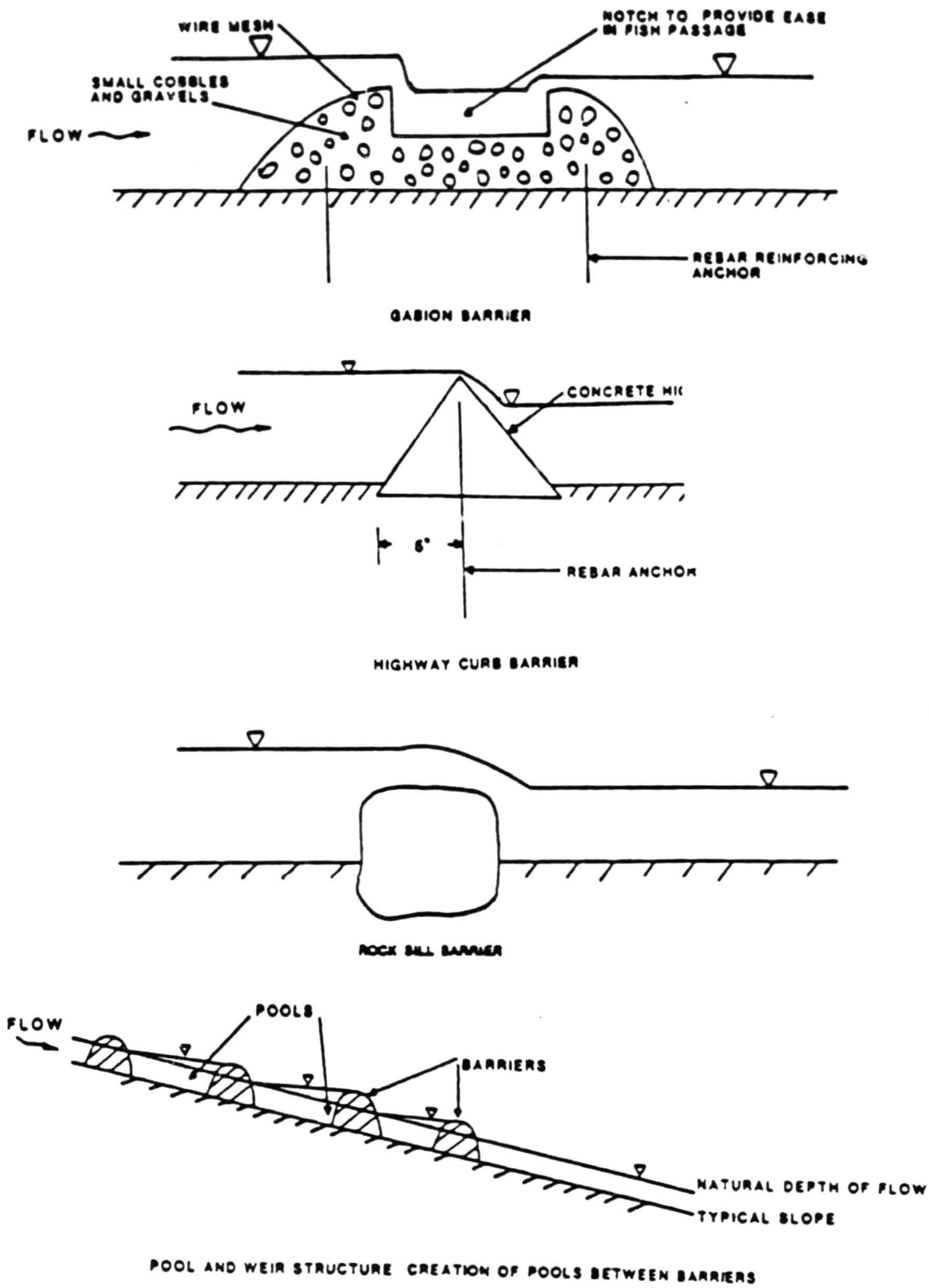
An additional benefit of the excavation process would be the opportunity to improve the substrate in the slough. Replacement of existing substrate with suitable spawning gravels would provide additional spawning habitat. Sorting of the existing substrate will be undertaken to remove unsuitable particle sizes. The excavation process would be designed to develop additional spawning and rearing habitat.

An estimate of the cost to excavate a typical slough mouth in the middle portion of the Susitna River is $26,000. An estimate of the cost to lower a typical slough profile by 2 feet for a length of 2,000 feet in the middle section of the Susitna River is $34,000.

3.2.2 Channel Barriers

Fish access through passage reaches is also improved by creating a series of pools. Barriers are placed to break the flow on long, steep passage reaches and create pools between obstacles. Fish passage over the obstacles is accomplished if sufficient steps of decreased barrier height are provided to permit surmounting the original barrier (Bell 1973).

Channel barriers are used on long slopes to create fish resting pools, as shown in Figure 3. These barriers with heights of 10 to 14 inches act as weirs, with a section of decreased height to improve fish passage between pools. The barriers are constructed of various materials. Concrete highway curbs anchored to the bed with rebar (Figure 3) or cobbles and boulders placed to create a sill may be used. Logs may also be attached to the banks and anchored securely to the bed to prevent movement at high discharges. Gabions shaped as shown in Figure 3 may also be used (Lister et al. 1980).



Fish Passage Mitigation Utilizing Barriers

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Figure 3

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AND
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HARZA-EBASCO
SUSITNA JOINT VENTURE

Channels are constrained in width to form effective pools. For a wide channel, channel widths are modified where a pool and weir structure is desired.

Estimates of costs per barrier on the basis of a two barrier system are listed below. Each slope will require more than one barrier to create a series of pools. As more barriers are built on a site, the cost per barrier will decrease because of the economies of scale; the major cost involved in the construction of the barrier is the cost of transporting equipment.

Barrier	Cost/Barrier
Concrete highway curbs	$ 12,000
Rock sill	16,000
Gabions	12,000
Anchored logs available on site	11,000
Anchored logs not available on site	12,000

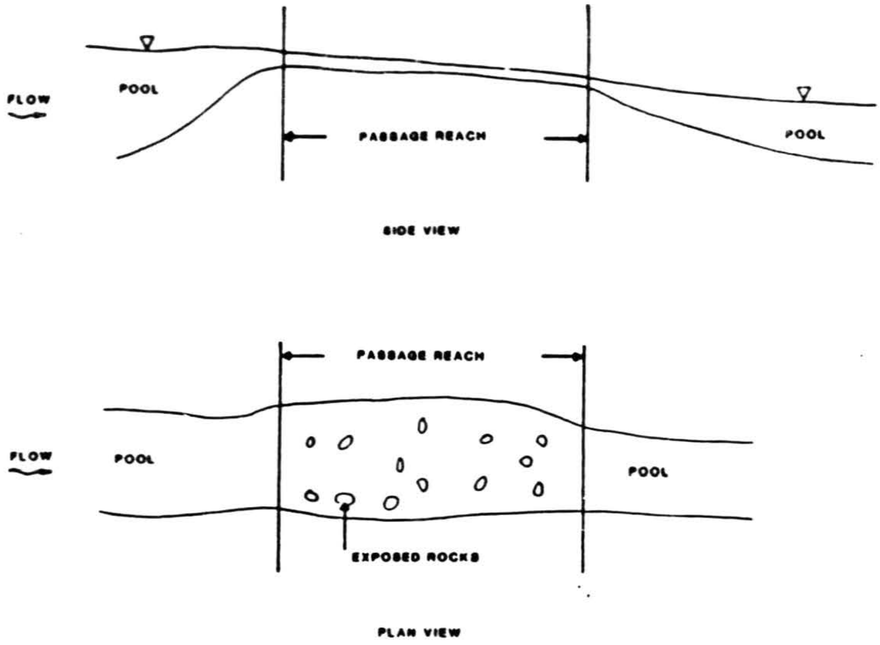
3.2.3 Channel Width Modifications

Channeling slough flow will improve fish access through passage reaches by constricting the width and increasing the depth of the channel. This technique is especially useful in modifying short, wide passage reaches (Figure 4). Wing deflectors extending out from the channel bank or rock gabions restructuring the cross section of the natural channel may be used to constrict the flow width (Bell 1973).

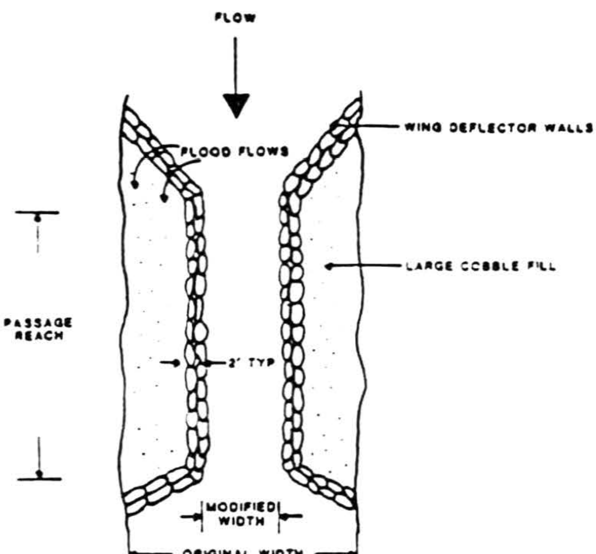
In determining the modified width for the channel, a maximum velocity criteria of 8 fps was used to permit fish access through the reach (Bell 1973).

(A) Wing Deflectors

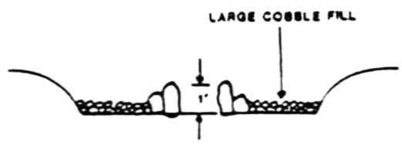
Wing deflectors are used to divert the flow in a channel. Two wing deflectors placed on opposite banks will funnel the flow from a wider to a narrower cross section as shown in Figure 4. The narrowed channel is designed to provide fish passage at the minimum flow. At



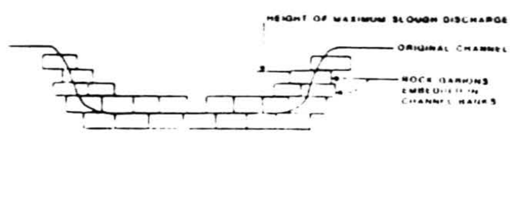
TYPICAL PASSAGE REACH OF SLOUGH ALONG
MIDDLE SECTION OF THE SUSITNA RIVER



PLAN VIEW
WING DEFLECTOR



WING DEFLECTOR



ROCK GABION CHANNEL

Fish Passage Mitigation by Modifying Channel Width

Figure 4

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

higher flows, the wing deflectors are inundated; fill between the banks and the wing deflector walls is sized to prevent scouring at higher discharges. Fill will typically be composed of large cobbles available at the sloughs.

Wing deflector walls are constructed either of rock or gabions formed of wire mesh and filled with cobbles. Another alternative is the use of 12-inch-diameter timbers, anchored to the banks and channel bed. A wing deflector costs $31,000 when constructed of rock, approximately $24,000 when constructed with gabions, and $22,000 if timber logs available on site are used. For sites where timber is not available, a log wing deflector would cost $23,000. Estimates are based on a typical passage reach of approximately 200 feet for a slough on the middle Susitna River (Figure 4).

(B) Rock Gabion Channel

Reshaping the original cross section of the channel with rock gabions is an alternative method of channelizing the slough flow. The channel is excavated and gabions are used to establish the new configuration. The new channel shape is designed to maximize depth at minimum flows; at higher discharges, the gabions prevent scouring of the channel banks. Figure 4 illustrates a typical cross section for a reshaped passage reach. For long passage reaches, resting areas are created by widening the channel between the rock gabions forming the minimum discharge channel. The gabions are provided throughout the length of the passage reach and protected upstream by riprap or wing wall gabions. The gabion banks extend higher than the height of the maximum slough discharge to prevent collapse from erosion.

The gabions composing the channel banks prevent scouring of the banks; the channel will be more stable than a similar channel modified by wing deflectors. For passage reaches with greatly varying discharges, the added stability of the rock gabion channel is an advantage. The cost of constructing the gabion channel is approximately $60,000 for a typical passage reach 200 feet in length.

3.2.4 Prevention of Slough Overtopping

Project flows are higher than natural discharges in the winter. Ice staging at these discharges would result in an increase in mainstem stage and increase the probability of overtopping of sloughs downstream of the ice cover front.

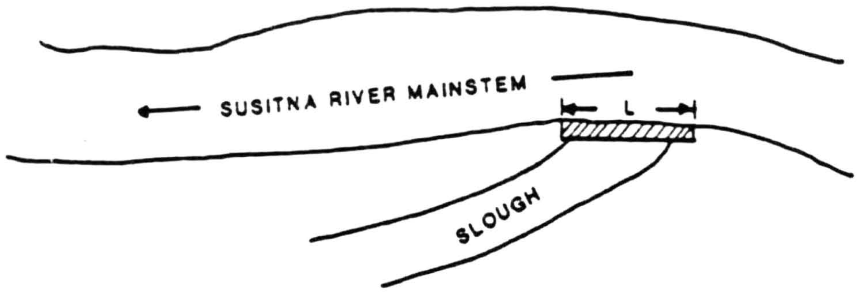
An influx of cold mainstem water into the incubating area of the Slough 8A in 1982 caused adverse impacts (ADF&G 1983b). To prevent overtopping, the height of the slough berms would be increased as shown in Figure 5.

Cost estimates per berm range from $24,000 to $161,000 or higher depending on the slough head configurations and the mainstem stage.

3.2.5 Gated Water Supply System

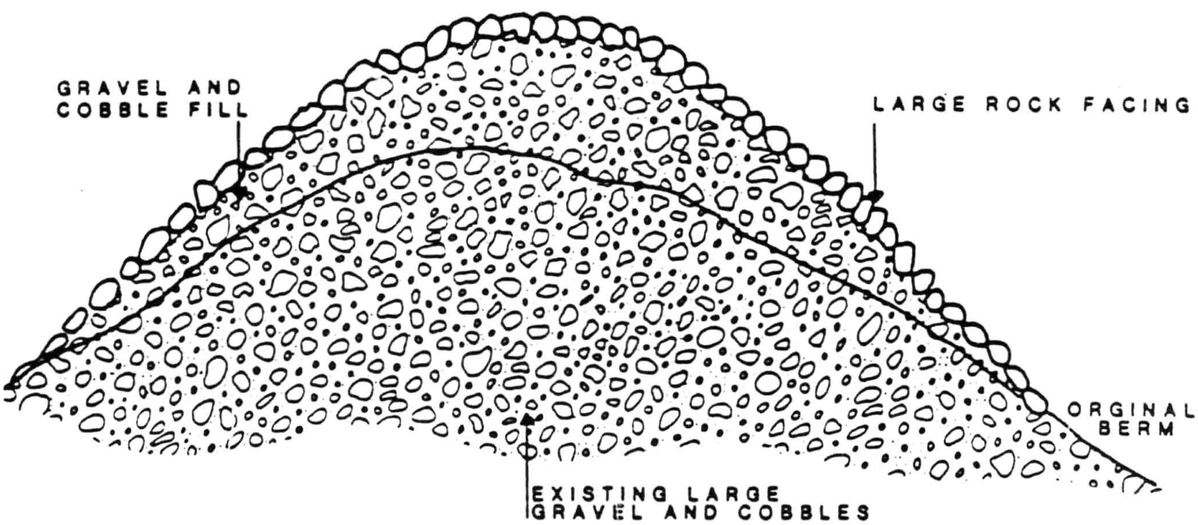
In the absence of large flows in sloughs and side channels, debris buildup, siltation, and algal growth may create passage restrictions and decrease available spawning habitat. Side sloughs and side channels are breached under natural conditions with a frequency from 1 to 4 years. The large breaching flows remove obstacles caused by debris and scour the channel bed. Flows of 50 cfs or greater may be required for the removal of debris and channel scouring. Under project conditions, breaching of the sloughs and side channels will occur less frequently in spring and summer months and may not provide sufficient flushing of the channel. A gated pipeline extending under the berm at the head of a slough or side channel could provide large quantities of flow under unbreached conditions.

The gated water supply system consists of a 3 ft diameter corrugated pipe with a gate valve structure. The pipe intake is protected by a riprap cover to prevent the entrainment of fish and debris. The riprap will stabilize the bank of the berm at the intake by preventing scour. Large riprap at the outlet will create turbulent conditions for improved air entrainment and the dissipation of energy to prevent excessive channel bed erosion. The gate valve structure will enable the manual opening of the



PLAN VIEW

L=LENGTH OF BERM



CROSS SECTIONAL VIEW

Overtopping Prevention Mitigation by Increasing Berm Height

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Figure 5

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pipe to allow large flows into the channel. In order to provide the suggested 50 cfs of slough flow, the pipe system will be operated at a high mainstem discharge. To prevent the influx of turbid water during chum spawning or near-freezing water during incubation, the pipe gate valve will remain closed during the fall and winter months.

A gated water supply system to provide a minimum of 50 cfs is feasible if the head difference between the mainstem elevation and the slough bed is large enough to drive water through the required pipe length. A 3 ft head difference will deliver 60 cfs through a 4500 ft or less pipe length. A 1 ft head difference requires a pipe length of less than 1300 ft. Given the head difference and pipe length requirements, a gated water supply system is feasible at Sloughs 9, 11, and 21. The estimated cost of a system with a pipe length of 2500 ft is $100,000.

3.3 - Artificial Propagation

In the Fish Mitigation Plan, artificial propagation was proposed as a means of maintaining the productivity of chum salmon populations should the highest priority options prove unsuccessful. At the time the plan was drafted, streamside egg incubation boxes were chosen as the preferred method for achieving this goal. As discussed in the plan, incubation boxes require a reliable water supply with appropriate water quality characteristics, particularly water temperature. The temperature regime of the identified source water, Deadhorse Creek at Curry Station, appeared to be somewhat cooler than the incubation temperatures encountered by chum salmon embryos incubating in side sloughs (Vining et al. 1985). It was suggested that the Deadhorse Creek temperature regimes be matched with a stock of chum salmon that spawned under a similar regime, tributary spawners for example, to ensure that emergence of fry occurs at a time that coincides with natural emergence. Since that plan was presented, an alternative technique for artificially incubating eggs currently in use in British Columbia was evaluated. This technique consists of an incubation pit that is buried in the ground and is constructed with an open bottom enabling it to intercept groundwater flow.

The incubation pit consists of a wooden box 10 x 20 x 5 ft deep set to a depth of 3 feet below the lowest water table elevation. A slotted wood floor installed in the bottom of the box approximately 6 inches above the base intercepts the groundwater flow.

The incubation pit can accommodate a monolayer of 500,000 eggs and requires a flow rate of approximately 50 gpm. The advantages of the incubation pit over the traditional egg incubation box include 1) a wide range of potential sites for installation, 2) direct installation in a slough eliminating the need to construct rearing ponds, 3) a constant reliable water source somewhat independent of weather conditions, and 4) access to the same source of upwelling groundwater that surrounds naturally incubating embryos.

4.0 FRAMEWORK FOR MIDDLE SUSITNA RIVER FISH MITIGATION PLAN

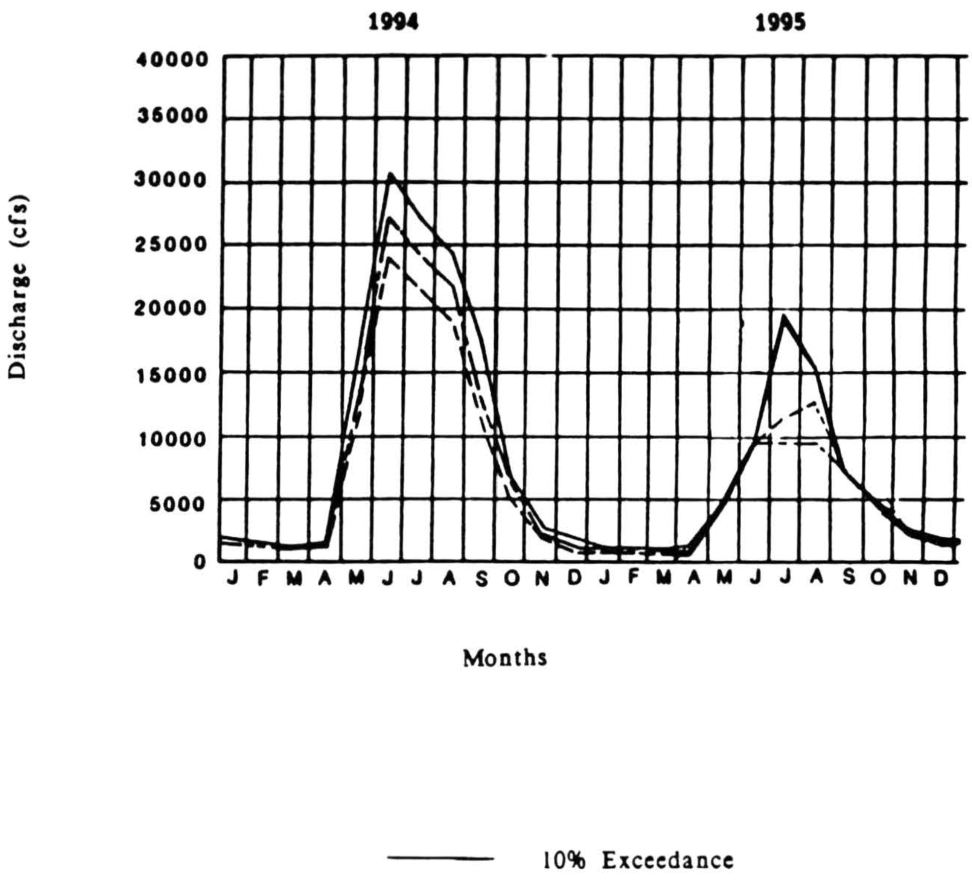
The recently adopted three-staged construction plan for the Susitna Hydroelectric Project not only provides decision points for project development based on energy demands but also permits formulation of a mitigation plan that is tailored to the impacts associated with reservoir filling and each stage of project development. The magnitude of impacts to the evaluation species/life stages that would accompany reservoir filling and each stage of operation would vary as would the level of mitigation effort necessary to mitigate for these impacts. For example, with the exception of the filling stage, impacts to chum salmon spawning would generally increase with each stage and the energy demand within each stage. Conversely, incubation conditions would improve with project development as the frequency of winter overtopping in some sloughs would decrease, particularly with Stage 3 and year 2020 energy demands. This section presents a framework for impact and mitigation option analysis that will facilitate incorporation of additional information as it becomes available and will eventually lead to development of a detailed and acceptable mitigation plan.

4.1 - Stage I (1996-2001)

4.1.1 Impact Analysis

(A) Filling - 1995

Impoundment of water from the Susitna River for the Watana reservoir is presently scheduled to commence in May 1995 with the spring runoff. Coincident with the initiation of reservoir filling would be the institution of Case E-VI flow constraints. During the open water season, flow releases would be at or near E-VI minimum levels in May, June, September, and October. Flow release levels during July and August would depend on the hydrologic conditions of that year. Preliminary estimates of monthly average regulated flow releases for May through October are compared to natural flows for the same periods under dry, average, and wet hydrologic conditions (90, 50, 10 percent exceedence) (Figure 6). Under dry conditions flow



Susitna River Flows at Gold Creek Under Natural (1994) and Filling of Reservoir (1995) Regimes with Case E-VI Flow Requirements.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Figure 6

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HARZA-EBASCO SUSITNA JOINT VENTURE

releases in July and August would be at E-VI dry year minimum of 8,000 cfs. In an average year July and August flows would be about 11,400 and 12,400 cfs, somewhat higher than E-VI minimum (9,000 cfs) yet substantially reduced from average natural flows of 24,000 cfs and 22,000 cfs. In a wet year flow releases would increase to 19,400 and 15,200 cfs, closer to the average natural condition. During the first winter following filling, November 1995 - March 1996, the reservoir level would be held constant so that releases would match inflow. Power generation would commence in April 1996.

Downstream water temperatures from May through October are expected to be similar to pre-project temperature, although some time lag would occur.

Turbidity levels during filling would decrease in the open water season and increase over natural levels during the ice-covered months.

(i) Primary Evaluation Species

- Chum Salmon

  . Adult Spawning

Detailed analysis of mainstem flows required for successful passage into the major chum salmon spawning sloughs have been conducted by ADF&G (Blakely et al. 1985). However, a quantitative assessment of the availability of successful passage conditions during reservoir filling using this information is not possible for average and wet years since the available flow data, mean monthly flows, mask the monthly variability in flows caused by short-term rainstorm events that often provide passage. It can be assumed, however, that since the mean monthly flows for filling are less than those for natural conditions in August and September for average and wet conditions that the frequency of successful passage conditions would be reduced. In a dry year with E-VI minimum flows during the spawning period and assuming no local runoff (no variability around the minimum flow value) passage would be possible at only two passage reaches of the seven sites evaluated - one in Slough 8A and one in Side Channel 21.

. Embryos and Pre-Emergent Fry

Incubation conditions during the winter following the summer filling period would be similar to natural conditions and no project-induced impacts are expected to embryos and pre-emergent fry.

- Chinook Salmon

. Juvenile Rearing

Chinook salmon juveniles rear principally in tributaries and side channels in the open water season (Schmidt et al. 1984). The filling flow during this period would reduce the amount of rearing habitat in currently utilized side channels. Tributary habitat would be unaffected. Additional rearing habitat may become available in other middle Susitna River areas. This is the subject of ongoing analysis, the results of which should become available in early fall, 1985.

(ii) Secondary Evaluation Species

- Chum Salmon

. Returning Adults

Chum salmon migrate up the Susitna River to spawning areas during the summer. The 9,000 cfs minimum flows during filling (8,000 in a dry year) would not impede their upstream migration.

. Juvenile Rearing

Chum salmon rearing occurs in natal areas, primarily sloughs and tributaries, during the early summer (May to first part of June). In mid-summer (late June and July), densities remain high in tributaries and increase in upland sloughs. During outmigration, which is generally complete by the end of July, juvenile chum use mainstem areas for short-term rearing. Filling flows would decrease the amount of rearing habitat in side sloughs through the elimination of overtopping conditions and to a lesser extent a reduction in backwaters. Similarly, the backwater in upland sloughs would be reduced. The availability of mainstem sites for short-term rearing is not expected to decrease although the locations of suitable sites would change with decreased flows.

. Out-migrant Juveniles

Filling flows would reduce the frequency and amplitude of spring runoff flows that can act as stimuli for outmigration for chum salmon. These reductions are not expected to impact seaward migration because other factors such as photoperiod, water temperature increases and physiological condition also stimulate outmigration.

- Chinook Salmon

. Returning Adults

Filling flows during summer would not impede the upstream migration of chinook salmon adults in the Susitna River and into tributaries.

. Out-migrant Juveniles

Age-1+ chinook salmon migrate out of the middle river by July. As mentioned with chum salmon, this outmigration would not be substantially affected by filling flows.

- Sockeye Salmon

. Returning Adults

Filling flows would not impede the summer upstream migration of sockeye salmon adults. Sockeye spawn in side sloughs in the middle river similar to chum salmon.

. Spawning Adults

The restricted access conditions to sloughs and side channels discussed for chum salmon would also apply to sockeye.

. Embryos and Pre-emergent Fry

The incubation conditions during the winter following the summer filling period would be similar to natural conditions and no project-induced impacts are expected to embryos and pre-emergent fry.

. Rearing Juveniles

Sockeye juveniles generally rear in natal side sloughs during early summer and relocate to upland sloughs by July. Reductions in the amount of habitat available in these habitat types due to filling flows would result from reduced backwater and breaching flows. The degree of habitat loss would be site specific.

. Out-migrant Juveniles

Outmigration of sockeye salmon would not be impacted by project filling flows.

- Coho Salmon

. Returning Adults

Filling flows during summer would not impede the upstream migration of chinook salmon adults in the mainstem Susitna River and access into tributaries.

. Rearing Juveniles

Coho salmon rear primarily in tributaries and upland sloughs. Project filling flows are not expected to impact these habitats.

. Out-migrant Juveniles

The outmigration of coho juveniles would not be impacted by project flows.

- Pink Salmon

. Returning Adults

Filling flows during summer would not impede the upstream migration of pink salmon adults in the mainstem Susitna River.

. Spawning Adults

A limited amount of pink salmon spawning occurs in slough habitats and filling could restrict access to these areas during the spawning season.

. Embryos and Pre-emergent Fry

The similar-to-natural condition during the winter incubation months would preclude any project-induced impacts of pink embryos and pre-emergent fry.

. Out-migrant Juveniles

Pink salmon fry migrate to Cook Inlet shortly after emergence. For reasons discussed previously, the project is not expected to interfere with outmigration.

- Arctic Grayling

Arctic grayling rear in tributary mouths and overwinter in mainstem habitat. Filling flow level would increase the availability and stability of tributary mouth habitat for rearing (Klinger and Trihey 1984). The winter flow regime would approximate that of natural conditions so no impacts to overwintering based on flow would be expected.

- Rainbow Trout

Rainbow trout use side sloughs and tributary mouth habitats for rearing and mainstem areas for overwintering. The increase in tributary mouth habitat during summer and the maintenance of natural conditions in winter during filling should sustain rainbow trout production at current levels.

- Dolly Varden

Dolly Varden's primary use of project affected habitats is overwintering in the mainstem. Since winter flow during filling would approximate natural conditions no impacts are anticipated.

- Burbot

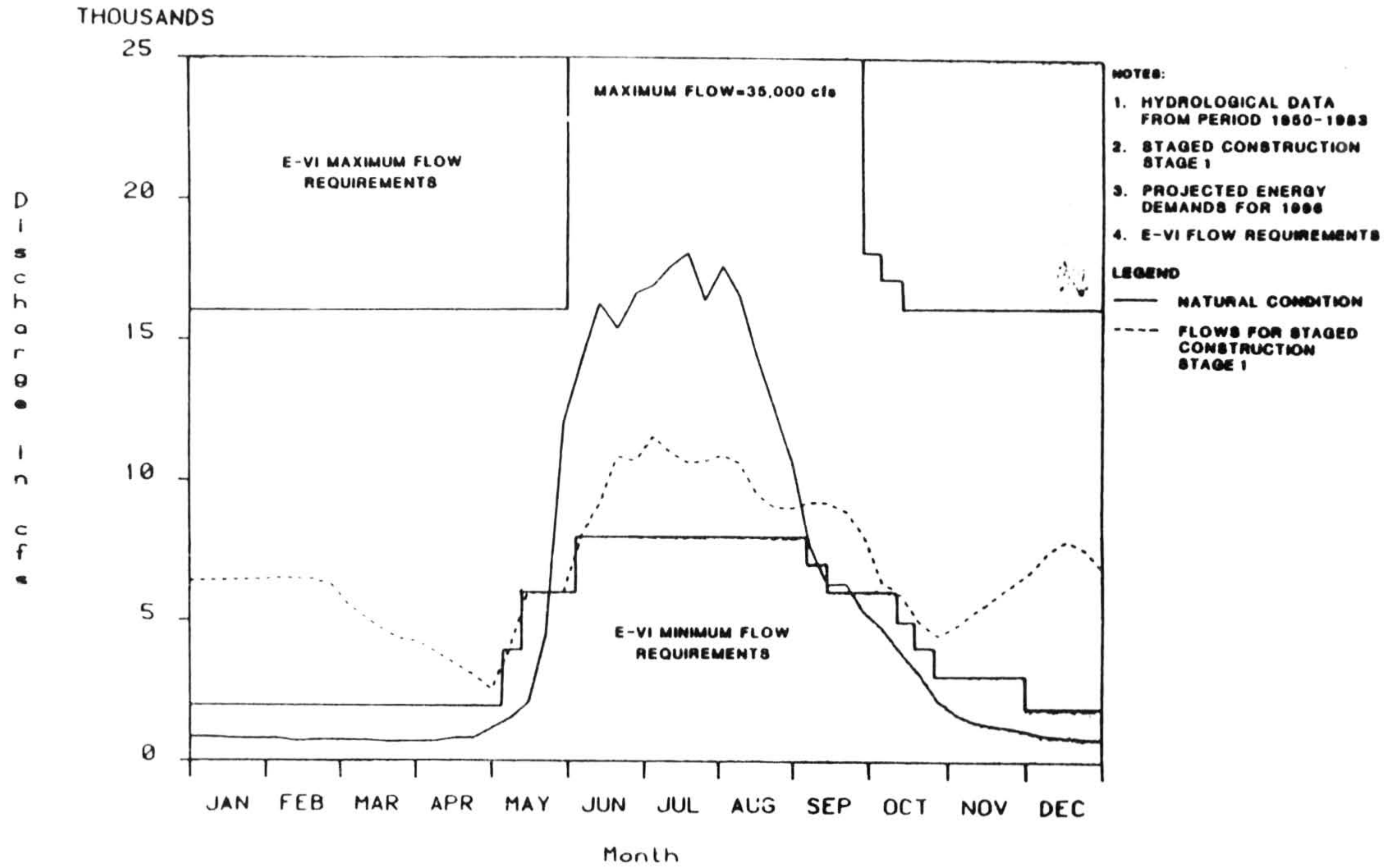
Burbot use mainstem habitat for all life history stages, showing a preference for turbid backwater sites and slough mouths. The lower flows during summer filling would increase the areas with low velocity, backwater characteristics. No project impacts would occur during the winter months. Therefore, the project filling flows would maintain sufficient habitat to support present levels of burbot.

