SUSITNA
HYDROELECTRIC PROJECT

FEDERAL ENERGY REGULATORY COMMISSION
PROJECT No. 7114

DOWNSTREAM AQUATIC IMPACT ASSESSMENT REPORT

PREPARED BY

ENTRIX, INC.

UNDER CONTRACT TO

HARZA-EBASCO
SUSITNA JOINT VENTURE

DRAFT REPORT

FEBRUARY 1986
DOCUMENT No. 3417

Alaska Power Authority

Document No. 3417
Susitna File No. 4.3.1.9

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Draft Report
February 1986

NOTICE

ANY QUESTIONS OR COMMENTS CONCERNING
THIS REPORT SHOULD BE DIRECTED TO
THE ALASKA POWER AUTHORITY
SUSITNA PROJECT OFFICE

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

LIST OF TABLES

(Section 5 to be added)

LIST OF FIGURES

(Section 5 to be added)

LIST OF FIGURES (Continued)

1.0 INTRODUCTION

1.1 Background

Since the original License Application for the proposed Susitna Hydroelectric Project was filed before the FERC in February 1983, the APA has engaged in extensive consultation with interested agencies with the common goal of identifying the project's environmental impacts, improving project design and operation, and cooperatively resolving as many issues as possible. By March 1984, the APA, in conjunction with the state, federal and local resource agencies, identified 56 issues ranging from minor concerns to significant resource utilization issues. These issues have provided a mechanism for the APA, appropriate resources agencies and concerned citizens to focus on environmental impact analyses and mitigation planning.

Twelve of the 56 issues are related to fisheries concerns or other effects on aquatic resources (Table 1). These 12 aquatic issues are addressed in a four volume Aquatic Impact and Mitigation Report Series. The location of specific volume coverage for each issue is provided in Table 2. As indicated in Table 2, this report addresses issues related to physical changes downstream from the proposed dams. Downstream issues are further defined within the report.

1.2 Project Area

The Susitna River is a large, glacial-fed river located within the northern portion of Southcentral Alaska. The sites of the proposed Watana and Devil Canyon dams are located in the upper Susitna River basin. The basin is bounded by the Talkeetna Mountains to the southeast and the Alaska Range to the north and west (Figure 1). The Watana dam will be sited between river mile (RM) 184 and RM 185; the Devil Canyon dam will be built 32 miles downstream at approximately RM 152. Geographical designations for sections of the Susitna River that would be affected by the project include the impoundment zone, middle Susitna River, and lower Susitna River (Figure 2). The impoundment zone includes those portions of the Susitna River that would be inundated following construction of each of the dams. The middle Susitna River refers to the reach of the Susitna River between Devil Canyon and its

Table 1. Alaska Power Authority Susitna Hydroelectric Project Aquatic Issues List, March 6, 1984.

F-1. Significance of altered flow regime on salmon and resident fish habitats and populations downstream of the dams, including effects on migration/access, spawning, and rearing during summer months, and effects on incubation and rearing during winter months.

F-2. Significance of changes in water quality parameters (turbidity, pH, heavy metals, dissolved nitrogen, temperature, nutrients) on salmon and resident fish habitats and populations downstream of the dams.

F-3. Significance of altered ice processes on salmon and resident fish habitats and populations downstream of the dams, including effects on fish access and changes due to staging.

F-4. Significance of changes in stream morphology on salmon and resident fish habitats and populations downstream of the dams.

F-5. Significance of impoundment effects on resident fish habitat and populations upstream of the dams.

F-6. Significance of physical effects of access corridors on fish habitats.

F-7. Significance of physical effects of transmission line corridors on fish habitats.

F-8. Significance of water quality and quantity effects of construction camp and permanent village on fish habitats.

F-9. Significance of water quality and stream morphology effects of borrow and spoil areas on fish habitats.

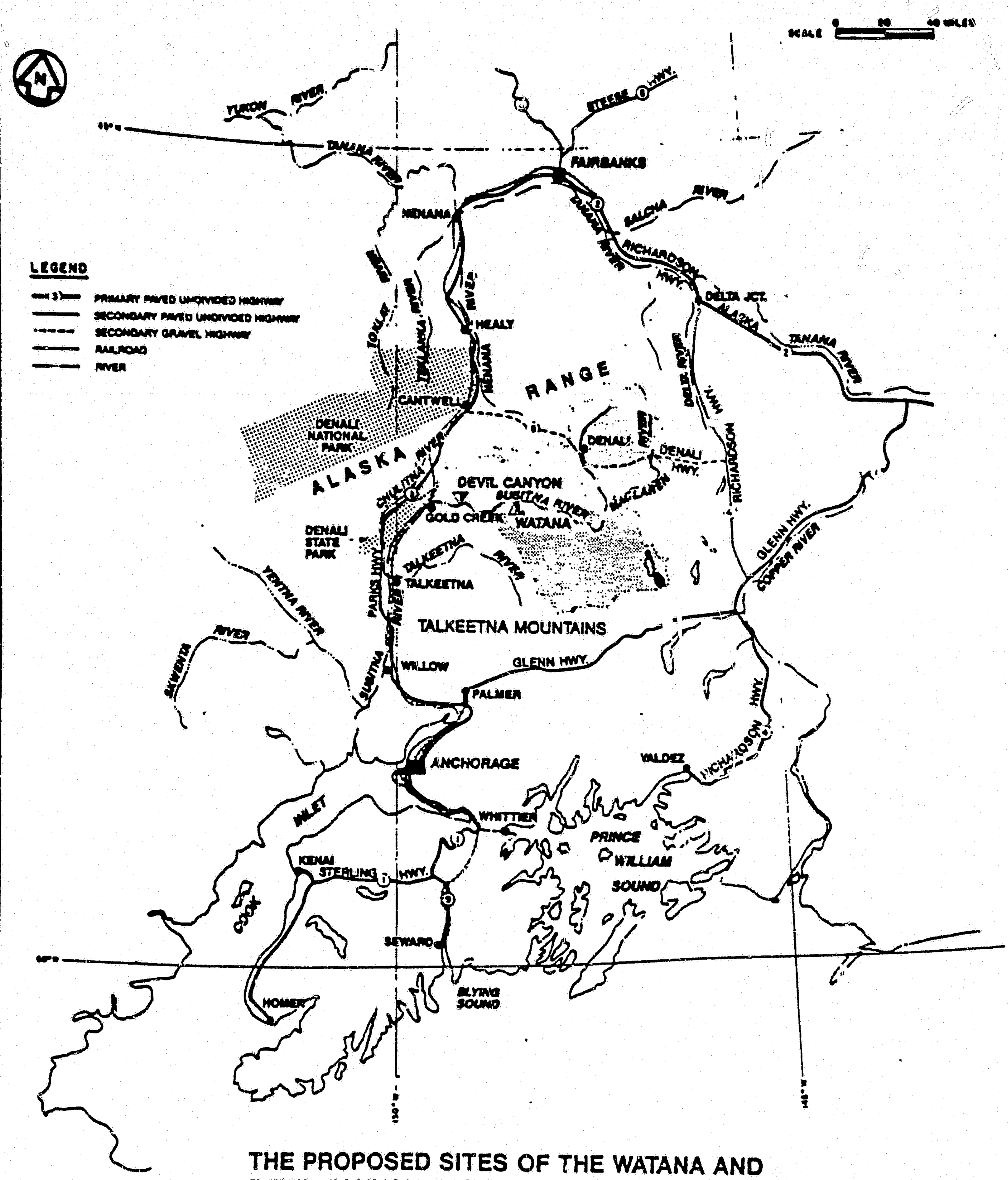
F-10. Significance of disturbance effects of human instream activities on fish.

F-11. Feasibility and desirability of specific mitigation options, including structural modifications, flow allocation, physical habitat modification, hatcheries, and management options.

F-12. Formulation and implementation of post-construction plan to monitor significant impacts and the efficacy of specific mitigation measures.

Table 2. Location of information pertaining to aquatic issues within the Aquatic Impacts and Mitigation Report Series.

Issue No.	Report No. 1 Access, Construction and Transmission Line Impacts and Mitigation	Report No. 2 Impoundment Area Impacts and Mitigation	Report No. 3 Downstream Impacts and Mitigation: Flow Alteration	Report No. 3 Downstream Impacts and Mitigation: River Morphology	Report No. 3 Downstream Impacts and Mitigation: Water Quality	Report No. 4 Aquatic Monitoring Plan
F-1			*			
F-2					*	
F-3					*	
F-4				*		
F-5		*				
F-6	*					
F-7	*					
F-8	*					
F-9	*					
F-10	*					
F-11			*			
F-12						*



THE PROPOSED SITES OF THE WATANA AND DEVIL CANYON DAMS

SOURCE: APA 1985a

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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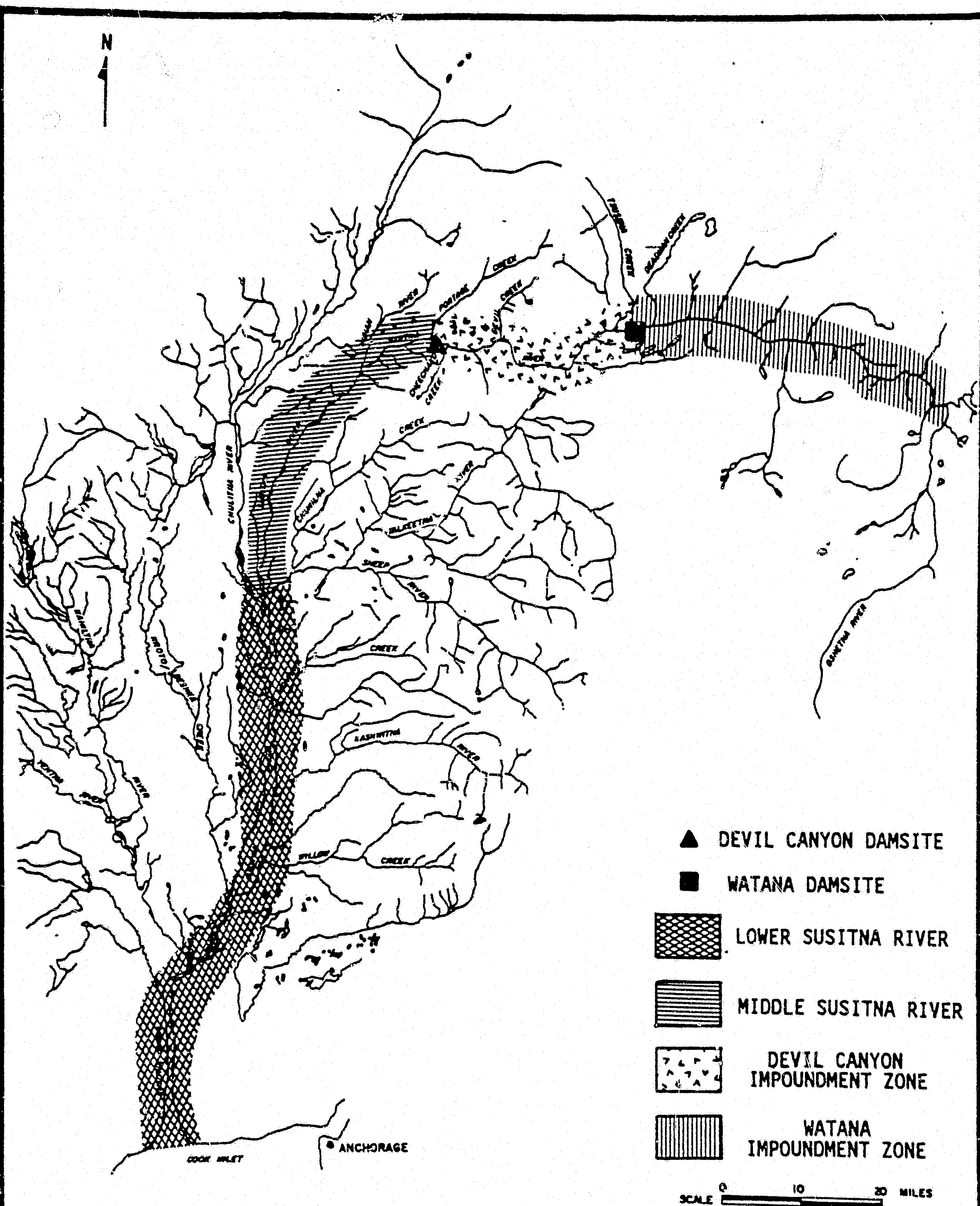
FIGURE 1



GEOGRAPHICAL SECTIONS OF THE SUSITNA RIVER

FIGURE 2

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confluence with the Talkeetna and Chulitna rivers while the lower Susitna River indicates the reach below the confluence with the Talkeetna and Chulitna rivers to Cook Inlet (Figure 2).

The aquatic resources of the Susitna River include resident and anadromous fish which utilize a diverse range of mainstem-associated habitats for migration, spawning, incubation, rearing and overwintering. The upstream extent of anadromous fish use is generally considered to be Devil Canyon although a few chinook salmon migrate beyond this point to spawn in streams tributary to the Susitna River. The high velocities and turbulent conditions in Devil Canyon likely block the upstream passage of other fish species.

1.3 Organization

The Downstream Fish Impact Assessment and Mitigation Plan report is divided into two parts. Part I of the document discusses the potential impacts to the aquatic resources in the middle Susitna River and presents an appropriate mitigation plan. It also includes discussions of project-related effects on the reach of river between Watana and Devil Canyon prior to inundation. Impacts and mitigation for the lower Susitna River are addressed in Part II.

Within Part I, Section 2 presents a description of the proposed three stage project, with emphasis given to features that may affect downstream aquatic resources. Potential impacts to aquatic resources, identified by linking the habitat utilization by each of the evaluation species (Section 3) to the predicted physical changes during each stage of the proposed project (Section 4), are described in Section 5. Section 6 presents the mitigation plan for these potential impacts. Data and figures supporting summary information presented in the text are provided in the appendices.

The organization of Part II of this report is outlined in the introduction to that document.

2.0 PROJECT DESCRIPTION AND SCHEDULE

The proposed Susitna Hydroelectric Project is located in the southcentral region of Alaska, approximately 120 miles north-northeast of Anchorage and 145 miles south-southwest of Fairbanks. The two proposed dams, Watana and Devil Canyon, are to be built at RM 184 and 152, respectively, on the Susitna River, the sixth largest river in Alaska.

The project involves construction in three distinct stages at the two sites. The Stage I construction at the Watana site is described in Section 2.1. Stage II at the Devil Canyon site is presented in Section 2.2. The Stage III construction at the Watana site is summarized in Section 2.3. The project schedule is presented in Section 2.4. Additional details are available in Exhibit A of the FERC License Application Amendment (APA 1985a).

2.1 Stage I - Watana Initial Reservoir

The Watana Stage I dam will be located at mile 184 above the mouth of the Susitna River, in a broad U-shaped valley approximately 2.5 miles upstream of the Tsusena Creek confluence. The dam will be an earth and rockfill embankment consisting of an impervious core protected by fine and coarse filters upstream and downstream. The upstream and downstream outer shells will consist of rockfill.

The Watana dam will be built to a nominal crest elevation of 2,025 ft with a maximum height of approximately 700 ft above the foundation and a crest length of 2,700 ft. The maximum water surface elevation during flood conditions will be 2,017 ft. At the normal maximum operating level of 2,000 ft, a reservoir approximately 39 miles long with a maximum width of approximately two miles will be created. The minimum operating level of the reservoir will be 1,850 ft resulting in a maximum drawdown of 150 ft.

The two power intake structures will be located on the north bank with an approach channel from the reservoir excavated in rock. The excavated rock will be used in the construction of the dam and would minimize or eliminate the need for opening a quarry site during Stage I. The intakes will be concrete structures with multi-level gates capable of operating over the full 150-ft drawdown range. From the intake structures, two 24-ft diameter concrete-lined power conduits and shafts will lead to an underground powerhouse complex, housing four generating units with Francis type turbines and synchronous generators. Turbine discharge will flow through four draft tube tunnels to a surge chamber downstream from the powerhouse. The surge chamber will discharge to the river through a 34-ft modified-horseshoe concrete-lined tailrace tunnel.

The underground powerhouse complex will be accessed by an unlined access tunnel connecting to a road located on the downstream toe of the dam. Overhead transmission lines will transport electricity from the powerhouse switching station.

An outlet facility with a capacity of approximately 24,000 cfs will also be located on the north bank and will consist of a gate structure, pressure tunnel, and an energy dissipation and control structure housing located beneath the spillway flip bucket. The primary function of the outlet facility will be to discharge floods with recurrence frequencies of up to once in 50 years after they have been routed through the Watana reservoir. A flood storage pool is provided between el. 2,000 and el. 2,014 ft. In combination with the average powerhouse flow of 9,200 cfs, the 50-year flood can be stored and released without raising the pool level above el. 2,014 ft and without requiring use of the spillway. The structure will accommodate six fixed-cone valves which will discharge into the river 105 ft below. The use of fixed-cone discharge valves will ensure that downstream erosion will be minimal and the dissolved nitrogen content in the discharges will be reduced sufficiently to avoid harmful effects on the downstream fish population. A secondary function will be to provide the capability to rapidly draw down the reservoir during an extreme emergency situation.