(B) Operation

Power generation for the Susitna Hydroelectric Project would commence in April 1996 after approximately one year of filling. Regulated flow releases have been simulated for the first year of operation based on anticipated energy demands. Natural and Stage 1-1996 operating flows are compared at the 97, 50, and 6 percent exceedance probabilities (Figures 7-9). The 1996 flow regime is typical of project operation - higher flows in winter and during periods of peak energy demand and lower flows in summer during the filling process.

Water temperatures during Stage 1 would be 2-3^{o}C colder than natural in the spring. By mid-summer, project temperatures would be similar to natural ones. In the fall and winter, warmer than natural streamflow temperatures would result from the heat stored in the reservoir. The difference between natural and project temperature is inversely related to the distance from the dam. Figures 10-12 compare natural and simulated Stage 1 (2001) temperatures at three locations below the dam.

The warmer winter water temperatures and higher than natural flows would delay the formation of the ice front and result in its upstream progression only to RM 136.5 in an average winter (1981-1982). The higher flows would also increase the thickness of the ice cover and



Comparisons of Susitna River Natural and Stage 1 1996 Streamflows Exceeded 97% of the time at Gold Creek

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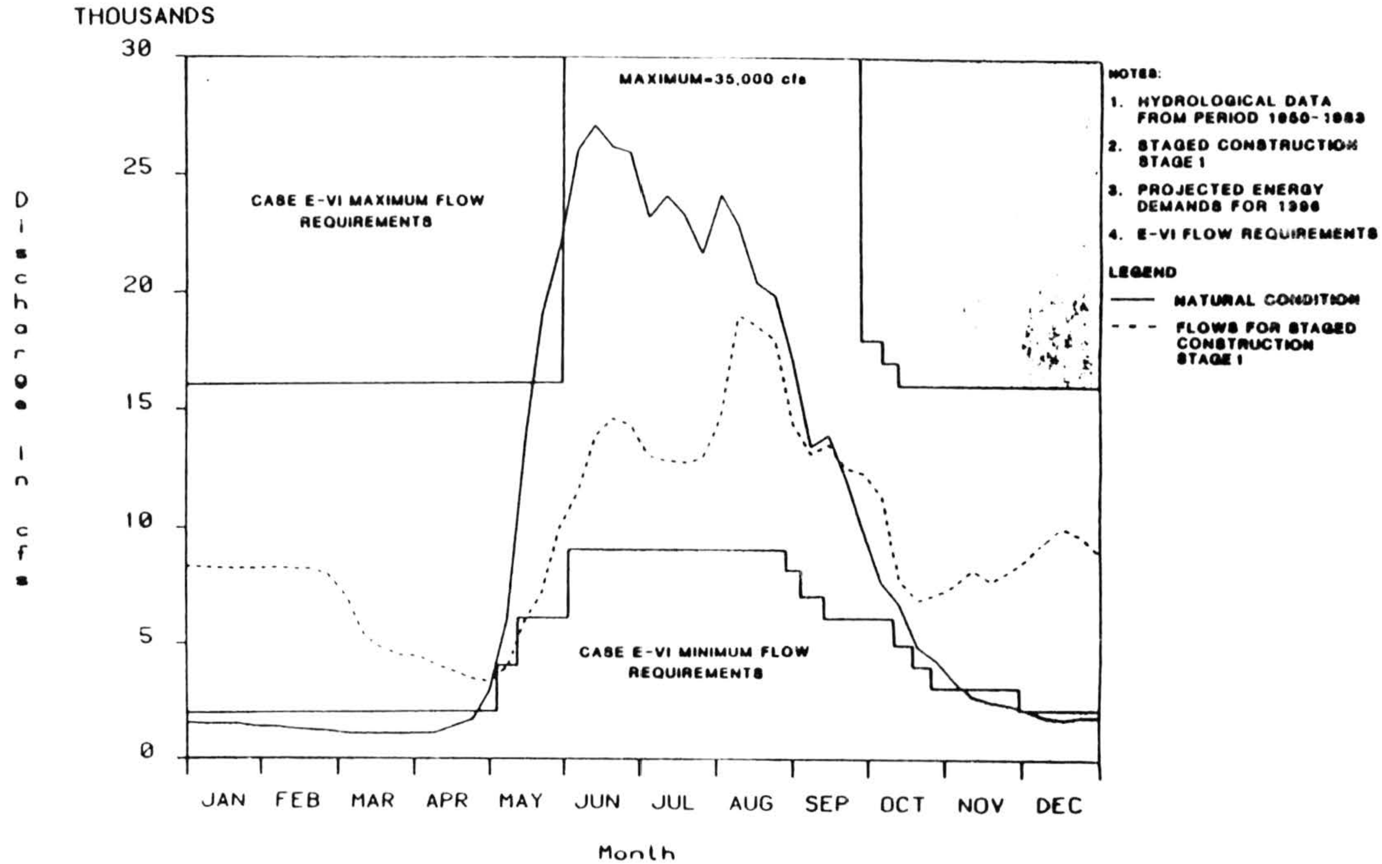
Figure 7

Reference: Harza-Ebasco 1985



Comparisons of Susitna River Natural and Stage 1 1996 Streamflows Exceeded 50% of the time at Gold Creek

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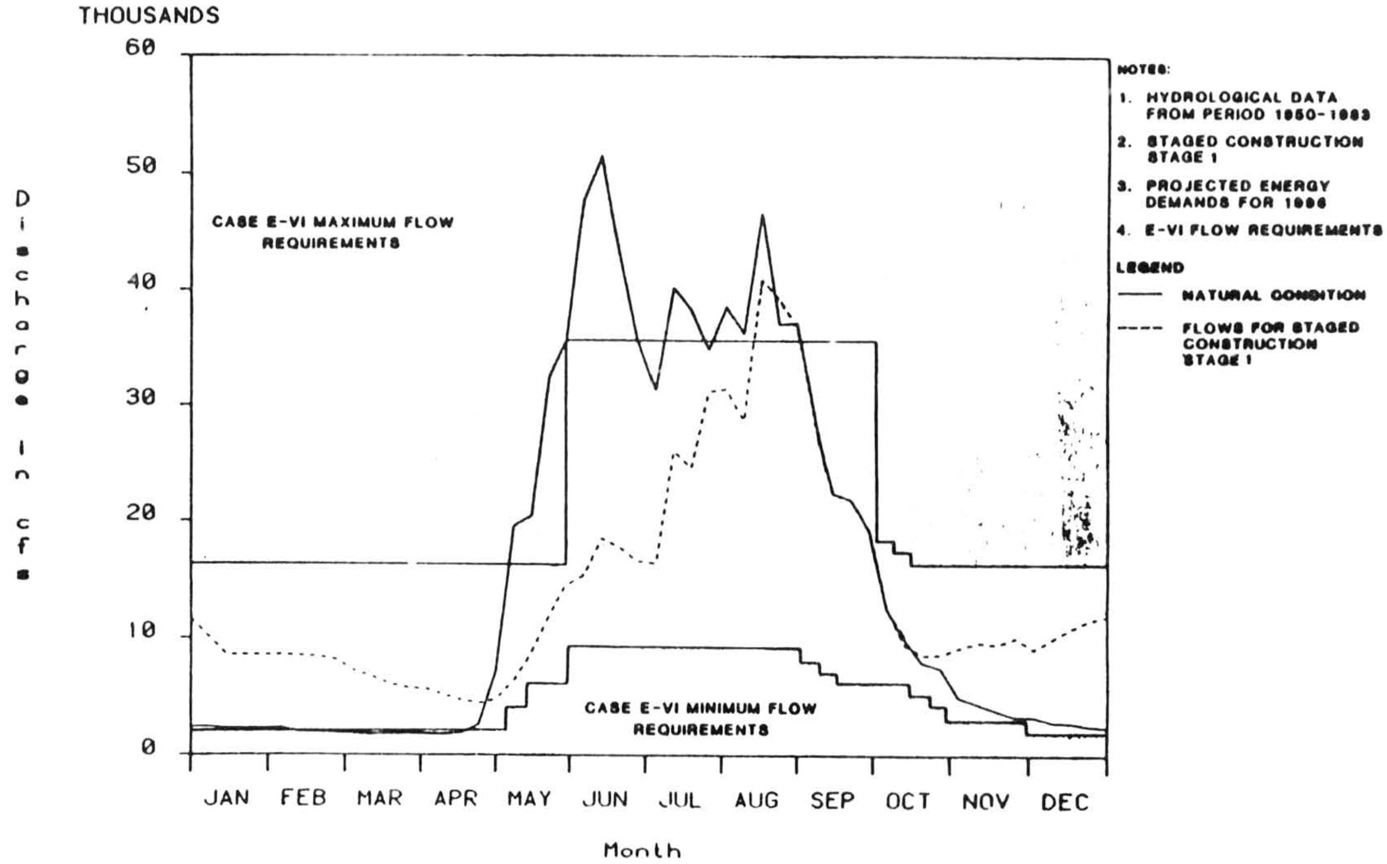
Figure 8

Reference: Harza-Ebasco 1985



Comparisons of Susitna River Natural and Stage 1 1996 Streamflows Exceeded 6% of the time at Gold Creek

Figure 9

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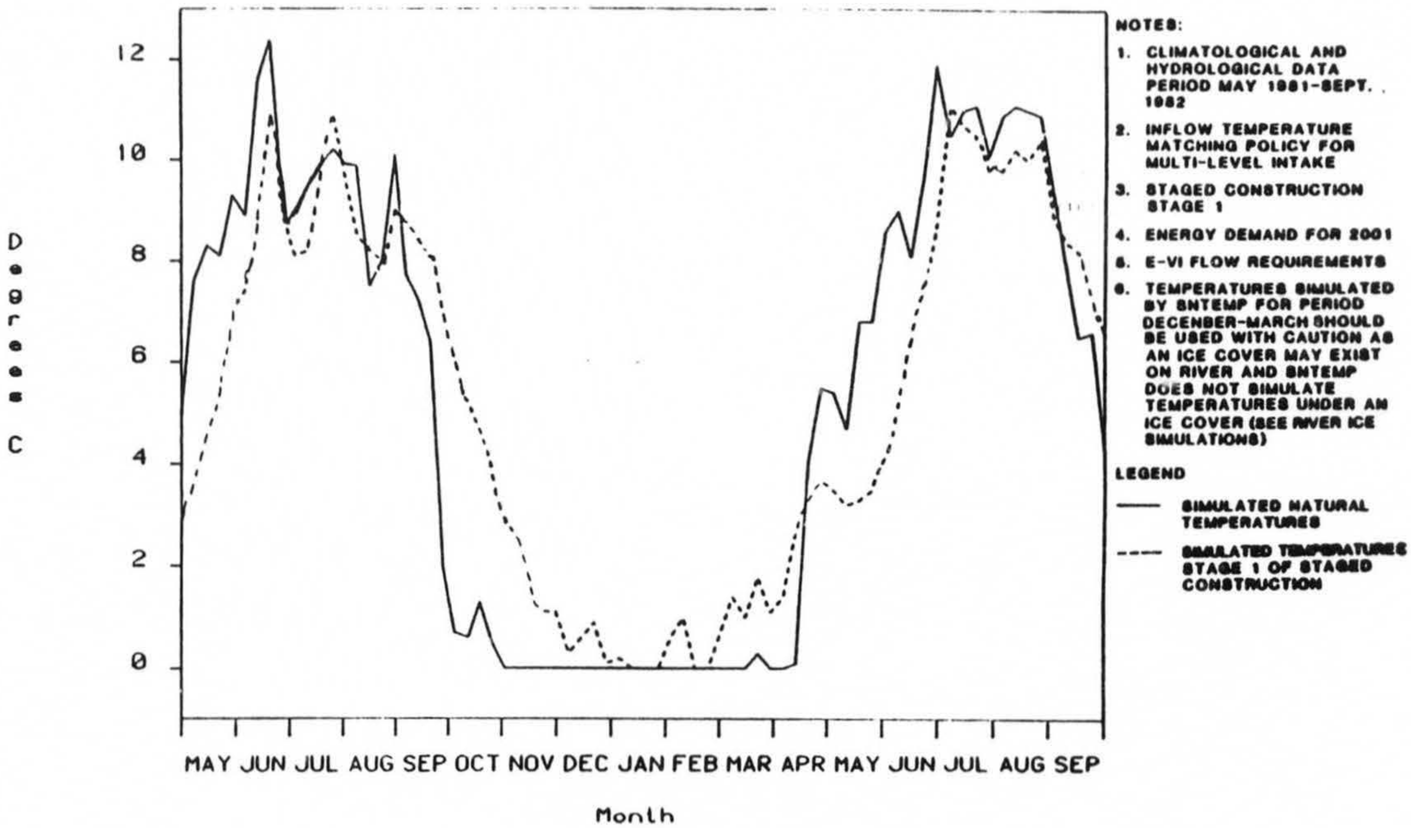
HARZA-EBASCO
SUSITNA JOINT VENTURE

Reference: Harza-Ebasco 1985



Simulated Natural and Stage 1 2001 Susitna River Temperatures at River Mile 150

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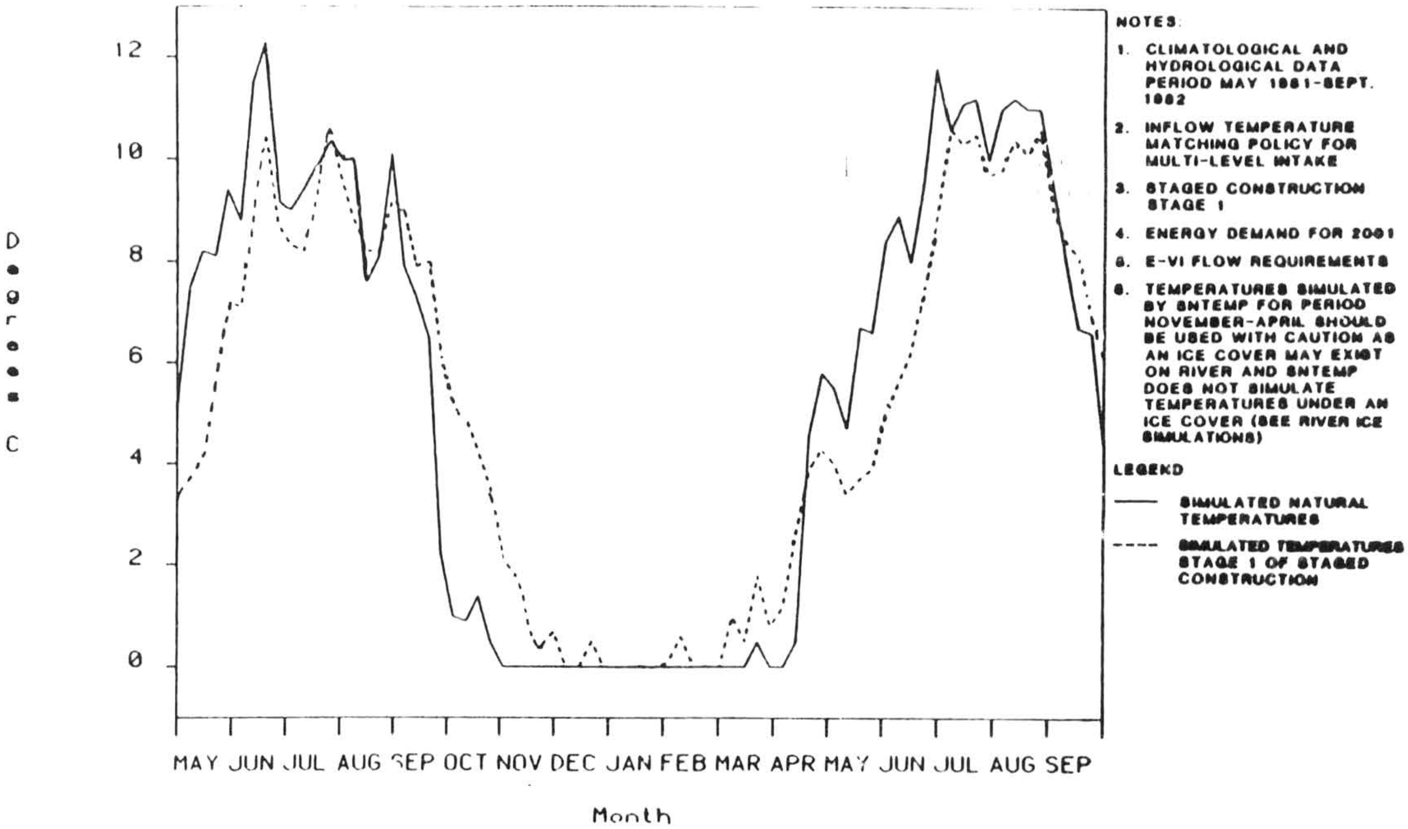
Reference: Harza-Ebasco 1985

Figure 10



Simulated Natural and Stage 1 2001 Susitna River Temperatures at River Mile 130

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

Reference: Harza-Ebasco 1985

Figure 11

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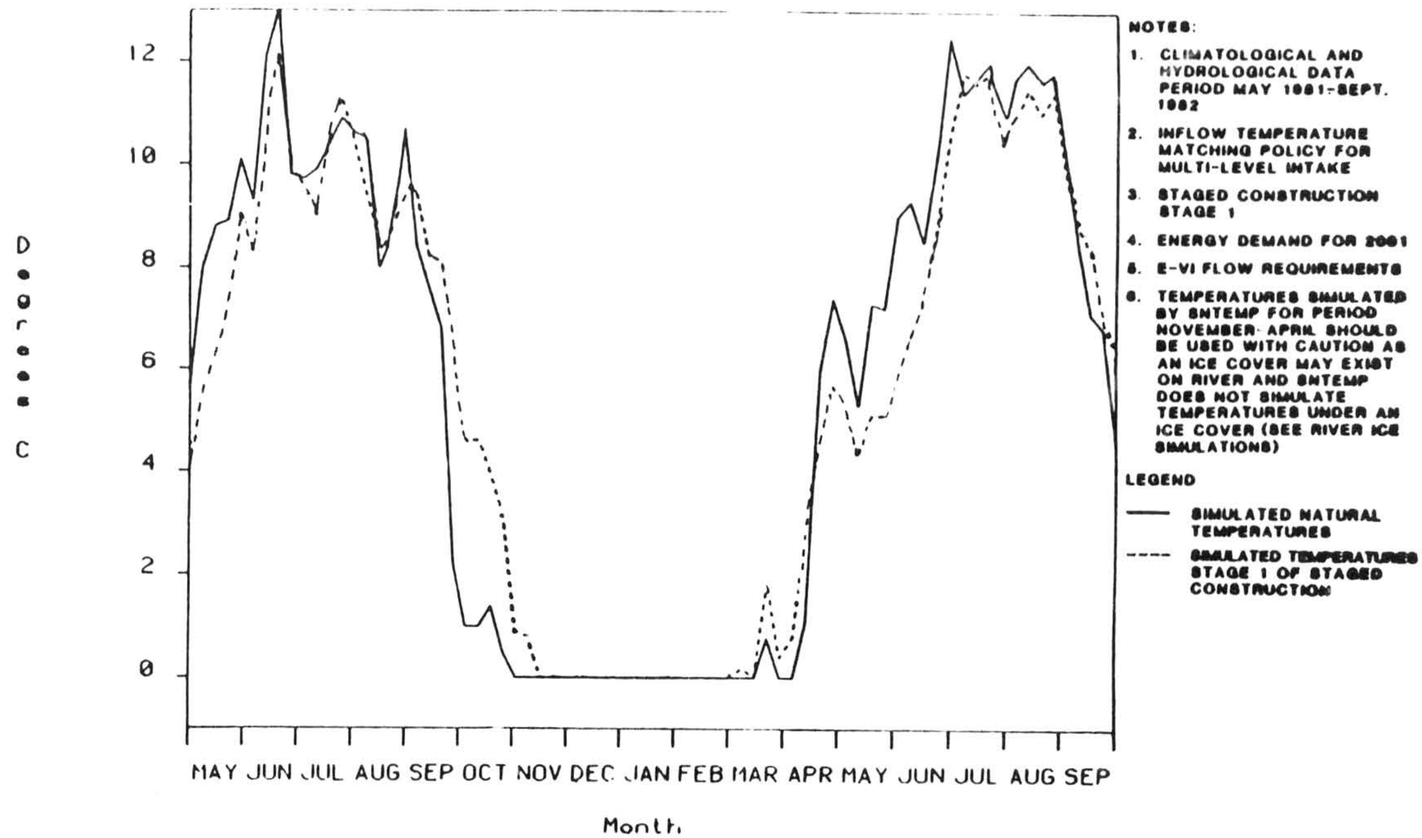
SUSITNA JOINT VENTURE



Simulated Natural and Stage 1 2001 Susitna River Temperatures at River Mile 100

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Reference: Harza-Ebasco 1985

Figure 12

result in higher staging in the ice covered areas. Upstream of the ice front the stage of the open water would be less than the effective stage of the ice cover formed under natural condition.

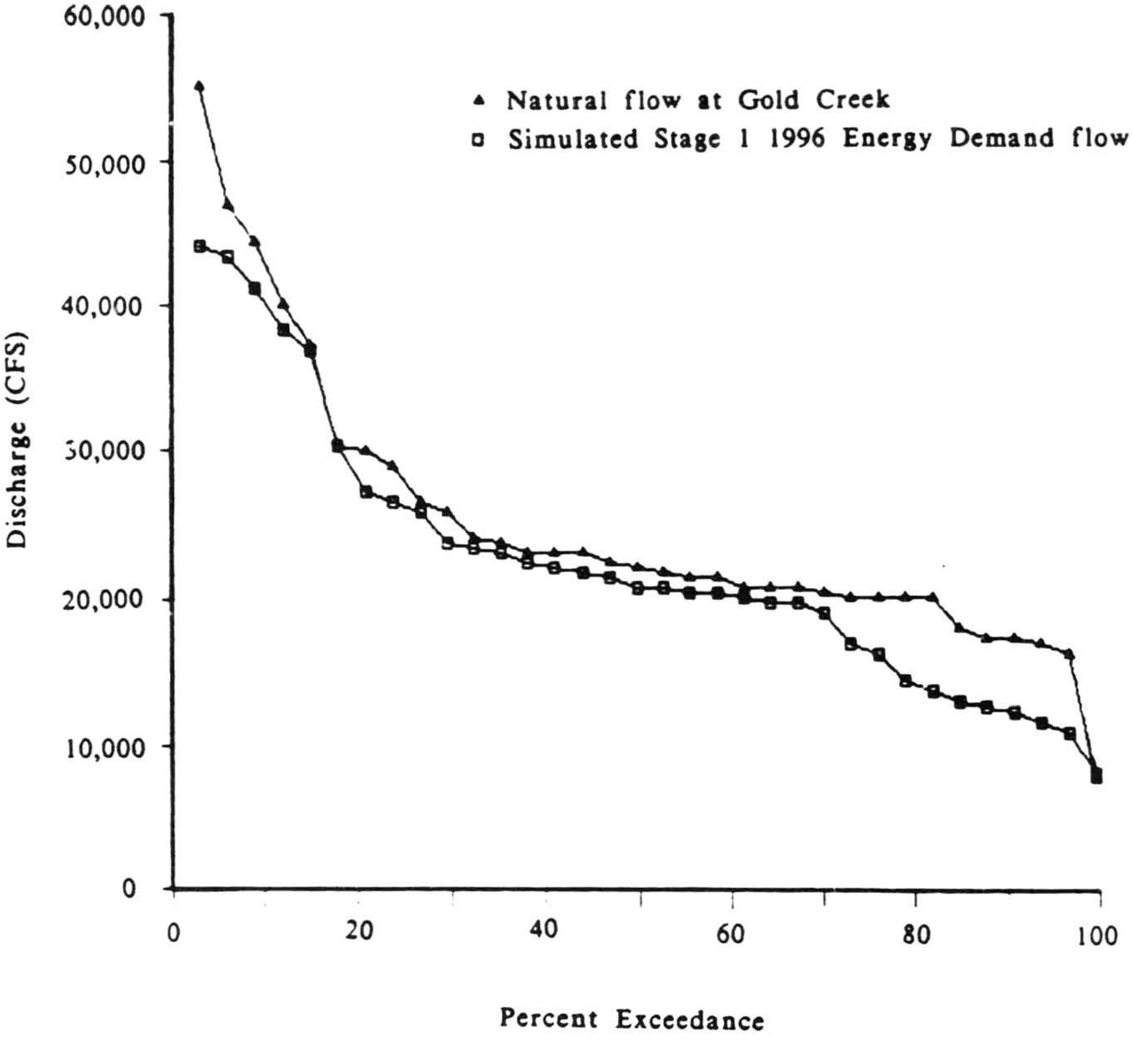
Turbidity levels during Stage 1 would be less than natural in the summer and greater than natural in the winter.

(i) Primary Evaluation Species

- Chum Salmon

. Spawning Adults and Incubating Embryos and Pre-Emergent Fry

Stage 1 - 1996 project flows during the spawning season for chum salmon (August 12 - September 15) would be less than natural flows. Flow duration curves for natural and simulated Stage 1 mean weekly flows based on 34 years of record are compared for each week of the spawning period (water weeks 45-49) in Appendix Figures 1-5. Natural and simulated Stage 1 weekly flow duration curves based on the maximum mean weekly flow for weeks 45-49 of each year for the 34 years of record are presented in Figure 13. Although the flows are substantially greater than E-VI minimum constraints, a reduction in the frequency of occurrence of successful passage conditions and availability of suitable habitat would occur. The extent of these reductions for the major chum producing sloughs and side channels (sloughs 8A, 9, 9A, 11, 21 and Upper Side Channel 11 and Side Channel 21) were analyzed. The percent of time successful passage conditions would be available at the passage reach of each slough was estimated by selecting the exceedance value associated with the minimum mainstem discharge that provided passage either



Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for weeks 45 to 49 based on mean weekly flows for 34 years of record.

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Figure 13

through backwater, controlling breaching flows or local flow (excluding direct surface runoff). The results of these analyses are presented in the discussion of individual sloughs below.

Stage 1 - 1996 project flows during the incubation period for chum salmon would be higher than natural from October through April. As the winter ice cover forms, the staging associated with the higher than natural flows would result in increased upwelling benefitting incubation but would also result in near-0°C mainstem water overtopping sloughs and possibly retarding the growth and delaying the emergence of embryos that ordinarily incubate at 2-3°C. This upstream progression of the ice front and potential for overtopping would range from RM 127 to RM 145 for Stage 1 - 1996 depending on year-specific meteorological conditions.

Increasing the height of berms at the slough head was proposed in the Fish Mitigation Plan (WCC 1984) as a method to prevent the overtopping of sloughs during winter. While this may be beneficial for incubation it would reduce the frequency of successful passage conditions resulting from breaching flows during the spawning season. In the analysis of Stage 1-1996 flow effect on passage conditions that follows, both unbermed and bermed conditions for each slough are considered.

. Slough 8A

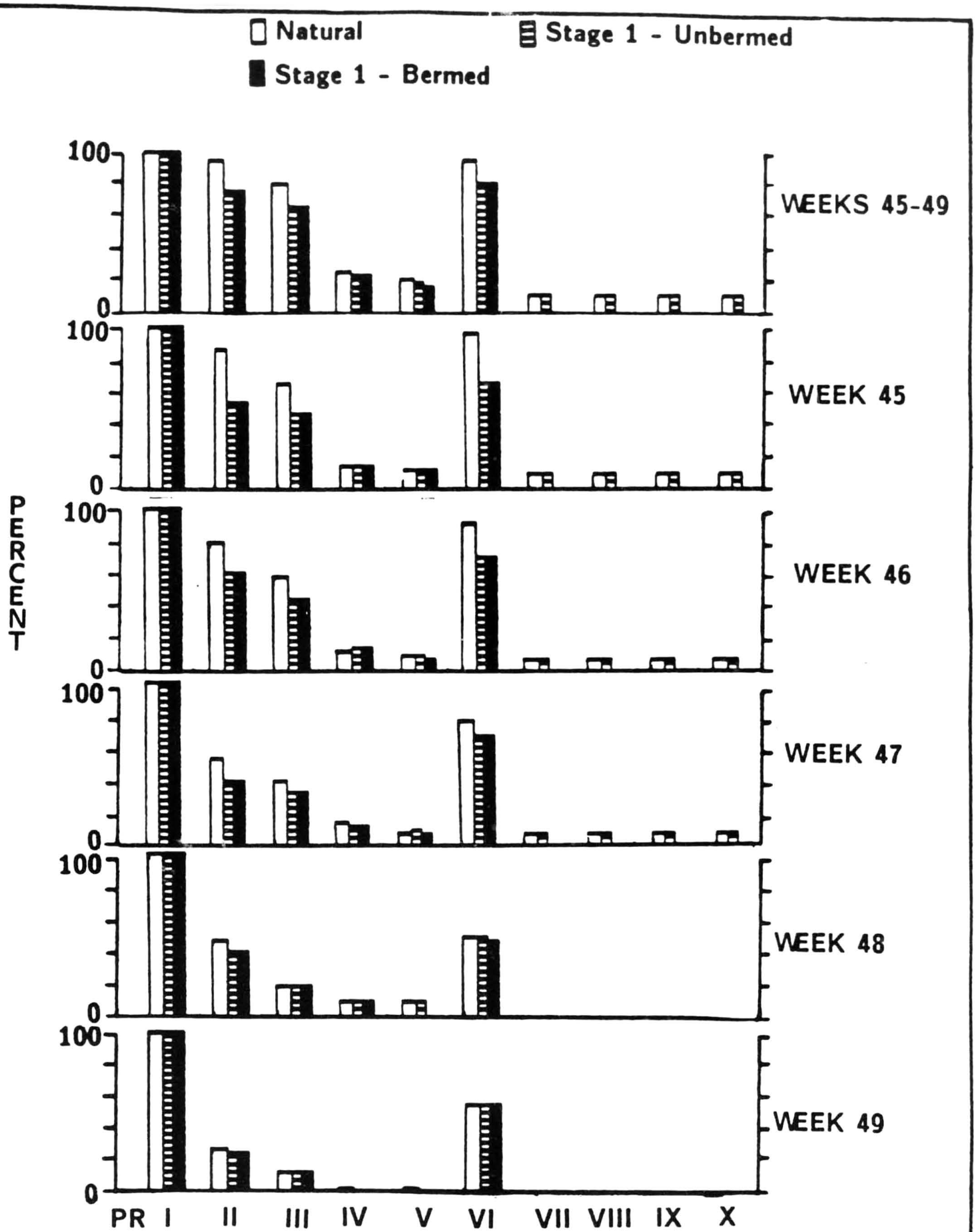
.. Relative Utilization

During the 1981-1984 studies, the mean peak counts of chum salmon and sockeye salmon in Slough 8A were 478 (range: 37-917) and 110 (range 67-177). The mean estimated total escapements to the slough were 1009 chum (range: 112-2383) and 247 sockeye (range: 131-532) (Barrett et al. 1985). Slough 8A mean chum and sockeye escapements comprised 14.9 and 14.3 percent of the total escapement to sloughs in the middle Susitna River.

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 8A under natural, Stage 1 unbermed, and Stage 1 bermed are graphically depicted for each week and for all weeks combined of the spawning period in Figure 14. The prevailing mechanism for passage (backwater, local flow or breaching) and associated frequency values are listed for each week and for the entire period in Appendix Tables 1 to 6.

Under natural and Stage 1 flow regimes, the frequency of successful passage conditions decreases progressively with each week of the spawning season as mainstem flows decline. The differences between natural and Stage 1 flows are greatest, although not substantial, at the beginning of the spawning season (Week 45) and gradually narrow by the last week (Week 49). This is attributable to the passage provided by the relatively high breaching discharges at Slough 8A, 27,000 and 33,000 cfs, which occur at a greater frequency with natural flows than with project flows early in the season. Later in the season the frequencies of these flows are at or near zero for both natural and project flows. A similar pattern is evident with both a bermed and unbermed slough. The most noteworthy decrease in frequency of successful passage occurs at Passage Reaches VII-X where the natural frequency of 15 percent for the entire periods



Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Slough 8A

Figure 14

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(weeks 45-49) drops to 0 percent for the Stage 1 bermed condition.

The probability of Slough 8A overtopping in the winter is high under Stage 1-1996 flows. The length, height, locations, and costs of berms necessary to prevent the likelihood of overtopping will be assessed in an upcoming summer field program.