The spillway located on the north bank will consist of an upstream ogee control structure with three radial gates, an inclined concrete chute, and a flip bucket designed to pass a maximum discharge of 278,300 cfs with a corresponding reservoir elevation of 2,014 ft. This spillway, together with the outlet facilities, will be capable of discharging the estimated Probable

Maximum Flood (PMF) of 326,000 cfs, while maintaining eight feet of freeboard on the dam. Emergency release facilities will be located in one of the diversion tunnels after closure to allow lowering of the reservoir over a period of time for emergency inspection or repair of impoundment structures.

2.1.1 Construction

During construction, the river will be diverted into two 36-ft diameter circular diversion tunnels. The tunnels will be concrete-lined and located on the north bank of the river. The tunnels will have an average length of 3,700 ft.

Flows through the tunnels during construction will be essentially uncontrolled. The tunnels are designed to pass a flood with a return frequency of 1:50 years, equivalent to a peak inflow of 89,500 cfs. Routing effects are expected to be small, and thus at peak flow the tunnels will discharge 77,000 cfs. The estimated maximum water surface elevation upstream from the cofferdam for this discharge will be 1,532 ft. Downstream flows will be essentially the same as under natural conditions. The upper tunnel will be converted to the permanent emergency outlet after construction (Section 2.1.2).

Cofferdams will be constructed upstream and downstream of the damsite. The upstream cofferdam will be founded on the diversion dike. The diversion dike will be constructed to el. 1,480 ft, and will consist of finer material on the upstream side grading to coarser material on the downstream side. Seepage will be controlled by constructing a slurry trench cutoff through the river bed alluvium to bedrock. The upstream cofferdam will consist of an impervious core, fine and coarse upstream and downstream filters, and rock and/or gravel supporting shell zones with slope protection on the upstream face to resist ice action. This cofferdam will be constructed to el. 1,550 ft and provide an 18-ft freeboard for wave run-up and ice protection. The downstream cofferdam will be a zoned earth and rockfill embankment. The cofferdam will be raised to crest elevation of 1,495 ft to allow dewatering of the river reach between the cofferdams.

2.1.2 Filling

As construction on the dam nears completion, the upper diversion tunnel will be converted to a low-level outlet or emergency release facility. It is estimated that one year will be required to construct and install the permanent low-level outlet in the existing tunnel. During the construction of the low-level outlet, the intake gates in the upper tunnel (No. 1) will be closed. This will require that the lower tunnel (No. 2) pass all flows during this period. The main dam will, at this time, be at an elevation sufficient to allow a 100-year recurrence interval flood (99,000 cfs) to pass through Tunnel No. 2. A flood of this magnitude will result in a reservoir elevation of approximately 1,618 ft.

Upon commencing operation of the low-level outlet, the lower tunnel (No. 2) will be closed with a permanent plug and filling of the reservoir will commence. When the lower tunnel (No. 2) is closed, the main dam crest will have reached an elevation sufficient to start filling the reservoir and still have adequate storage available to store a 250-year recurrence period flood.

The filling of the Watana reservoir, Stage I, is scheduled to commence in May 1998. During the filling operation, the low-level outlet is expected to pass summer flows of approximately 12,000 cfs. In case of a large flood occurring during the filling operation, the low-level outlet would be opened to its maximum capacity of 30,000 cfs to maintain the reservoir pool at a safe level.

It will take only one summer to fill the reservoir to a level sufficient to operate the units. If a dry sequence of flows were to occur in the first summer of filling, the reservoir water level would not be high enough to operate the mid-level (cone valve) outlet works and non-power releases would be made from the low-level outlet works. If an average or wet sequence were to occur, winter non-power releases may be made through the mid-level outlet works instead of the low-level outlet works. The reservoir would be filled to its normal maximum level during the second summer. Testing and commissioning of the units is scheduled to begin during July 1998 (Section 2.1.3). Unit one is planned to become operable in October 1998 and unit two in January 1999. During filling, downstream flow requirements will be met and a flood storage safety factor will be maintained.

(a) Minimum Flows

The Case E-VI flow requirements will be maintained during the summer of filling. Case E-VI flow requirements are designed to reduce downstream aquatic impacts while maintaining economical project operation. Minimum target flows at Gold Creek will be attained by releasing that flow necessary from the Watana impoundment which, when added to the flow contribution from the intervening drainage area between Watana and Gold Creek, will equal the minimum Gold Creek target flow. During filling, flows at Gold Creek will be monitored and the flow at Watana adjusted as necessary to provide the required Gold Creek flow.

In the winter months (November-March), the maximum flow requirement of 16,000 cfs at Gold Creek is intended to provide a level of protection to aquatic habitat. The winter minimum flow requirement of 2,000 cfs is established to prevent dewatering of aquatic habitat and represents a high mean natural winter flow. Minimum summer flow requirements are established to maintain aquatic habitat and provide greater flow stability. The 9,000 cfs minimum flow requirement from June to early September may be reduced to 8,000 cfs during June, July, and August during dry years (one in ten year low flow). Flows during the transitional periods between summer and winter are also constrained as shown in Table 3 and Figure 3.

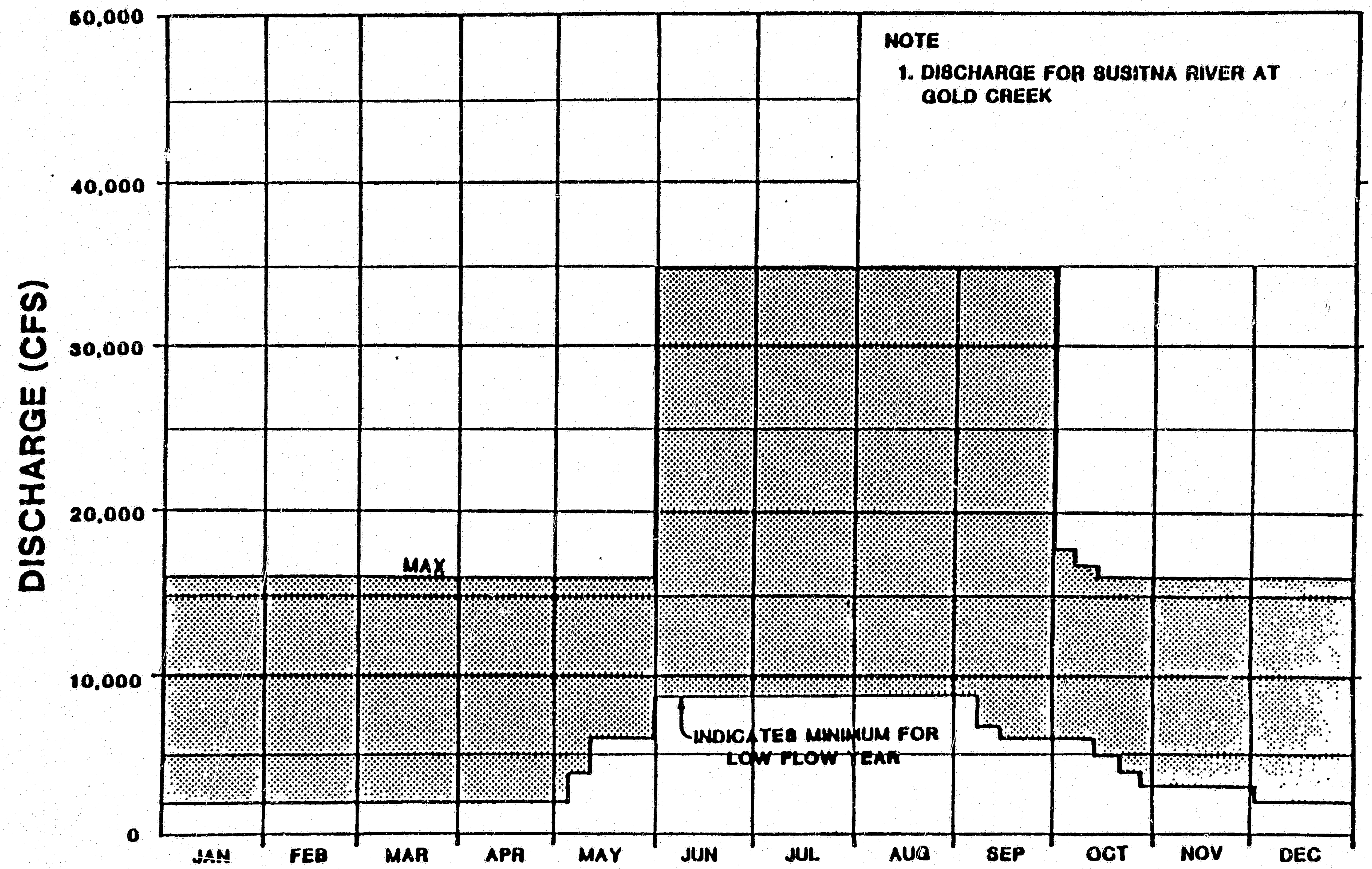
Flow will be released from the reservoir to meet the requirements at Gold Creek. Excess water will be stored in the reservoir. If a dry year should occur during filling, the 8,000 cfs flow requirement for the months of June through early September will allow filling of the

Table 3. Flow constraints for environmental flow requirement Case E-VI.

Water Week	Gold Creek Flow (cfs) Minimum	Maximum	Water Week	Gold Creek Flow (cfs) Minimum	Maximum
14	2,000	16,000	40	9,000 *	35,000
15	2,000	16,000	41	9,000 *	35,000
16	2,000	16,000	42	9,000 *	35,000
17	2,000	16,000	43	9,000 *	35,000
18	2,000	16,000	44	9,000 *	35,000
19	2,000	16,000	45	9,000 *	35,000
20	2,000	16,000	46	9,000 *	35,000
21	2,000	16,000	47	9,000 *	35,000
22	2,000	16,000	48	9,000 *	35,000
23	2,000	16,000	49	8,000	35,000
24	2,000	16,000	50	7,000	35,000
25	2,000	16,000	51	6,000	35,000
26	2,000	16,000	52	6,000	35,000
27	2,000	16,000	1	6,000	18,000
28	2,000	16,000	2	6,000	17,000
29	2,000	16,000	3	5,000	16,000
30	2,000	16,000	4	4,000	16,000
31	2,000	16,000	5	3,000	16,000
32	4,000	16,000	6	3,000	16,000
33	6,000	16,000	7	3,000	16,000
34	6,000	16,000	8	3,000	16,000
35	6,000	16,000	9	3,000	16,000
36	9,000 *	35,000	10	2,000	16,000
37	9,000 *	35,000	11	2,000	16,000
38	9,000 *	35,000	12	2,000	16,000
39	9,000 *	35,000	13	2,000	16,000

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

Source: APA 1985c



ENVIRONMENTAL FLOW REQUIREMENTS

CASE E VI

SOURCE: APA 1985c

FIGURE 3

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reservoir to a level of sufficient for testing and commissioning of the first unit and commercial power operation in the following winter.

During the winter after the summer of filling, the minimum flow requirement will be natural flows. This means that the Watana reservoir water level would not be allowed to rise during the winter. Minimum requirements will be maintained by releases through the powerhouse supplemented, if necessary, by releases from the low-level or mid-level outlet works depending on the height of the water level.

(b) Flood Storage Protection

Sufficient reservoir storage will be made available during the filling sequence so that flood volumes for all floods up to the 250-year recurrence interval flood can be temporarily stored in the reservoir and discharged through the low-level outlet works without endangering the main dam. When floods occur and use part of this storage capacity, discharge from the Watana reservoir will be increased up to the maximum capacity of the outlet to lower the reservoir level.

2.1.3 Testing and Commissioning

Testing and commissioning of the powerhouse units will commence as reservoir filling nears completion and the reservoir level is above the minimum drawdown elevation (el. 1,850 ft).

Testing of units is scheduled to begin in July 1998 with additional units tested at three month intervals. The process of testing and commissioning each unit may take several months and will require a number of tests. It will be carried out in a manner to maintain downstream flow stability.

The largest fluctuations in powerhouse flow could occur during the full-load-to-off or off-to-full-load tests when the flow through the turbine being tested will be quickly reduced from approximately 3,500 cfs to 0 or increased from 0 to 3,500 cfs, respectively. This will be compensated for by opening or closing the outlet facility gates or other units which have previously been tested to stabilize flow downstream and to prevent sudden changes in downstream flows. When testing is done during summer, the Case E-VI requirements will be maintained and this will also help to stabilize the flow.

If testing occurs in winter and flow is less than the test flow through the unit at Watana, flow will be gradually increased to that level over a one day period prior to the testing and maintained at that level through the testing period. If testing is temporarily halted, flow will be gradually reduced.

2.1.4 Operation

This section describes the project during the period from the summer of 1999, when all four powerhouse units are planned to be operational, to the construction and filling of Stage II.

Watana will be operated in a storage-and-release mode, so that summer flows will be stored for release in winter. Generally, the Watana reservoir will be at or near its normal maximum operating level of el. 2,000 ft each year at the end of September. The reservoir will then be drawn down gradually to meet winter energy demand. The flow during this period will be governed by environmental flow constraints, the winter energy demand, the water level in the reservoir, and the powerhouse characteristics. The turbine characteristics will allow a maximum powerhouse flow of approximately 14,000 cfs at full gate. Normal powerhouse discharges are simulated to range from approximately 2,700 cfs to 12,000 cfs.

In early May, the reservoir will reach its minimum annual level of approximately el. 1,870 ft and then begin to refill with the spring runoff. Flow in excess of both the downstream flow requirements and power needs will be stored during the summer until the reservoir reaches the normal maximum operating level of el. 2,000 ft. If the reservoir reaches el. 2,000 ft and inflows exceed environmental and energy requirements, excess flow will be released to prevent encroachment on dam safety requirements.

During project operation the Case E-VI environmental flow requirements will be maintained. Minimum requirements will be met by releases from the powerhouse and, if necessary, the outlet works. Daily discharge would be allowed to vary between 90 percent and 110 percent of the average weekly discharges. The corresponding expected range of stage fluctuations in the middle river would be from 0.2 ft to 0.7 ft.

The operation of the project during floods will focus on dam safety. If the Watana reservoir level exceeds the normal maximum operating level, dam safety criteria will supersede both weekly flow constraints and flow stability constraints. Environmental considerations are built into the dam safety criteria as discussed herein. Project operation at Watana will be similar for both Watana operating alone and Watana operating with Devil Canyon once the Watana reservoir reaches or exceeds the normal maximum operating level.

If the water level in the Watana I reservoir reaches el. 2,000 ft and continues to rise, Watana discharge will be increased by releasing water through the outlet works. Because the intake to the outlet works is approximately 80 ft below the water surface, operation of the outlet works results in reduced downstream water temperatures. In order to provide for as gradual a change in water temperature as possible, the following guidelines will apply:

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

- Increase the outlet works discharge at the estimated minimum rate required to prevent the water level from exceeding el. 2,000.5 ft. If the inflow to the reservoir is more than 24,000 cfs greater than the powerhouse can discharge, then the release from the outlet works will be 24,000 cfs when the water level reaches el. 2,000.5 ft.

If the outlet works are not releasing water at full capacity and the water level rises above el. 2,000.5 ft, the outlet works will be opened immediately to full capacity. If the full capacity of the outlet works and powerhouse flow are not sufficient to discharge all the inflow the water level will continue to rise.

If the water level exceeds el. 2,000.5 ft but does not reach el. 2,014.0 ft then the Watana discharge will remain relatively constant until the water level decreases to el. 2,000.5 ft. If the water level starts to decrease below el. 2,000.5 ft then the outlet works will be closed in a gradual manner as they were opened. The rate of closure will be that estimated to cause the water level to reach el. 2,000.0 ft when the outlet works discharge reaches zero. The outlet works will be completely closed before the water level is allowed to decrease below el. 2,000.0 ft.

The outlet works capacity and flood surcharge level have been planned to store and release the 50-year flood without operating the spillway. Thus, there is less than a 1 in 50 chance that in any one year the water level will continue to rise to el. 2,014.0 ft. If the water level reaches el. 2,014.0 ft and continues to increase, the spillway will be opened. Since spillway operation may increase gas concentrations in the river downstream, the spillway will also be opened up as gradually as possible, consistent with providing sufficient freeboard on the dam to meet safety requirements. The powerhouse and outlet works releases will continue as before, and the spillway will be opened at the estimated minimum rate required to prevent the water level from exceeding el. 2,014.3 ft. If the water level reaches el. 2,014.3 ft and continues to rise, the spillway gates will be opened as much as needed to prevent the water level from increasing any further. As explained in Exhibit F of the FERC License Application Amendment (APA 1985b), the spillway has the capacity to pass the 10,000-year flood at a reservoir level of el. 2,014.3 ft. Thus, there is less than a one in 10,000 chance in any year that the water level would exceed el. 2,014.3 ft.

If the reservoir water level reaches el. 2,014.3 ft and the fully opened spillway, outlet works and powerhouse are insufficient to pass the inflow, the water level will increase uncontrolled. The spillway is designed to pass the Probable Maximum Flood (PMF). The water level would reach approximately el. 2,017 ft, eight feet below the dam crest during a PMF. Watana discharge would not be controlled again until the water level decreased to el. 2,014.3 ft. When this occurs, the spillway will be closed gradually in a manner estimated for the water level to reach el. 2,014.0 ft when the spillway discharge is zero. The spillway gates will be completely closed before the water level is allowed to decrease below el. 2,014.0 ft.