Slough 9 - 9B

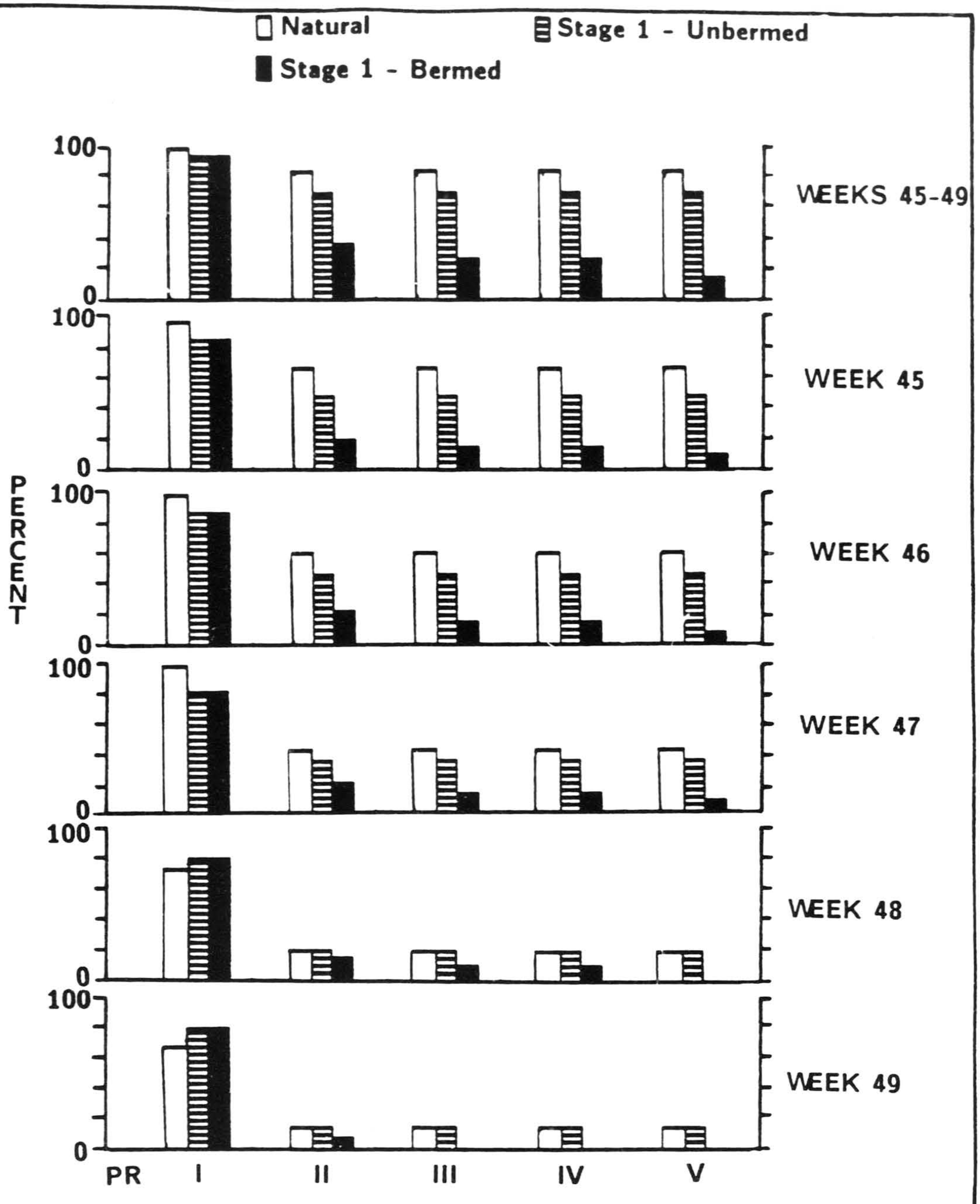
.. Relative Utilization

During the 1981-1984 studies, the mean peak counts of chum and sockeye salmon in Slough 9 (including 9B) were 312 (range: 175-423) and 28 (range: 2-91). The mean estimated total escapements to the slough were 531 chum (range: 430-645) and 70 sockeye (range: 0-230) (Barrett et al. 1985). Slough 9 and 9B mean chum and sockeye escapements comprised 7.8 and 4.0 percent of the total mean escapement to sloughs in the middle Susitna River.

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 8A under natural and Stage 1 flows with the slough bermed and unbermed are graphically depicted for each week and for all weeks of the spawning period combined in Figure 15. The prevailing mechanism for passage and associated frequency values are listed for each week and for the period in Appendix Tables 7 to 12.

In general, the reduction in frequency of passage from natural to an unbermed slough under Stage 1 for each



Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Slough 9

Figure 15

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week and for the entire period would not likely be sufficient to alter present utilization patterns. However, given the relatively low breaching discharge (19,000 cfs), a bermed slough would substantially reduce the frequency of passage from natural conditions at Passage Reaches II-V. Passage into Slough 9B through Slough 9, in particular, is dependent on breaching flows.

Slough 9 would likely be overtopped in most years of operation. The length, height, locations and costs of berms necessary to prevent overtopping will be assessed in an upcoming summer field program.

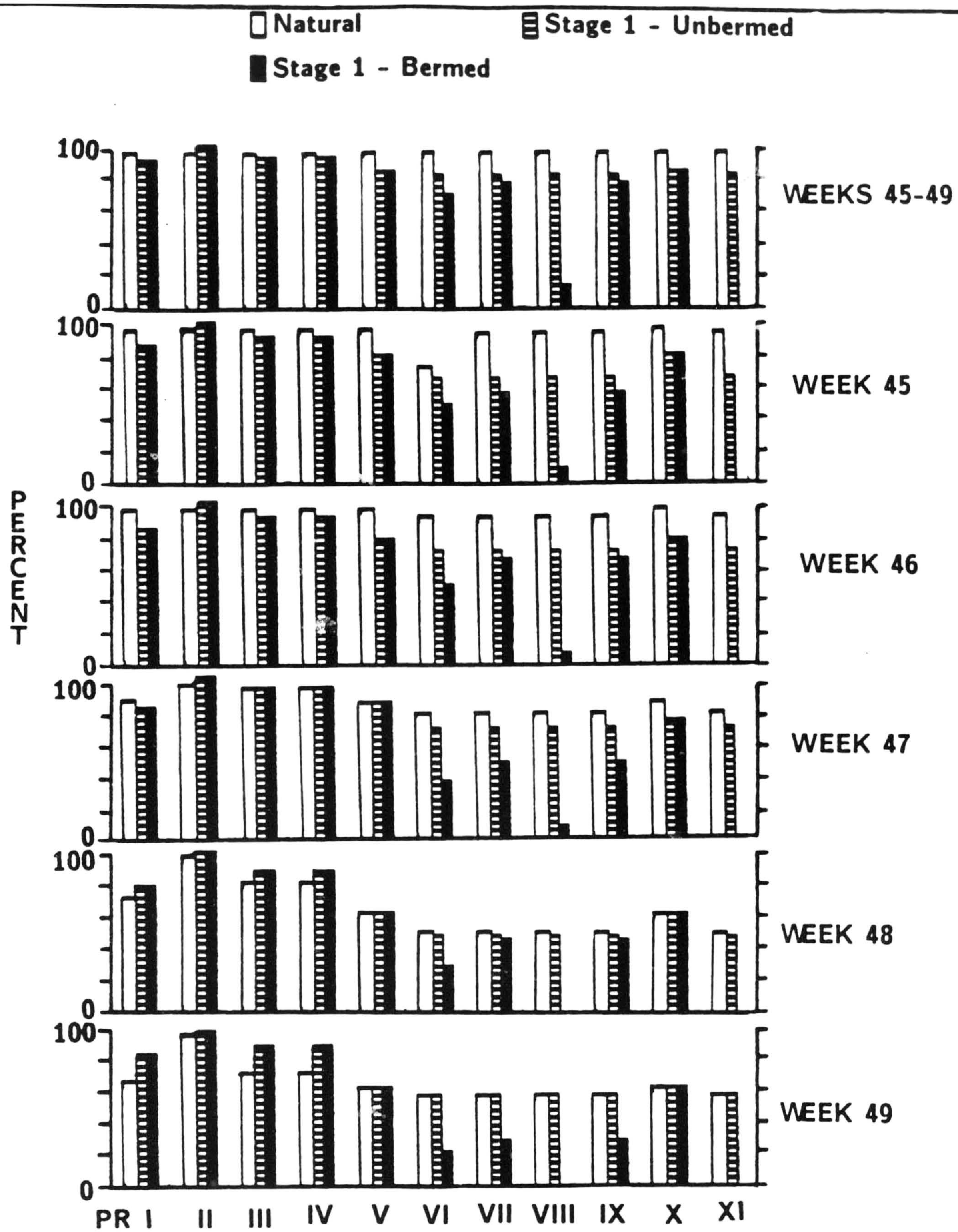
. Slough 9A

.. Relative Utilization

During the 1981-1984 studies, the mean peak count of chum salmon in Slough 9A was 17 (range: 105-303) while the mean estimated total escapement to the slough was 246 chum (range 86-528) (Barrett et al. 1985). Slough 9A mean chum and sockeye escapement comprised 3.6 and 0.1 percent of the total escapement to sloughs in the middle Susitna River.

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 9A under natural and Stage 1 flows with the slough bermed and unbermed are graphically depicted for each week and for all weeks of the spawning period combined in Figure 16. The prevailing mechanism for passage and associated frequency values are listed for each week and for the period in Appendix Tables 13 to 18.



Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Slough 9A

Figure 16

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The low breaching flow (13,500 cfs) and low mainstem discharges that provide the local flow necessary for passage at most passage reaches account for the slight and inconsequential reductions in passage frequencies from the natural to project flows. Even with a bermed slough only two passage reaches, VIII and XI, experience substantial declines in the frequency of passage.

Slough 9A with its low breaching flow is predicted to be overtopped in most years. The length, height, locations and costs of berms necessary to prevent overtopping will be assessed in an upcoming field program.

. Slough 11

.. Relative Utilization

During the 1981-1984 studies, the mean peak counts of chum salmon and sockeye salmon in Slough 11 and Upper Side Channel 11 were 674 (range: 238-1586) and 540 (range: 248-893). the mean estimated total escapements to the slough were 1572 chum (range: 674-3,481) and 1,166 sockeye (range: 564-1,620) (Barrett et al. 1985). Slough 11 and Upper Side Channel 11 mean chum and sockeye escapements comprised 23.2 and 67.3 percent of the total escapement to sloughs in the middle Susitna River.

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 11 under natural flows and Stage 1 flows with the slough bermed and unbermed are graphically depicted for each week and for all weeks combined of the spawning period in Figure 17. The prevailing mechanism for passage and associated frequency values are listed for each week and for the period in Appendix Tables 19 to 24.

Project flows would reduce the frequency of successful passage only to a minor degree in Slough 11. The relatively high breaching discharge at this site indicates that it contributes infrequently to passage. Construction on berms at this slough would reduce passage in the upper passage reaches by about 6 percent. The other passage reaches would be unaffected.

Slough 11 is predicted to be overtopped in years of average or colder meteorological conditions.

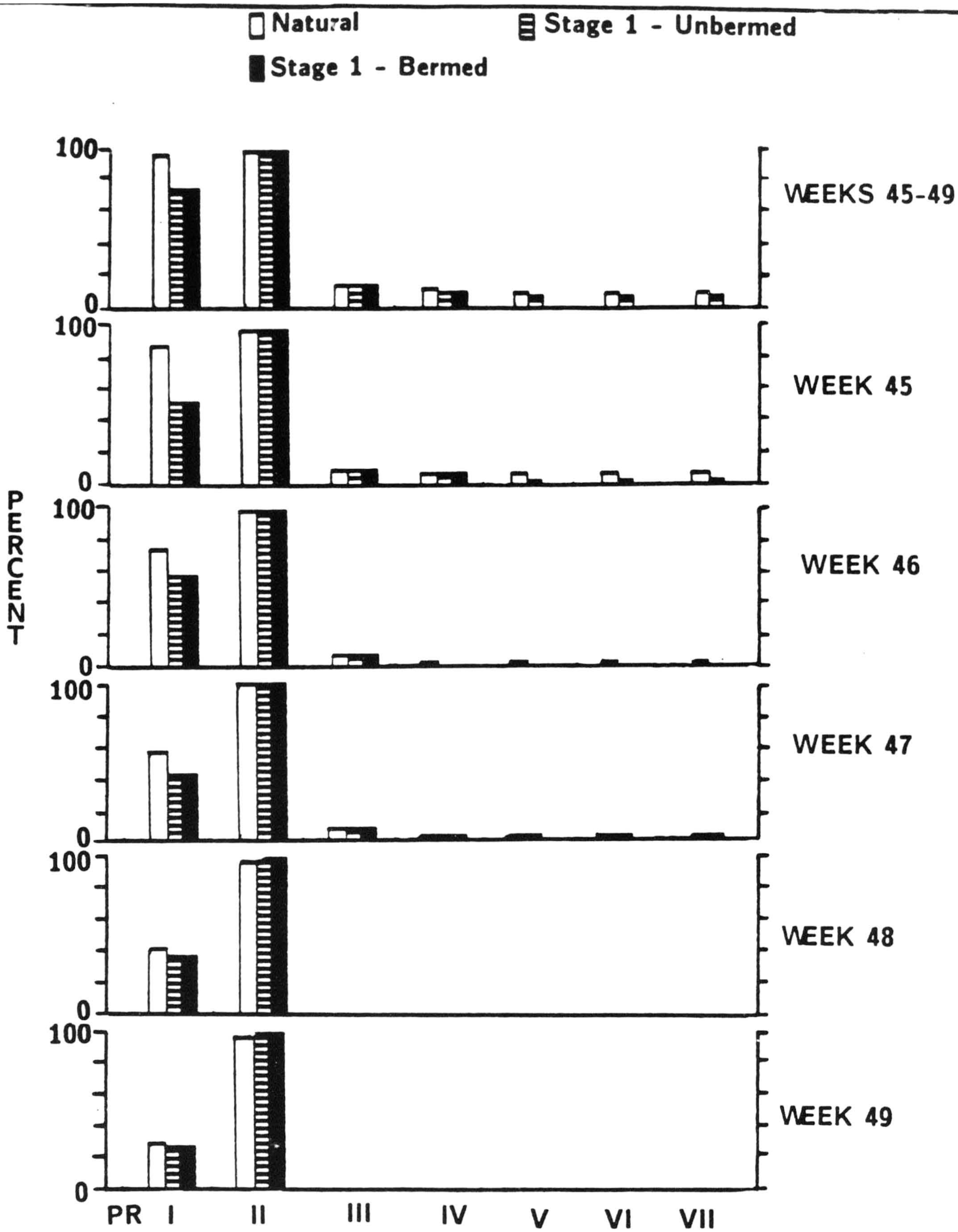
. <u>Upper Side Channel 11</u>

.. <u>Relative Utilization</u>

(see Slough 11)

.. <u>Impact Mechanism</u>

The frequencies of occurrence of successful passage conditions at each passage reach of Upper Side Channel 11 under natural flows and Stage 1 flow with the side channel bermed and unbermed are graphically displayed for each week and all weeks of the spawning period in Figure 18. Insufficient data were available to evaluate the influence of mainstem discharge on local flow and backwater effects at Passage Reach II (Appendix Tables 19-24).



Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Slough 11

Figure 17

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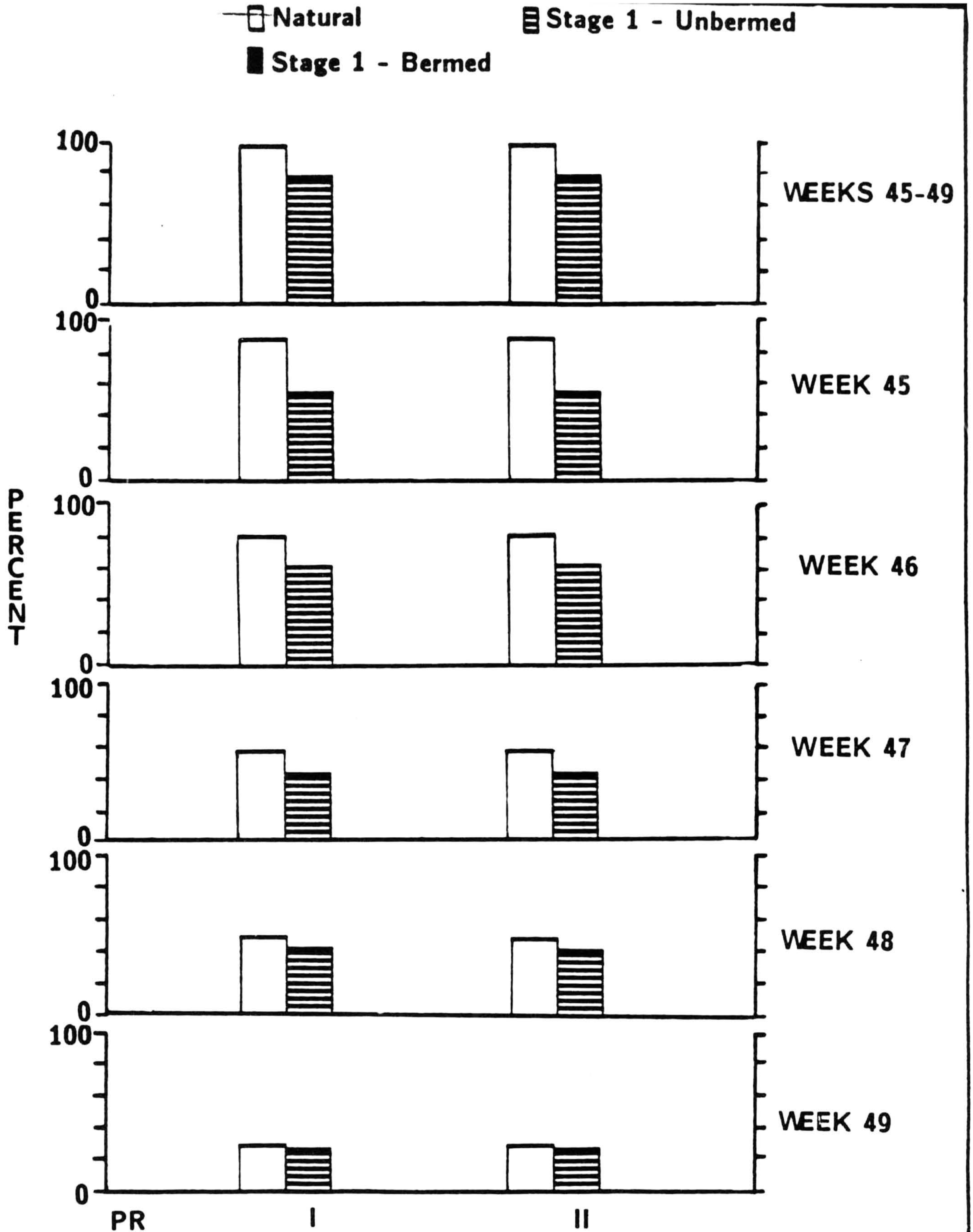

Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Upper Side Channel 11

Figure 18

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The difference in the percent of time passage is available under natural and Stage 1 project flows based on breaching flows would not likely affect the utilization of this site to a large degree. The lack of data mentioned previously does not all a discussion of passage condition with the side channel bermed.

This site is predicted to be overtopped under Stage 1 flow with average or colder meteorological conditions. The length, height, location and cost of berms to prevent overtopping will be assessed in an upcoming field program in conjunction with Slough 11 and with which it is contiguous.

. Slough 21

.. Relative Utilization

During the 1981-1984 studies, the mean peak counts of chum salmon and sockeye salmon in Slough 21 and Side Channel 21 were 921 (range: 274-2,354) and 103 (range 38-197). The mean estimated total escapements to the slough were 1,7780 chum (range: 481-4,245) and 150 sockeye (range: 63-294) (Barrett et al. 1985). Slough 21 and Side Channel 21 mean chum and sockeye escapements comprised 25.9 and 8.7 percent of the total escapement to sloughs in the middle Susitna river.

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 21 under natural flows and Stage 1 flow with the slough bermed and unbermed are graphically displayed for each week and for all weeks combined of the spawning period in

Figure 19. The prevailing mechanism for passage and associated frequency values are listed for each week and for the period in Appendix Tables 25 to 30.

Project flows would reduce the frequency of passage only slightly for an unbermed slough and for a bermed slough at Passage Reaches I and II. Passage at Passage Reaches IIIL and IIIR for a bermed conditions would be reduced about 29 percent from the natural condition.

Slough 21 has a low probability of overtopping which would only occur in the coldest of years. Berming of this slough would therefore not be a high priority.

. Side Channel 21

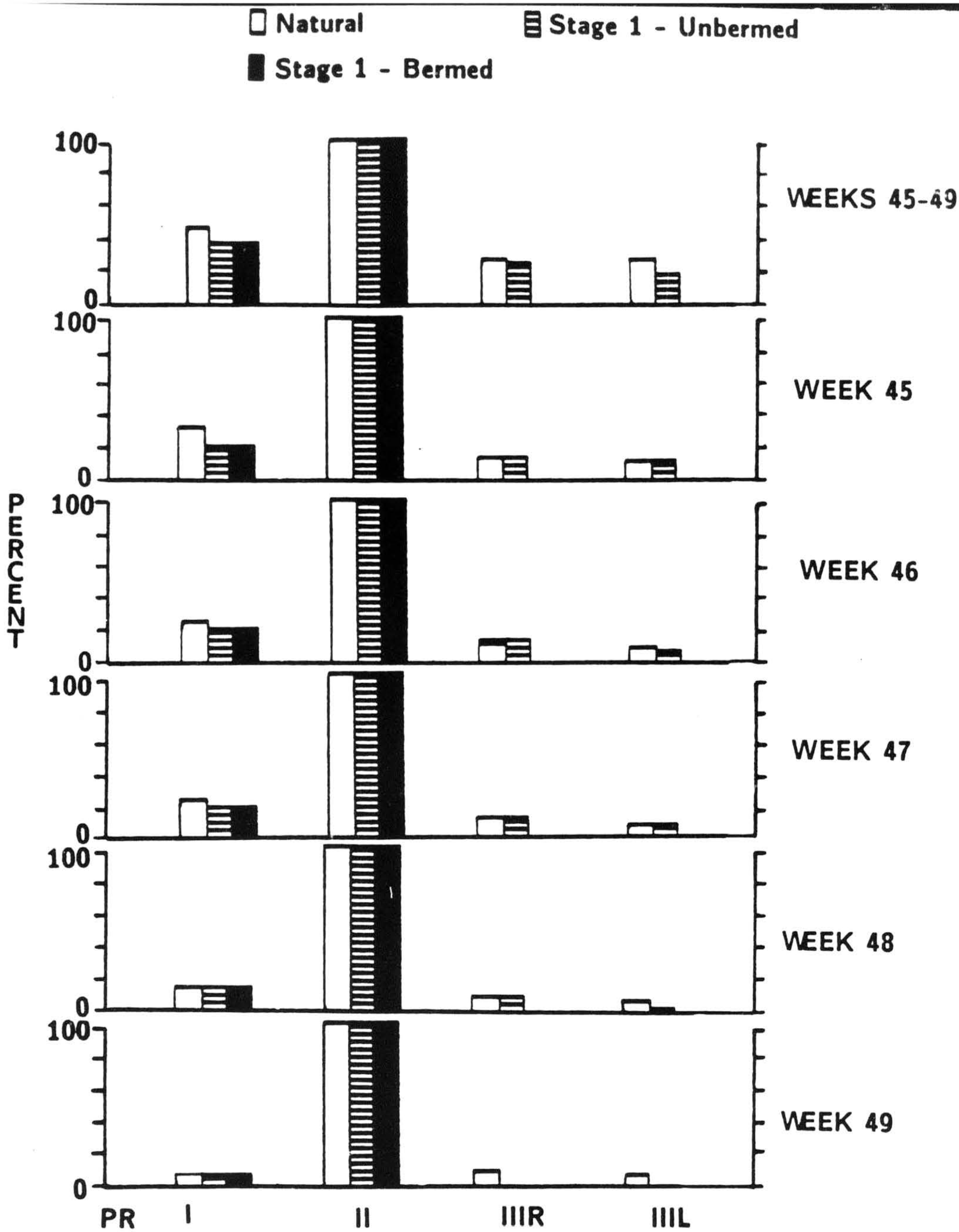
.. Relative Utilization

(see Slough 21)

.. Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 21 under natural flow and Stage 1 flows with the side channel bermed and unbermed are graphically displayed for each week and for all weeks combined of the spawning period in Figure 20. The prevailing mechanism and values are also listed for each week and for the period in Appendix Tables 25 to 30.

Due to the low breaching flow (12,000 cfs) that affects the majority of passage reaches in the side channel, project flows would slightly reduce the frequency of successful passage in an unbermed condition. For a



Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Slough 21

Figure 19

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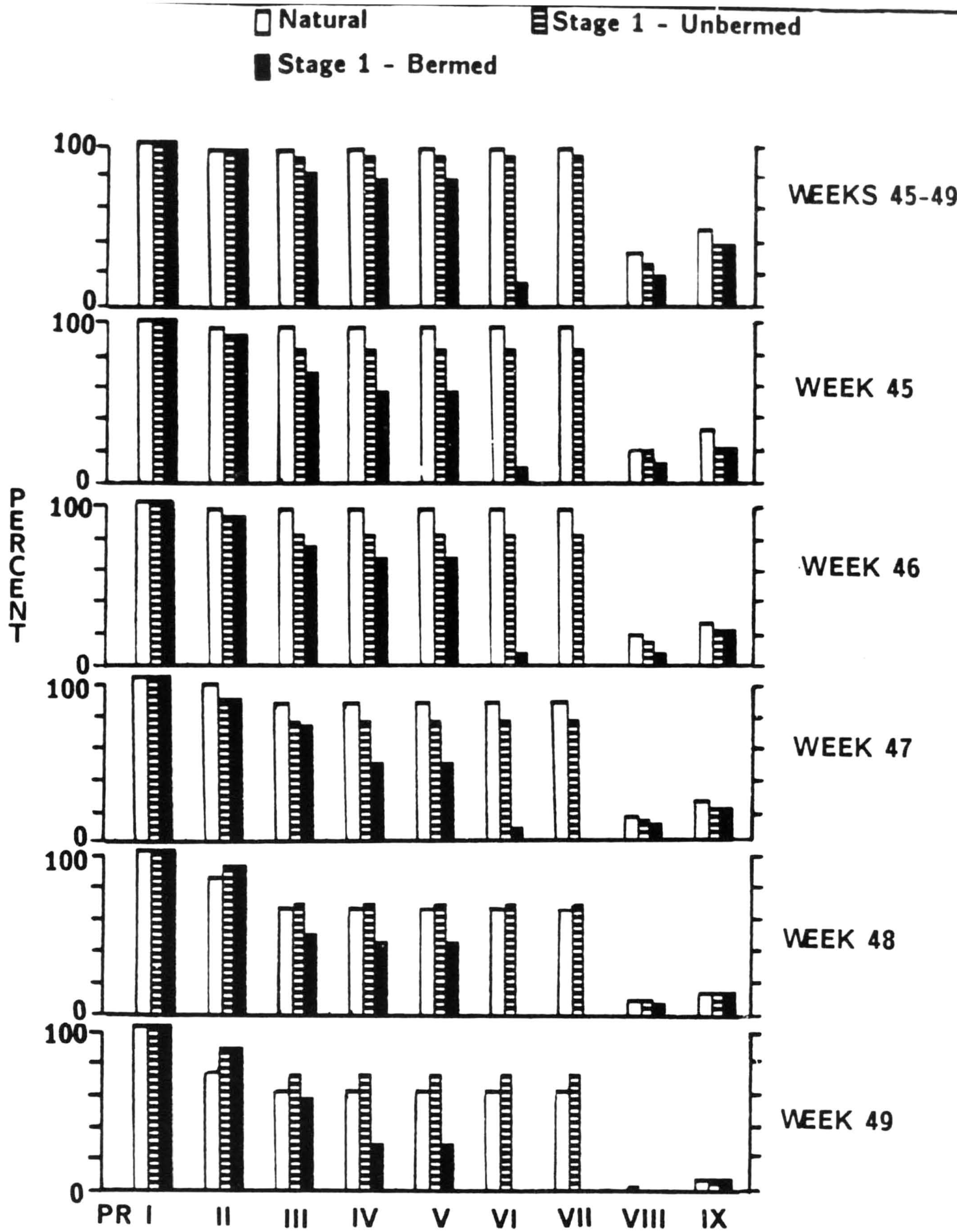

Percent of Time Successful Passage Occurs Under Natural and Stage 1 Flows at Side Channel 21

Figure 20

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bermed condition, local flow or backwater effects would maintain passage at a high frequency for Passage Reaches I-V. Substantial reductions in frequency would occur at Passage Reaches VI and VII.

The ice front would not progress as far as Side Channel 21 in an average winter; however, in the colder winter it would and overtopping may result. Based on this low probability, berming may not be necessary.

- Chinook Salmon

  . Rearing Juveniles

The open water flow regime during Stage 1 provides higher flows than filling yet lower flows than natural. In general, the flows are substantially greater than the E-VI minimums which were designed to minimize impacts to juvenile chinook rearing. As results of an ongoing study of juvenile chinook rearing habitat-flow relationship are made available in fall 1985, impacts of Stage 1 flows can be assessed.

Impacts to juvenile chinook overwintering habitat resulting from overtopping of sloughs and side channel is also of concern. As information on the extent of overtopping that may occur with Stage 1 flows is acquired in the summer field program, potential impacts to juveniles chinook rearing in these areas may, in part, be addressed.

(ii) Secondary Evaluation Species

In the evaluation of the effect of project filling flows on the habitat of the secondary evaluation species, no significant impacts were identified. Since Stage 1 open water flows lie between filling and natural flows, no impacts are anticipated.

The Stage 1 winter flows, however, are substantially greater than filling and natural flows. The higher flows accompanied by ice staging in winter would increase depths, wetted surface area and the number and extent of backwater sites in the mainstem side channels and slough mouths. This potential increase in overwintering habitat may offset habitat lost from overtopping of some sloughs.

4.1.2 Mitigation

(A) Filling

The primary impact identified during filling flows is restricted access into sloughs by adult chum salmon. The extent of this impact would depend on hydrologic conditions of that year. During a wet year, impacts would likely be minimal. Assuming a worst case dry year (based on the hydrologic record during filling up to August of that year) E-VI minimum flows would be provided during the spawning season.

Under E-VI minimum flows extensive modification of most sloughs would be required to maintain the average natural access conditions. These modifications would be in excess of those required for Stage 1, 2, and Stage 3-2008 operational flows.

The E-VI minimum flows during filling as compared to the substantially higher operational flows of subsequent years can be compared to the natural occurrence of dry years. For example, the E-VI minimum flow during August, 9,000 cfs, is greater than the maximum weekly average flow during the 1969 spawning period of 7399 cfs.

It is suggested therefore that if 1995 were a dry or average year and mitigation measures designed for 1996 operational flows are not complete or are insufficient, temporary low cost measures be employed to improve passage such as manually modifying critical passage reaches or physically transporting fish into the sloughs.

As mentioned previously, impacts to juvenile chinook rearing are in the process of being evaluated and should any be identified appropriate measures will be developed.

Impacts to secondary evaluation species, other than those that would be mitigated for by measures for chum salmon, are not anticipated.

(B) Operation

(i) Primary Evaluation Species

- Chum Salmon

. Spawning Adults and Incubating Embryos and Pre-Emergent Fry

The principal impacts identified for chum salmon spawning resulting from Stage I flows would be a reduction in the frequency of successful passage conditions in sloughs and a reduction in the quality of incubation habitat due to sloughs being overtopped with near $0^{o}C$ water.

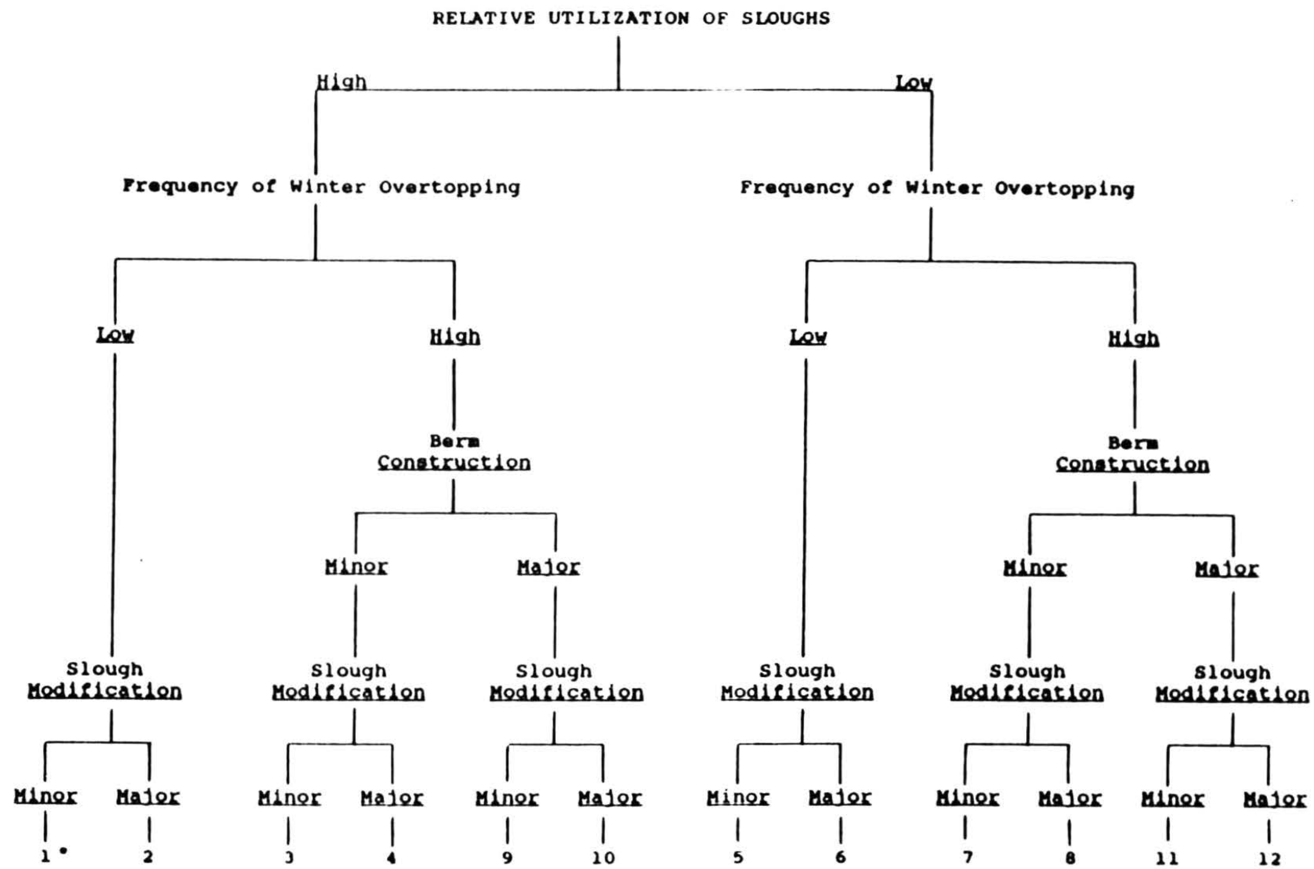
Since Stage 1-1996 operational flows would generally be well within the bounds of E-VI minimum and maximum flow constraints, Case E-VI would be considered of little mitigative value during this early stage with respect to the identified impacts. However, Case E-VI constraints on limiting the amount of daily and weekly fluctuations would be of importance in maintaining a stable habitat.

Habitat modification is the mitigative option of choice to rectify impacts to chum salmon spawning and incubation habitat. Various measures to maintain these habitats were described in Section 3.0.

The increase in ice staging with Stage 1 flow compared with that described for the License Application project may necessitate construction of more extensive berms than those described in the Fish Mitigation Plan (WCC 1984). As mentioned previously the length, height, location and cost of additional berming that may be necessary at the seven sites examined for passage may prove to be excessive and not cost-effective. In such cases, mitigation efforts should be directed to other sites.

A set of criteria has been developed to establish a means of ranking sloughs for modification on a benefit-cost basis. The criteria applied to each slough include the relative utilization, the frequency of overtopping, the extent of berming required to prevent overtopping, and the location and extent of passage reach modifications. The use of these criteria in a decision making flow chart is presented in Figure 21. As indicated in the chart, a slough with higher relative utilization, low probability of winter overtopping, and minor passage reach modification requirements would receive the highest ranking. As information on the extent of berming necessary for each site is acquired, this set of criteria will be applied to each of the major chum salmon producing sloughs.

If the cost of modifying one or more of these sloughs is excessive, alternative sites will be evaluated for modification as replacement habitat. A sufficient number of sites will be modified to insure there is no net loss of habitat value.



* The smaller the rank value at a site, the more cost-effective would be mitigation work at the site.

Flow Chart for Ranking Sites for Mitigation Decision Making

Figure 21

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- Chinook Salmon

  . Juvenile Rearing

  Juvenile chinook rearing habitat-flow relationships will be made available in fall, 1985 at which time any impacts that may result from project operation will be evaluated and appropriate mitigation measures proposed.

(ii) Secondary Evaluation Species

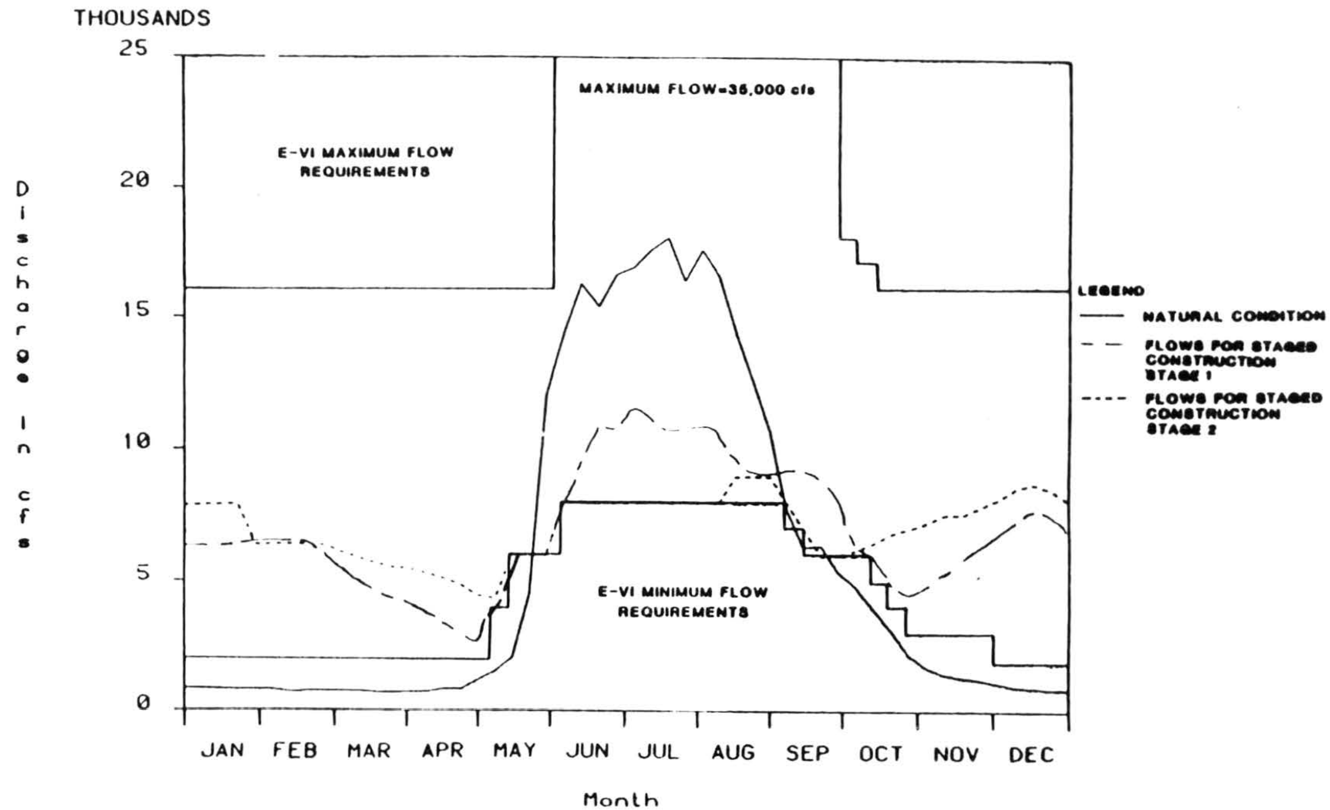
Mitigation measures proposed for chum salmon spawning will also mitigate for impacts to sockeye salmon spawning habitat. No other impacts have been identified for the other evaluation species for which mitigation measures need to be implemented.

4.2 - Stage 2 (2002-2008)

4.2.1 Impact Analysis

Power generation with Stage 2 (Devil Canyon) completed would commence in 2002. Regulated flow releases have been simulated for the first year of Devil Canyon-Watana operation based on anticipated 2002 energy demands. Natural, Stage 1-1996 and Stage 2-2002 flow regimes are compared at the 97, 50, and 6 percent exceedance probabilities in Figures 22-24. Stage 2 flows would generally be greater than Stage 1 flows during March and April and in late July and August and will be slightly less than Stage 1 flows in late fall to mid-winter in average and wet years. The opposite would occur in dry years (97 percent exceedence), with Stage 2 flows less than Stage 1 flows in summer and greater in winter. In contrast to Stage 1 flow, Stage 2 flows would reach Case E-VI minimum flow requirements during the spring filling period. The drier the year, the greater length of time flows would be at the minimum level.

Streamflow temperatures during Stage 2 operation would depend to some degree on the depth of drawdown and the use of multilevel intakes in Devil



Comparisons of Susitna River Natural, Stage 1 1996 and Stage 2 2002 Streamflows Exceeded 97% of the time at Gold Creek.

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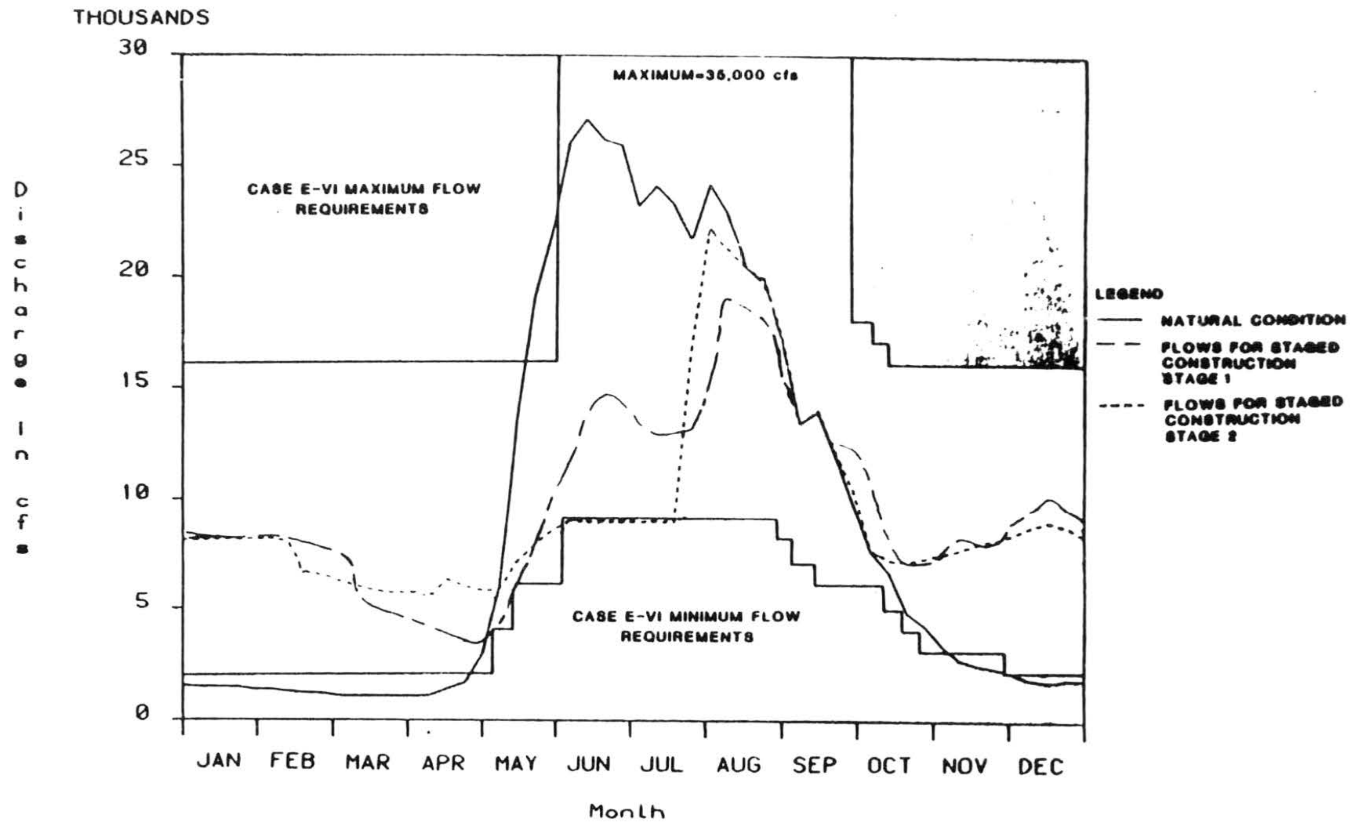
Reference: Harza-Ebasco 1985

Figure 22



Comparisons of Susitna River Natural, Stage 1 1996 and Stage 2 2002 Streamflows Exceeded 50% of the time at Gold Creek.

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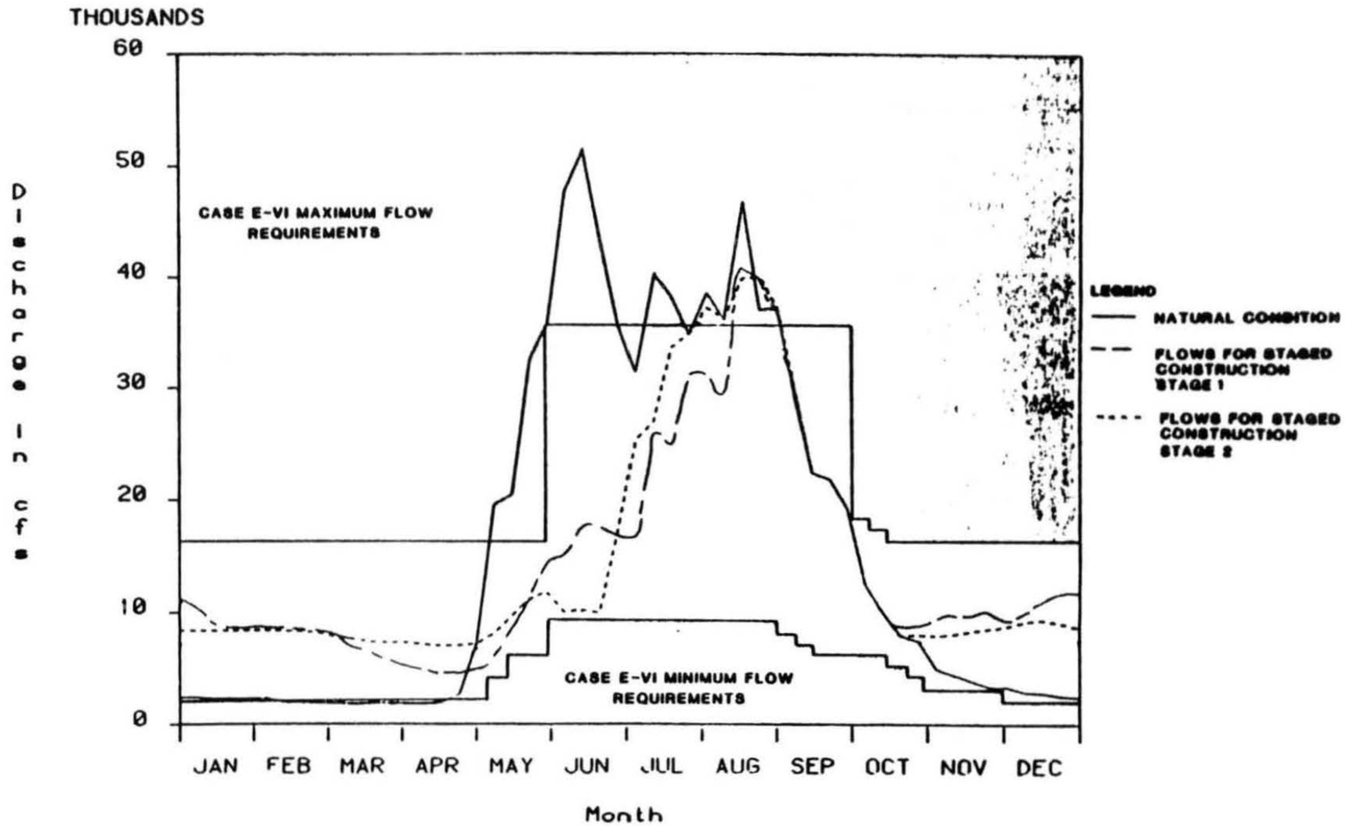
Figure 23

Reference: Harza-Ebasco 1985



Comparisons of Susitna River Natural, Stage 1 1996 and Stage 2 2002 Streamflows Exceeded 6% of the time at Gold Creek.

Figure 24

Reference: Harza-Ebasco 1985

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Canyon operation. In general, release temperatures would be cooler than Stage 1 in April through September (about 2-5°C less than natural) and warmer than Stage 1 from September to April (about 2-6°C greater than natural) (Harza-Ebasco 1985). The temperature regimes for three locations downstream of Devil Canyon RM 100, 130, and 150 are presented for a 50 ft drawdown and 2 levels of intakes in operation in Figures 25-27. The upstream progression of the ice front in Stage 2 would be to about RM 131 based on average climatological conditions (1981-1982).

Turbidity during Stage 2 is expected to be at similar levels and exhibit the same annual variations as described for Stage 1.

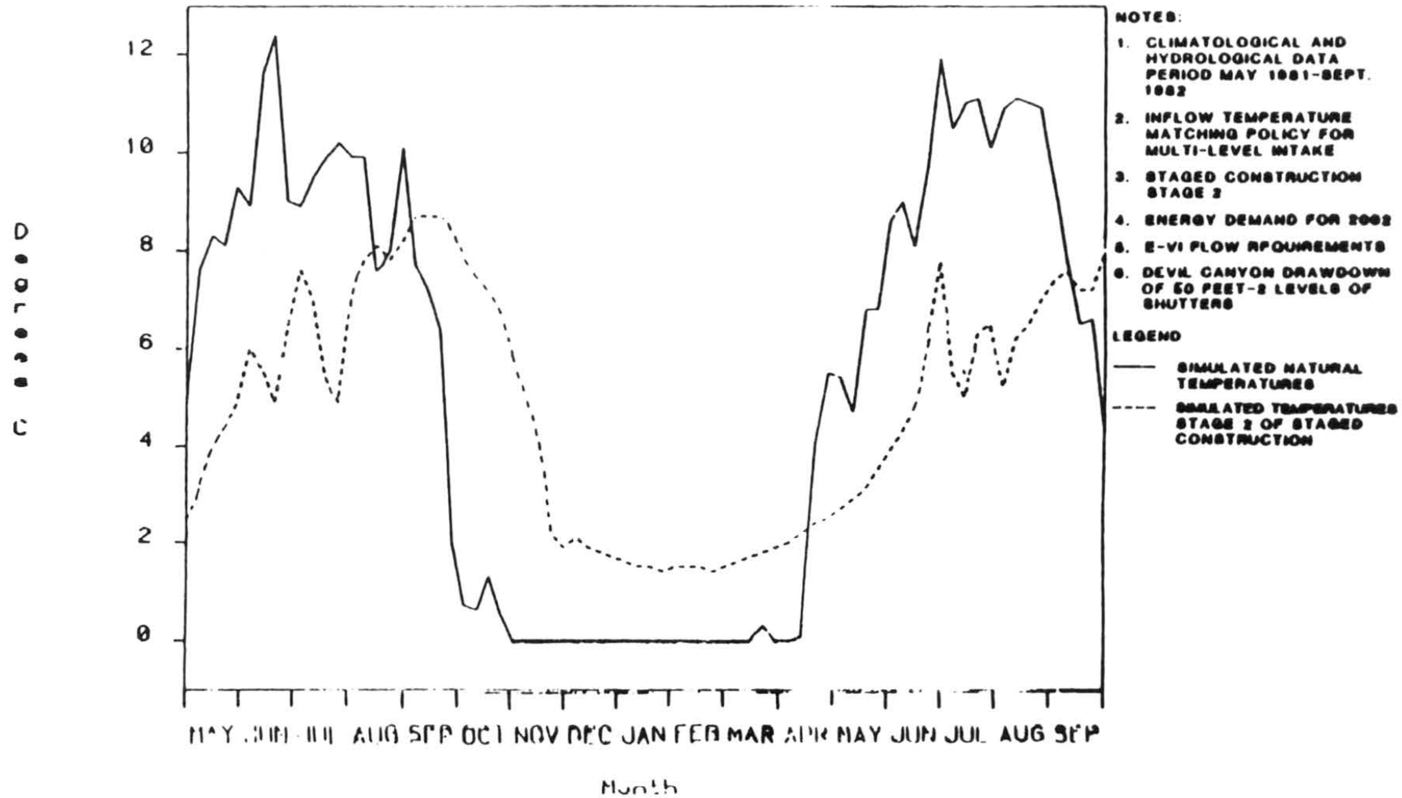
(i) Primary Evaluation Species

- Chum Salmon

. Adult Spawning and Incubating Embryos and Pre-Emergent Fry

Flow duration curves for simulated Stage 1-1996 and Stage 2-2002 mean weekly flows based on 34 years of hydrologic conditions are compared for each week of the spawning period in Appendix Figures 6-10. Simulated Stage 1 and Stage 2 flow duration curves based on the maximum mean weekly flow for weeks 45-49 of each year for the 34 years of record are presented in Figure 28. The Stage 2 flows above about 30,000 cfs that are important for passage would occur at a greater frequency than similar Stage 1 flows. Stage 2 flows greater than 40,000 cfs would occur at lesser frequency.

Slough modifications measures implemented under Stage I would have altered the natural conditions and consequently a comparison of the percent of time passage occurs under natural and Stage 2 flows is not feasible. The slightly



Simulated Natural and Stage 2 2002 Susitna River Temperatures at River Mile 150

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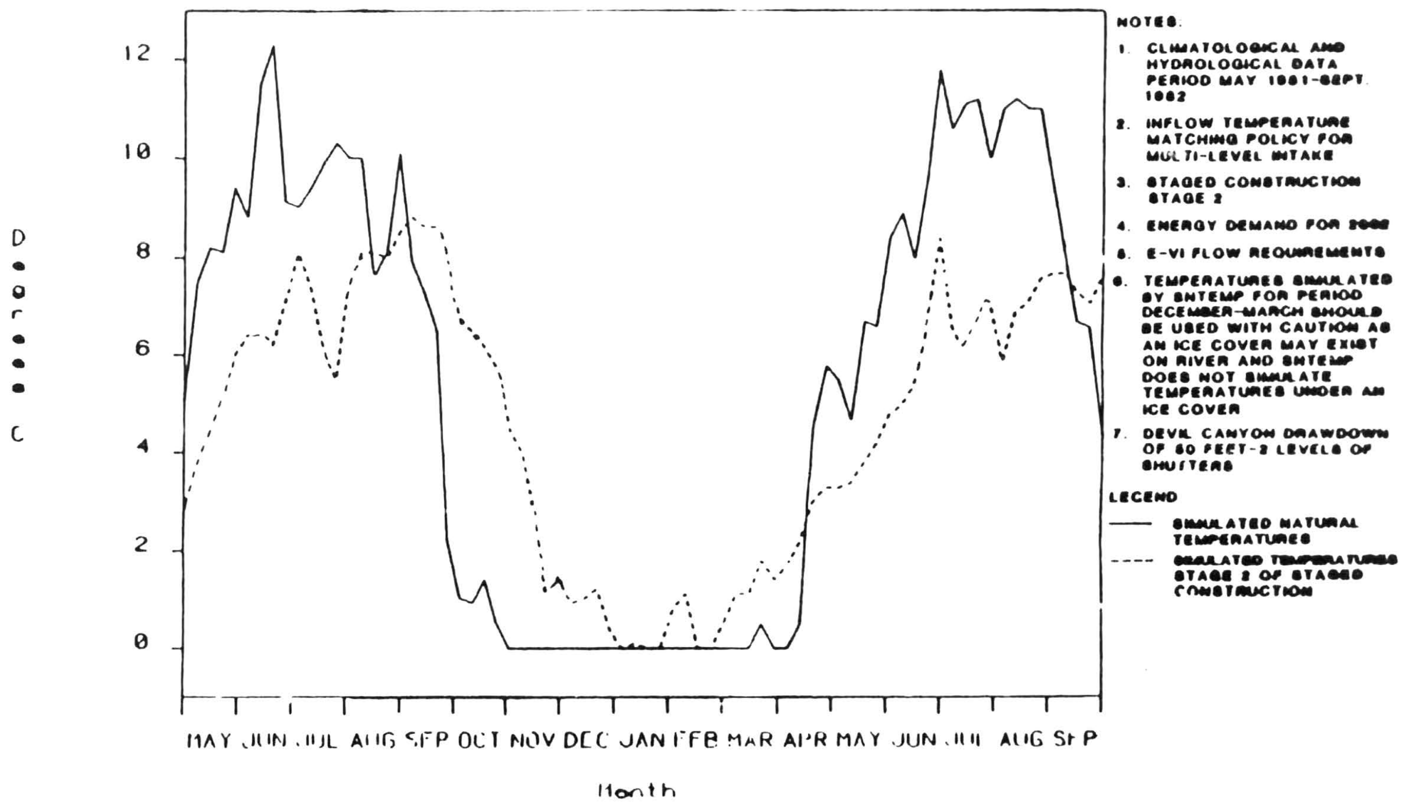
Reference: Harza-Ebasco 1985

Figure 25



Simulated Natural and Stage 2 2002 Susitna River Temperatures at River Mile 130

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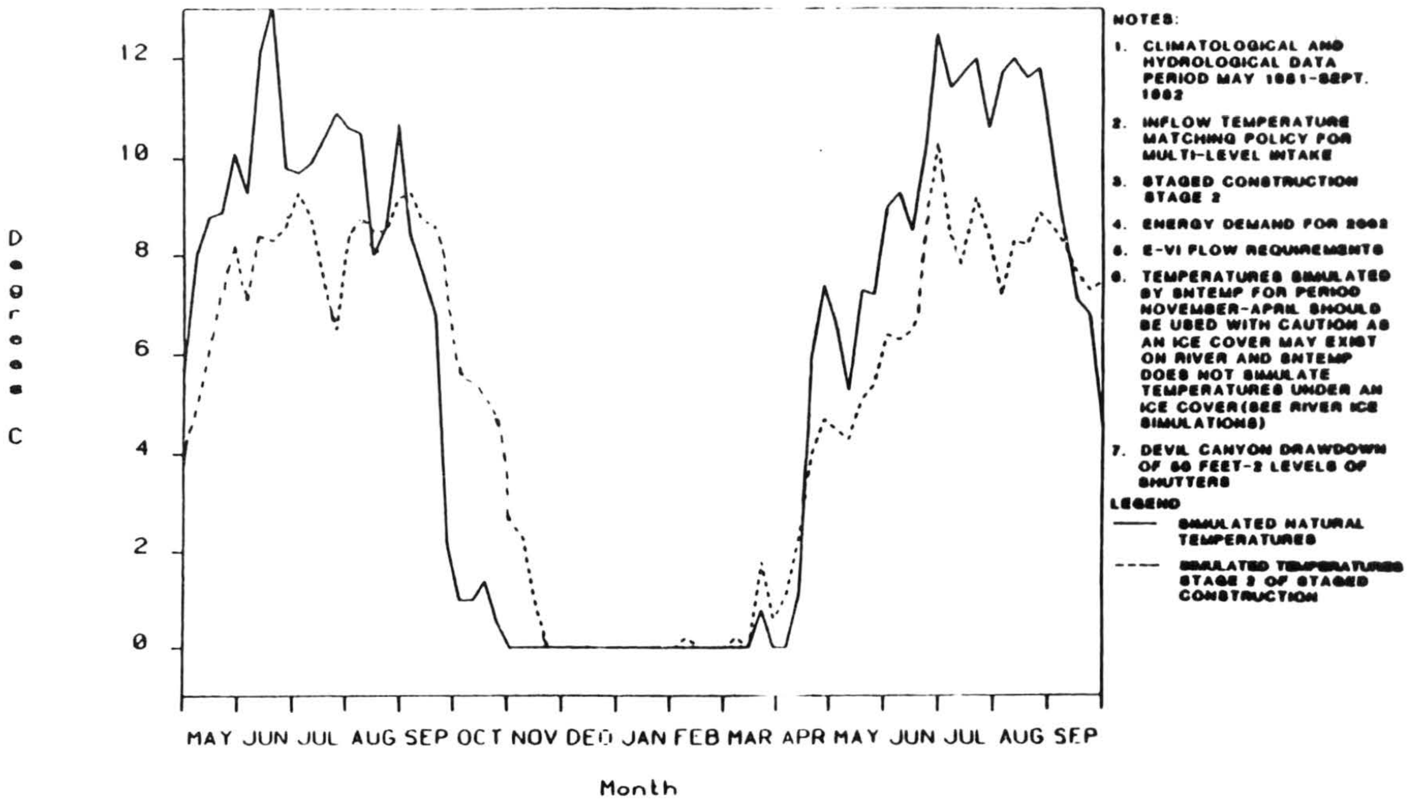
Reference: Harza-Ebasco 1985

Figure 26



Simulated Natural and Stage 2 2002 Susitna River Temperatures at River Mile 100

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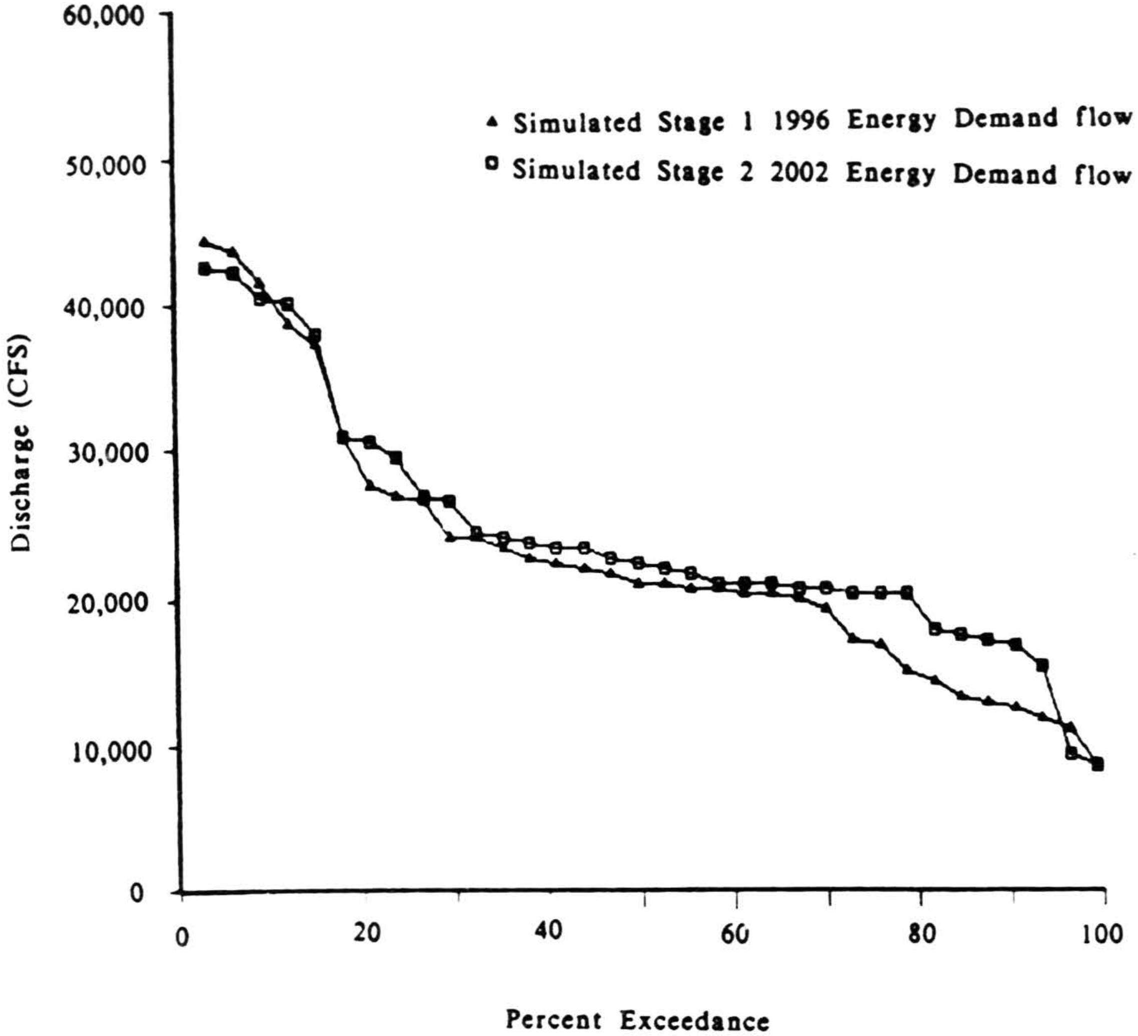
Reference: Harza-Ebasco 1985

Figure 27



Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for weeks 45 to 49 based on mean weekly flows for 34 years of record.

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Figure 28

higher flows provided by Stage 2 would, however, maintain or enhance passage at the modified sloughs.

The construction of berms to prevent sloughs from being overtopped by mainstem flows during Stage 1 would insure against similar impacts during Stage 2.