In emergency situations, if powerhouse operation is not possible, outlet facilities will be operated to meet the flow requirements. Correspondingly, if another part of the energy generation system is temporarily lost, Watana may be operated to make up the deficit. The resulting discharge variation may exceed the maximum variation rate of 10 percent, and discharge may reach the maximum flow constraint. However, the discharge at Gold Creek will not be allowed to exceed the maximum weekly flow requirement and the rate of change of discharge will be constrained by the rates established for Case E-VI.

2.2 Stage II - Devil Canyon

The Stage II Devil Canyon development will be located at mile 152 in a narrow canyon 32 miles downstream of the Watana development. A reservoir approximately 26 miles long with a maximum width of 0.5 miles will be created.

The dam will be a double curvature thin arch concrete dam with a crest elevation of 1,463 ft (not including a 3-ft parapet) and maximum height of

646 ft. The dam will be supported by mass concrete thrust blocks on each abutment. On the south bank, the lower bedrock surface will require the construction of a substantial thrust block. Adjacent to this thrust block, a saddle dam will provide closure to the south bank. The saddle dam will be an earth and rockfill embankment generally similar in cross section to the Watana dam. The dam will have a nominal crest elevation of 1,470 ft and a maximum height above foundation level of approximately 245 ft. During normal operation, the reservoir level will reach a maximum elevation of 1,455 ft. The minimum operating level will be 1,405 ft providing a drawdown of 50 ft. The maximum water surface elevation during the design PMF flood conditions will be 1,466 ft (APA 1985b).

A power intake on the north bank will consist of an approach channel excavated in rock leading to a reinforced concrete gate structure. From the intake gate structure, four 20-ft diameter concrete-lined penstock tunnels will lead to an underground powerhouse complex housing four units with Francis turbines and synchronous generators. The turbines will discharge to the river by means of a single 38-ft diameter tailrace tunnel leading from a surge chamber downstream from the powerhouse cavern. Access to the powerhouse complex will be by means of an unlined access tunnel approximately 3,200 ft long as well as by a 950-ft deep vertical access shaft. A cable shaft will connect to the switchyard at the surface. From the switchyard, electricity produced at the Devil Canyon powerhouse will be transported by overhead transmission lines.

Outlet facilities consisting of seven individual outlet conduits will be located in the lower part of the main dam. These will be designed to discharge all flood flows of up to the estimated 50-year flood with Watana in place. Each outlet conduit will have a fixed cone valve similar to those provided at Watana to dissipate energy and minimize undesirable nitrogen supersaturation in the flows downstream.

An overflow spillway will also be located on the north bank. As at Watana, this spillway will consist of an upstream ogee control structure with three vertical fixed-wheel gates, an inclined concrete chute, and flip bucket. This spillway, together with the outlet facilities, will be capable of discharging the routed PMF from Watana without overtopping the dam.

2.2.1 Construction

During construction, the river will be diverted by means of a single 35.5-ft diameter concrete-lined diversion tunnel on the south bank of the river. The Devil Canyon diversion tunnel is scheduled to be completed in 1999 and construction on the main dam will begin in that year. The tunnel will have a horseshoe-shaped cross section with a major dimension of 35.5 ft. It will be 1,490 ft in length. The tunnel is designed to pass a flood with a return frequency of 1:25 years routed through the Watana reservoir. The peak flow that the tunnel will discharge will be approximately 43,000 cfs. The maximum water surface elevation upstream of the cofferdam will be el. 944 ft.

Cofferdams will be constructed upstream and downstream of the damsite is a manner similar to the cofferdams constructed during Stage I. The cofferdams will be zoned embankments consisting of an impervious core, fine and coarse upstream and downstream filters, and rock shells with larger stone. Slurry wall cutoffs will minimize seepage into the main dam excavation.

The flow regime during construction will be regulated by the Stage I Watana dam. Under the proposed schedule, the Watana development will be operational during construction of the Stage II Devil Canyon dam. Little storage of flow is expected due to the diversion tunnel and flows will be essentially controlled by the operation of the Watana development (Section 2.1.4).

2.2.2 Filling

Upon completion of the Devil Canyon dam to a height sufficient to allow ponding to a level above the outlet facilities, the intake gates will be partially closed allowing for a discharge of minimum environmental (Case E-VI) flows while raising the upstream water level. This first phase of the filling process will require from 1 to 4 weeks depending on time of year and Watana powerhouse flows when filling is begun. Once the level rises above the lower level of discharge valves, the diversion tunnel will be permanently closed and discharge will be through the 90-inch diameter fixed-cone valves in the dam. The diversion tunnel will be plugged with concrete and curtain grouting performed around the plug. Construction will take approximately 1 year. During this time the reservoir will not be allowed to rise above el. 1,135 ft unless a flood exceeding the outlet works capacity occurs. In this case the water level will be allowed to rise as needed to store the flood.

Filling of the reservoir to its normal operating level of el. 1,455 ft will be accomplished as quickly as possible following the completion of construction. Case E-VI flow requirements will be maintained downstream of the reservoir.

The Devil Canyon reservoir will be filled from the normal Watana releases for power generation and flood releases while maintaining the instream flow requirements. During the filling period, the Watana powerhouse will be operated to supply as much of the total railbelt energy demand as possible so that the Devil Canyon reservoir can be filled in a timely manner. The flow from the Watana reservoir in excess of the Case E-VI requirement will be used to fill the Devil Canyon reservoir. The rate of filling will also be dependent on the need to monitor dam and foundation performance during filling to assure a safe structure.

2.2.3 Testing and Commissioning

Testing and commissioning is scheduled to begin in October 2004. Each power generating unit will be tested individually. The testing and commissioning of the units involves many sequences of bringing the unit on-line and taking it off-line. These will be carried out in a manner to minimize impacts to flow stability. To compensate for flow passing through the units during testing, the flow through the outlet works will be reduced by a comparable amount as discussed for the testing and commissioning of the Watana Stage I units (Section 2.1.3).

2.2.4 Operation

After Devil Canyon comes on line, Watana Stage I will be operated as a peaking plant and Devil Canyon will re-regulate Watana flows. Advantage will be taken of the two-reservoir system to optimize energy production with the constraint that the Case E-VI downstream flow requirements will be met. Devil Canyon discharges may vary between 90 percent and 110 percent of the average weekly flow. The Case E-VI environmental flow requirements will be maintained by releases from the powerhouse and, if necessary, the outlet works.

The Devil Canyon reservoir will normally be at its maximum water level, el. 1,455 ft, between January and May. In dry years Devil Canyon will be drawn down below maximum level between May and December reaching its minimum level of el. 1,405 ft in August. In average flow years, the reservoir will be drawn down below maximum level between June and August reaching a minimum of approximately el. 1,435 ft in July. Average weekly Devil Canyon powerhouse flows will be similar to Watana, but slightly higher due to additional inflow in the intervening area between the two dams.

With Devil Canyon on line, Watana will still be operated in a storage-and-release mode similar to Stage I, so that summer flows will be stored for release in winter. Generally, the Watana reservoir will be at or near its normal maximum operating level of el. 2,000 ft each year at the end of September. The reservoir will gradually be drawn down to meet winter energy demand. The flow during this period will be governed by winter energy demand, water level in the reservoir, and powerhouse characteristics. The turbine characteristics will allow a maximum powerhouse flow of approximately 14,000 cfs at full gate. Normal Watana average weekly powerhouse discharges will range from approximately 3,000 cfs to 8,500 cfs.

In early May, the Watana reservoir will reach its annual minimum level of approximately el. 1,870 ft and then begin to refill with the spring runoff. Flow in excess of both the downstream flow requirements and power needs will be stored during summer until the reservoir reaches the normal maximum operating level of el. 2,000 ft. If the reservoir reaches el. 2,000 ft, and inflow exceeds energy and instream flow requirements, excess flow will be released to maintain dam safety requirements.

Dam safety criteria at Watana with both Watana and Devil Canyon operating will be similar to Watana only operation when the water level in Watana reservoir exceeds el. 2,000.0 ft, especially in the early years of Devil Canyon operation. However, while while Watana reservoir is filling in the spring, and before the water level reaches el. 2,000.0 ft, the Devil Canyon powerhouse will be used to generate most of the system energy demand. Watana still must generate a portion of the energy in order to meet peak energy demands. This policy was adopted to minimize downstream temperature effects resulting from the use of the Devil Canyon outlet works. When the Watana water level reaches el. 2,000.0 ft, it is necessary to switch energy generation from Devil Canyon to Watana in order to pass the 50-year flood through Watana without using the spillway. The change from the Devil Canyon to the Watana powerhouse would be made in a gradual manner, but in no case would the Watana water level be allowed to rise above el. 2,000.5 ft without the Watana powerhouse supplying available system energy demands and the Watana outlet works releasing at 24,000 cfs. After the system load is transferred from Devil Canyon to Watana, the operation at Watana would be identical to that for Watana only operation.

When the Watana water level reaches el. 2,000.0 ft, the Devil Canyon reservoir will be allowed to fill while minimum flow requirements are being met. The Watana and Devil Canyon outlet works and operating policies have been planned so that while the Devil Canyon reservoir is filling, the outlet works will be opened up in a gradual manner estimated to prevent the water level from exceeding el. 1,455.0 ft. When the water level reaches el. 1,455.0 ft, the outlet works will be opened as much as necessary to keep the water level stable. In this period, Devil Canyon will operate as essentially a run-of-river project, passing Watana outflows and intervening flows. The rates of change of Devil Canyon discharge will be similar to those for Watana with small modifications resulting from variations in intervening flow.

Devil Canyon can pass all of the Watana outflows and all intervening flows through its outlet works without using its spillway unless the Watana spillway is operating. The 50-year flood inflow may exceed the capacity of the Devil Canyon outlet works (APA 1985b). Therefore, surcharge storage is provided to store the flow in excess of the outlet works capacity. During floods, the Devil Canyon water level will be maintained at el. 1,455.0 ft until the outlet works are discharging at full capacity. If the inflow exceeds the capacity, the water level will be allowed to increase to el. 1,456.0 ft. In this manner the 50-year flood can be stored and released without operating the spillway. If the water level continues to rise above el. 1,456.0 ft, the Devil Canyon spillway must be opened to maintain freeboard on the dam. The chance the spillway would be operated in any one year is less than 1 in 50. The spillway gates will be opened at whatever rate is necessary to keep the pool at this level. The spillway has the capacity to pass the 10,000-year flood with the reservoir at el. 1,456.0 ft (APA 1985b). Thus, there is less than a 1 in 10,000 chance that the Devil Canyon water level would exceed this level in any one year. If the spillway gates were opened completely and the reservoir level continued to rise, discharge from Devil Canyon would be uncontrolled. The Devil Canyon spillway is designed to pass the PMF. The maximum water level obtained during routing of the PMF is el. 1,465.6 ft, which is 0.4 ft below the top of the concrete parapet and 4.4 ft below the crest of the rockfill sections of the dam. Control would not be regained until the water level receded to el. 1,455.0 ft. When the water level decreases to el. 1,455.0 ft the spillway and outlet works will be closed in a manner to keep the water level at el. 1,455.0 ft.

2.3 Stage III - Watana High Reservoir

Stage III involves raising the Watana dam 180 ft to el. 2,205 ft; at the maximum normal reservoir el. of 2,185 ft, a reservoir approximately 48 miles long with a maximum width of approximately 5 miles will be created. The maximum water surface elevation during flood conditions will be 2,199.3 ft. The minimum normal operating level of the reservoir will be el. 2,065 ft, providing a normal drawdown of 120 ft.

The Stage I internal zoning will be maintained in raising the dam. Some excavation at the top of the Stage I dam will be necessary to ensure continuity of the zones. The nominal crest elevation of the dam will be 2,205 ft, with a maximum height of 885 ft above the foundation and a crest length of 4,100 ft. The embankment crest will initially be cambered to el. 2,210 ft to allow for potential settlement. The total volume of fill material placed in the dam during Stage III construction will be 26,363,000 cubic yards, bringing the total volume of the dam to 58,470,000 cubic yards.

A new power intake will be constructed adjacent to the existing two intakes. The existing intake concrete superstructure will be raised to accommodate the higher reservoir level. Simultaneously, the concrete superstructure for the outlet facilities will also be raised. The approach channel constructed during Stage I will be adequate for the efficient flow of water to all intakes. There will be no change to the outlet facilities downstream of the intake structure.

Additional power capacity will be achieved by the increased head on the Stage I generating units, which were designed for this reservoir raising, and the two additional generating units installed during this stage. This installation will require an extension of the powerhouse chamber to the south of the service bay. Similar extensions will be required to the south of the transformer gallery and surge chamber.

A third power shaft and tunnel bifurcating into penstocks to supply water to the two generating units will be excavated and lined with concrete from the new intake structure. The power conduit will have an internal diameter of 24 ft.

The penstocks will be steel-lined for a distance of 200 ft upstream of the powerhouse. The steel-lined section will have a diameter of 15 ft. The remaining penstock reach to the bifurcation will be 18 ft in diameter.

The surge chamber extension will be hydraulically joined to the powerhouse cavern by two draft tube tunnels. The turbine discharges will flow from the south end of the surge chamber by a second 34-ft diameter concrete-lined modified-horseshoe tunnel. This tunnel will intersect the Number 2 diversion tunnel (Section 2.1), which will be used to complete the tunnel tailrace system, and discharge to the river downstream of the dam. The transformer gallery extension will house the added transformers serving the two generators.

The spillway control structures, however, will require substantial modification. The bridge will be removed, and the piers and abutment wall concrete will be raised. This will be followed by raising the overflow spillway to a crest elevation of 2,135 ft. The Stage I radial gates and hydraulic hoists will be re-installed. The ogee section will, in effect, be a gravity dam section with its downstream face forming the upper reach of the spillway chute prior to joining the lower reach which was constructed during Stage I. The spillway will still have the capacity to pass the PMF without overtopping the dam. The emergency release facilities constructed in diversion tunnel No. 1 will still be available for lowering of the reservoir over a period of time to permit emergency inspection or repair to the impoundment structures.

Work on raising the Watana dam to its Stage III crest level of el. 2,205 ft is currently scheduled to begin in 2006, following the completion of the Devil Canyon dam. Filling of Watana Stage III will occur at the same time the dam crest level is being raised. Therefore, construction and filling of Stage III are not distinct phases. As addressed in the following section, the construction phase will refer to the period between the year 2006 and the beginning of filling of Watana Stage III. This phase will end when the dam crest is high enough that the water level can be raised without adversely affecting the safety of the structure. It is currently planned that the dam crest can be raised to el. 2,100 ft by the year 2010. Work on raising the power intake and spillway ogee crest levels will begin in 2008 and 2010, respectively. Filling of the Stage III reservoir will begin in 2011 even though construction is not scheduled to be completed until 2012.

The Stage III operational period refers to the period after the normal maximum water level has reached el. 2,185 ft, which may be between two and six years after the beginning of filling, depending on the reservoir inflow and energy production. Stage III operation is anticipated to begin in 2016.

2.3.1 Construction

Passage of river flows during Stage III will be accomplished by in-place Stage I project features. Stage III diversion will involve reconstructing the downstream cofferdam over the in-place slurry trench cutoff, and dewatering the area between the Stage I dam and the cofferdam by pumping. The construction on the dam will be accomplished in the dry during the seasonal drawdown when the Stage I reservoir elevation is below 1,925 ft. The placement of the fill on the downstream face of the Watana dam and raising of the crest elevation prior to filling will not affect power generation or flows as described in Section 2.2.4.

2.3.2 Filling

Filling of the Stage III reservoir from a normal maximum water level of el. 2,000 ft to a normal maximum level of el. 2,185 may take between three and seven years depending on inflow to the project, energy demands and progress in construction of the dam, powerhouse intake and spillway. Flood flows which would normally be released through the outlet works in Stage II will be utilized to fill the reservoir. This will result in a decrease in July-September flows and a stabilization of river flows during the period of filling. Filling will take place in a gradual manner as the dam crest, spillway ogee crests, and intake tower are raised. Since portions of the spillway crest will be constructed during this period, storage will be provided in the reservoir so the remaining spillway capacity will be sufficient to ensure the safety of the dam. This will be one limit on the rate that the reservoir water level can be raised. A second limit on the water level will be the amount of flow incoming to the reservoir and the power generated by the project during this period. A third constraint will be the environmental flow requirements of Case E-VI.

During normal operation of Stage II, between zero and 2,000,000 acre-feet of water will be passed through the outlet works in the July-September period every year to maintain dam freeboard requirements and ensure the safety of the structures. During Stage III filling, this water will be used to raise the normal maximum water level. Power generation will be maintained at Watana during the filling process and water levels in the reservoir will vary in the same manner as for normal operation. That is, they will reach their highest point in September and be reduced throughout the winter. Beginning in May, water levels will start to rise. Water levels will generally continue to rise through July, August, and September, provided that sufficient flood storage is available to compensate for reduced spillway capacity during spillway construction and provided the multi-level intake tower has been raised. The maximum water level attained in September will increase from year to year until the normal maximum level of el. 2,185 ft is reached.