- Chinook Salmon

. Rearing Juveniles

It is anticipated that analyses on flow requirements for juvenile chinook rearing would have been available prior to 2002 and that an acceptable flow regime would be in effect.

(ii) Secondary Evaluation Species

The Stage 2 flow regime would not result in any additional impacts to the secondary evaluation species.

4.2.2 Mitigation

The lack of additional adverse impacts resulting from Stage 2 operation would limit mitigation efforts to maintaining and monitoring the effectiveness of mitigation measures implemented during Stage 1.

4.3 - Stage 3 (2008-2020)

4.3.1 Impact Analysis

(A) Filling

The details of Stage 3 filling flows are not available at this time. However, it is anticipated that filling will coincide with construction over a 2 or 3 year period. The level of filling would be determined by the crest elevation of the dam. The spring and summer flows during the multi-year filling process would likely be less than those simulated for Stage 2-2002 and Stage 3-2008 energy demands but greater than E-VI minimum levels. As information on Stage 3 filling becomes available anticipated impacts and appropriate mitigation measures will be incorporated into this document.

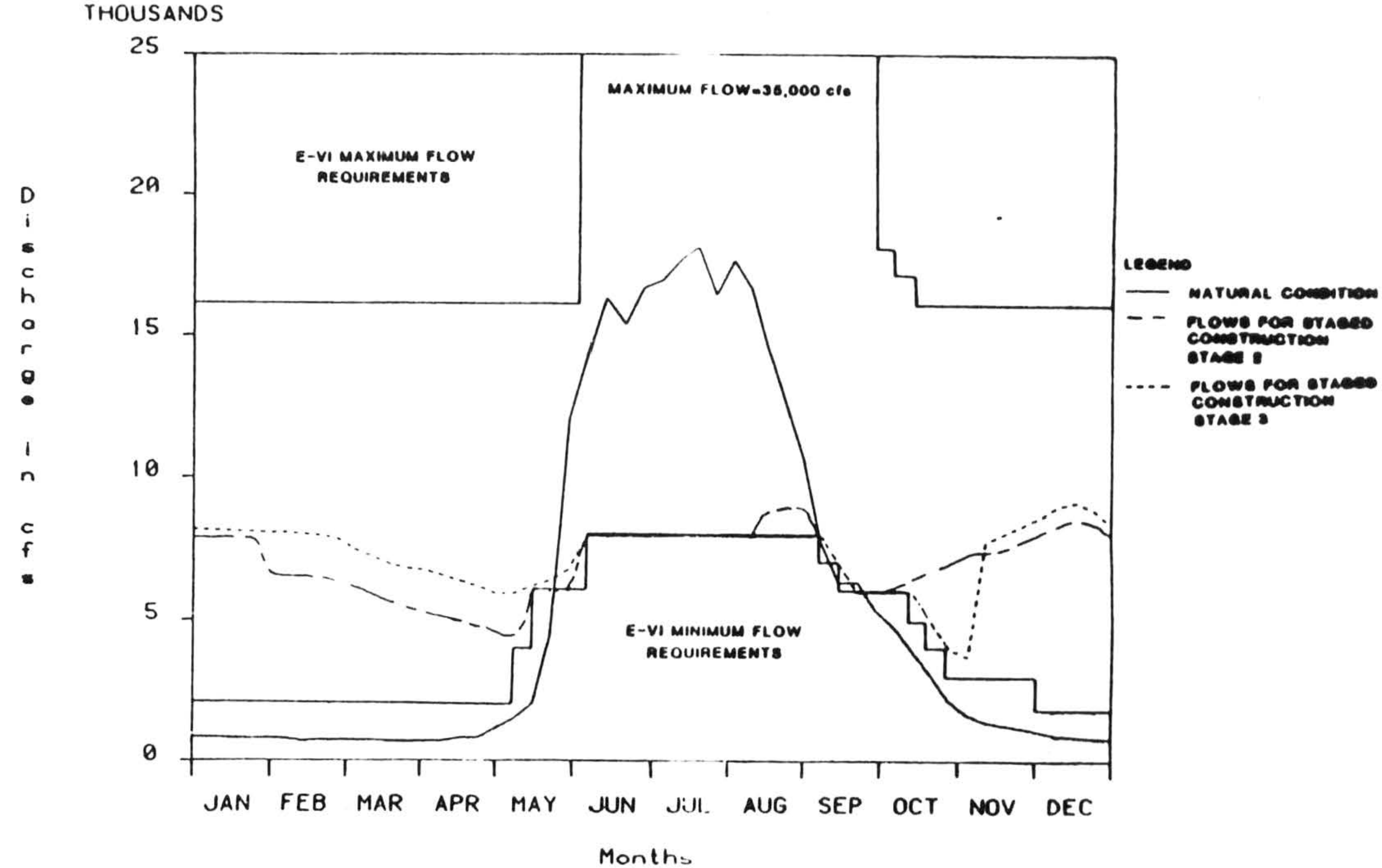
(B) 2008 Energy Demand

Power generation with Watana Dam constructed to its full height would commence in 2008 or within a few years thereafter. Regulated flow releases have been simulated for the first year of operation based on anticipated 2008 energy demands. Natural, Stage 2-2002 and Stage 3-2008 operating flows are compared at the 97, 50, and 6 percent exceedence probabilities in Figures 29-31. Stage 3-2008 flows would be similar to or slightly higher than Stage 2 flows in the winter and spring (November through May). In the summer during average or wet hydrologic conditions Stage 3 flows would be similar to or slightly less than Stage 2 flows. In the driest years, Stage 3-2008 and Stage 2 flows would be maintained at the E-VI minimum during the spring-summer filling period.

(C) 2020 Energy Demand

Regulated flow releases have been simulated for Stage 3-2020 energy demand. Natural, Stage 3-2008, and Stage 3-2020 operation flows are compared at the 97, 50, and 6 percent exceedence probabilities in Figures 32-34. In years with average and wet hydrologic conditions Stage 3-2020 flows would be about 2000 cfs higher than Stage 3-2008 from mid-October through May. In the summer months, Stage 3-2020 flow would be at or near Case E-VI minimum except during the wettest of years.

Streamflow temperatures under Stage 3 flow regimes would be about 0.5 to 1°C warmer than Stage 2 in the winter and similar to Stage 2 in the summer (Figure 35).

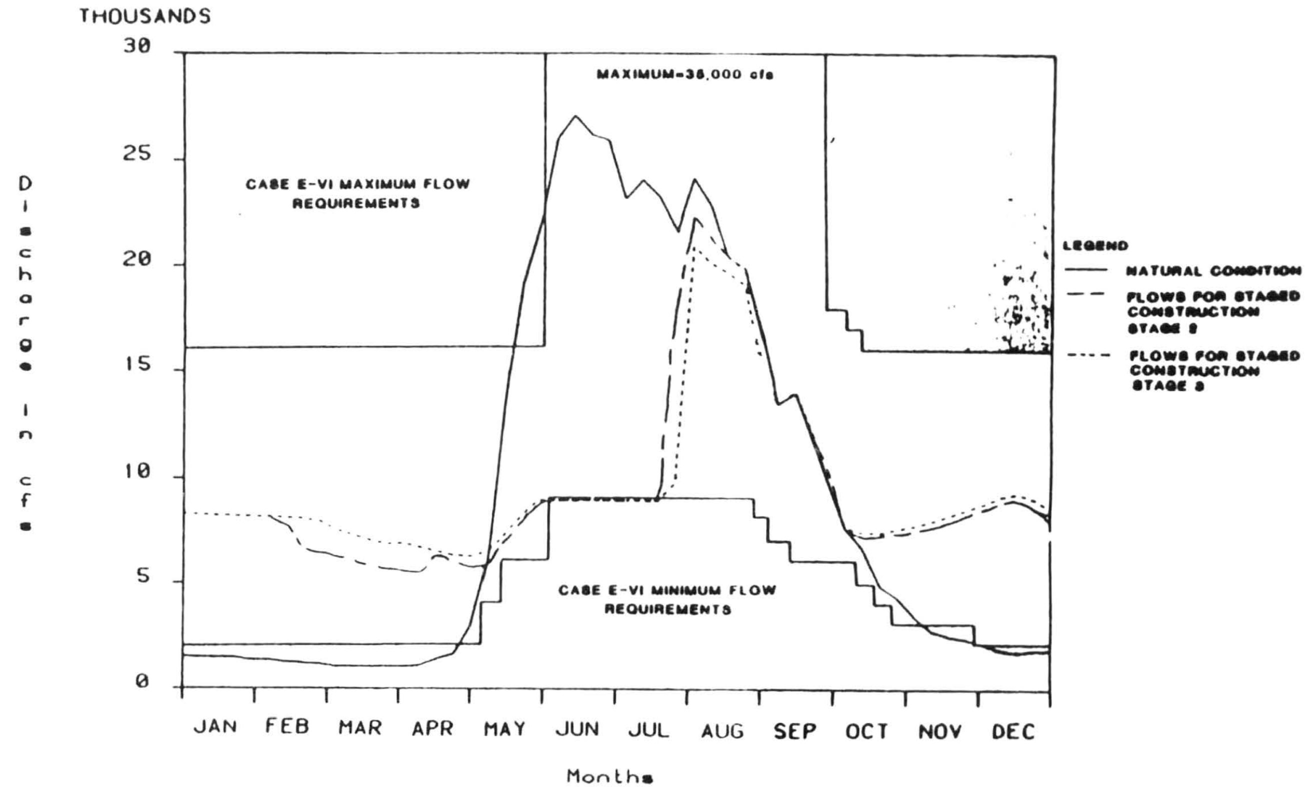


Comparisons of Susitna River Natural, Stage 2 2002 and Stage 3 2008 Streamflows Exceeded 97% of the time at Gold Creek.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Figure 29

Reference: Harza-Ebasco 1985



Comparisons of Susitna River Natural, Stage 2 2002 and Stage 3 2008 Streamflows Exceeded 50% of the time at Gold Creek.

Reference: Harza-Ebasco 1985

Figure 30

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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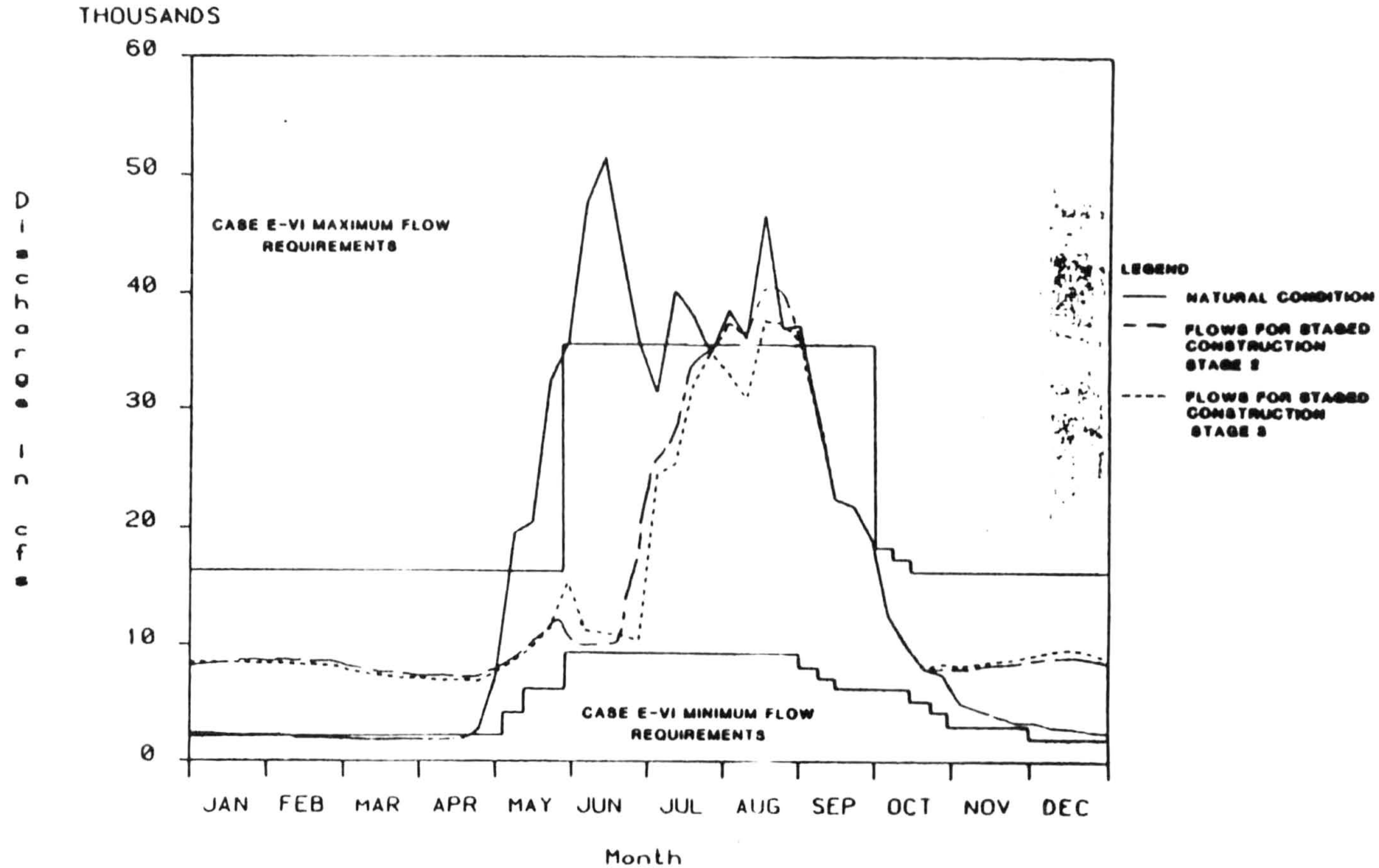
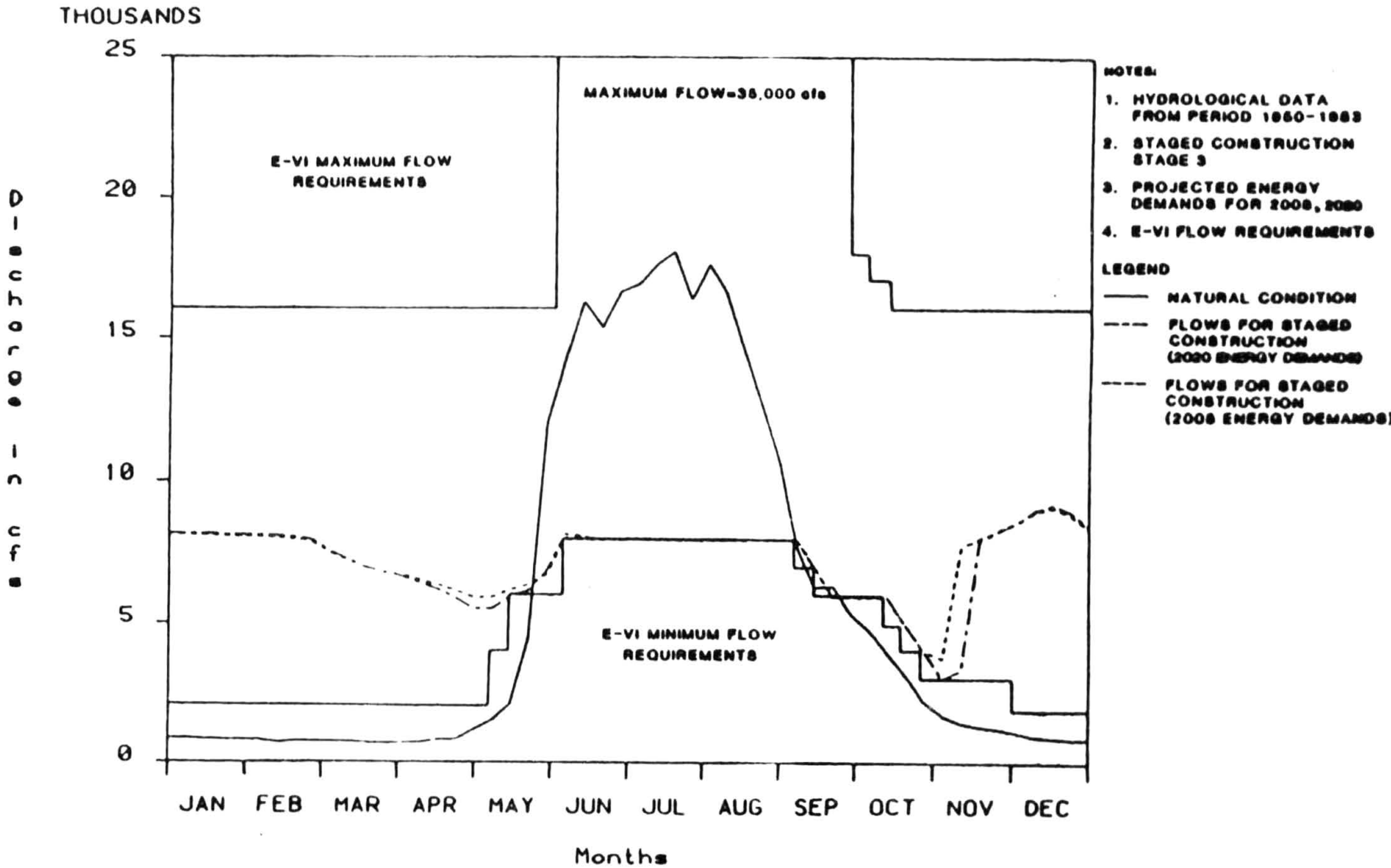


Comparisons of Susitna River Natural, Stage 2 2002 and Stage 3 2008 Streamflows Exceeded 6% of the time at Gold Creek.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Figure 31

Reference: Harza-Ebasco 1985



Comparisons of Susitna River Natural, Stage 3 2008, and Stage 3 2020 Streamflows Exceeded 97% of the time at Gold Creek

Reference: Harza-Ebasco 1985

Figure 32

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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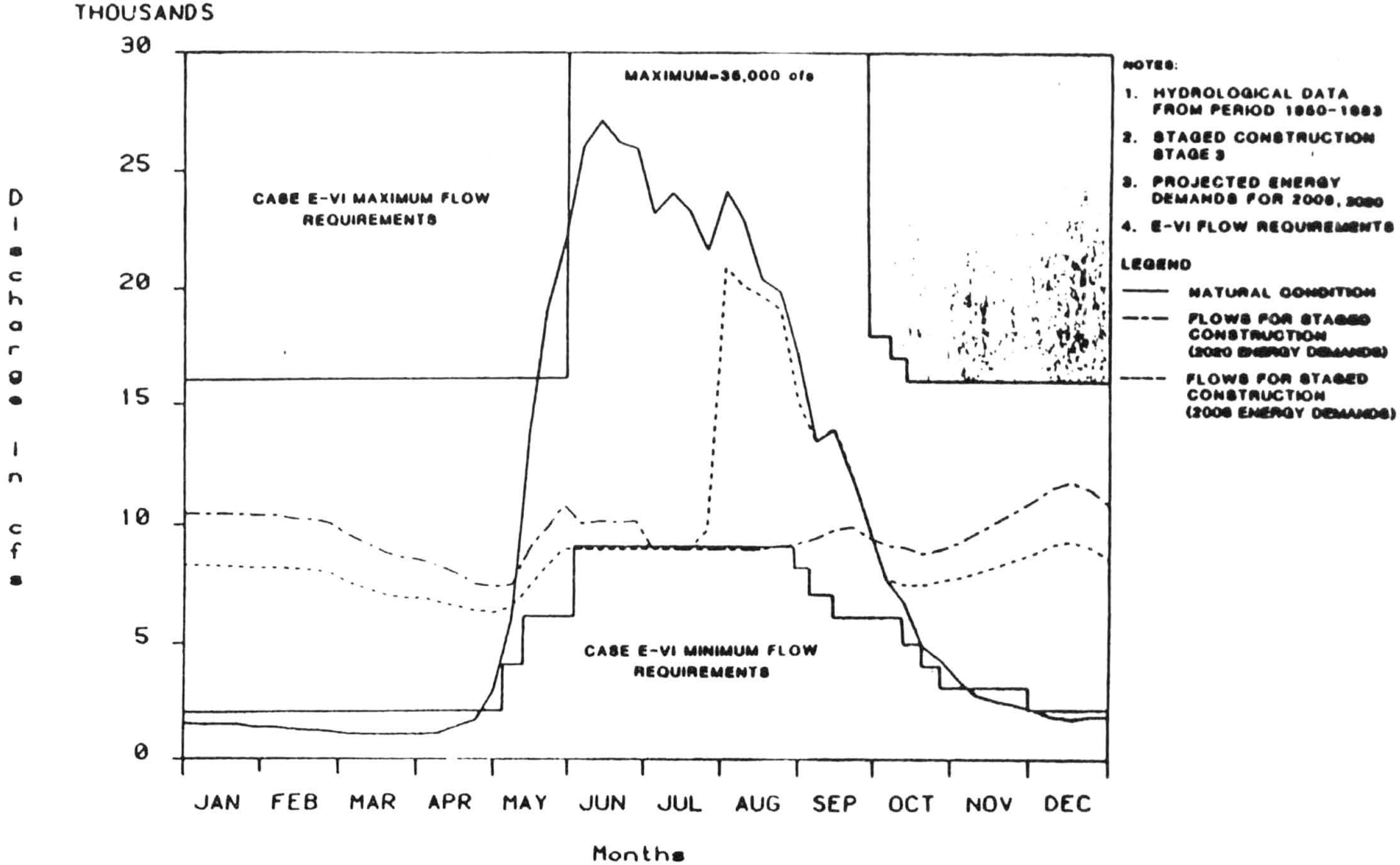

Comparisons of Susitna River Natural and Stage 3 2008, and Stage 3 2020 Streamflows Exceeded 50% of the time at Gold Creek

Reference: Harza-Ebasco 1985

Figure 33

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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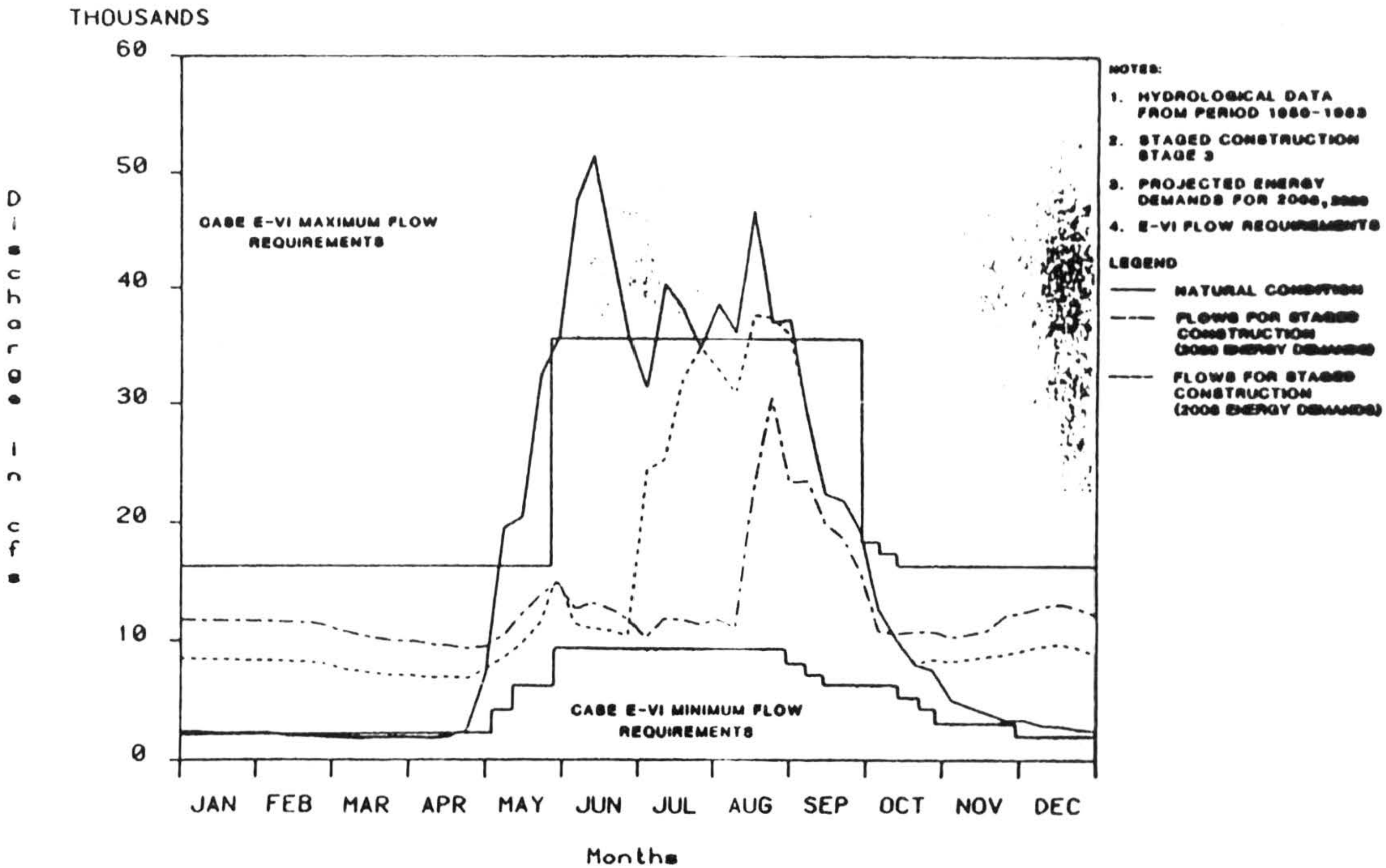

Comparisons of Susitna River Natural, Stage 3 2008, and Stage 3 2020 Streamflows Exceeded 6% of the time at Gold Creek

Reference: Harza-Ebasco 1985

Figure 34

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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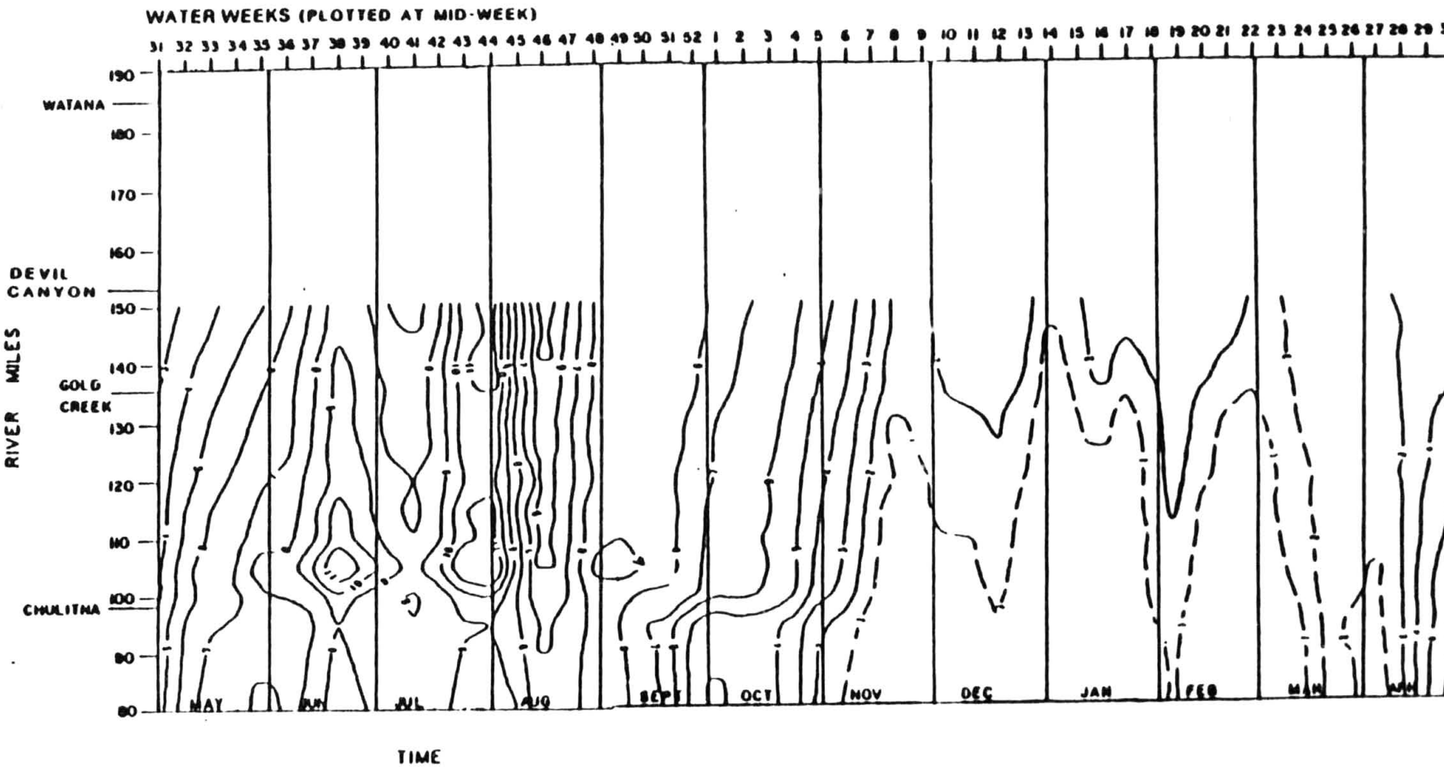

NOTES :

1. TEMPERATURES IN °C.
2. ICE SIMULATION NOT MADE FOR THIS CASE. TEMPERATURES FOR NOVEMBER THROUGH MARCH SHOULD NOT BE USED.
3. 1981-1982 CLIMATE DATA

Simulated Stage 3 2020 Susitna River Temperatures from River Mile 150 to 80.

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Reference: Harza-Ebasco 1985

Figure 35

Seasonal turbidity levels under Stage 3 would exhibit seasonal variations similar to Stage 2.

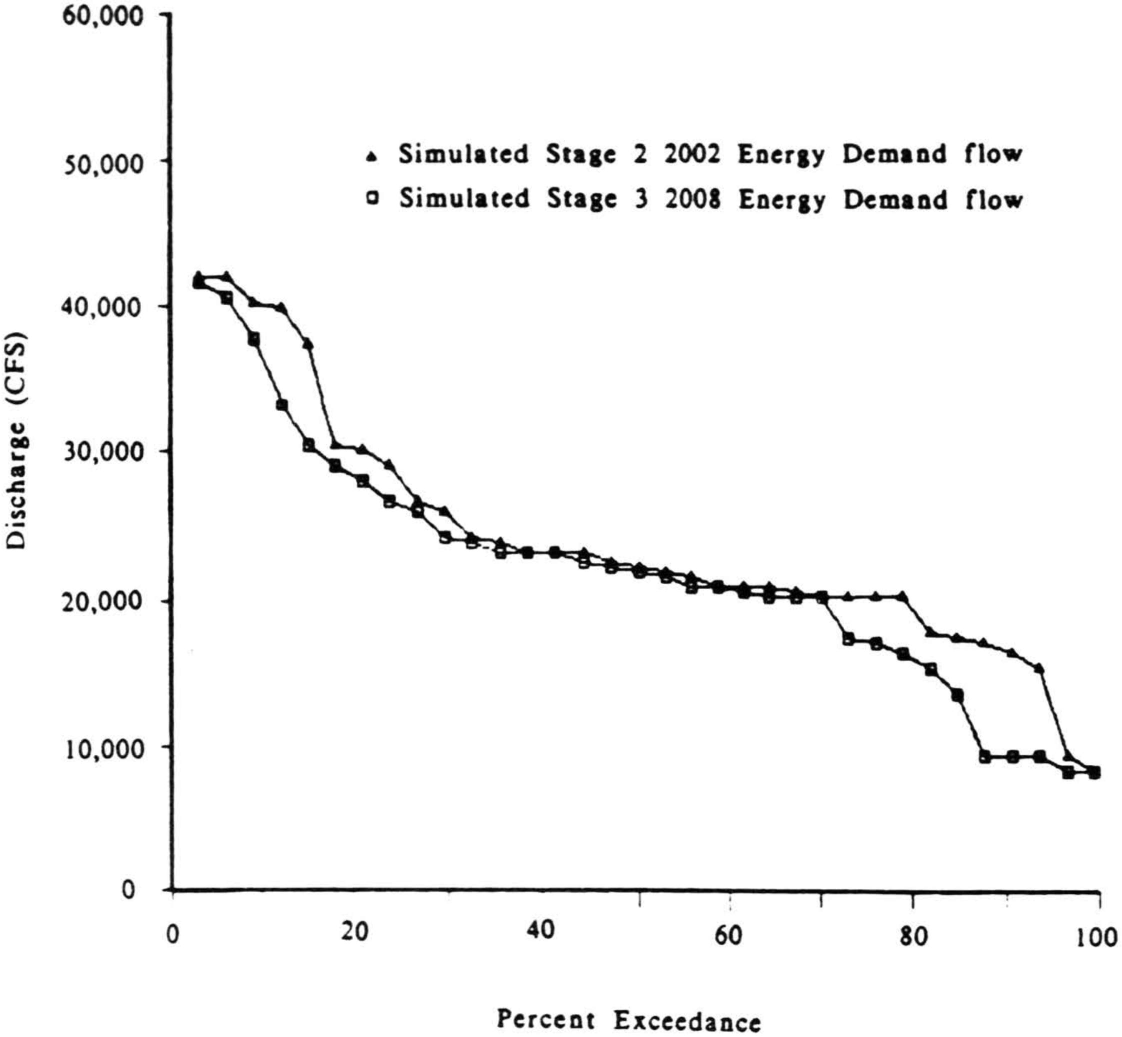
(i) Primary Evaluation Species

- Chum Salmon

. Spawning Adults

Comparisons of Stage 2-2002, Stage 3-2008 and Stage 3-2020 mean weekly flow duration curves for each week of the spawning period are shown in Appendix Figures 11-20. Similar comparisons based on the maximum mean weekly flow for weeks 45-49 of each year for the 34 years of record are presented in Figures 36 and 37. The percentage of time flows that provide passage occur is similar for Stage 2-2002 and Stage 3-2008. However, there is a marked reduction in the frequency at which flows necessary for passage is provided in under the Stage 3-2020 energy demand as compared to the Stage 3-2008 energy demand. The transition from adequate flows in 2008 to the reduced flows during the spawning period in 2020 would occur over a period of 12 years. This time period would allow assessment of any impacts that may result from these flow reductions. There is also the possibility that the patterns of utilization of different habitat types may occur during this interval without a net decrease in productivity. Attempting to assess impacts in 2020 based on current utilization patterns would therefore not be productive. Provision will be made in a long-term monitoring program to assess changes in productivity of the evaluation species.

There are no anticipated impacts to the incubation life stage of chum salmon resulting from Stage 3 development.



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for weeks 45 to 49 based on mean weekly flows for 34 years of record.

Figure 36

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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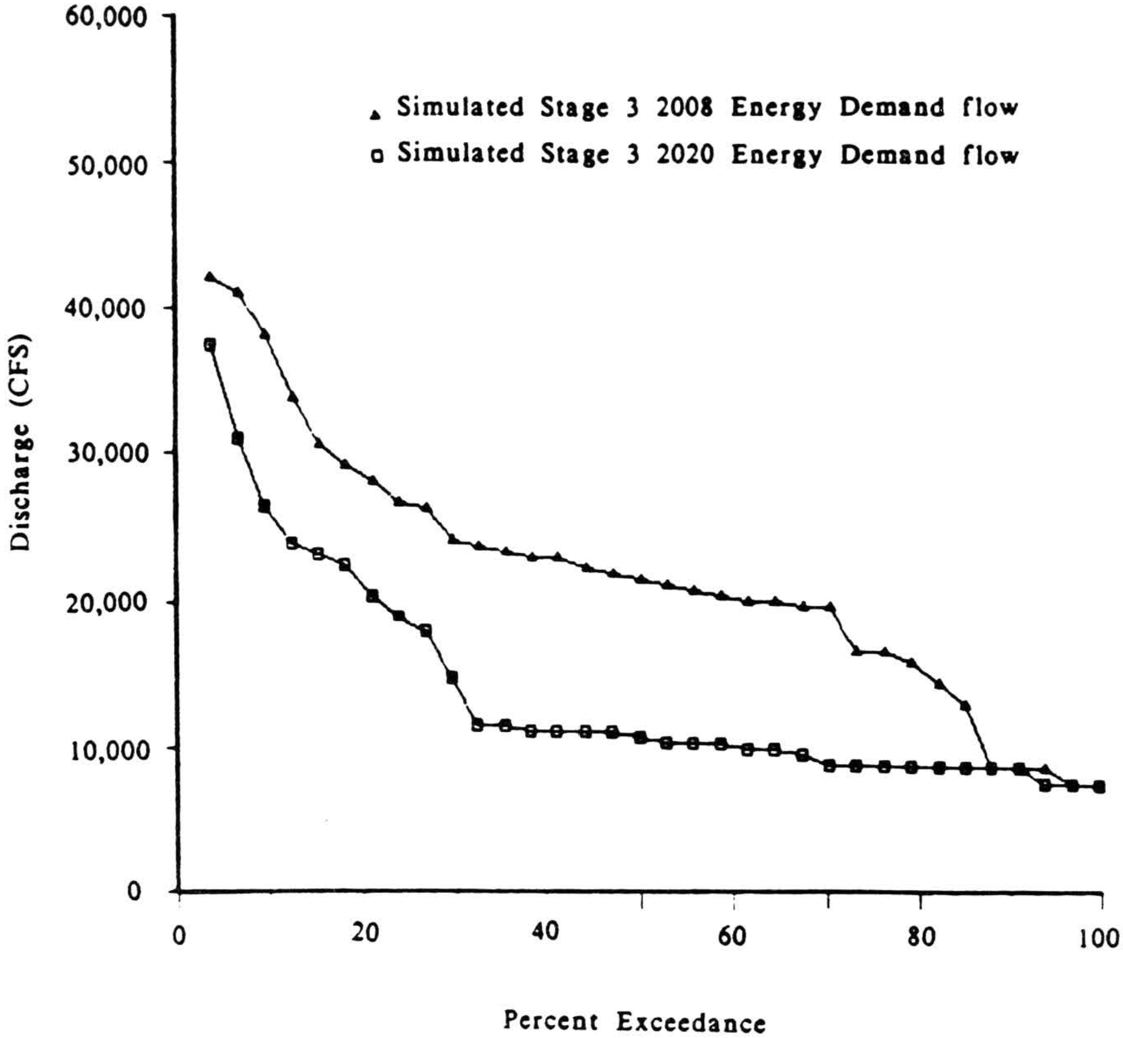

Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for weeks 45 to 49 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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Figure 37

- Chinook Salmon

  . Rearing Juveniles

  It is anticipated that the mitigation measures applied to chinook rearing in Stage 1 would also mitigate for Stage 3-2020 flows.

(ii) Secondary Evaluation Species

No additional impacts are anticipated for the Stage 3 flow regimes.

4.3.2 Mitigation

During Stage 3 of the projects, the long-term monitoring program would identify impact to the evaluation species and appropriate mitigation measures would be implemented as needed.

4.4 - Scheduling of Mitigation

4.4.1 Flow Release

Case E-VI flow constraints, or a similar negotiated flow regime would be instituted in May 1995 during the first year of filling. The constraints of this flow regime would then be in effect for the duration of the project.

4.4.2 Structural Modification of Habitats

Modifications of slough and side channel habitats to accommodate spawning by chum salmon and to a lesser extent rearing of juvenile salmon would be scheduled according to the timing of impacts identified with each stage of project development. With the exception of filling flows impacts to chum salmon spawning and incubation habitat aduring Stage 1, Stage 2 and Stage 3-2008 energy demands would be similar.

The construction of berms to prevent overtopping take priority over modifications within sloughs since the berms will also serve to protect these modifications. If proposed berm construction were extensive it could be initiated during the construction phase of Watana and also take advantage of previously mobilized equipment to reduce costs. Candidate sites for pre-operational berming would be those sites that do not depend on breaching conditions during the spawning season for passage (e.g. Slough 11). Berming of such a site would eliminate the need for immediate slough modifications. The flows during the winter following the first summer of filling in 1995 would be at natural levels and berming would not be necessary to protect incubating embryos. All proposed berming would be completed by the winter of 1996-1997. Modification of sloughs and side channels could also be staggered over a multiyear period if necessary. A full scale modification of a slough would require about two weeks time. Minor modification could be accomplished in a few days or less.

Modification to slough and side channel would generally occur between June 1 and July 15, after most fry or juveniles have left their natal areas and before adults have returned to spawn. The timing may be adjusted on a site specific basis. Modification to sloughs and side channels should be completed by summer, 1996 or if possible by summer 1995.

As information on the extent of berming required for different sites is acquired this summer and specific sites or parts of sites are selected for modification, a detailed scheduling program will be developed.

Should additional modification measures be necessary during the later stages of the project, scheduling would be on an as-needed basis and at the least sensitive time of the year for the particular activity.

4.5 - Monitoring

A monitoring program is recognized as an essential project mitigation feature, particularly in a staged development in which the impacts will vary over time. A detailed monitoring program is currently being developed as a separate document that will address impacts and mitigation measures presented in this volume and the other two volumes of this three volume mitigation series.

The middle Susitna River portion of the monitoring program will focus on (1) monitoring salmon population and production levels to ensure that the predicted level of impact is not being exceeded and (2) evaluating the effectiveness of the implemented mitigation measures. These two areas of focus are outlined below.

4.5.1 Monitoring of Salmon Populations

Salmon populations in the Devil Canyon to Talkeetna reach will be monitored to assess whether populations maintain historical levels during the operation phase. Monitoring will consist of enumerating returning adults and estimating fry and smolt production. The adult monitoring program will include:

1) Monitoring the long-term trend in catches at fixed fishwheel stations.

2) Monitoring the long-term trend in spawning ground counts.

3) Monitoring the long-term trend in age and size composition of spawning adults.

4) Relating the above trends to physical, chemical and biological changes in the system, including changes induced by the project.

The juvenile salmon monitoring program will provide estimates of fry and smolt production in the middle Susitna River over a period of years encompassing natural and with-project conditions. Production estimates and changes in production patterns over the years can be compared directly with changes in physical conditions due to project operation. Factors affecting smolt production estimates will be evaluated by:

1) Obtaining data on survival rates from egg deposition to fry-smolt production.

2) Monitoring long-term trends in the timing of emergence and outmigration of juvenile salmon by use of tagging of young fish and recapture in outmigrant traps.

3) Monitoring long-term trends in the development, growth and relative condition of young salmon.

Pre-project data will be compared to with-project data to determine whether substantial changes are occurring as a result of the project. In addition, the data collected from the above studies, data from the commercial fish harvest, sportfish harvest surveys,and subsistence fishing will be considered in the overall evaluation of the salmon resources.

4.5.2 - Mitigation Monitoring

Mitigation features to be monitored for evaluation of the level of mitigation being achieved include:

- Slough modifications
- Replacement habitats
- Incubation pits

The monitoring activity will include evaluating the operation and maintenance procedures to ensure that the facilities are operating effectively. If a mitigation feature is not meeting the intended level of effectiveness, modifications to the mitigation feature will be made to increase its effectiveness.

(A) Monitoring Slough Modifications

The various measures incorporated for slough habitat maintenance will be monitored to assess whether they are meeting their intended function and are operating properly. Methods used to evaluate the slough mitigation features will be consistent with methods currently being used to assess baseline conditions of the parameters to be monitored.

Mitigation features designed to allow adult salmon passage into and within the sloughs will be annually inspected after breakup to identify and conduct needed repairs prior to the adult return. Annual monitoring of returning adults will allow identification of additional passage problems. Appropriate corrective actions will be taken.

Modifications to sloughs designed to maintain spawning areas will be annually inspected prior to the spawning season to verify that the area contains suitable spawning conditions such as upwelling, amount of flow, depth of water, and suitable substrate. Areas that become overly silted will be cleaned. If slough flows diminish so that spawning is no longer possible, appropriate corrective actions will be taken.

The number of spawning adults returning to the sloughs will be monitored annually to measure changes in distribution to assess if the combination of minimum flow and slough modifications is maintaining natural production. This monitoring will also serve to assess whether the capacity of the modified areas is being exceeded. Appropriate remedial actions will be taken when spawning sites are inadequate.

Fry production will be monitored annually to evaluate incubation success. Fry monitoring will include an assessment of out-migration timing and success.

The annual slough monitoring will include an evaluation of general slough conditions including vegetative encroachment, beaver occupation, and general condition of the spawning and rearing areas. Appropriate remedial actions will be performed to maintain slough productivity.

Representative sloughs will be monitored for temperature and slough flow. Monitoring of the physical processes will be continued until slough conditions stabilize under the regulated flow regime. This monitoring will be used in part to assess whether further modifications to the physical habitat must be made to maintain slough productivity.

(B) Monitoring Replacement Habitats

Replacement habitats which develop as a result of the lower and more stable project mainstem flows during the spawning season will be monitored to quantify use of these areas by adult salmon. Monitoring methodology will be similar to that currently used to evaluate spawning habitats and will include standard physical and chemical measurements as well as biological analyses.

(C) Monitoring of Artificial Propagation

Stream-side incubation pits, if utilized, will be monitored to evaluate their effectiveness in producing the number of returning chum salmon for which they were designed.

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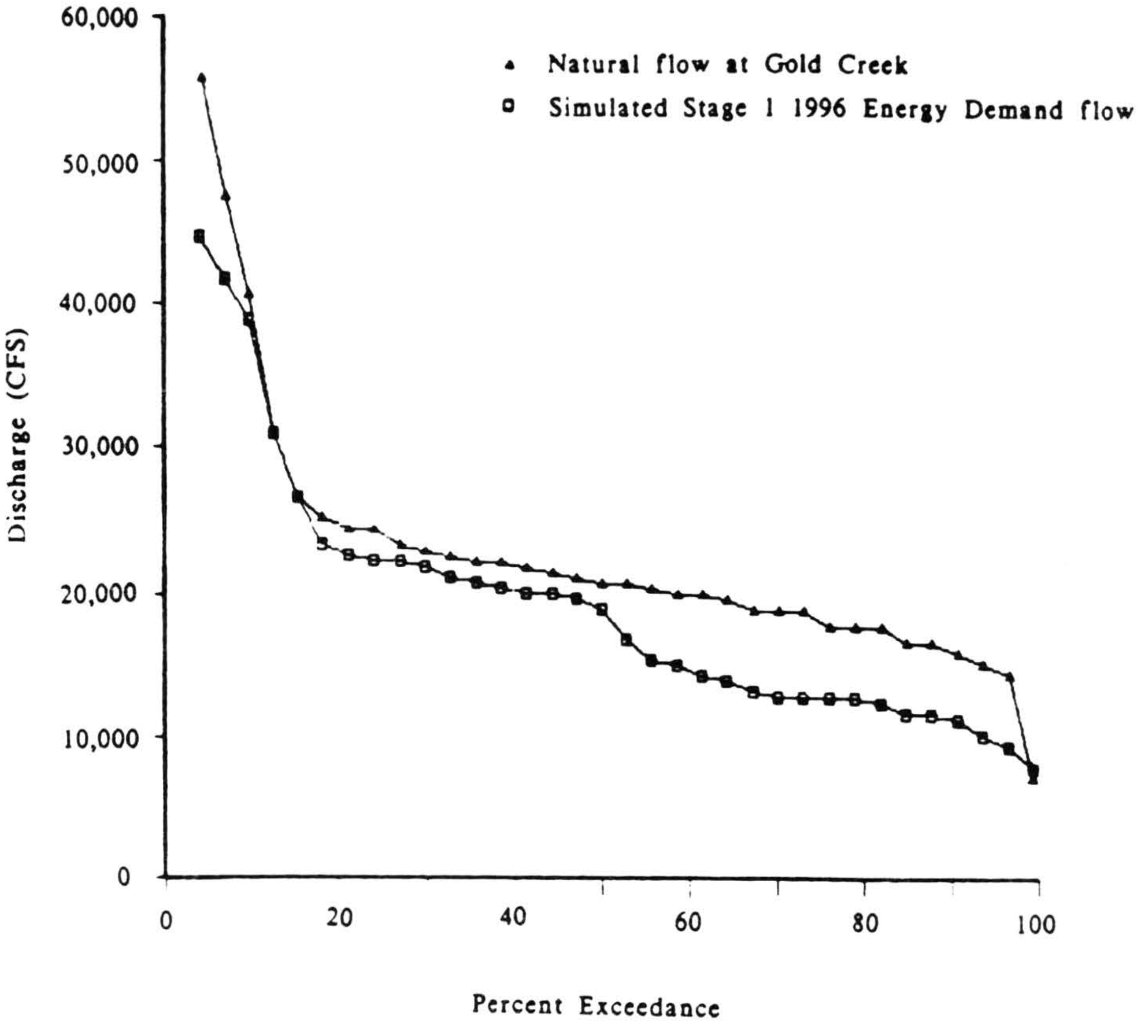
APPENDIX

APPENDIX FIGURES



Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for week 45 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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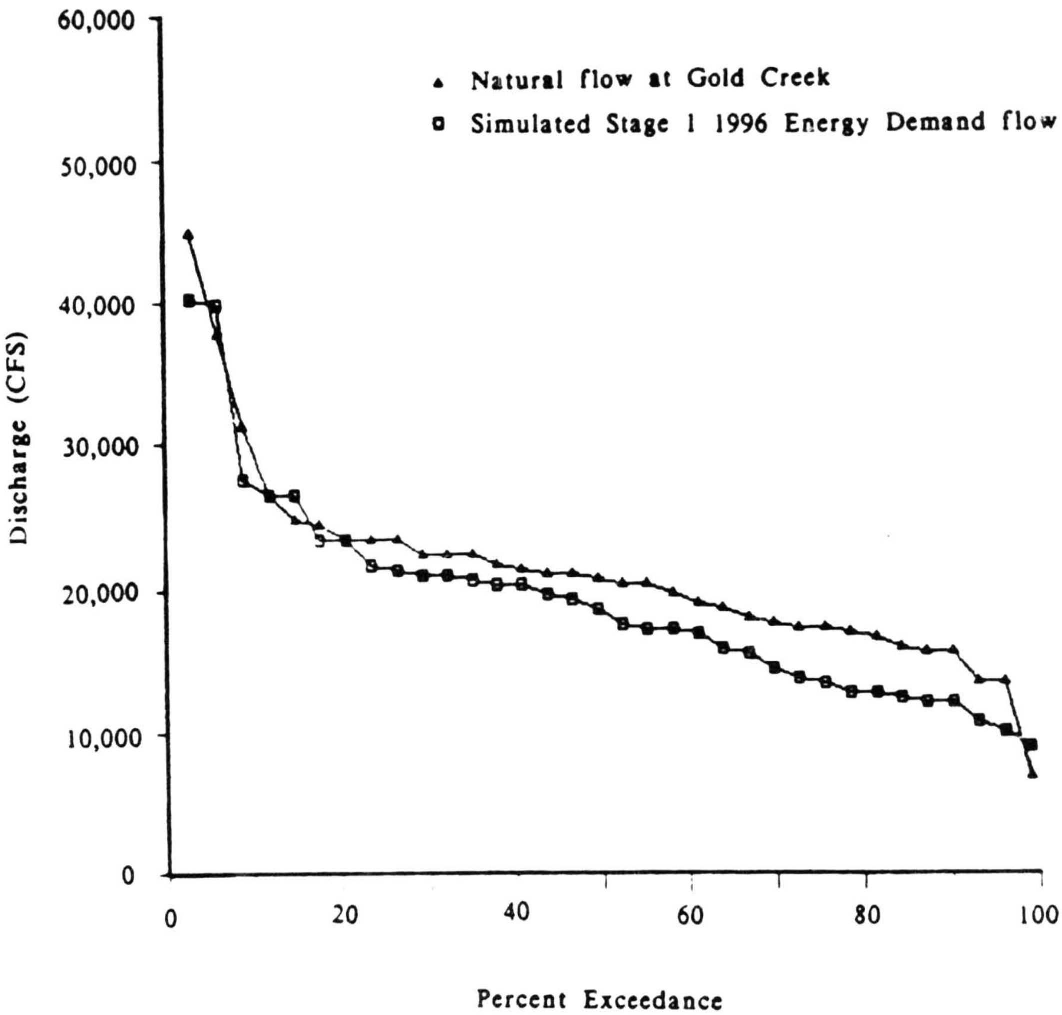
Appendix Figure 1



Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for week 46 based on mean weekly flows for 34 years of record.

Appendix Figure 2

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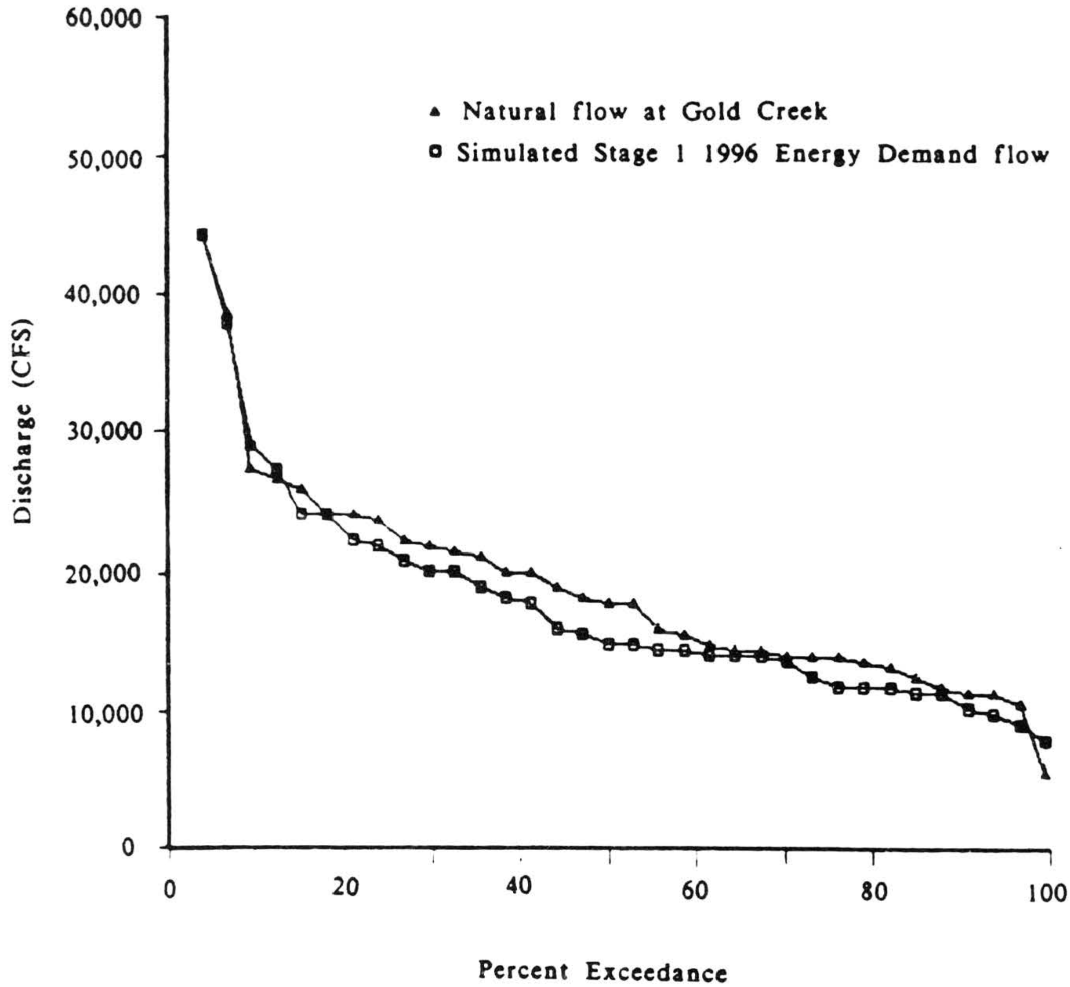

Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for week 47 based on mean weekly flows for 34 years of record.

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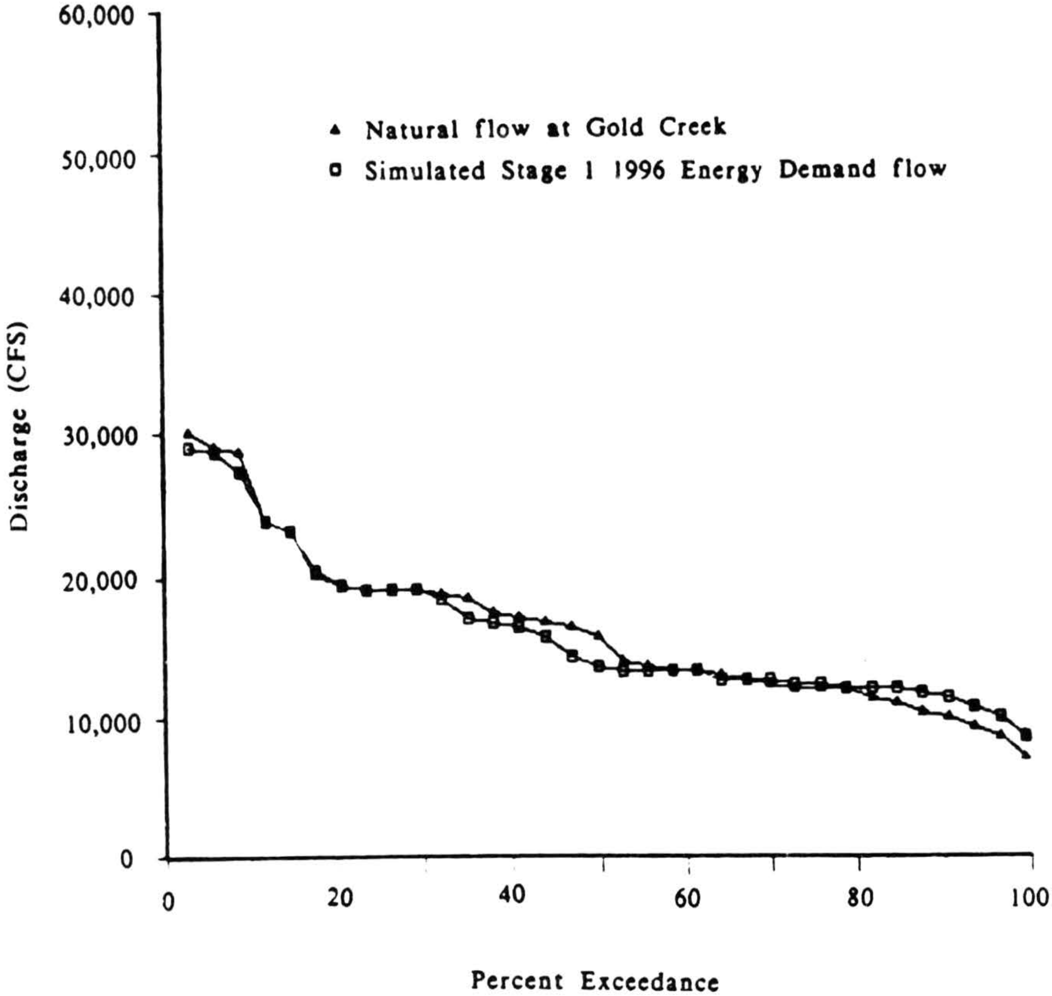
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

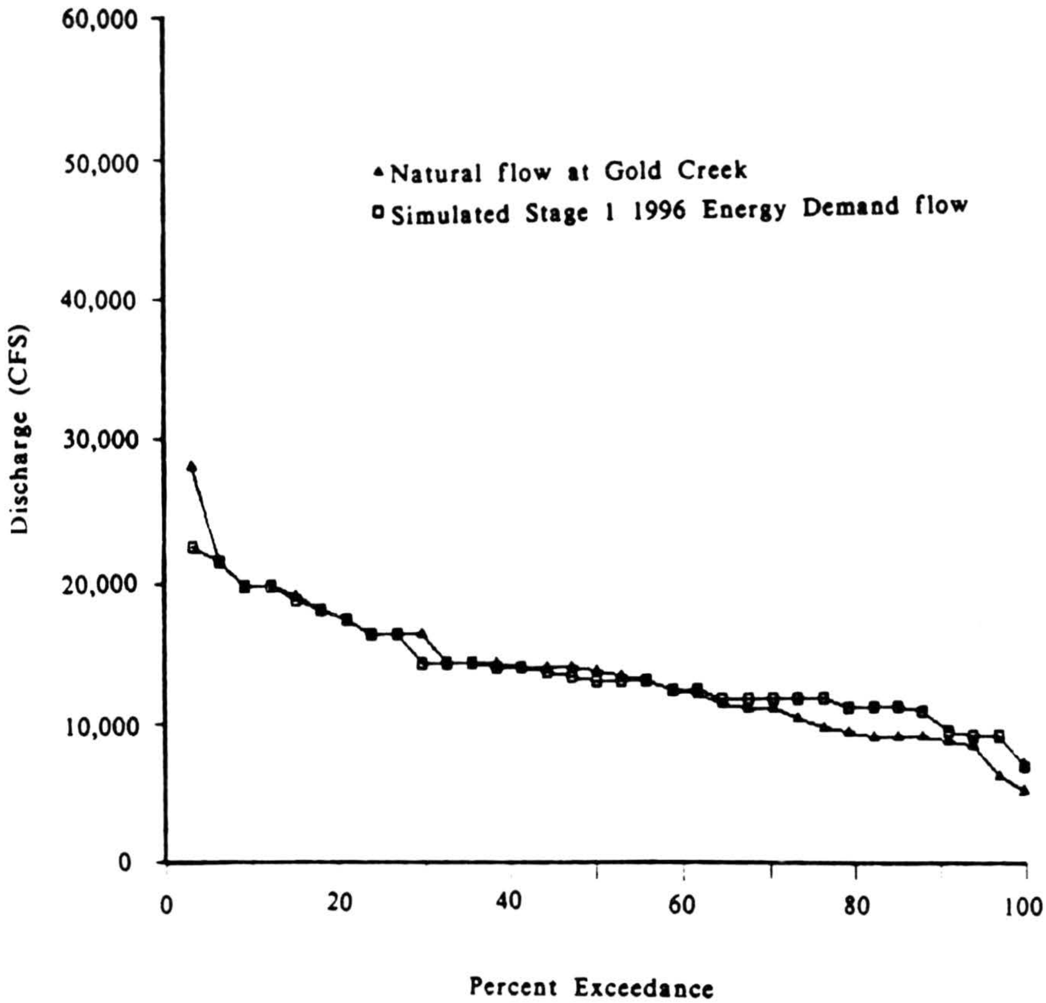
Appendix Figure 3



Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for week 48 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

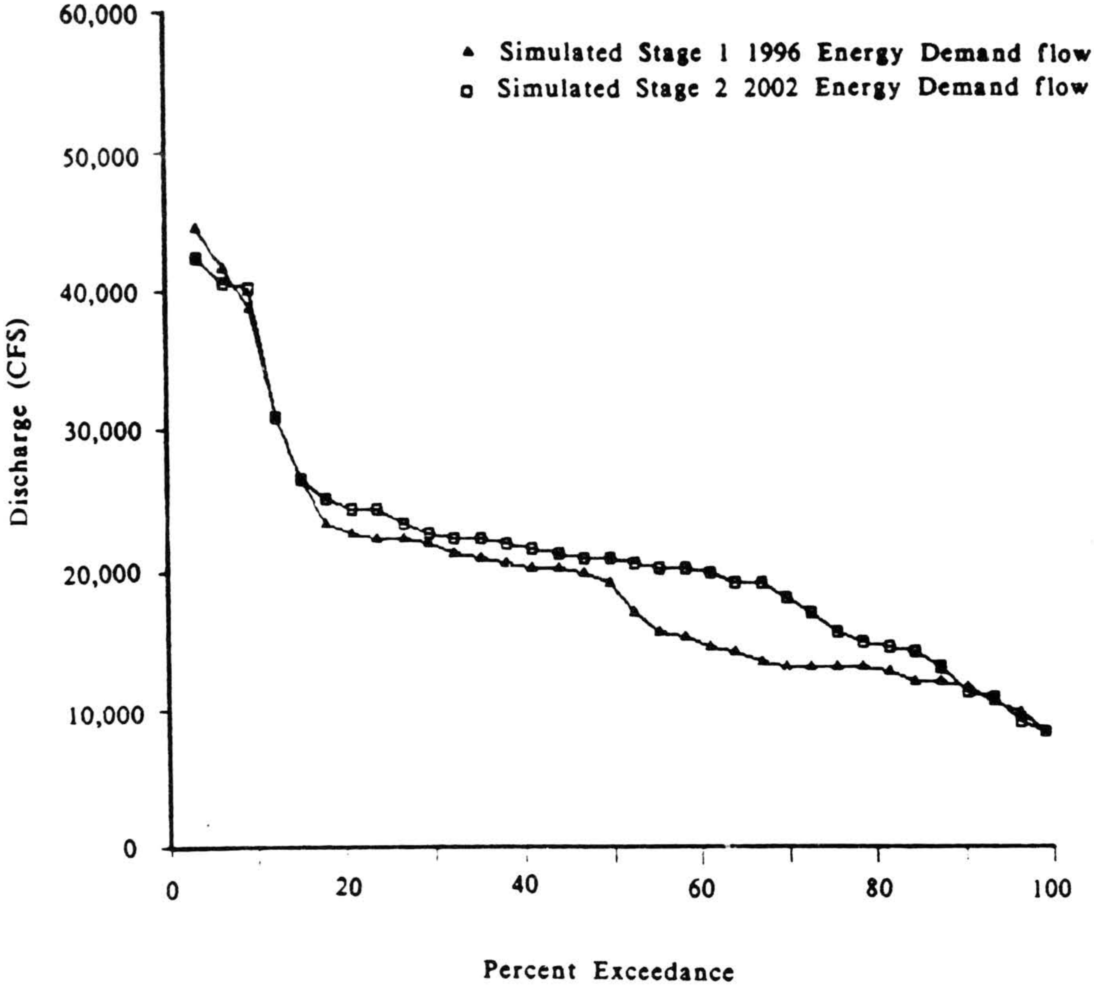
Appendix Figure 4



Comparison of flow duration curves for natural and simulated Stage 1 1996 Energy Demand streamflows for week 49 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Appendix Figure 5



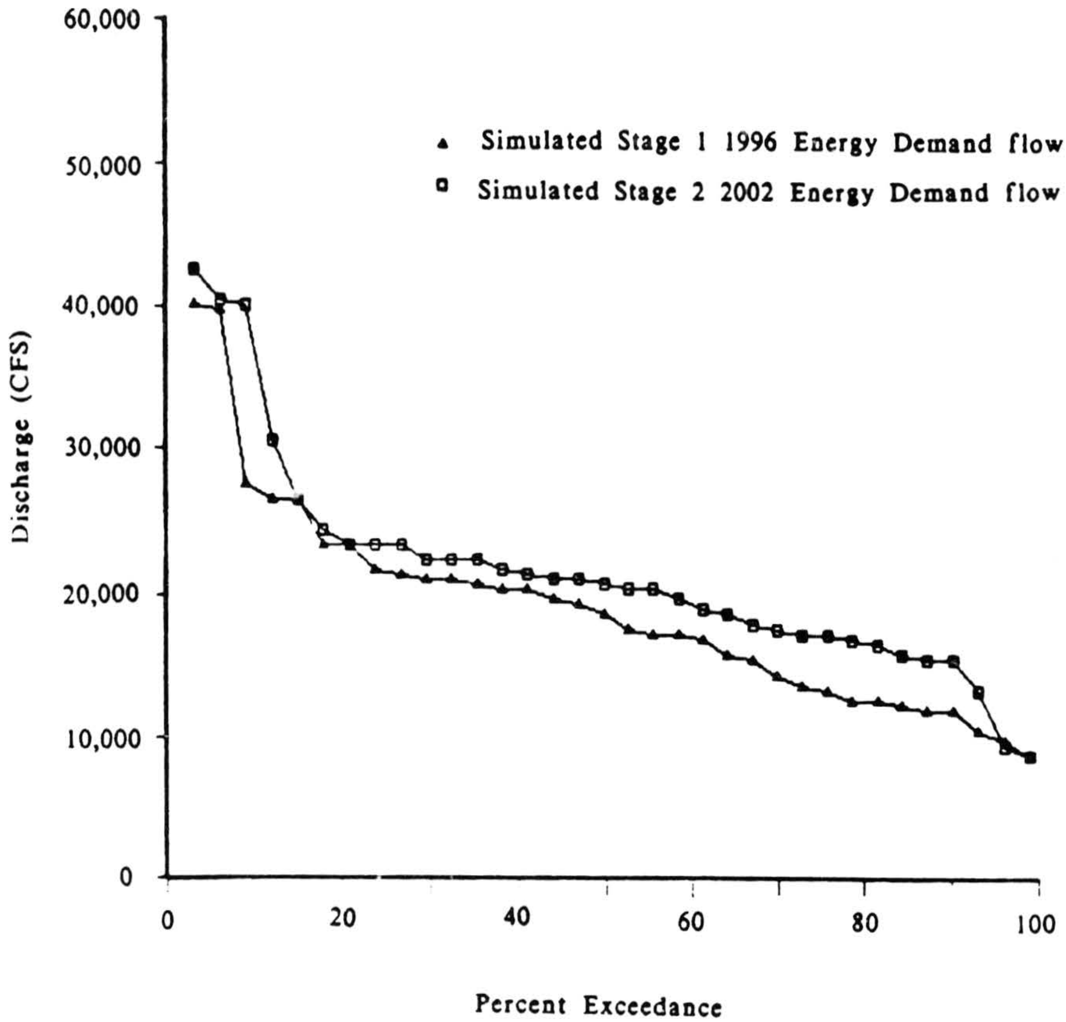
Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for week 45 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants AND ENTRIX, INC.