During the filling process the Case E-VI flow requirements will be maintained. Since excess July-September flows will be stored in Watana the flows at Gold Creek will be reduced from normal operational flows in July through September. The flows will generally be near the minimum flow requirements during the summer.

Flood flows downstream will be reduced since these will be stored in the reservoir. As noted before, sufficient storage will be maintained so that the structure is not endangered by floods.

2.3.3 Testing and Commissioning

The fifth unit at Watana and the first unit to be installed in Stage III is scheduled to be tested and commissioned in spring of 2012. The second unit will be tested and commissioned in the summer of 2012. The testing of the units requires several sequences of bringing the units on-line and taking them off-line. These will be accomplished in a manner to minimize the effects on flow stability. This can be done in several ways, any of which may be selected. One method would be to reduce flows through the outlet works or other units by amounts comparable to the test flow through the unit. A second method would be to store the test flow at Devil Canyon Reservoir without releasing it downstream.

2.3.4 Operation

After Stage III comes on line, Watana will be operated as a peaking plant and Devil Canyon as a baseloaded plant subject to discharge fluctuation constraints between 90 percent and 110 percent of the weekly average. Advantage will be taken of the two-reservoir system to optimize energy production with the constraint that the Case E-VI downstream flow requirements will be met. Minimum requirements will be met by releases from the powerhouse and, if necessary, the outlet works.

Devil Canyon Reservoir will re-regulate peak discharges from Watana. The Devil Canyon Reservoir will normally be at its maximum water level, el. 1,455 ft, between November and May. In dry years Devil Canyon will be drawn down between May and November reaching its minimum level of el. 1,405 ft in August. In average flow years, the reservoir will be drawn down between June and August reaching a minimum of approximately el. 1,440 ft in July.

Watana will still be operated in a storage-and-release mode similar to Stage II, so that summer flows will be stored for release in winter. Generally, the Watana Reservoir will be at or near its normal maximum operating level of el. 2,185 ft each year at the end of September. Gradually, the reservoir will be drawn down to meet winter energy demand. The flow during this period will be governed by winter energy demand, water level in the reservoir, and powerhouse characteristics. The turbine characteristics will allow a maximum powerhouse flow of approximately 22,000 cfs.

In early May, the Watana reservoir will reach its annual minimum level of between approximately el. 2,080 ft and 2,130 ft, depending on energy demand and inflow, and then begin to refill with the spring runoff. Flow in excess of both the downstream flow requirements and power needs will be stored during the summer until the reservoir reaches the normal maximum operating level of el. 2,185 ft. If the reservoir reaches el. 2,185 ft, and inflow exceeds energy and environmental flow requirements, excess flow will be released and the reservoir water level will rise as the flood is being stored.

Project operation for dam safety criteria at Watana with both Watana and Devil Canyon operating in Stage III will be similar to Stage II operations. However, the normal maximum water level in Watana Reservoir will be el. 2,185 ft and the flood surcharge level will be el. 2,193 ft. While Watana reservoir is filling in the spring, and before the water level reaches el. 2,185.0 ft, the Devil Canyon powerhouse will be used to meet system energy demands. Watana must still generate a portion of the energy in order to meet peak system energy demands. When the Watana water level reaches el. 2,185.0 ft, it is necessary to switch energy generation from Devil Canyon to Watana in order to pass the 50-year flood without using the spillway. The change from Devil Canyon to Watana would be made in a gradual manner, but in no case would the Watana water level be allowed to rise above el. 2,185.5 ft without the Watana powerhouse supplying all available system energy demands and the Watana outlet works releasing at 24,000 cfs. After the system load is transferred from Devil Canyon to Watana, the operation at Watana would be identical to that for Watana only operation.

When the Watana water level reaches el. 2,185 ft, Devil Canyon reservoir will be allowed to fill while minimum flow requirements are being met. While the Devil Canyon reservoir is filling, the outlet works will be opened up in a gradual manner estimated to prevent the water level from exceeding el. 1,455.0 ft. When the water level reaches el. 1,455.0 ft the outlet works will be opened as much as necessary to keep the water level stable. In this period, Devil Canyon will operate as essentially a run-of-river project, passing Watana outflows and intervening flows. The rates of change of Devil Canyon discharge will be similar to those for Watana with small modifications resulting from variations in intervening flow.

Devil Canyon can pass all of the Watana outflows and all intervening flows through its outlet works without using its spillway unless the Watana spillway is operating. The 50-year flood inflow may exceed the capacity of the Devil Canyon outlet works (APA 1985b). Therefore, a surcharge storage is provided to store the flow in excess of the outlet works capacity. During floods the Devil Canyon water level will be maintained at el. 1,455.0 ft until the outlet works are discharging at their full capacity. If the inflow exceeds the capacity, the water level will be allowed to increase to el. 1,456.0 ft. In this manner, the 50-year flood can be stored and released without operating the spillway.

If the water level continues to rise above el. 1,456.0 ft, the Devil Canyon spillway gates must be opened to maintain freeboard on the dam. The chance the spillway would be operated in any one year is less than 1 in 50. The spillway gates will be opened at whatever rate is necessary to keep the pool at this level. The spillway has the capacity to pass the 10,000-year flood with the reservoir water level at el. 1,456.0 ft (APA 1985b). Thus, there is less than 1 in 10,000 chance that the Devil Canyon water level would exceed this level in any one year. If the spillway gates were opened completely and the reservoir level continued to rise, discharge from Devil Canyon would be uncontrolled. The Devil Canyon spillway is designed to pass the PMF. The maximum water level obtained during a routing of the PMF was el. 1,463.1 ft which is 2.9 ft below the crest of the concrete parapet wall and 7 ft below the top of the rockfill dam sections. Control would not be regained until the water level receded to el. 1,455.0 ft. When the water level decreases to el. 1,455.0 ft the spillway and outlet works will be closed in a manner to keep the water level at el. 1,455.0 ft.

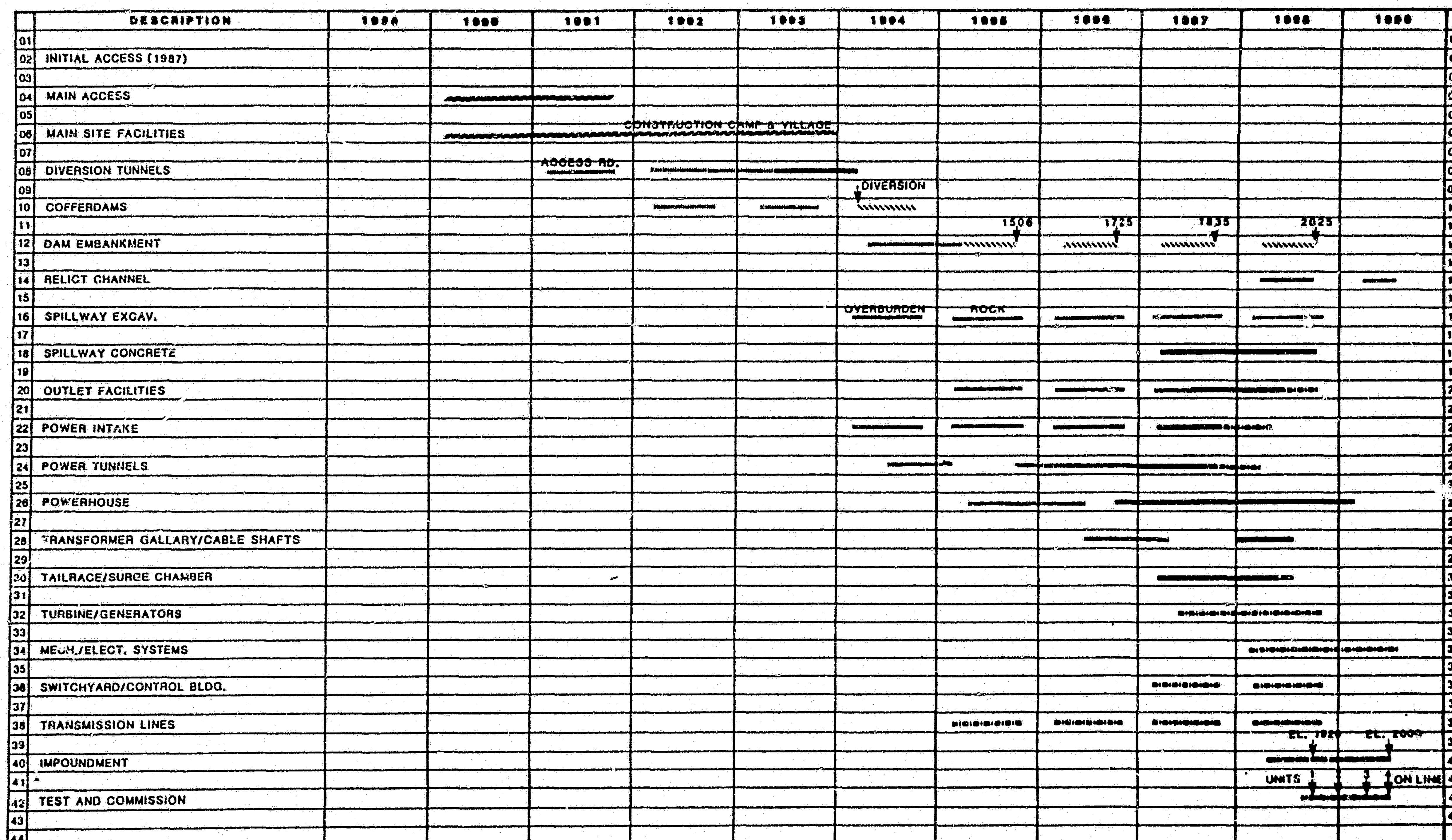
When system energy demand increases, the operation to pass floods would differ slightly from the early years of Devil Canyon operation. If the water level at Watana were to rise above el. 2,185.0 ft it would not be necessary to switch all the energy generation to Watana. Only that generation would be switched which would be necessary to keep the Watana water level from exceeding el. 2,193.0 ft for the 50-year flood. It is estimated that this requires a Watana powerhouse discharge of 7,000 cfs.

Additionally, the increased energy demand means that Devil Canyon would have the capacity to discharge some flow from its powerhouse before it becomes necessary to open the outlet works. The additional Devil Canyon powerhouse flow would make it possible to pass the 50-year flood without surcharging the reservoir.

Overall, operation of the two dams with greater system energy demands will result in more gradual changes in discharge and less chance of outlet works or spillway operation than in the first years of Stage III operation. In an emergency situation where part of the energy generation system is temporarily out of operation, Watana and/or Devil Canyon may be operated to provide the needed power as described in Section 2.1.4.

2.4 Project Schedule

The proposed schedules for each stage of the Project are presented in Figures 4 through 6. Access construction for Stage II will overlap the construction on the Stage I Watana dam. Construction of Stage III will be initiated following completion of Stage II construction.



LEGEND
- ACCESS/FACILITIES
- EXCAVATION/FOUNDATION TREATMENT
- FILL
- CONCRETE
- MECHANICAL/ELECTRICAL
- IMPOUNDMENT

WATANA STAGE I CONSTRUCTION SCHEDULE

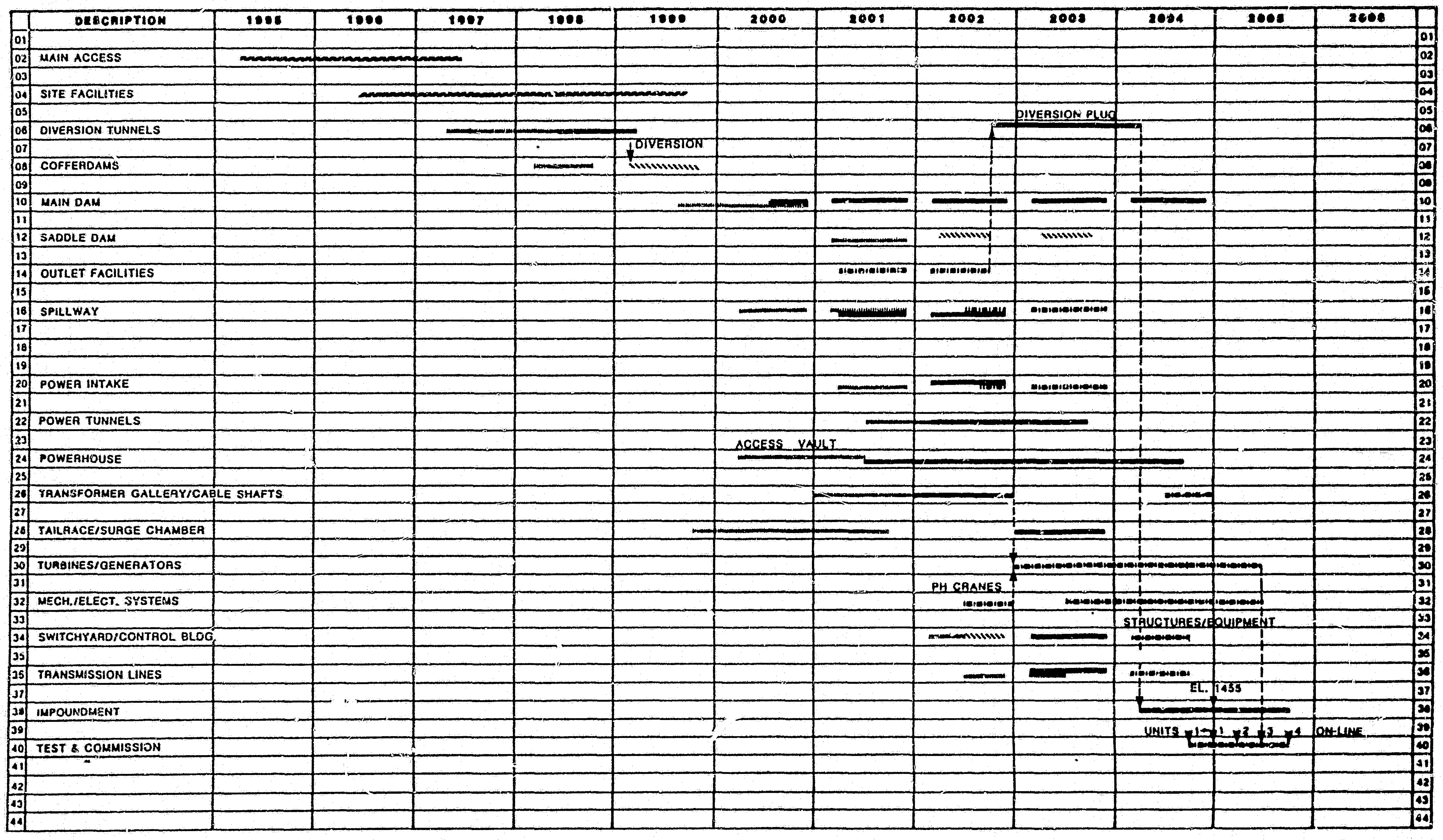
SOURCE: APA 1985a

FIGURE 4

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



LEGEND

- ACCESS/FACILITIES
- EXCAVATION/FOUNDATION TREATMENT
- FILL
- CONCRETE
- MECHANICAL/ELECTRICAL
- IMPOUNDMENT

DEVIL CANYON STAGE II CONSTRUCTION SCHEDULE

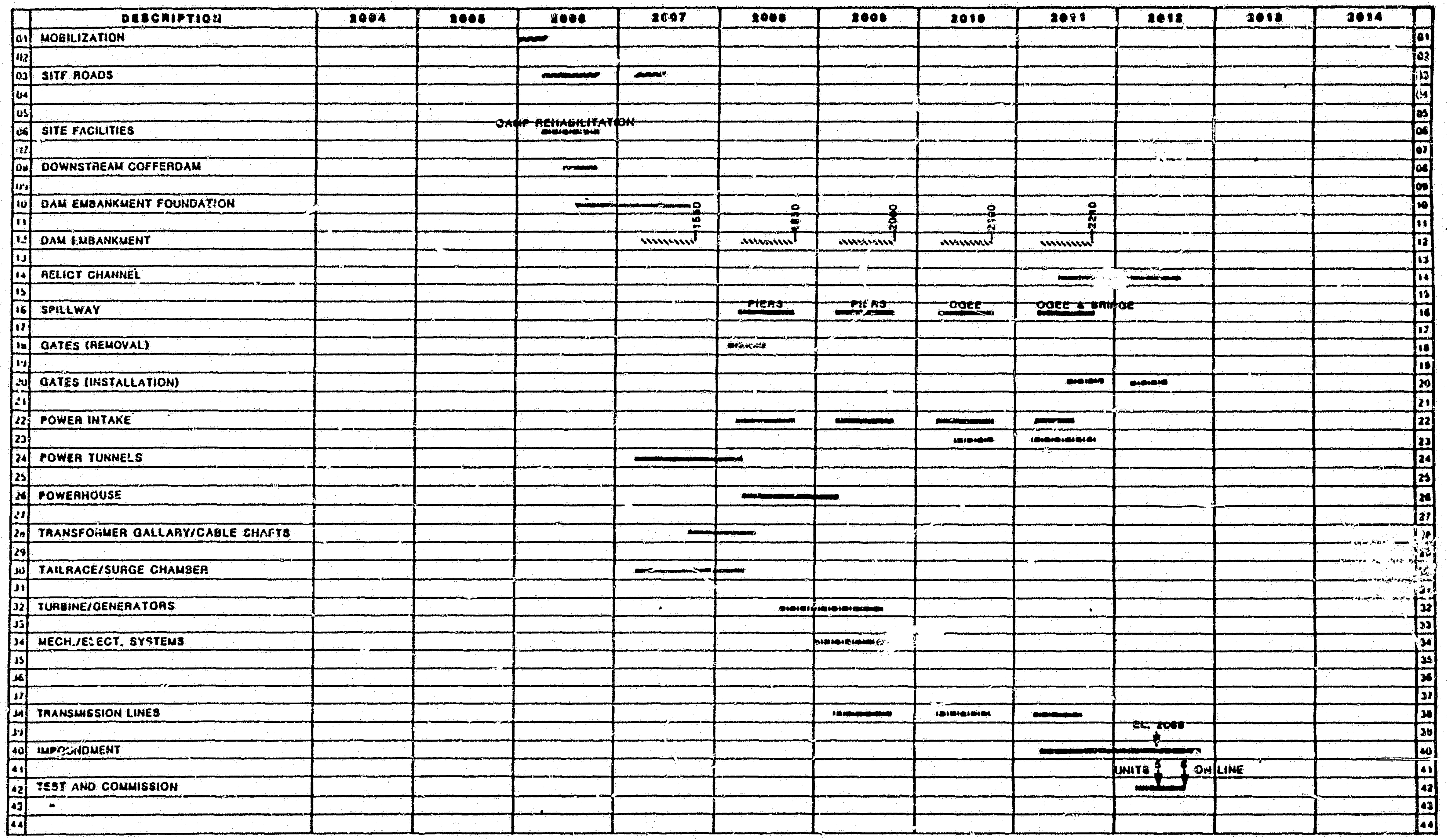
SOURCE: APA 1985a

FIGURE 5

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



WATANA STAGE III CONSTRUCTION SCHEDULE

SOURCE: APA 1985a

LEGEND

- ACCESS/FACILITIES
- EXCAVATION/FOUNDATION TREATMENT
- FILL
- CONCRETE
- MECHANICAL/ELECTRICAL
- IMPOUNDMENT

FIGURE 6

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

3.0 EVALUATION SPECIES

3.1 Selection

Various species and life stages have different critical life requirements and respond differently to habitat alterations. A change in habitat conditions that benefits one species or life stage may adversely affect another. Moreover, project impacts on the habitats of certain sensitive fish species are 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. Therefore, the criteria used in the evaluation species selection process were:

- o High human use value;
- o Dominance in the ecosystem; and
- o Sensitivity to project impacts.

The evaluation species for the middle Susitna River 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. Project effects on the rearing life stage of juvenile salmon, particularly chinook salmon, are also of concern. The chinook juveniles rear in the river for up to two years and coho salmon juveniles for up to 3 years prior to outmigration. 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

<u>Chinook Salmon</u>

- Rearing/overwintering juveniles

<u>Chum Salmon</u>

- Spawning adults
- Embryos and pre-emergent fry

SECONDARY

<u>Chinook Salmon</u>

- Returning adults
- Outmigrant juveniles

<u>Chum Salmon</u>

- Returning adults
- Rearing juveniles
- Outmigrant juveniles

Sockeye Salmon

- Returning adults
- Spawning adults
- Embryos and pre-emergent fry
- Rearing/overwintering juveniles
- Outmigrant juveniles

Coho Salmon

- Returning adults
- Rearing/overwintering juveniles
- Outmigrant juveniles

Pink Salmon

- Returning adults
- Spawning adults
- Embryos and pre-emergent fry
- Outmigrant juveniles

Rainbow Trout

- Adults
- Juveniles

Arctic Grayling

- Adults
- Juveniles

Burbot

- Adults
- Juveniles

Dolly Varden

- Adults

3.2 Habitat Utilization by Evaluation Species

Twenty species of fish have been observed in the Susitna River (WCC 1985a). Of the twenty species, nine were chosen as evaluation species for the assessment of project effects on fish in the middle reach of the Susitna River (Section 3.1). The evaluation species include chinook, chum, sockeye, coho, and pink salmon, rainbow trout, Arctic grayling, burbot, and Dolly Varden. A detailed discussion of species biology and utilization of the various habitat types in the middle Susitna River is found in WCC (1985a).

Fishery resources of the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvests and provide sport fishing opportunities for anglers. Five species of Pacific salmon form the base of the commercial and sport fisheries. The annual escapements of the five salmon species to various locations in the Susitna River for 1981 through 1984 are presented in Table 4.

Based on escapements to Curry Station (RM 120) for 1981 through 1984, the middle reach of the Susitna River provides habitat for annual escapements of approximately 13,000 chinook; 28,200 chum; 2,400 sockeye; 1,600 coho; 87,900 even-year pink; and 3,300 odd-year pink (Table 4). Chinook and coho salmon spawn in tributary streams and tributary mouths in the middle Susitna River, pink salmon primarily in tributary streams and tributary mouths (with a small number utilizing slough habitats), chum salmon in tributary streams, sloughs, and tributary mouths, and sockeye almost exclusively in sloughs (ADF&G 1985a). Relatively few salmon spawn in the mainstem and side channels in the middle Susitna River. Of those which do, chum salmon predominate (ADF&G 1985a).

Four of the five salmon species present use middle Susitna River habitats for rearing (ADF&G 1984a). From May to September, juvenile chinook salmon rear in tributaries, tributary mouths, and side channels; coho mostly rear in tributaries, tributary mouths, and upland sloughs; and sockeye move from natal side sloughs to upland sloughs for rearing. From May to July rearing chum salmon are distributed in tributaries, side sloughs, and side channels. Pink salmon juveniles move downstream to Cook Inlet shortly after emergence and do not rear in the middle Susitna River (ADF&G 1984a).

Table 4. Estimated salmon escapements by species and locations in the Susitna River, 1981-1984.

Sampling Location	Year	Escapement 1/					
		Chinook	Sockeye 2/	Pink	Chum	Coho	Total
Flathorn Station	1984	3/	605,800	3,629,900	812,700	190,100	5,238,500
Yentna Station	1981	4/	139,400	36,100	19,800	17,000	212,300
	1982		113,800	447,300	27,800	34,100	623,000
	1983		104,400	60,700	10,800	8,900	184,800
	1984		149,400	369,300	26,500	18,200	563,400
Sunshine Station	1981	3/	133,500	49,500	262,900	19,800	465,700
	1982	52,900	151,500	443,200	430,400	45,700	1,123,700
	1983	90,100	71,500	40,500	265,800	15,200	483,100
	1984	121,700	130,100	1k017,000	765,000	94,700	2,128,500
Talkeetna Station	1981	3/	4,800	2,300	20,800	3,300	31,200
	1982	10,900	3,100	73,000	49,100	5,100	141,200
	1983	14,400	4,200	9,500	50,400	2,400	80,900
	1984	24,800	13,100	177,900	98,200	11,800	325,800
Curry Station	1981	3/	2,800	1,000	13,100	1,100	18,000
	1982	11,300	1,300	58,800	29,400	2,400	103,200
	1983	9,700	1,900	5,500	21,100	800	39,000
	1984	18,000	3,600	116,900	49,300	2,200	190,000

1/ Escapement estimates were derived from tag/recapture population estimates except Yentna Station escapements which were obtained using side scan sonar.

2/ Second run sockeye salmon escapements only.

3/ Chinook salmon were not monitored for escapement.

4/ Yentna Station side scan sonar equipment was not operational on the dates required to estimate the total Yentna River chinook salmon escapements for 1981-84.

Source: ADF&G 1985a.

Rainbow trout, Arctic grayling, and Dolly Varden spawn in tributaries of the middle reach of the Susitna River. Juvenile and adult rainbow trout, Arctic grayling, and Dolly Varden rear in tributaries, tributary mouths, and to a lesser extent sloughs. Most fish of these three species apparently move from tributaries to the mainstem to overwinter (ADF&G 1984a, 1985b).

Estimates of the rainbow trout population size in the middle Susitna River range from 1,000 to 5,000 fish (ADF&G 1984a, 1985b). The Arctic grayling population size in the middle Susitna River is estimated to range from 2,500 to 7,000 fish (ADF&G 1985b). Dolly Varden are not abundant in the middle Susitna River, with insufficient numbers of fish caught to estimate population size.

From May to September in the middle Susitna River, juvenile and adult burbot are found in turbid mainstem-influenced areas, typically in low-velocity, deep-water areas of the mainstem and slough mouths. Burbot also spawn and overwinter in mainstem areas. Burbot densities in the middle Susitna River were estimated to be 15 fish per mile in 1983 (ADF&G 1984a).

To facilitate the assessment of project effects on fish in the middle Susitna River, a summary of the habitat utilization of the primary and secondary evaluation species and life stages is presented in the following sections. A detailed discussion of the habitat types and their response to changes in flow can be found in EWT&A and WCC (1985).

3.2.1 Mainstem and Side Channel Habitats

The mainstem of the middle Susitna River has both single and split channel configurations. Single channel reaches are generally stable with non-erodible banks controlled by valley walls, bedrock, or an armor layer consisting of gravel and cobbles. The channel is either straight or meandering. In straight channel reaches, the thalweg often meanders across the channel. Split channel configurations are characterized by moderately stable channels with a gravel/cobble substrate. There are usually no more than two channels in a given reach. Channels are separated by well established vegetated islands.

Side channels are generally located in peripheral areas of the mainstem corridor. Side channels have a diverse morphology with some having broad channels while others are narrow and deep. Side channels are highly influenced by mainstem discharge and water quality. In general, a side channel habitat conveys less than 10 percent of the total discharge in the river, but conveys mainstem discharge more than 50 percent of the time during the summer high flow months (EWT&A 1984, 1985). Side channels normally breach, i.e. convey mainstem water, at mainstem discharges less than 20,000 cfs (EWT&A and AEIDC 1985). Side channels have relatively low velocity (less than 3-4 ft/sec), shallow depths, and convey turbid water during the summer. When mainstem discharge decreases in the late fall and winter, side channels may become completely dewatered or may convey water derived from local runoff, tributaries, or upwelling groundwater.

The utilization of the mainstem and side channels by the primary and secondary evaluation species and life stages is summarized below.

(a) Primary Evaluation Species

(i) Chinook Salmon - rearing/overwintering juveniles

Some rearing juvenile chinook salmon move into the mainstem from natal tributaries as part of their downstream redistribution to rearing areas in the middle Susitna River or the lower Susitna River. Thus, the mainstem serves as a migrational corridor for rearing juvenile chinook salmon. The movement of rearing juvenile chinook through the mainstem to rearing areas usually commences in May or June and continues through September (ADF&G 1984a). Juvenile chinook also use the mainstem as a migrational corridor from September through November, when moving from rearing areas to overwintering areas.

Side channels provide habitat for the largest proportion of rearing juvenile chinook salmon in the middle Susitna River, excluding tributaries. Approximately 23 percent of the catch per unit effort for juvenile chinook salmon was from side channels in 1983 (ADF&G 1984a). Rearing juvenile chinook utilize side channels from late May or early June to October (ADF&G 1984a). It appears that most juvenile chinook move out of side channels in September and October and move to overwintering areas in sloughs.

(ii) Chum Salmon - spawning adults, embryos, and pre-emergent fry

Chum salmon spawning adults utilize the mainstem and side channels in the middle Susitna River. In 1984, when a concerted effort was made to locate mainstem spawning areas, approximately 3,800 adult chum salmon (8 percent of the estimated chum escapement to Curry Station) spawned in the mainstem and side channels (ADF&G 1985a). Most spawning activity occurred in areas of upwelling groundwater during September and October. Chum salmon embryos and pre-emergent fry remain in spawning sites until emergence in March or April.

(b) Secondary Evaluation Species

(i) Chinook Salmon - returning adults, outmigrant juveniles

Chinook salmon returning adults utilize the mainstem, and to a lesser extent side channels, as migrational corridors to spawning areas in tributaries. Based on estimated escapements at Curry Station for 1981 through 1984, approximately 13,000 chinook salmon annually utilize the mainstem for upstream movements. Migrational timing of adult chinook salmon in the middle Susitna River extends from June through July (ADF&G 1985a). The mainstem and side channels also serve as migrational corridors for outmigrant juvenile chinook salmon. Juvenile chinook salmon utilize the mainstem and side channels for outmigration from May through September in the middle Susitna River (ADF&G 1984a).

(ii) Chum Salmon - returning adults, rearing juveniles, outmigrant juveniles

Chum salmon returning adults use the mainstem and side channels for movement to spawning areas in the middle Susitna River. Based on estimated escapements at Curry Station for 1981 through 1984, approximately 28,200 chum salmon annually migrate into the middle Susitna River (ADF&G 1985a). The adult chum migration lasts from mid-July through mid-September in the middle Susitna River.

Rearing juvenile chum salmon utilize side channels during May and June. Side channels and the mainstem are also important migrational corridors for outmigrant juvenile chum salmon. The juvenile chum salmon outmigration lasts from May to early July in the middle Susitna River (ADF&G 1984a).

(iii) Sockeye Salmon - returning adults, spawning adults, embryos and pre-emergent fry, rearing/overwintering juveniles, outmigrant juveniles

Sockeye salmon returning adults and outmigrant juveniles utilize the mainstem and side channels primarily as migrational corridors. Returning adults migrate through the mainstem, and to a lesser extent side channels, from July through mid-September to spawning areas in side sloughs (ADF&G 1985a). Based on estimated escapements to Curry Station for 1981 through 1984, approximately 2,400 sockeye annually utilize the mainstem for upstream migration to spawning areas.

Juvenile sockeye utilize the mainstem and side channels for movements to other areas for rearing, overwintering, and outmigration. The outmigration timing of juvenile sockeye salmon extends from May through September in the middle Susitna River (ADF&G 1984a).

Sockeye spawning adults rarely utilize the mainstem or side channels. Hence, embryos and pre-emergent fry also occur infrequently in these areas. Rearing and overwintering juvenile sockeye primarily utilize sloughs and rarely use the mainstem or side channels.

(iv) Coho Salmon - returning adults, rearing/overwintering juveniles, outmigrant juveniles

Coho salmon returning adults and outmigrant juveniles utilize the mainstem and side channels primarily as migrational corridors. Returning adults migrate through the mainstem, and to a lesser extent side channels, from mid-July to mid-September to spawning areas in tributaries. Based on estimated escapements at Curry Station for 1981 through 1984, approximately 1,600 coho annually utilize the mainstem for upstream migration to spawning areas (ADF&G 1985a).

Juvenile coho salmon utilize the mainstem and side channels for movements from natal tributaries to other areas for rearing, overwintering, and outmigration. These movements through the mainstem and side channels occur primarily during May through September (ADF&G 1984a).

Rearing and overwintering juvenile coho rarely use the mainstem or side channels.

Coho salmon outmigrant juveniles utilize the mainstem and side channels for downstream movements from May through September (ADF&G 1984a).

(v) Pink Salmon - returning adults, spawning adults, embryos and pre-emergent fry, outmigrant juveniles

Pink salmon returning adults utilize the mainstem and side channels primarily as migrational corridors. Returning adults migrate through the mainstem, and to a lesser extent side channels, from mid-July through August to spawning areas in tributaries and sloughs. Based on estimated escapements at Curry Station for 1981 through 1984, approximately 87,900 even-year and 3,300 odd-year pink salmon annually utilize the mainstem for upstream migration to spawning areas (ADF&G 1985a).

Pink salmon spawning adults rarely use the mainstem or side channels. Hence, few embryos and pre-emergent fry are in the mainstem or side channels.

Pink salmon outmigrant juveniles utilize the mainstem and side channels for downstream movements from May to mid-July (ADF&G 1984a).

(vi) Rainbow Trout - adults, juveniles

Rainbow trout adults move into the mainstem for overwintering (ADF&G 1984a, 1985b). The movement of adult rainbow trout into the mainstem occurs from October to December. Rainbow trout utilize the mainstem for overwintering until April or May, when they move into tributaries to spawn.

Rainbow trout adults and juveniles also utilize the mainstem and side channels as migrational corridors from natal tributaries to rearing areas in sloughs. The movement of rainbow trout into sloughs usually coincides with the timing of salmon spawning (August and September) (ADF&G 1984a).

(vii) Arctic Grayling - adults, juveniles

Arctic grayling adults move into the mainstem for overwintering (ADF&G 1984a). Arctic grayling move into the mainstem in the fall, reside primarily downstream of natal tributaries, and move from the mainstem into tributaries to spawn in late April and May (ADF&G 1984a).

Arctic grayling adults and juveniles also utilize the mainstem, and to a lesser extent side channels, as migrational corridors from natal tributaries to rearing areas in sloughs. The use of sloughs by Arctic grayling adults and juveniles appears to be limited (ADF&G 1983a).

(viii) Burbot - adults, juveniles

Burbot adults and juveniles utilize the mainstem throughout the year (ADF&G 1983a, 1984a). Side channels are also utilized during the summer high-flow season. All life stages of burbot (spawning, incubation, rearing, and overwintering) occur in the mainstem. Spawning adults utilize the mainstem in late December to February. Incubating embryos are in the mainstem from mid-winter until March to June.