HARZA-EBASCO SUSITNA JOINT VENTURE

Appendix Figure 6



Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for week 46 based on mean weekly flows for 34 years of record.

Appendix Figure 7

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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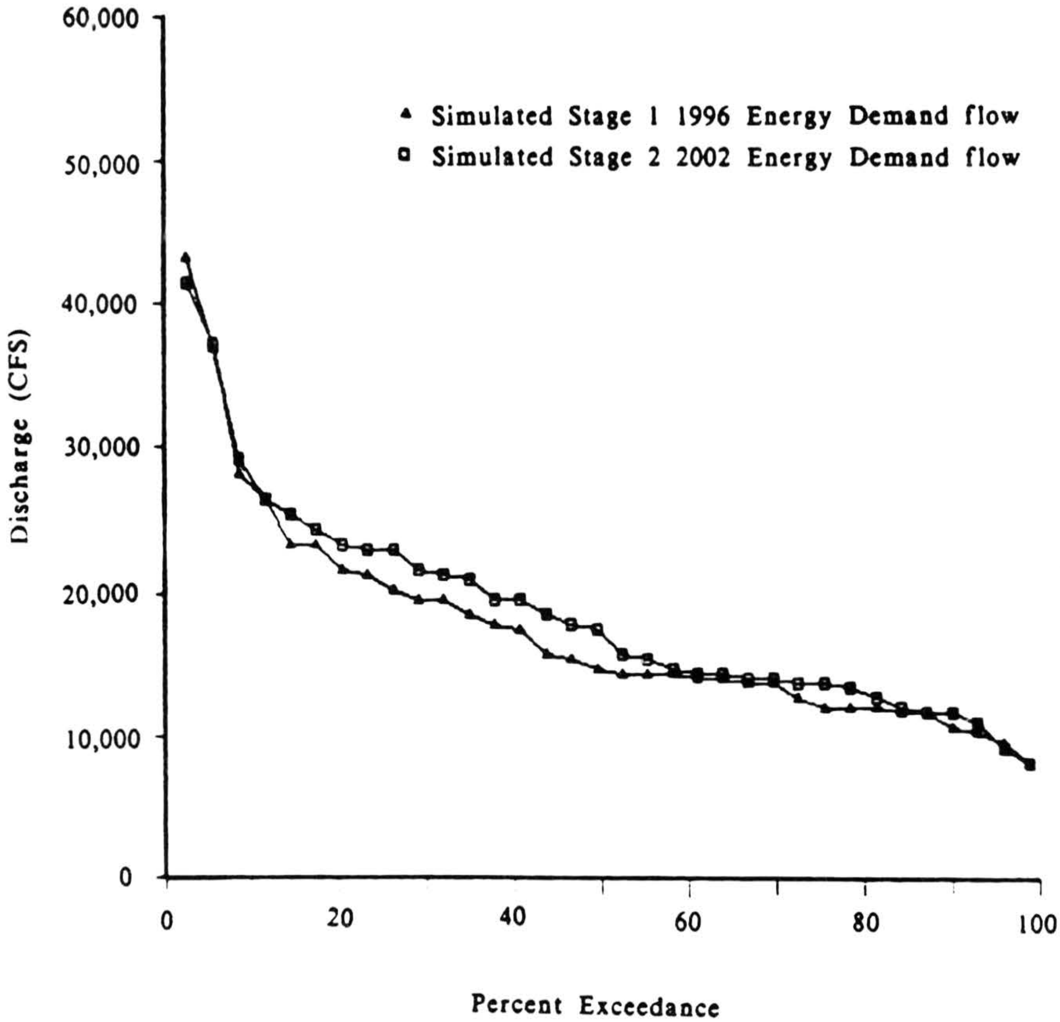
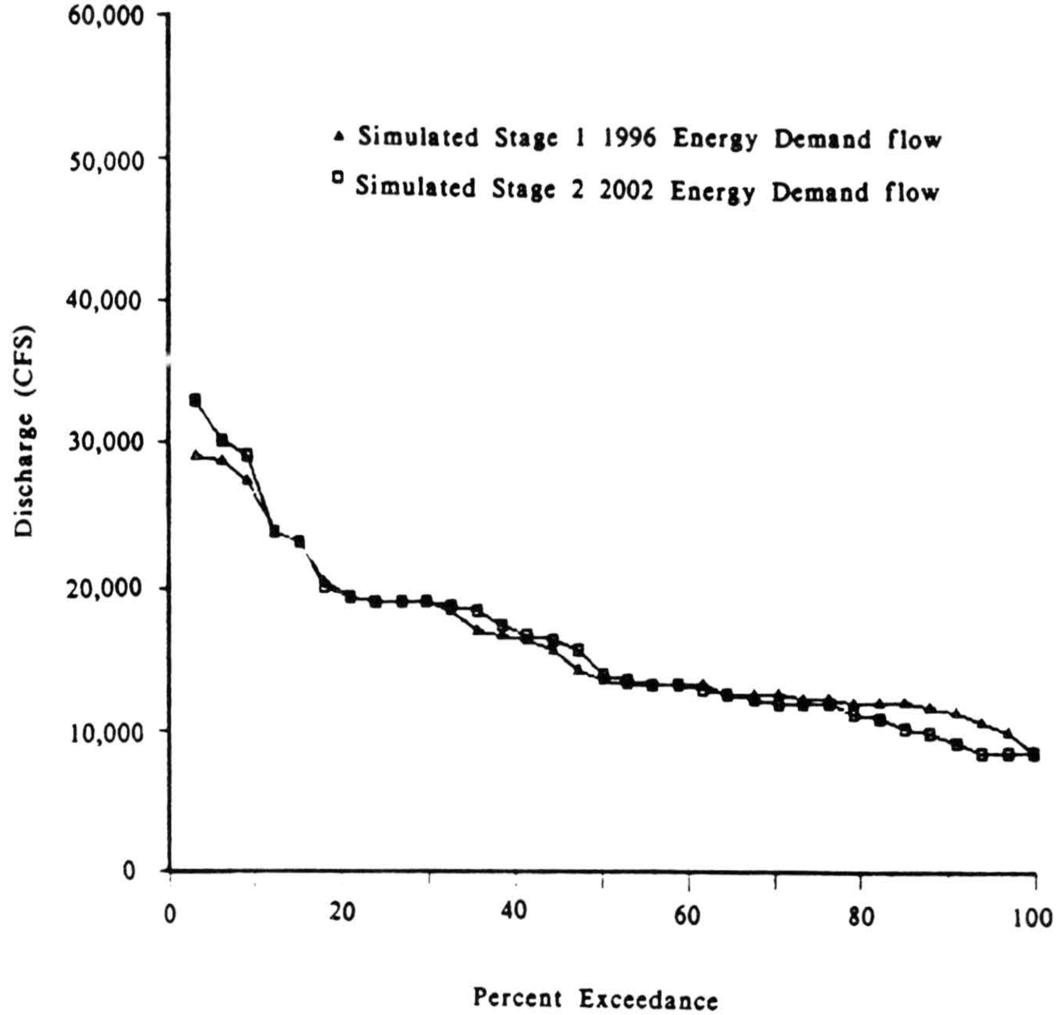


Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for week 47 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

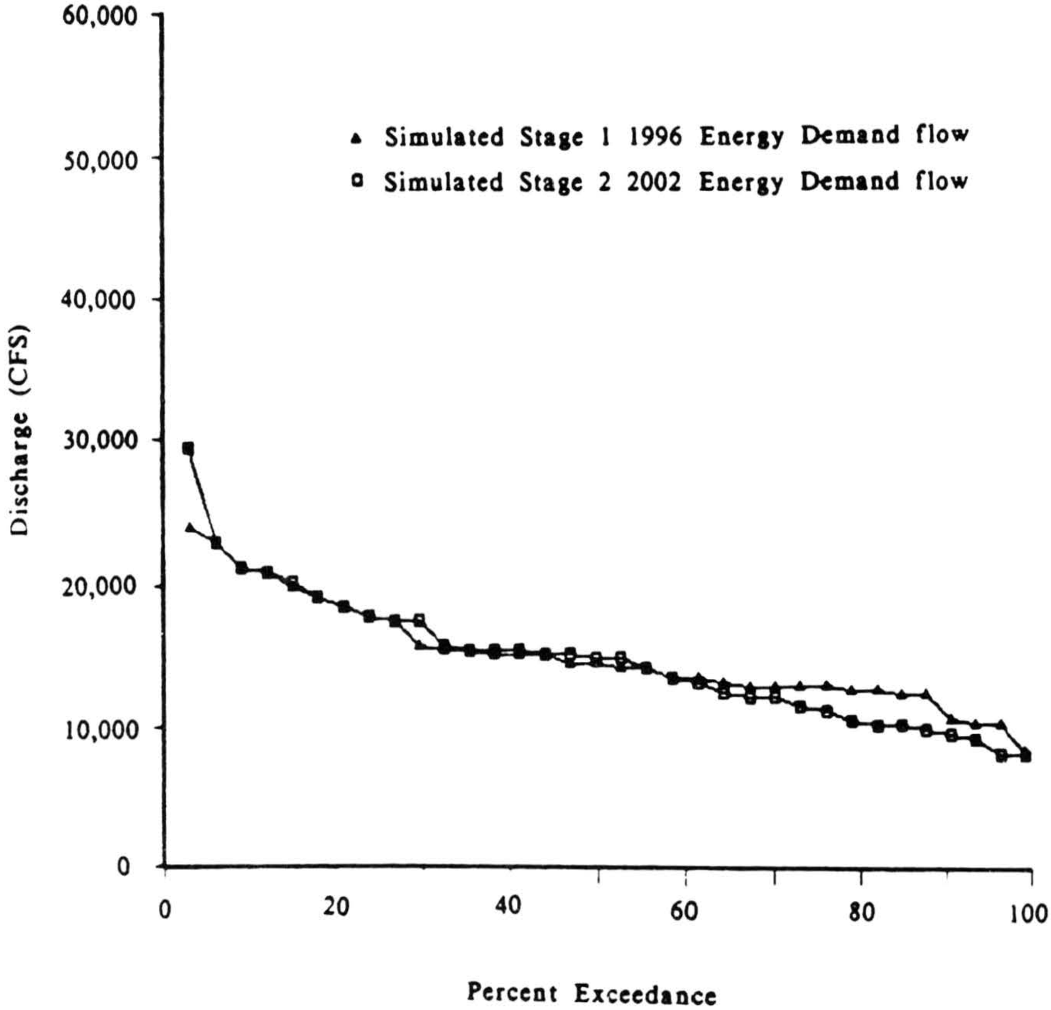
Appendix Figure 8



Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for week 48 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

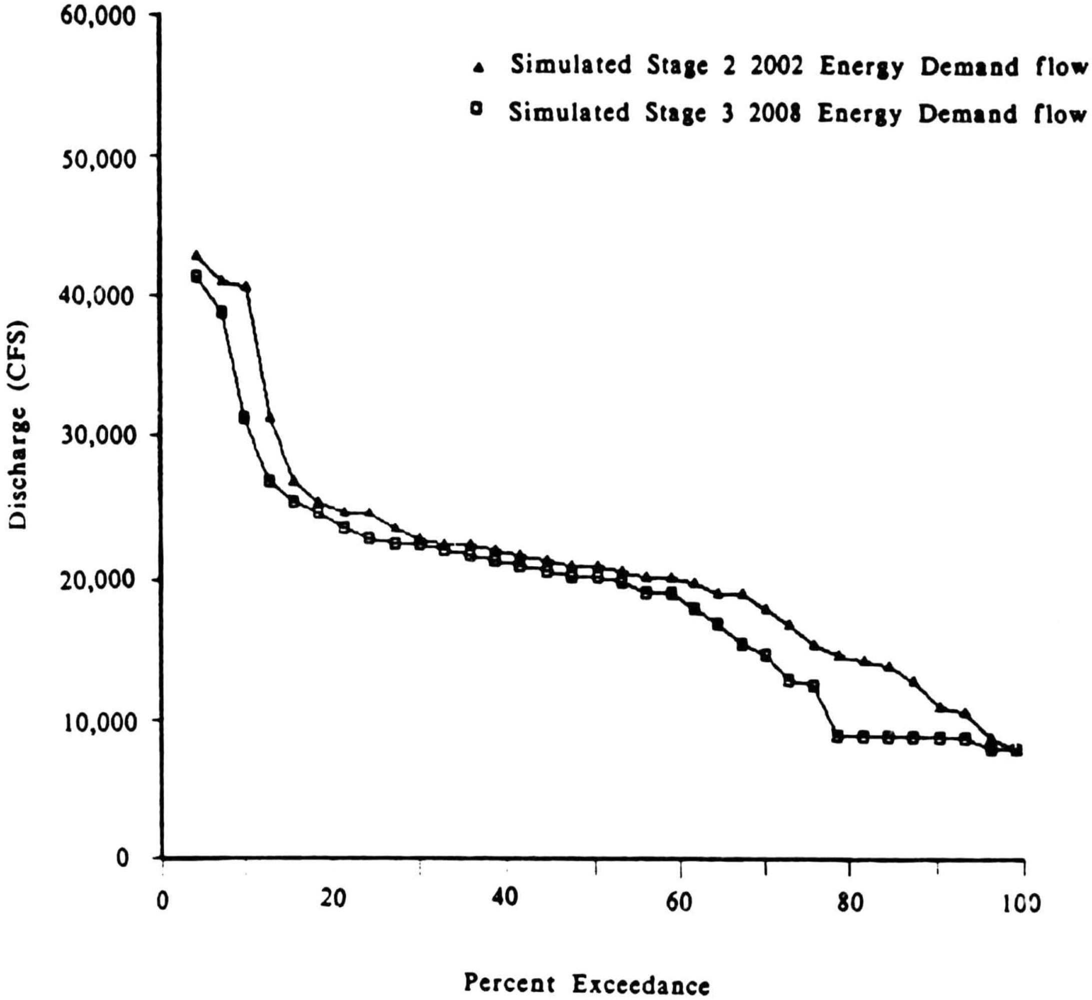
Appendix Figure 9



Comparison of flow duration curves for simulated Stage 1 1996 and simulated Stage 2 2002 Energy Demand streamflows for week 49 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

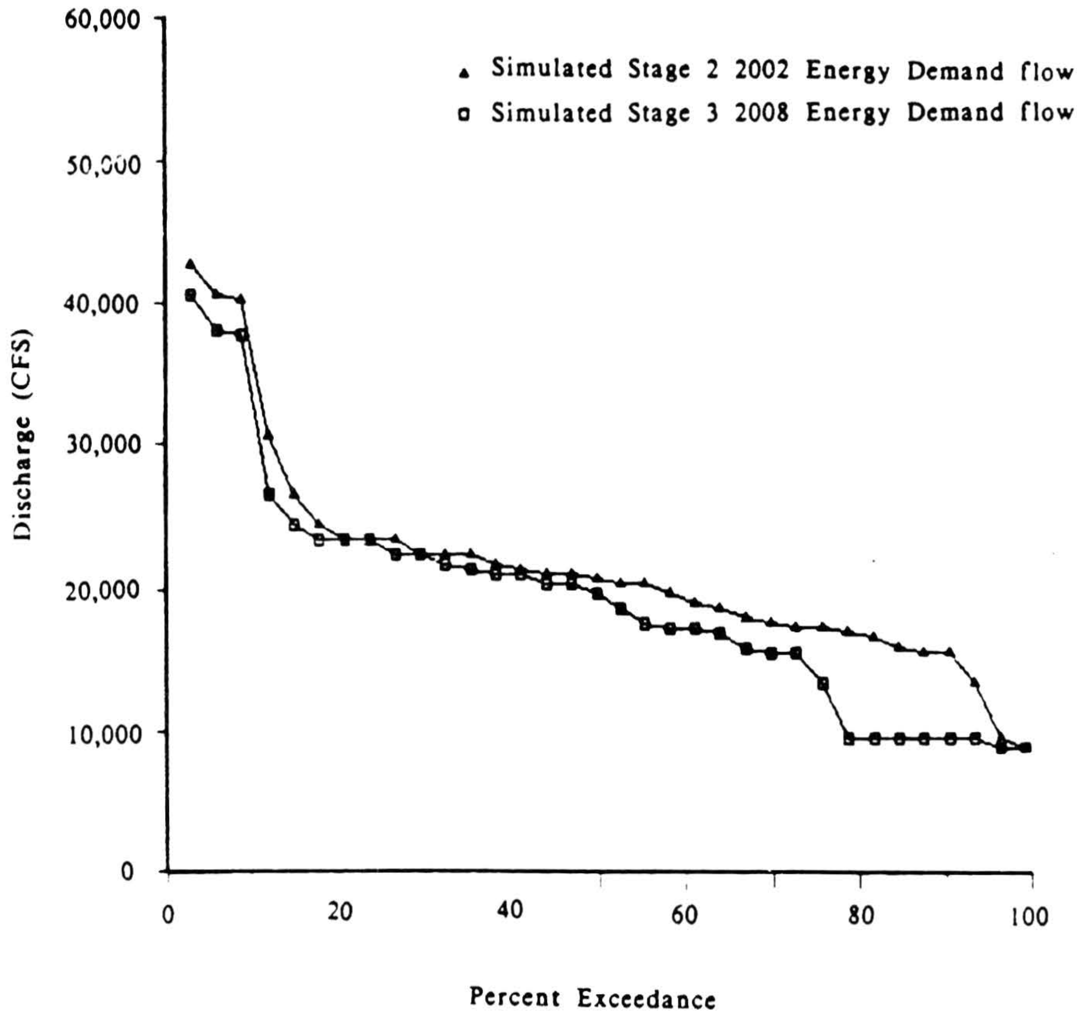
Appendix Figure 10



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for week 45 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

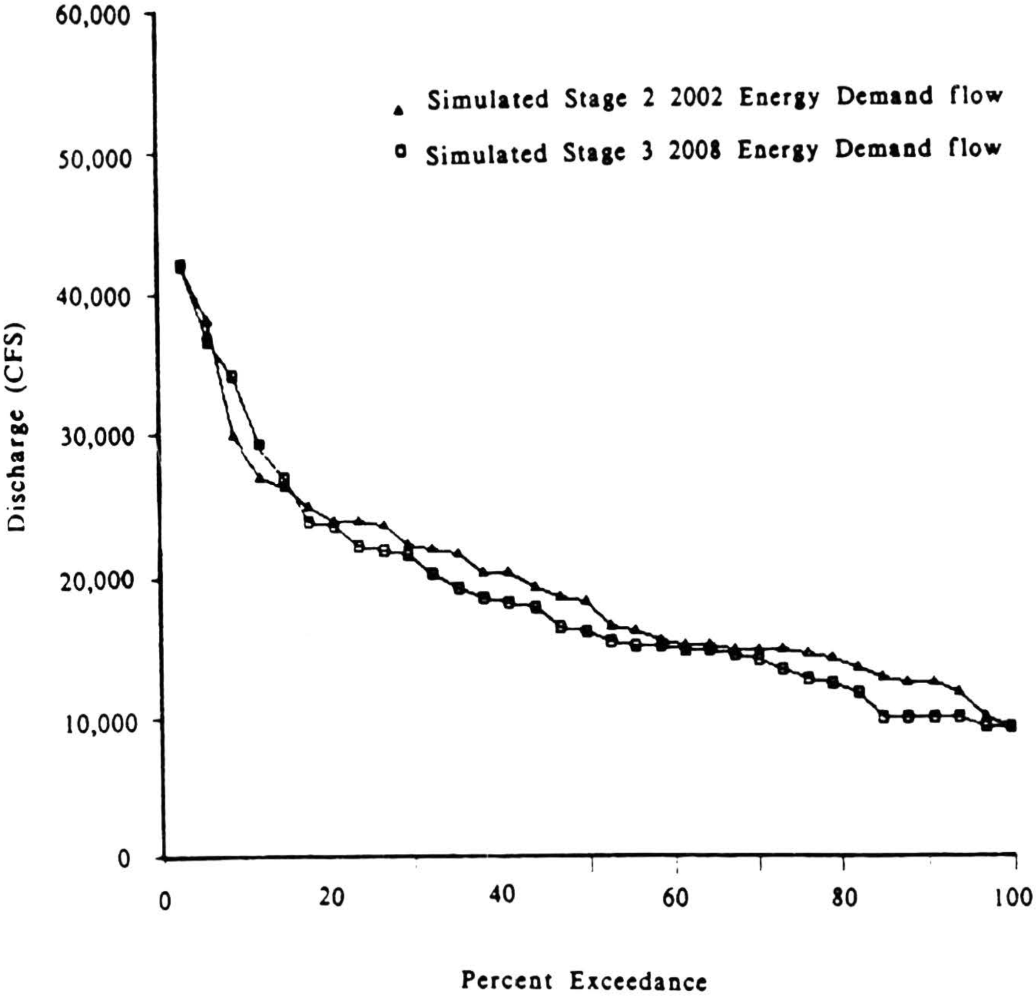
Appendix Figure 11



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for week 46 based on mean weekly flows for 34 years of record.

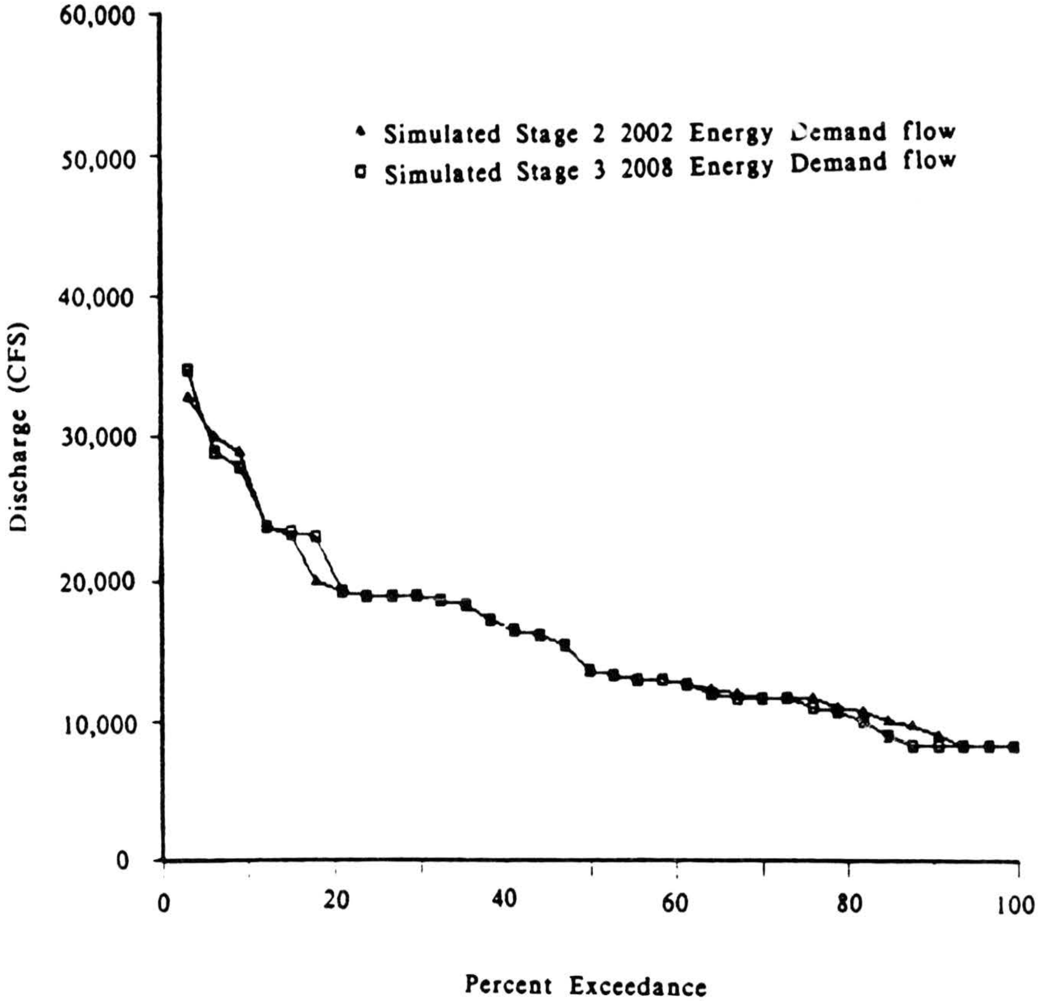
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Appendix Figure 12



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for week 47 based on mean weekly flows for 34 years of record.

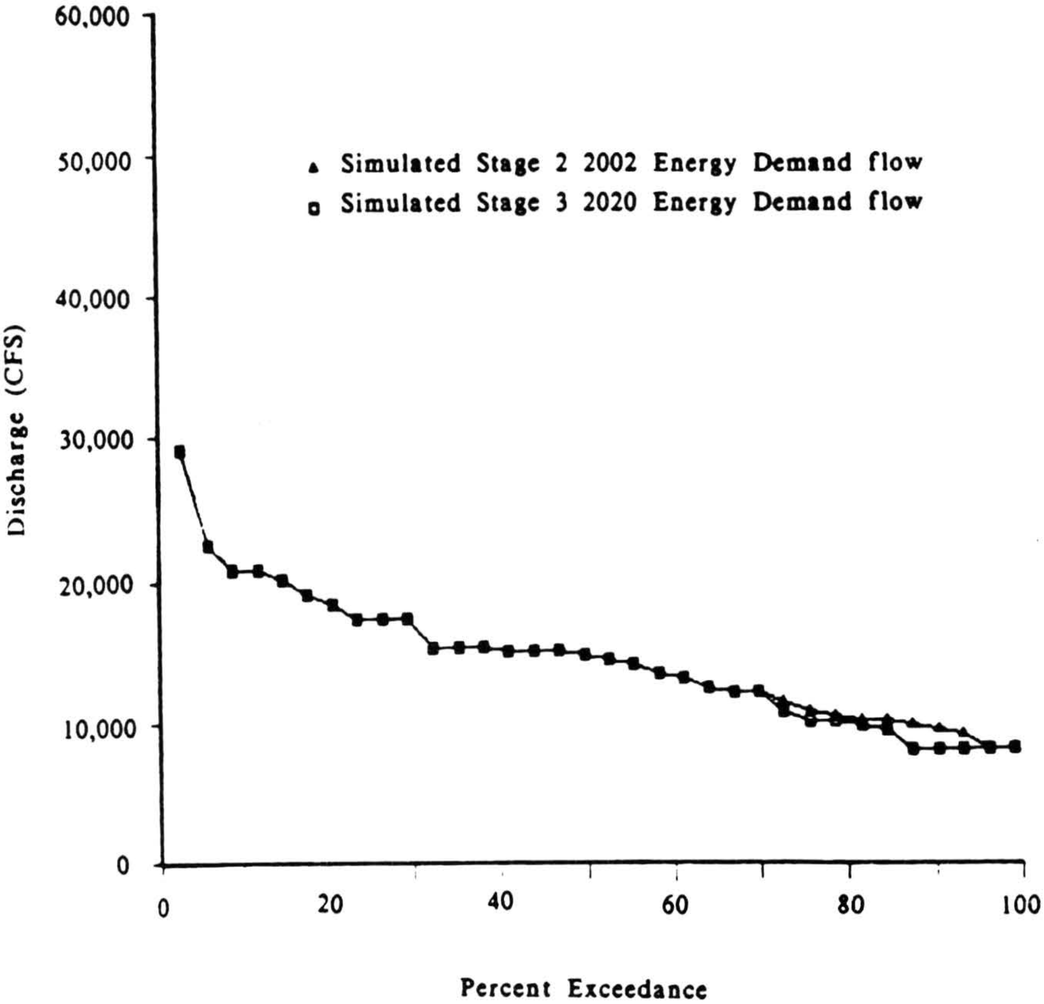
Appendix Figure 13	ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
	Woodward-Clyde Consultants **AND** **ENTRIX, INC.**	HARZA-EBASCO SUSITNA JOINT VENTURE



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for week 48 based on mean weekly flows for 34 years of record.