(ix) Dolly Varden - adults

Dolly Varden adults move into the mainstem from tributaries presumably in October and November (ADF&G 1983a, 1984a). Dolly Varden overwinter in the mainstem until April or May, when they move into tributaries to rear (ADF&G 1984a).

3.2.2 Side Slough and Upland Slough Habitats

Side sloughs are morphologically similar to side channels and distinctions between side sloughs and side channels are somewhat arbitrary (EWT&A 1985). Side sloughs may be distinguished from side channels by the mainstem discharges required to breach the upstream ends. A mainstem discharge of approximately 20,000 cfs was selected (EWT&A and AEIDC 1985). Hence, side sloughs convey mainstem water less than approximately 50 percent of the time during the summer high flow months.

Upland sloughs are analogous to small tributaries (EWT&A 1984). Discharge in upland sloughs is derived from local runoff, small tributaries, and groundwater upwelling. Many of the upland sloughs are inhabited by beavers. The upstream ends of upland sloughs are often separated from the mainstem by vegetated areas indicating that breaching of the upstream end occurs only at extremely high mainstem discharge.

The utilization of side sloughs and upland sloughs by the primary and secondary evaluation species and life stages is summarized below.

(a) Primary Evaluation Species

(i) Chinook Salmon - rearing/overwintering juveniles

Rearing juvenile chinook salmon utilize side sloughs and upland sloughs, but the proportion of the catch per unit effort in side sloughs and upland sloughs was only 16 percent in 1983 (ADF&G 1984a). Rearing juvenile chinook utilize side sloughs and upland sloughs throughout the summer (May through September). Juvenile chinook salmon also use side sloughs and upland sloughs for overwintering (ADF&G 1985c).

(ii) Chum Salmon - spawning adults, embryos and pre-emergent fry

Chum salmon spawning adults utilize side sloughs, and occasionally upland sloughs. Side sloughs are important areas for spawning chum salmon in the middle Susitna River. In 1984, about 50 percent of the estimated chum salmon spawning in the middle Susitna River occurred in side sloughs (ADF&G 1985a). Incubating embryos and pre-emergent fry are present in side sloughs through the winter until emergence in March and April.

(b) <u>Secondary Evaluation Species</u>

(i) <u>Chinook Salmon - returning adults, outmigrant juveniles</u>

Chinook salmon returning adults and outmigrant juveniles rarely utilize side slough or upland slough habitats.

(ii) <u>Chum Salmon - returning adults, rearing juveniles, outmigrant juveniles</u>

Adult chum salmon in sloughs are considered spawning adults [Section 3.2.2(a)].

Chum salmon rearing juveniles utilize natal sloughs for rearing for one to two months after emergence (ADF&G 1984a). Outmigrant juvenile chum move out of sloughs from May to July (ADF&G 1984a).

(iii) <u>Sockeye Salmon - returning adults, spawning adults, embryos and pre-emergent fry, rearing/overwintering juveniles, outmigrant juveniles</u>

In the middle Susitna River, almost all sockeye salmon spawning adults utilize side sloughs. Based on slough escapement surveys during 1981 through 1985, over 95 percent of the adult sockeye in the middle Susitna River spawned in side sloughs (ADF&G 1985a, 1986). Hence, most sockeye incubating embryos and pre-emergent fry in the middle Susitna River are present in side sloughs.

After fry emergence, juvenile sockeye rear in side sloughs for a short time before outmigrating in July and August (ADF&G 1984a). Outmigrant juvenile sockeye either move to upland sloughs to rear and overwinter or move downstream to the lower Susitna River or Cook Inlet (ADF&G 1984a).

(iv) Coho Salmon - returning adults, rearing/overwintering juveniles, outmigrant juveniles

Coho salmon returning adults rarely utilize sloughs.

Some rearing juvenile coho salmon move out of natal tributaries and into sloughs for rearing. From May through November 1983, the proportion of the coho catch per unit effort was about 35 percent in upland sloughs and approximately 10 percent in side sloughs (ADF&G 1984a). Juvenile coho salmon also use upland sloughs to overwinter.

Outmigrant juvenile coho move downstream out of sloughs or tributaries to other rearing or overwintering areas throughout the summer (May to September) (ADF&G 1984a). Some juvenile coho outmigrants move into the lower Susitna River or Cook Inlet.

(v) Pink Salmon - returning adults, spawning adults, embryos and pre-emergent fry, outmigrant juveniles

Some pink salmon spawning adults utilize sloughs in the middle Susitna River. The use of sloughs by spawning pink salmon is dependent on run size. During even years, the use of side sloughs for spawning is higher than during odd years. Overall, the utilization of sloughs by spawning adult pink salmon is a small proportion of the estimated pink salmon escapement to Curry Station (ADF&G 1985a). Hence, incubating pink embryos and pre-emergent fry are present in sloughs, but not abundant.

Juvenile pink salmon move out of natal areas almost immediately after emergence (ADF&G 1984a). Thus, most pink salmon outmigrants move out of sloughs in April and May.

(vi) Rainbow Trout - adults, juveniles

Some rainbow trout adults and juveniles use sloughs in the middle Susitna for rearing and overwintering. The use of sloughs by rearing rainbow trout occurs primarily during the salmon-spawning period (August and September). Rainbow trout apparently feed on salmon eggs that are dislodged from spawning areas (ADF&G 1984a).

Rainbow trout utilize sloughs in the middle Susitna River to a limited extent for overwintering (ADF&G 1983a). The mainstem and tributaries appear to be the preferred habitats in the middle Susitna River for overwintering rainbow trout.

(vii) Arctic Grayling - adults, juveniles

The use of sloughs in the middle Susitna River by Arctic grayling adults and juveniles appears to be limited (ADF&G 1983a).

(viii) Burbot - adults, juveniles

The use of sloughs in the middle Susitna River by burbot appears to be limited. Juvenile burbot have been found in sloughs and adults are thought to use the deep, backwater areas in slough mouths (ADF&G 1983a, 1984a). However, the population size of burbot in the middle Susitna River appears to be low and few burbot have been caught in sloughs.

(ix) Dolly Varden - adults

Sloughs are rarely utilized by Dolly Varden in the middle Susitna River.

3.2.3 Tributary and Tributary Mouth Habitats

Tributaries that flow into the middle Susitna River all convey clear water into the river. Tributary streamflow, sediment, and thermal regimes reflect the integration of the hydrology, geology, and climate of the tributary drainage. Hence, the physical attributes of tributaries are not dependent on mainstem conditions. The two major tributaries of the middle Susitna River are Indian River (RM 138.6) and Portage Creek (RM 148.8), each of which have an annual average discharge of approximately 500 cfs.

Tributary mouth habitat extends from upstream in the tributary, at the point where backwater effects from the mainstem are observed, into the mainstem where mainstem water mixes with the tributary water. The downstream extent of tributary habitat is obvious during the summer when the mainstem water is turbid and the tributary water is clear. The size and the lateral location of the available tributary mouth habitat varies with mainstem discharge and discharge from the tributary itself. At high mainstem discharge, the habitat tends to be near the bank vegetation at the mouth of the tributary, whereas at low mainstem discharge, the habitat is further away from the bank vegetation.

The utilization of tributary and tributary mouth habitats by the primary and secondary evaluation species and life stages is summarized below.

(a) Primary Evaluation Species

(i) Chinook Salmon - rearing/overwintering juveniles

Rearing juvenile chinook salmon utilize natal tributaries throughout the summer. From May through November in 1983, approximately 61 percent of the catch per unit effort of juvenile chinook was from tributaries (ADF&G 1984a). Thus, tributaries are important rearing areas for juvenile chinook in the middle Susitna River.

Some juvenile chinook salmon remain in tributaries throughout the winter (ADF&G 1985c). Juvenile chinook that overwinter in tributaries move out of tributaries in May, June, and July (ADF&G 1984a).

Tributary mouths are utilized by rearing juvenile chinook salmon during summer. In August and September juvenile chinook move to tributary mouths to feed on salmon eggs dislodged from the spawning areas of adult salmon (ADF&G 1984a, 1985c).

(ii) Chum Salmon - spawning adults, embryos and pre-emergent fry

Tributaries are important spawning areas for chum salmon in the middle Susitna River. In most years approximately 50 percent or more of the chum salmon spawning in the middle Susitna River occurs in tributaries (ADF&G 1984b, 1985a). Hence, chum embryos and pre-emergent fry are abundant in tributaries.

Tributary mouths in the middle Susitna River are also utilized by chum spawning adults (ADF&G 1985a). Thus, chum embryos and pre-emergent fry occur in tributary mouths. The use of tributary mouths is a relatively small proportion of the total chum salmon spawning in the middle Susitna River.

(b) Secondary Evaluation Species

(i) Chinook Salmon - returning adults, outmigrant juveniles

Chinook salmon returning adults utilize tributary mouths as migrational corridors to spawning habitats in tributaries. Almost all spawning chinook salmon in the middle Susitna River utilize tributaries (a few spawn in tributary mouths) (ADF&G 1984b, 1985a). Hence, nearly all returning chinook salmon in the middle Susitna River move through tributary mouths to spawn in tributaries. The utilization of these areas by chinook salmon occurs in late June and July (ADF&G 1985a).

Outmigrant juvenile chinook salmon begin moving out of natal tributaries in June. The downstream redistribution of juvenile chinook continues throughout the summer. Thus, outmigrant juveniles move out of tributaries into tributary mouths or other areas from June through September (ADF&G 1984a).

(ii) Chum Salmon - returning adults, rearing juveniles, outmigrant juveniles

Chum salmon returning adults utilize tributary mouths as migrational corridors to spawning areas in tributaries. Chum salmon move into tributaries in late July through mid-September in the middle Susitna River (ADF&G 1984b, 1985a). The utilization of tributaries and tributary mouths by spawning chum salmon was discussed in Section 3.2.3(a).

Rearing juvenile chum salmon use natal tributaries for one to three months after fry emergence (ADF&G 1984a). In 1983 about one-third of the catch per unit effort for juvenile chum salmon was in tributaries (ADF&G 1984a). Outmigrant juvenile chum salmon move out of tributaries in May, June, and early July. By mid-July most juvenile chum salmon have moved downstream of Talkeetna (ADF&G 1984a).

(iii) Sockeye Salmon - returning adults, spawning adults, embryos and pre-emergent fry, rearing/overwintering juveniles, outmigrant juveniles

Sockeye salmon rarely utilize tributaries and tributary mouths in the middle Susitna River.

(iv) Coho Salmon - returning adults, rearing/overwintering juveniles, outmigrant juveniles

Almost all spawning coho salmon in the middle Susitna River utilize tributaries (ADF&G 1984b, 1985a). Thus, coho salmon returning adults utilize tributary mouths as migrational corridors to spawning areas in tributaries. The migrational timing of coho salmon into tributaries extends from August into September (ADF&G 1984b).

Following the emergence of fry, many rearing juvenile coho salmon remain in tributaries. From May through November in 1983, over 50 percent of the catch per unit effort of juvenile coho salmon was in tributaries (ADF&G 1984a). Tributaries also provide overwintering habitat for juvenile coho salmon.

Some juvenile coho salmon move downstream to rear in tributary mouths. The greatest abundance of juvenile coho salmon in tributary mouths occurs in August and September during the salmon-spawning period. Presumably, the juveniles inhabit tributary mouths to feed on salmon eggs dislodged from spawning areas or drifting aquatic invertebrates (ADF&G 1984a). No overwintering juvenile salmon have been observed in tributary mouths.

Coho salmon outmigrant juveniles move out of natal tributaries to other rearing or overwintering areas, or to the lower Susitna River and Cook Inlet, from May through September (ADF&G 1984a).

(v) Pink Salmon - returning adults, spawning adults, embryos and pre-emergent fry, outmigrant juveniles

Most pink salmon in the middle Susitna River spawn in tributaries (ADF&G 1984b, 1985a). Thus, returning adults move through tributary mouths and into tributaries to spawn. The migrational timing of pink salmon into tributaries is from mid-July through August. Some pink salmon spawn in tributary mouths, but the use of these areas by spawning pink salmon comprises a relatively small proportion of the total pink salmon spawning in the middle Susitna River. Embryos and pre-emergent fry are present in tributaries and tributary mouths in direct proportion to the relative abundance of spawning adults.

Pink salmon outmigrant juveniles move out of natal tributaries and tributary mouths soon after fry emergence. Most juvenile pink salmon move downstream from natal areas in May and June, and by mid-July almost all juvenile pink have moved downstream of Talkeetna (ADF&G 1984a).

(vi) Rainbow Trout - adults, juveniles

All of the known rainbow trout spawning in the middle Susitna River occurs in tributaries (ADF&G 1984a, 1985b). Rainbow trout move from the mainstem into tributaries (through tributary mouths) during May and June to spawn. Hence, rainbow trout embryos are present in tributaries.

Tributaries are important rearing areas for juvenile and adult rainbow trout throughout the summer. In early fall (August and September) juvenile and adult rainbow trout move downstream to tributary mouths to feed on salmon eggs (ADF&G 1984a).

Most adult rainbow trout move out of tributaries and tributary mouths into the mainstem to overwinter (ADF&G 1984a). Rainbow trout usually move into the mainstem by late November or early December. Some adult and juvenile rainbow trout may remain in tributaries during winter.

(vii) Arctic Grayling - adults, juveniles

In the middle Susitna River, Arctic grayling spawn in tributaries in May and early June (ADF&G 1984a, 1985b). Prior to spawning, there is a migration from overwintering areas in the mainstem to spawning areas in tributaries. Grayling embryos are present in tributaries.

Tributaries are important areas for juvenile and adult Arctic grayling rearing (ADF&G 1984a). Most grayling adults and juveniles rear in tributaries throughout the summer. In the fall (August and September) some adult and juvenile grayling move downstream to tributary mouths. Most grayling move into the mainstem to overwinter, although it appears that some grayling may remain in tributaries to overwinter.

(vii) Burbot - adults, juveniles

Burbot adults and juveniles are rarely found in tributaries in the middle Susitna River. Burbot utilize tributary mouths in the middle Susitna River, but the use of these areas also appears to be limited (ADF&G 1984a).

(viii) Dolly Varden - adults

Dolly Varden adults move into tributaries in May and early June in the middle Susitna River. They remain in tributaries throughout the summer to rear. Dolly Varden adults are thought to spawn in tributaries during fall (October) (ADF&G 1984a). After spawning, it appears that most adult Dolly Varden move from tributaries to the mainstem for overwintering. The movement of Dolly Varden into the mainstem from tributaries likely occurs in November.

4.0 PHYSICAL CHANGES RESULTING FROM THE PROJECT

The physical changes in the middle Susitna River resulting from the proposed Susitna Hydroelectric Project as compared to natural conditions include variations in flows and water levels, river morphology, water quality, and groundwater conditions. Details of project operations which would cause these changes are presented in the project description and schedule (APA 1985b). Flows and water levels in the middle Susitna River will generally be increased in winter and decreased in summer during project operation. The morphology of the middle Susitna River is expected to adjust slightly to the altered flow and sediment regimes. Changes in water quality include variations in temperature, ice conditions, suspended sediment concentrations, and turbidity levels in the middle Susitna River. Water temperatures during project operation are expected to be generally warmer in the winter and cooler in the summer than during natural conditions. Ice is anticipated to develop later and break up earlier, and the upstream edge of the ice front is expected to be located downstream of the ice front under natural conditions. Suspended sediment concentrations and turbidity levels are expected to be substantially less than natural levels during summer and slightly greater than natural during winter. The water quality in the middle Susitna River is not expected to be affected by the use of fuel and hazardous materials or the production of concrete at the damsites, as potential contamination from these sources will be avoided or minimized as described in the Access Corridor, Construction Zone, and Transmission Corridor Impact Assessment and Mitigation Plan (Entrix 1985a).

4.1 Flows and Water Levels

The proposed Susitna Hydroelectric Project would regulate the river and alter water levels downstream from the damsites. Summer flows, generally high under natural conditions, will be reduced as water is stored in the reservoirs. Higher than natural winter flows would result from increased power generation during the winter. The flows would be less variable under project conditions compared with natural flows. Water levels during the open-water season would be lower in summer and higher in fall than natural levels. In winter, the water levels upstream of the ice front would be similar or lower than naturally occurring ice-staged water levels. Downstream of the ice front, water levels would be increased from natural ice staged water levels. Flood frequency would be reduced and flood occurrences would be shifted from the natural flood period of May to June to the July to September period.

4.1.1 Mean Monthly Flows and Water Levels

In general, with-project flows will be reduced during the summer and increased during the winter from natural flows. Water levels in the summer will also be reduced from natural conditions. However, water levels in the winter will not reach the low levels which occur naturally prior to ice staging in the fall. Water levels will depend upon the location of the ice front; water levels upstream of the ice front will be similar or lower and water levels downstream of the ice front will be higher than natural staged water levels. As the project progresses from Stage I to Stage III, flows and water levels will become increasingly uniform throughout the year.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

Mean monthly flows and water levels between Watana and Devil Canyon will be minimally affected during Stage I construction. There will be no significant change in flows and water levels during construction of the two diversion tunnels. Upon completion of the diversion facilities, closure of the upstream cofferdam will be completed and flow will be diverted through the lower of the two diversion tunnels. Although the mean monthly flows and water levels downstream of the dam will not be altered, a 0.6 mile section of the Susitna River will be dewatered in the construction zone. The resulting impacts are discussed in the construction zone impact assessment (Entrix 1985a).

- Filling

Mean monthly flows and water levels during May through September (1998) will be reduced from natural conditions during filling. Flows will be relatively steady and close to the Case E-VI criteria summarized in Section 2.1.2. During the winter following the one summer of filling, the minimum flow requirement will be natural flows. The Watana reservoir water level is expected to be sufficiently high to begin testing and commissioning the first unit in July 1986; testing and commissioning other units would follow on three-month intervals. Flows will be greater than winter minimum flows while testing and commissioning the powerhouse units. It is expected that the first two units would become operational in the 1998-1999 winter. The reservoir water level in the following spring (May) will likely be above the minimum operation level.

- Operation

In general, the downstream flow rate will be more stable than under natural conditions. Summer flows will be reduced and winter flows increased from natural discharge rates. Lowest flows occur in early May and October since the energy demands in these months are less than for other months. During most years of Stage I operation, discharges would likely be greater than the minimum flows experienced during the year of filling.

The reservoir normally begins to fill in May and the reservoir operating policy is to try to fill the reservoir by early September to ensure adequate energy production in the winter. Thus, May and June releases from the reservoir are generally lower than in July and August. In average and wet years the reservoir may fill before September. Releases would then be made in excess of power and environmental requirements.

(ii) Stages II and III

During construction of the Stage II dam, mean monthly flows and water levels in the Watana to Devil Canyon reach will remain unchanged from those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna (Middle River)

(i) Stage I

- Construction

No noticable changes in mean monthly flows or water levels in the middle Susitna River are expected during Stage I construction.

- Filling

Flows and water levels will be reduced from natural levels during the summer of filling in a manner similar to that described for the Watana to Devil Canyon reach. Flows during the following winter will be maintained at natural levels except during testing and commissioning of the powerhouse units, when the flows will exceed the natural flows.

- Operation

Although mean annual flow will remain the same, flow will be redistributed from the summer months to the winter months to meet energy demands. Mean weekly streamflows for 10, 50, and 90 percent exceedance levels are shown in Figure 7. Stage I mean monthly flows at Gold Creek are compared to natural flows in Table 5. Mean monthly water levels at three locations within the middle Susitna River are compared graphically for natural and Stage I conditions in Figure 8.

(ii) Stage II

- Construction

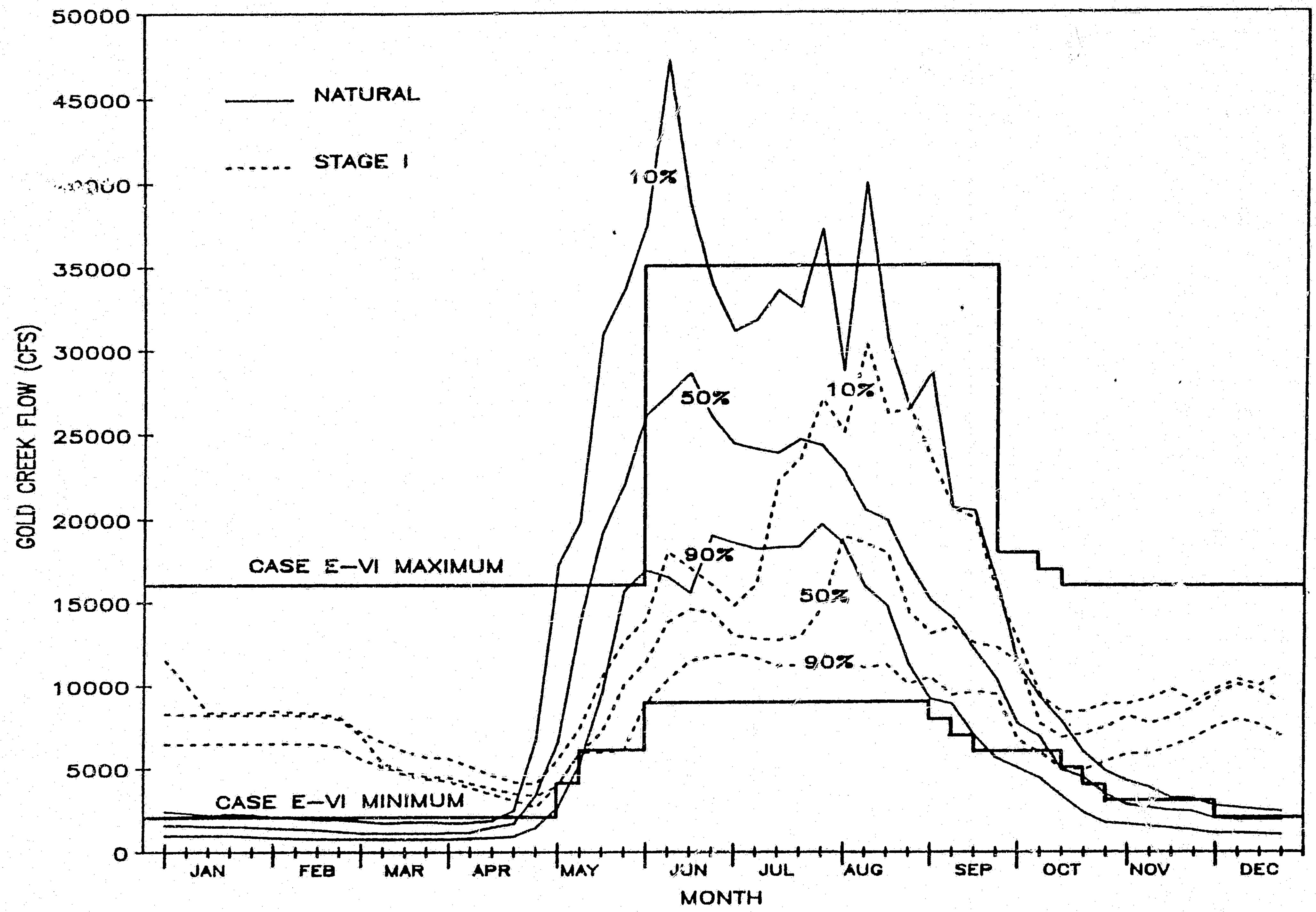
Downstream flows and water levels during Stage II construction will continue to be those described for Stage I operation.

- Filling

Devil Canyon reservoir will be filled in two distinct filling periods. The first will last one to four weeks and will take place during the construction phase, while the second will complete the filling at the conclusion of the dam construction. The total filling time for the Devil Canyon reservoir will be short (5-8 weeks). During both filling periods, flows will be reduced below Stage I operation levels at Gold Creek to near minimum requirements.

- Operation

After Devil Canyon comes on line, Watana Stage I will be operated as a peaking plant and Devil Canyon will re-regulate Watana flows. Devil Canyon discharges may vary between 90 percent and 110 percent of the average weekly



SOURCE: APA 1985c

MEAN WEEKLY NATURAL AND STAGE I DISCHARGES EXCEEDED 90%, 50%, AND 10% OF THE TIME

FIGURE 7

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

Table 5. Natural and project mean monthly flows at Gold Creek.

Stage I

Month	Natural	Stage I	Percent Change
January	1,500	8,100	+440
February	1,300	7,600	+480
March	1,200	5,700	+370
April	1,400	4,100	+190
May	13,500	6,400	- 50
June	27,800	13,300	- 50
July	24,400	14,500	- 40
August	21,900	18,300	- 20
September	13,500	14,200	+ 10
October	5,800	7,900	+ 40
November	2,600	7,800	+200
December	1,800	9,100	+400

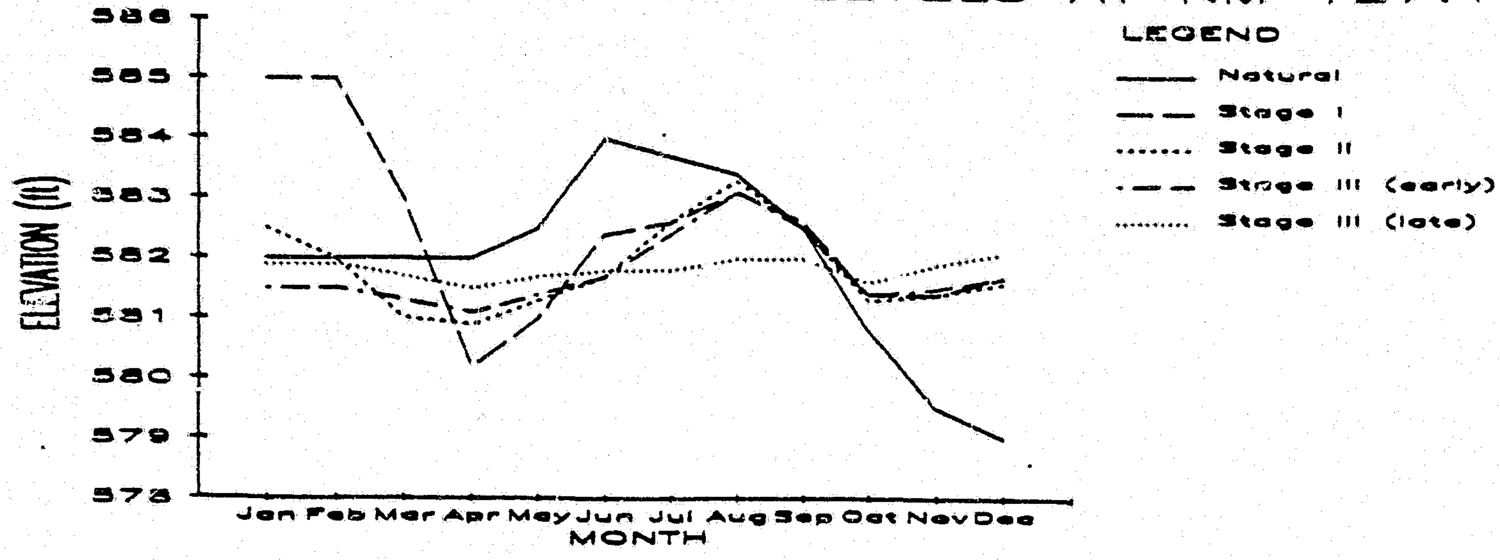
Stage II

Month	Natural	Stage II	Percent Change
January	1,500	8,000	+430
February	1,300	7,500	+480
March	1,200	6,300	+430
April	1,400	6,000	+330
May	13,500	7,100	- 50
June	27,800	9,200	- 70
July	24,400	14,900	- 40
August	21,900	20,300	- 40
September	13,500	13,600	- 10
October	5,800	7,600	0
November	2,600	7,900	+ 30
December	1,800	8,600	+200

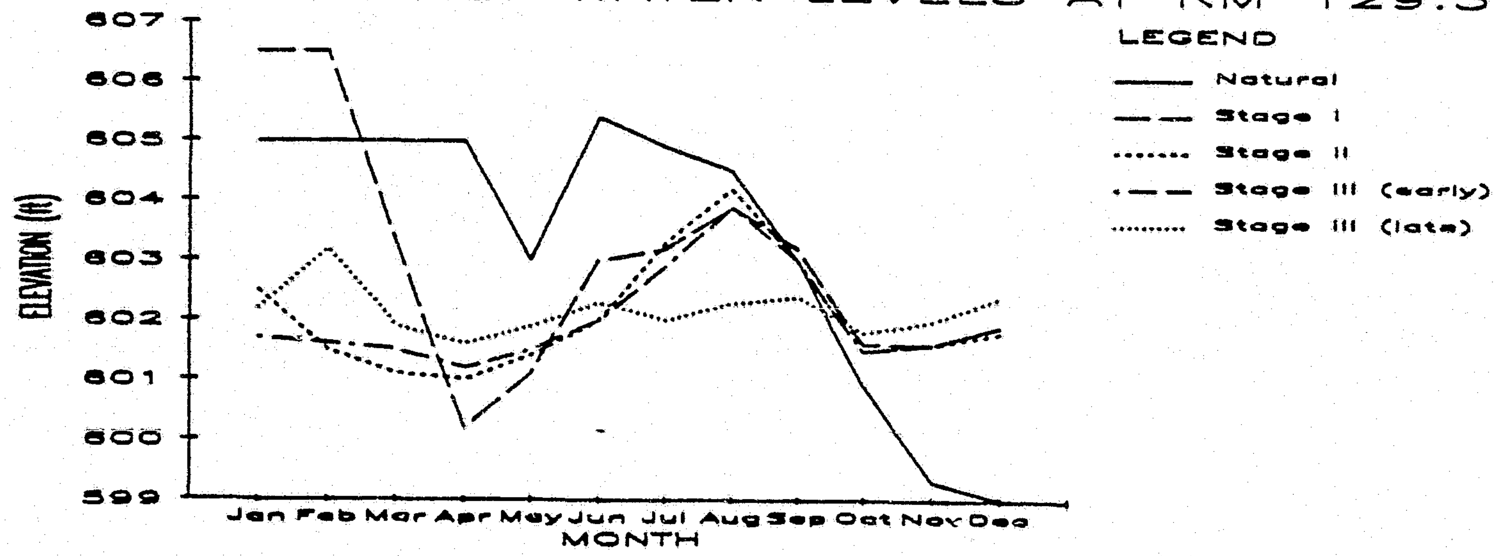
Stage III

		Stage III			
Month	Natural	Early	Percent Change	Late	Percent Change
January	1,500	8,300	+450	10,300	+590
February	1,300	8,100	+520	10,100	+680
March	1,200	7,300	+510	9,100	+660
April	1,400	6,600	+370	8,100	+480
May	13,500	7,600	-40	9,000	-30
June	27,800	9,200	-70	10,400	-60
July	24,400	13,200	-50	9,400	-60
August	21,900	18,500	-20	10,700	-50
September	13,500	13,400	0	10,800	-20
October	5,800	7,700	+30	8,600	+50
November	2,600	8,200	+220	9,500	+270
December	1,800	9,000	+400	11,000	+510