Appendix Figure 14

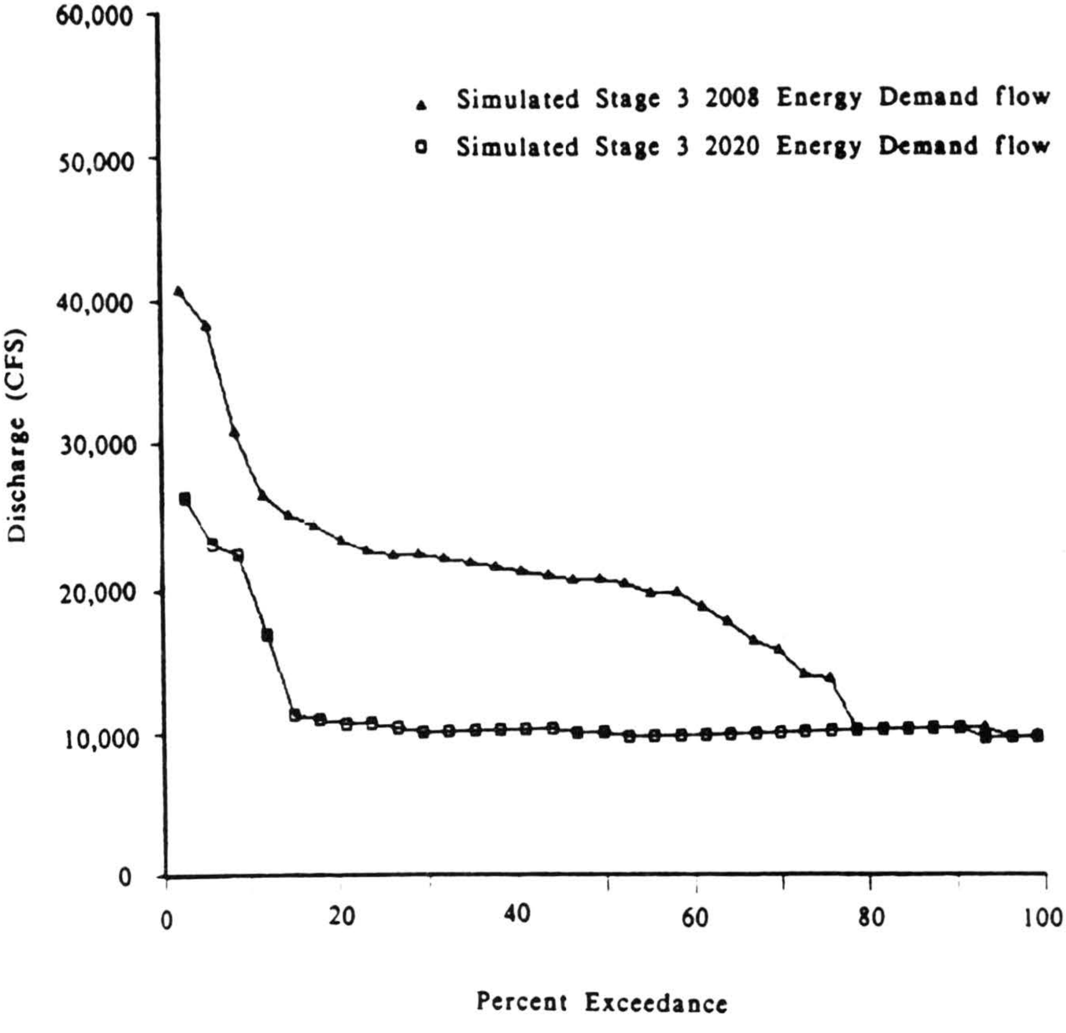
ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE



Comparison of flow duration curves for simulated Stage 2 2002 and simulated Stage 3 2008 Energy Demand streamflows for week 49 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

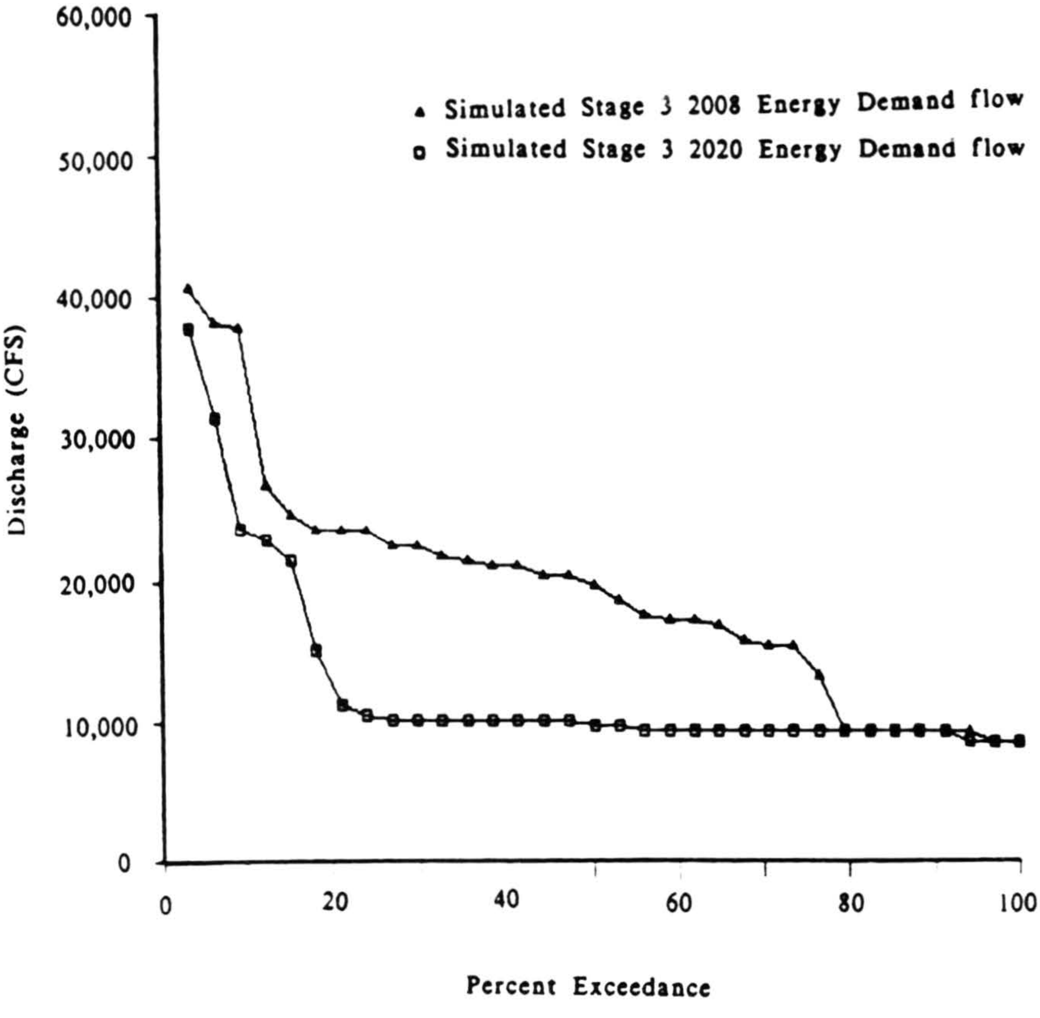
Appendix Figure 15



Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for week 45 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

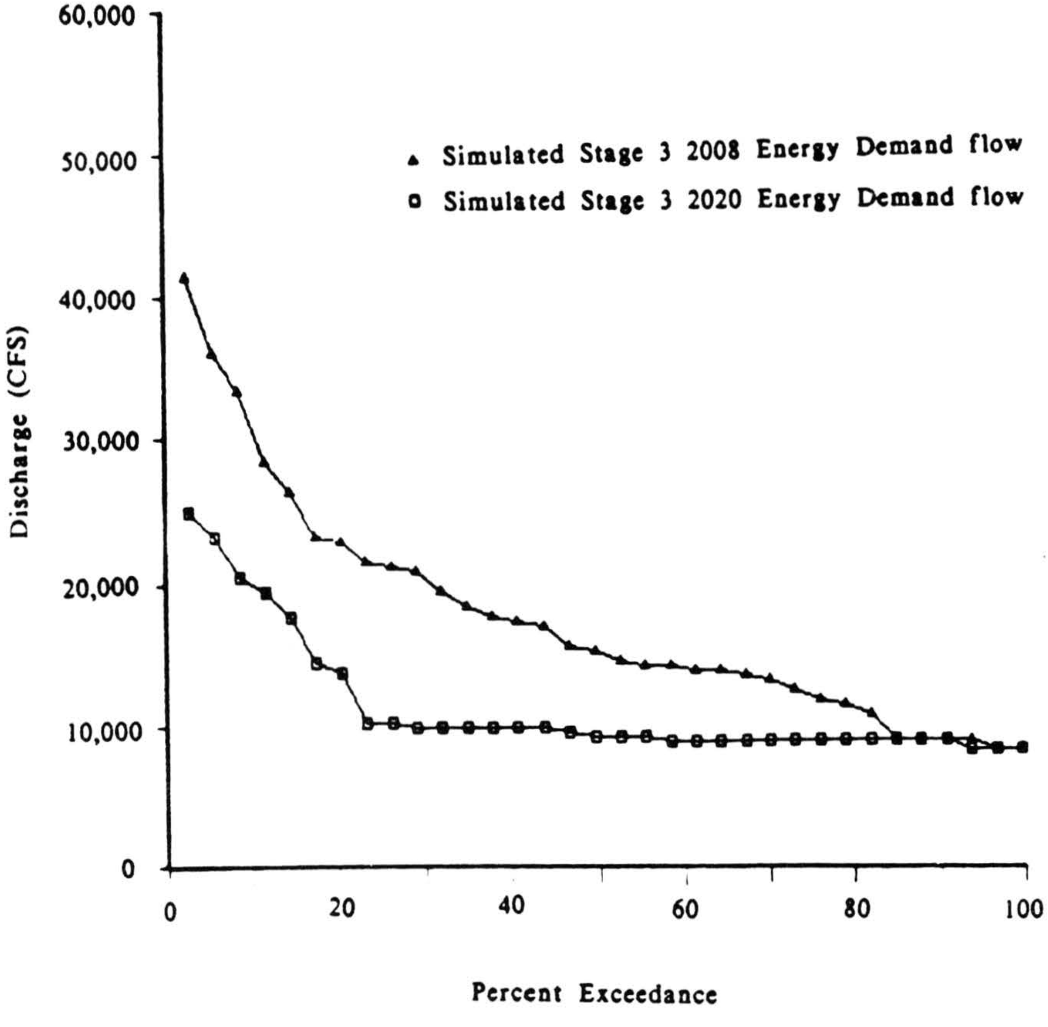
Appendix Figure 16



Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for week 46 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

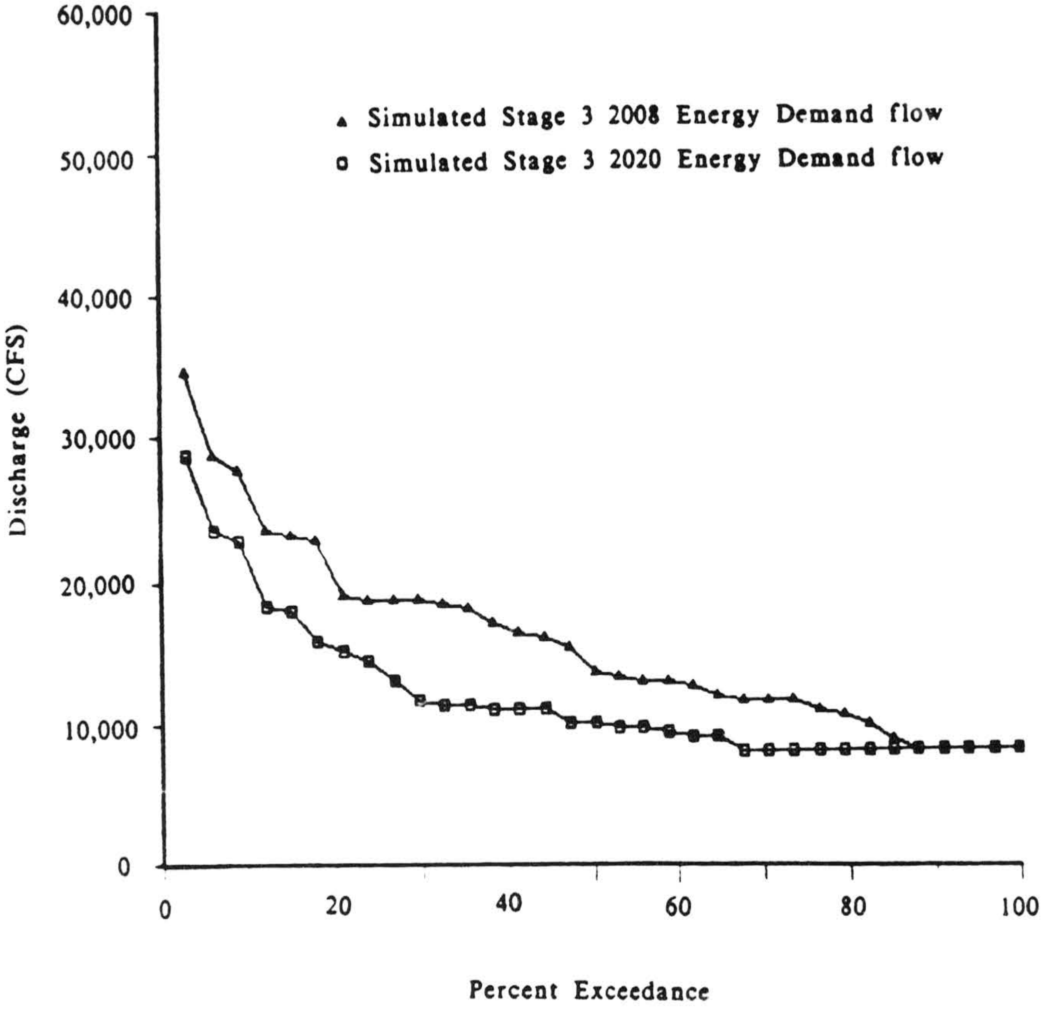
Appendix Figure 17



Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for week 47 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

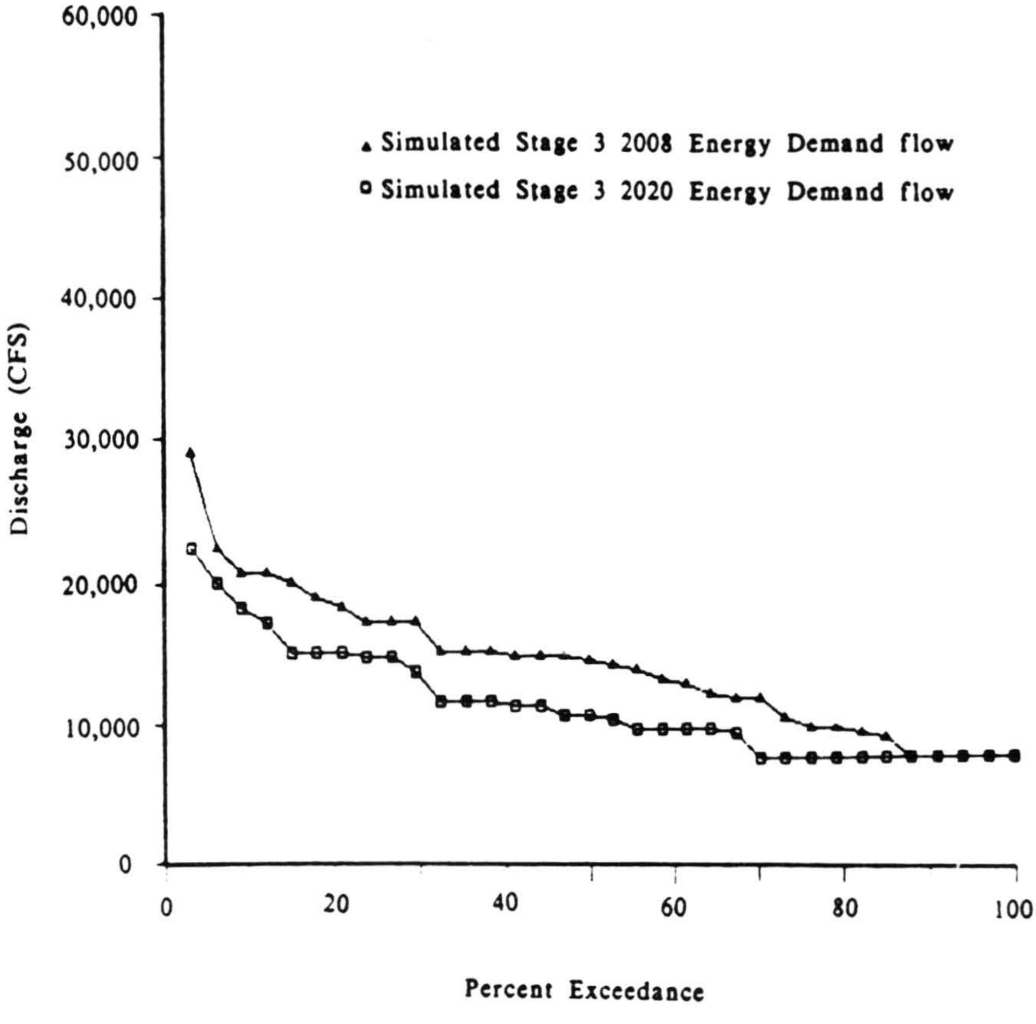
Appendix Figure 18



Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for week 48 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Appendix Figure 19



Comparison of flow duration curves for simulated Stage 3 2008 and simulated Stage 3 2020 Energy Demand streamflows for week 49 based on mean weekly flows for 34 years of record.

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
Woodward-Clyde Consultants AND ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Appendix Figure 20

APPENDIX TABLES

Appendix Table 1. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 45 at Slough 8A.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	88	53	53
	III	19,000	>60,000	27,000	65	47	47
	IV	25,000	>60,000	27,000	15	15	15
	V	30,000	>60,000	27,000	12	12	12
	VI	59,000	13,500	33,000	97	65	65
	VII	>60,000	>60,000	33,000	9	9	0
	VIII	>60,000	>60,000	33,000	9	9	0
	IX	>60,000	>60,000	33,000	9	9	0
	X	>60,000	>60,000	33,000	9	9	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 2. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 46 at Slough 8A.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	79	62	62
	III	19,000	>60,000	27,000	59	44	44
	IV	25,000	>60,000	27,000	12	15	15
	V	30,000	>60,000	27,000	9	9	9
	VI	59,000	13,500	33,000	91	71	71
	VII	>60,000	>60,000	33,000	6	6	0
	VIII	>60,000	>60,000	33,000	6	6	0
	IX	>60,000	>60,000	33,000	6	6	0
	X	>60,000	>60,000	33,000	6	6	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 3. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 47 at Slough 8A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage			Percent of Time*		
		Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	53	41	41
	III	19,000	>60,000	27,000	41	32	32
	IV	25,000	>60,000	27,000	15	12	12
	V	30,000	>60,000	27,000	6	9	6
	VI	59,000	13,500	33,000	77	68	68
	VII	>60,000	>60,000	33,000	6	6	0
	VIII	>60,000	>60,000	33,000	6	6	0
	IX	>60,000	>60,000	33,000	6	6	0
	X	>60,000	>60,000	33,000	6	6	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 4. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 48 at Slough 8A.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	47	41	41
	III	19,000	>60,000	27,000	18	18	18
	IV	25,000	>60,000	27,000	9	9	9
	V	30,000	>60,000	27,000	9	9	0
	VI	59,000	13,500	33,000	50	47	47
	VII	>60,000	>60,000	33,000	0	0	0
	VIII	>60,000	>60,000	33,000	0	0	0
	IX	>60,000	>60,000	33,000	0	0	0
	X	>60,000	>60,000	33,000	0	0	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 5. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 49 at Slough 8A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage			Percent of Time*		
		Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	29	27	27
	III	19,000	>60,000	27,000	15	15	15
	IV	25,000	>60,000	27,000	3	0	0
	V	30,000	>60,000	27,000	3	0	0
	VI	59,000	13,500	33,000	56	56	56
	VII	>60,000	>60,000	33,000	0	0	0
	VIII	>60,000	>60,000	33,000	0	0	0
	IX	>60,000	>60,000	33,000	0	0	0
	X	>60,000	>60,000	33,000	0	0	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 6. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during weeks 45-49 at Slough 8A.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
8A	I	7,700	5,500	27,000	100	100	100
	II	16,000	>60,000	27,000	97	77	77
	III	19,000	>60,000	27,000	82	68	68
	IV	25,000	>60,000	27,000	29	27	27
	V	30,000	>60,000	27,000	24	21	18
	VI	59,000	13,500	33,000	97	82	82
	VII	>60,000	>60,000	33,000	15	15	0
	VIII	>60,000	>60,000	33,000	15	15	0
	IX	>60,000	>60,000	33,000	15	15	0
	X	>60,000	>60,000	33,000	15	15	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 7. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 45 at Slough 9.

Slough	Passage Reach	Mainstem Discharge for Successful Passage			Percent of Time*		
		Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	97	85	85
	II	22,300	58,000	19,000	65	47	18
	III	25,500	>60,000	19,000	65	47	15
	IV	25,500	58,000	19,000	65	47	15
	V	34,400	>60,000	19,000	65	47	9

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 8. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 46 at Slough 9.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	97	85	85
	II	22,300	58,000	19,000	59	44	21
	III	25,500	>60,000	19,000	59	44	15
	IV	25,500	58,000	19,000	59	44	15
	V	34,400	>60,000	19,000	59	44	6

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 9. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 47 at Slough 9.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	94	77	77
	II	22,300	58,000	19,000	41	32	18
	III	25,500	>60,000	19,000	41	32	12
	IV	25,500	58,000	19,000	41	32	12
	V	34,400	>60,000	19,000	41	32	6

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 10. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 48 at Slough 9.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	71	77	77
	II	22,300	58,000	19,000	18	18	15
	III	25,500	>60,000	19,000	18	18	9
	IV	25,500	58,000	19,000	18	18	9
	V	34,400	>60,000	19,000	18	18	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 11. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 49 at Slough 9.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	65	77	77
	II	22,300	58,000	19,000	15	15	6
	III	25,500	>60,000	19,000	15	15	0
	IV	25,500	58,000	19,000	15	15	0
	V	34,400	>60,000	19,000	15	15	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 12. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during weeks 45-49 at Slough 9.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9	I	11,600	27,000	19,000	97	91	91
	II	22,300	58,000	19,000	82	68	35
	III	25,500	>60,000	19,000	82	68	15
	IV	25,500	58,000	19,000	82	68	27
	V	34,400	>60,000	19,000	82	68	15

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 13. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 45 at Slough 9A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	97	88	88
	II	15,000	7,500	13,500	97	100	100
	III	22,300	11,000	13,500	97	91	91
	IV	27,000	11,000	13,500	97	91	91
	V	33,500	12,500	13,500	97	80	80
	VI	44,600	18,000	13,500	74	65	50
	VII	47,300	15,000	13,500	94	65	56
	VIII	>60,000	31,500	13,500	94	65	9
	IX	>60,000	15,000	13,500	94	65	56
	X	>60,000	12,500	13,500	97	80	80
	XI	>60,000	50,000	13,500	94	65	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 14. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 46 at Slough 9A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	97	85	85
	II	15,000	7,500	13,500	97	100	100
	III	22,300	11,000	13,500	97	91	91
	IV	27,000	11,000	13,500	97	91	91
	V	33,500	12,500	13,500	97	77	77
	VI	44,600	18,000	13,500	97	71	50
	VII	47,300	15,000	13,500	91	71	65
	VIII	>60,000	31,500	13,500	91	71	6
	IX	>60,000	15,000	13,500	91	71	65
	X	>60,000	12,500	13,500	97	77	77
	XI	>60,000	50,000	13,500	91	71	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 15. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 47 at Slough 9A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	88	82	82
	II	15,000	7,500	13,500	97	100	100
	III	22,300	11,000	13,500	94	94	94
	IV	27,000	11,000	13,500	94	94	94
	V	33,500	12,500	13,500	85	85	85
	VI	44,600	18,000	13,500	77	68	35
	VII	47,300	15,000	13,500	77	68	47
	VIII	>60,000	31,500	13,500	77	68	6
	IX	>60,000	15,000	13,500	77	68	47
	X	>60,000	12,500	13,500	85	74	74
	XI	>60,000	50,000	13,500	77	68	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 16. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 48 at Slough 9A.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	71	77	77
	II	15,000	7,500	13,500	97	100	100
	III	22,300	11,000	13,500	79	88	88
	IV	27,000	11,000	13,500	79	88	88
	V	33,500	12,500	13,500	62	62	62
	VI	44,600	18,000	13,500	50	47	29
	VII	47,300	15,000	13,500	50	47	44
	VIII	>60,000	31,500	13,500	50	47	0
	IX	>60,000	15,000	13,500	50	47	44
	X	>60,000	12,500	13,500	62	62	62
	XI	>60,000	50,000	13,500	50	47	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 17. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 49 at Slough 9A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	65	82	82
	II	15,000	7,500	13,500	94	97	97
	III	22,300	11,000	13,500	71	88	88
	IV	27,000	11,000	13,500	71	88	88
	V	33,500	12,500	13,500	62	62	62
	VI	44,600	18,000	13,500	56	56	21
	VII	47,300	15,000	13,500	56	56	29
	VIII	>60,000	31,500	13,500	56	56	29
	IX	>60,000	15,000	13,500	62	62	52
	X	>60,000	12,500	13,500	62	62	52
	XI	>60,000	50,000	13,500	56	56	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 18. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during weeks 45-49 at Slough 9A.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
9A	I	11,500	15,000	13,500	97	91	91
	II	15,000	7,500	13,500	97	100	100
	III	22,300	11,000	13,500	97	94	94
	IV	27,000	11,000	13,500	97	94	94
	V	33,500	12,500	13,500	97	85	85
	VI	44,600	18,000	13,500	97	82	71
	VII	47,300	15,000	13,500	97	82	77
	VIII	>60,000	31,500	13,500	97	82	15
	IX	>60,000	15,000	13,500	97	82	77
	X	>60,000	12,500	13,500	97	85	85
	XI	>60,000	50,000	13,500	97	82	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 19. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 45 at Slough 11 and Upper Side Channel 11.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	88	52	52
	II	19,400	<8,500	42,000	97	97	97
	III	33,400	>60,000	42,000	9	9	9
	IV	40,300	48,000	42,000	6	6	6
	V	>60,000	>60,000	42,000	6	3	0
	VI	>60,000	>60,000	42,000	6	3	0
	VII	>60,000	>60,000	42,000	6	3	0
USC 11	I	44,000	a	16,000	88[b]	53[b]	0[b]
	II	a	a	16,000	88[c]	53[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 20. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 46 at Slough 11 and Upper Side Channel 11.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	74	56	56
	II	19,400	<8,500	42,000	97	97	97
	III	33,400	>60,000	42,000	6	6	6
	IV	40,300	48,000	42,000	3	0	0
	V	>60,000	>60,000	42,000	3	0	0
	VI	>60,000	>60,000	42,000	3	0	0
	VII	>60,000	>60,000	42,000	3	0	0
USC 11	I	44,000	a	16,000	79[b]	62[b]	0[b]
	II	a	a	16,000	79[c]	62[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 21. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 47 at Slough 11 and Upper Side Channel 11.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	53	41	41
	II	19,400	<8,500	42,000	97	97	97
	III	33,400	>60,000	42,000	6	6	6
	IV	40,300	48,000	42,000	3	3	3
	V	>60,000	>60,000	42,000	3	3	0
	VI	>60,000	>60,000	42,000	3	3	0
	VII	>60,000	>60,000	42,000	3	3	0
USC 11	I	44,000	a	16,000	53[b]	41[b]	0[b]
	II	a	a	16,000	53[c]	41[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 22. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 48 at Slough 11 and Upper Side Channel 11.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	41	35	35
	II	19,400	<8,500	42,000	94	97	97
	III	33,400	>60,000	42,000	0	0	0
	IV	40,300	48,000	42,000	0	0	0
	V	>60,000	>60,000	42,000	0	0	0
	VI	>60,000	>60,000	42,000	0	0	0
	VII	>60,000	>60,000	42,000	0	0	0
USC 11	I	44,000	a	16,000	47[b]	41[b]	0[b]
	II	a	a	16,000	47[c]	41[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 23. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 49 at Slough 11 and Upper Side Channel 11.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	29	27	27
	II	19,400	<8,500	42,000	97	97	97
	III	33,400	>60,000	42,000	0	0	0
	IV	40,300	48,000	42,000	0	0	0
	V	>60,000	>60,000	42,000	0	0	0
	VI	>60,000	>60,000	42,000	0	0	0
	VII	>60,000	>60,000	42,000	0	0	0
USC 11	I	44,000	a	16,000	29[b]	27[b]	0[b]
	II	a	a	16,000	29[c]	27[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 24. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during weeks 45-49 at Slough 11 and Upper Side Channel 11.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
11	I	16,500	28,000	42,000	94	74	74
	II	19,400	<8,500	42,000	97	97	97
	III	33,400	>60,000	42,000	15	15	15
	IV	40,300	48,000	42,000	12	9	9
	V	>60,000	>60,000	42,000	9	6	0
	VI	>60,000	>60,000	42,000	9	6	0
	VII	>60,000	>60,000	42,000	9	6	0
USC 11	I	44,000	a	16,000	97[b]	77[b]	0[b]
	II	a	a	16,000	97[c]	77[c]	d

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

[a] Mainstem discharges not evaluated as data insufficient for analysis.

[b] Percent exceedence evaluated for backwater and breaching mainstem discharges only.

[c] Percent exceedence evaluated for breaching mainstem discharge only.

[d] Percent exceedence not evaluated as data insufficient for analysis.

Appendix Table 25. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 45 at Side Channel 21 and Slough 21.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	97	91	91
	III	13,000	15,000	12,000	97	82	68
	IV	20,000	15,000	12,000	97	82	56
	V	25,900	15,000	12,000	97	82	56
	VI	32,100	48,000	12,000	97	82	9
	VII	45,900	>60,000	12,000	97	82	0
	VIII	50,000	28,000	24,000	21	21	12
	IX	51,400	22,000	24,000	32	21	21
Sl 21	I	51,400	22,000	25,800	32	21	21
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	15	15	0
	IIIR	>60,000	>60,000	29,000	≥12	≥12	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 26. **Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 46 at Side Channel 21 and Slough 21.**

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	97	91	91
	III	13,000	15,000	12,000	97	79	74
	IV	20,000	15,000	12,000	97	79	65
	V	25,900	15,000	12,000	97	79	65
	VI	32,100	48,000	12,000	97	79	6
	VII	45,900	>60,000	12,000	97	79	0
	VIII	50,000	28,000	24,000	18	15	6
	IX	51,400	22,000	24,000	27	21	21
Sl 21	I	51,400	22,000	25,800	27	21	21
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	12	15	0
	IIIR	>60,000	>60,000	29,000	9	6	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 27. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 47 at Side Channel 21 and Slough 21.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	97	88	88
	III	13,000	15,000	12,000	85	74	71
	IV	20,000	15,000	12,000	85	74	47
	V	25,900	15,000	12,000	85	74	47
	VI	32,100	48,000	12,000	85	74	6
	VII	45,900	>60,000	12,000	85	74	0
	VIII	50,000	28,000	24,000	15	12	9
	IX	51,400	22,000	24,000	24	18	18
Sl 21	I	51,400	22,000	25,800	24	18	18
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	12	12	0
	IIIR	>60,000	>60,000	29,000	6	6	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 28. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 48 at Side Channel 21 and Slough 21.

Slough	Passage Reach	Mainstem Discharge for Successful Passage			Percent of Time*		
		Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	85	91	91
	III	13,000	15,000	12,000	65	68	50
	IV	20,000	15,000	12,000	65	68	44
	V	25,900	15,000	12,000	65	68	44
	VI	32,100	48,000	12,000	65	68	0
	VII	45,900	>60,000	12,000	65	68	0
	VIII	50,000	28,000	24,000	9	9	6
	IX	51,400	22,000	24,000	15	15	15
Sl 21	I	51,400	22,000	25,800	15	15	15
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	9	9	0
	IIIR	>60,000	>60,000	29,000	6	3	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 29. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during week 49 at Side Channel 21 and Slough 21.

Slough	Passage Reach	Mainstem Discharge for Successful Passage: Backwater	Local Flow	Breaching	Percent of Time*: Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	74	88	88
	III	13,000	15,000	12,000	62	71	56
	IV	20,000	15,000	12,000	62	71	29
	V	25,900	15,000	12,000	62	71	29
	VI	32,100	48,000	12,000	62	71	0
	VII	45,900	>60,000	12,000	62	71	0
	VIII	50,000	28,000	24,000	3	0	0
	IX	51,400	22,000	24,000	6	6	6
Sl 21	I	51,400	22,000	25,800	6	6	6
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	3	0	0
	IIIR	>60,000	>60,000	29,000	3	0	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.

Appendix Table 30. Percent of time successful passage occurs under natural and Stage 1 mainstem discharges during weeks 45-49 at Side Channel 21 and Slough 21.

		Mainstem Discharge for Successful Passage			Percent of Time*		
Slough	Passage Reach	Backwater	Local Flow	Breaching	Natural	Unbermed Stage 1	Bermed Stage 1
SC 21	I	7,800	5,000	12,000	100	100	100
	II	10,300	15,000	12,000	97	97	97
	III	13,000	15,000	12,000	97	91	82
	IV	20,000	15,000	12,000	97	91	77
	V	25,900	15,000	12,000	97	91	77
	VI	32,100	48,000	12,000	97	91	15
	VII	45,900	>60,000	12,000	97	91	0
	VIII	50,000	28,000	24,000	32	27	18
	IX	51,400	22,000	24,000	47	38	38
Sl 21	I	51,400	22,000	25,800	47	38	38
	II	54,900	5,000	25,800	100	100	100
	IIIL	>60,000	>60,000	25,800	29	27	0
	IIIR	>60,000	>60,000	29,000	≥28	≥18	0

*Percent of time corresponds to the minimum of the three required discharges for successful passage provided by either backwater, local flow, or breaching.