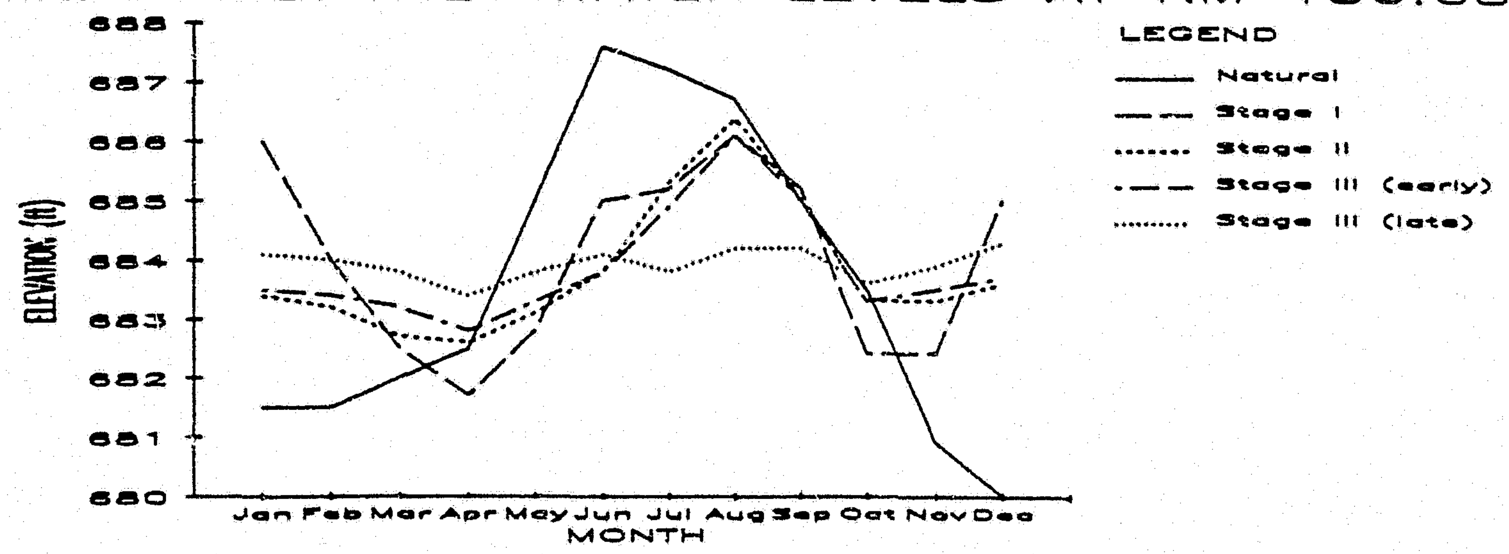
MEAN MONTHLY WATER LEVELS AT RM 127.1



MEAN MONTHLY WATER LEVELS AT RM 129.3



MEAN MONTHLY WATER LEVELS AT RM 136.68



MEAN MONTHLY WATER LEVELS

FIGURE 8

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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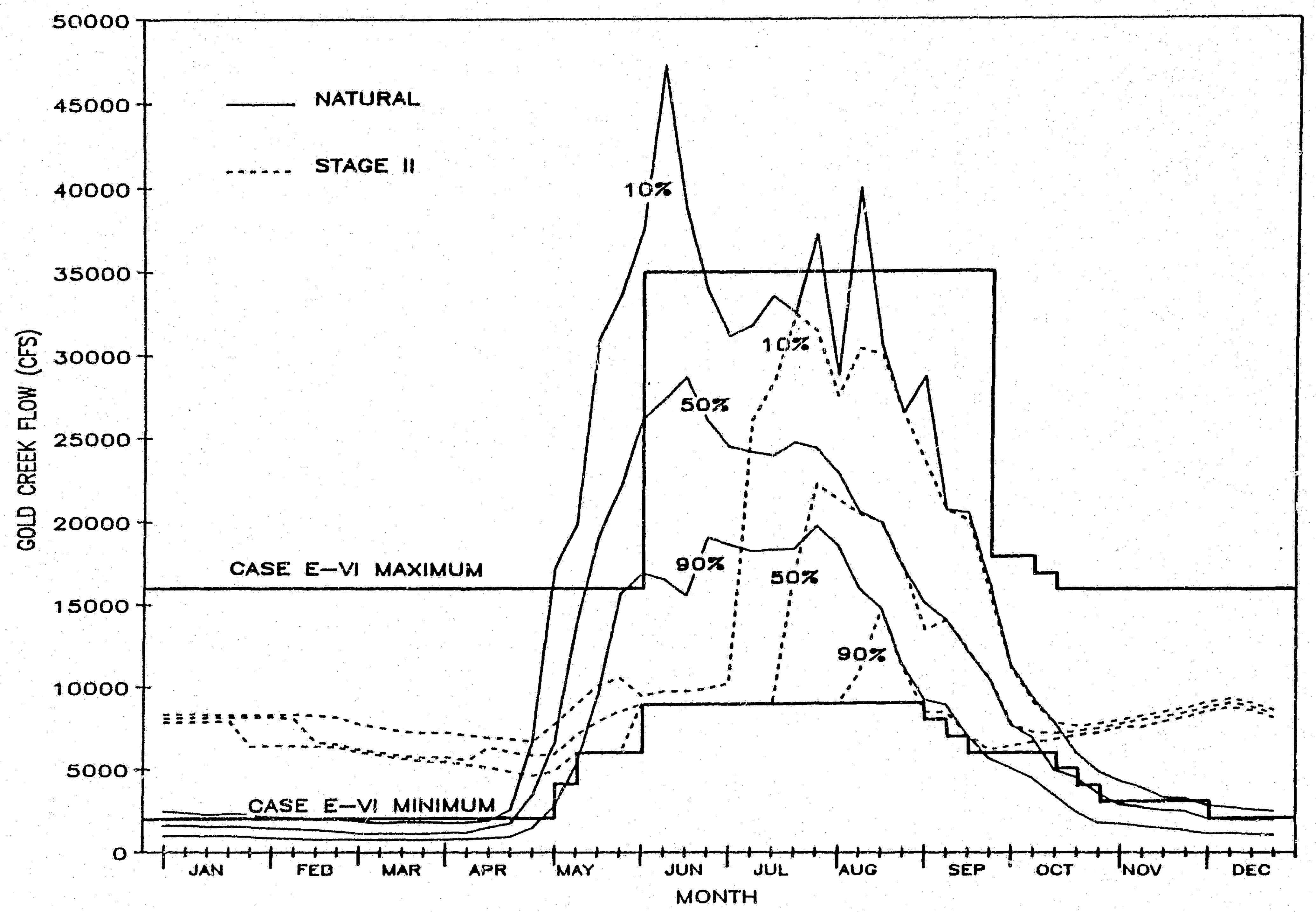
flow. A more detailed discussion of Stage II operation is included in Section 2.2.4.

The increase in hydraulic head and generating capacity when Devil Canyon becomes operational will allow winter energy demands to be met with less flow than in Stage I. Thus, less water is needed to meet mid-winter (December-February) demands and more water can be used in October, March, April, and May, thereby making Stage II winter flows more uniform than in Stage I. Since summer energy demands also require less flow, Watana storage is filled earlier in the summer and non-power releases are necessary earlier than in Stage I. This accounts for higher July-September flows with Stage II than for Stage I. Stage II mean monthly flows at Gold Creek are compared to natural flows in Table 5.

Although mean annual flow will remain the same, flow will be redistributed from the summer months to the winter months to meet energy demands. Flows at 10, 50, and 90 percent exceedance levels at Gold Creek during Stage II operation are shown in comparison to natural flows in Figure 9.

Water surface elevations corresponding to Gold Creek flows with 10, 50, and 90 percent exceedance levels for selected weeks during May through September are illustrated in Figure 8 for three mainstem locations between Portage Creek and Talkeetna. The figure illustrates the water level change expected as a result of Stage II operation. In general, there is a decrease in water level from natural levels to Stage II operation levels in the summer and an increase in stages in winter.



SOURCE: APA 1985c

MEAN WEEKLY NATURAL AND STAGE II DISCHARGES EXCEEDED 90%, 50%, AND 10% OF THE TIME

FIGURE 9

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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(iii) Stage III

- Construction

No change from Stage II operation flows will occur.

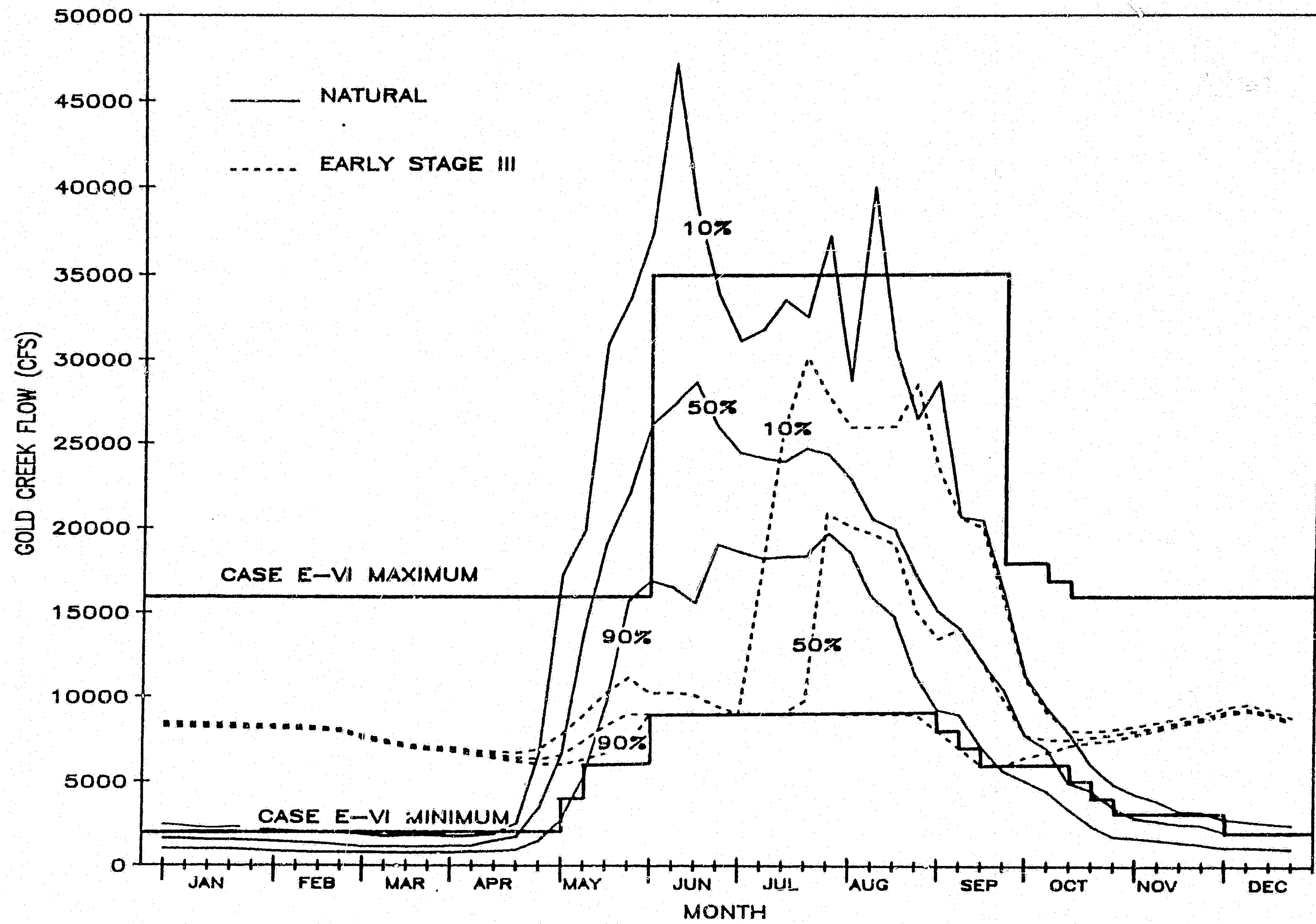
- Filling

Filling of Stage III will occur at the same time the dam crest is being raised, so construction and filling are not distinct phases. Since excess July-September flows will be stored in Watana, the flows at Gold Creek will be reduced from normal operational flows in July through September. Filling will take between three and seven years, beginning in 2011. The flows will generally be near the minimum flow requirements during the summer. Testing and commissioning of the last two units is scheduled to take place in 2012.

- Operation

Minimum flow requirements will be met by releases from the powerhouse and, if necessary, the outlet works. In general, operation results in higher than natural winter flows and lower than natural summer flows (Figures 10 and 11). Lowest flows occur in early May and October.

The flow regime during the early years of Stage III is similar to Stage II except in September and October of dry years when the early Stage III flows would be less than Stage II. As energy demand increases, the flow regime would become more uniform, and in average years during late Stage III, the flow would be very uniform throughout the year. In dry years there would be decreased flows in September and October and in wet years increased flows in August and September.



SOURCE: APA 1985c

MEAN WEEKLY NATURAL AND EARLY STAGE III DISCHARGES EXCEEDED 90%, 50%, AND 10% OF THE TIME

FIGURE 10

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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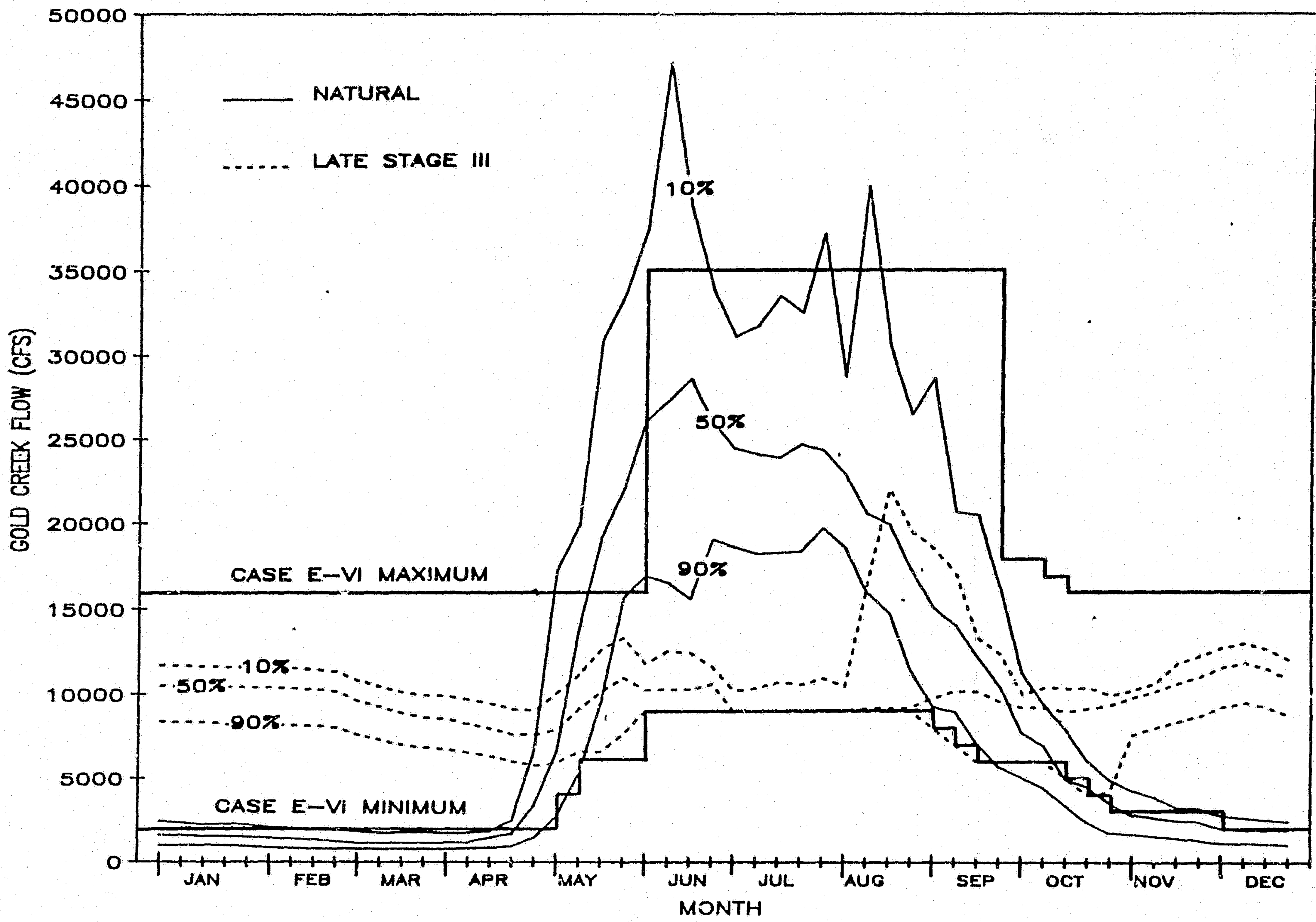
SUSITNA JOINT VENTURE



SOURCE: APA 1985c

MEAN WEEKLY NATURAL AND LATE STAGE III DISCHARGES EXCEEDED 90%, 50%, AND 10% OF THE TIME

FIGURE 11

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

- With-project mean monthly flows at Gold Creek are compared to natural flows in Table 5.

Water surface elevations corresponding to flows at 10, 50, and 90 percent exceedance levels at Gold Creek for selected weeks during May through September at three mainstem locations between Portage Creek and Talkeetna are illustrated in Figure 8 for early and late Stage III conditions. The figure illustrates the water level change expected as a result of operation of Stage III. In general, there is a decrease in water level from natural to with-project levels in the summer.

4.1.2 Floods

Flood peaks are expected to be reduced and flood durations would be extended compared to natural conditions. Floods would be expected to occur during the July to September period as a result of reservoir storage instead of the May to June period for most natural floods. Floods would become less likely as the project progresses from Stage I to Stage III due to the increasing volume of the reservoirs resulting in increasing flood storage capability.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

The two diversion tunnels are designed to pass the 50-year recurrence interval flood of 89,500 cfs with a maximum water surface elevation of 1,532 ft and a maximum outflow of 77,000 cfs. For flows up to the 50-year flood event, water levels and velocities downstream of the diversion tunnels will be almost the same as pre-project levels.

Floods greater than the 50-year event could overtop the Watana cofferdams and cause failure of the cofferdams. If a flood event of a magnitude large enough to overtop the cofferdam did occur, the area that would be affected the greatest is the main dam construction site. If the dam height is less than the cofferdam when overtopping occurs, significant losses would occur. However, if the main dam is somewhat higher than the cofferdam when overtopping occurs, no damage is anticipated. Although damage could occur further downstream, the relatively small volume of the head pond and the attenuation of the flood wave as it moves downstream would significantly reduce the potential for downstream flooding.

- Filling

The filling criteria dictate that the reservoir must be capable of storing the flood volume of a 250-year flood less the flow which can be discharged through the outlet facilities during the flood event. The maximum discharge of the outlet facilities at Watana is 30,000 cfs, which represents a substantial flood peak reduction. After a flood event, the outlet facility will continue to discharge at its maximum capacity until the storage volume criterion is reestablished. This will cause the flood to be extended beyond its normal duration although at a greatly reduced discharge.

- Operation

Table 6 presents the computed spring, summer, and annual flood frequencies at Watana. During a wet year, the Watana reservoir can be filled by July or August, after which time inflow will equal outflow. Consequently, with-project July-September discharges will be higher than May-June discharges, when the reservoir is recharging. Annual Stage

Table 6. Flood frequency at Watana during operation

Stage I

Period (Years)	May-June Natural	May-June Stage I	July-September Natural	July-September Stage I	Annual Natural	Annual Stage I
2	39,000	5,900	34,200	31,100	43,500	Similar to July-September Series
5	51,500	5,900	45,700	33,200	57,400	
10	60,000	5,900	54,500	33,200	67,000	
25	73,800	5,900	67,200	33,200	79,800	
50	84,400	5,900	77,800	33,200	89,500	

Stages II and III

Watana to Devil Canyon reach is inundated

I flood discharges would nearly always occur in the July-September period in contrast to naturally occurring annual floods, which typically occur in the May-June period.

(ii) Stages II and III

During construction of the Stage II dam, floods in the Watana to Devil Canyon reach will remain similar to those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna (Middle River)

(i) Stage I

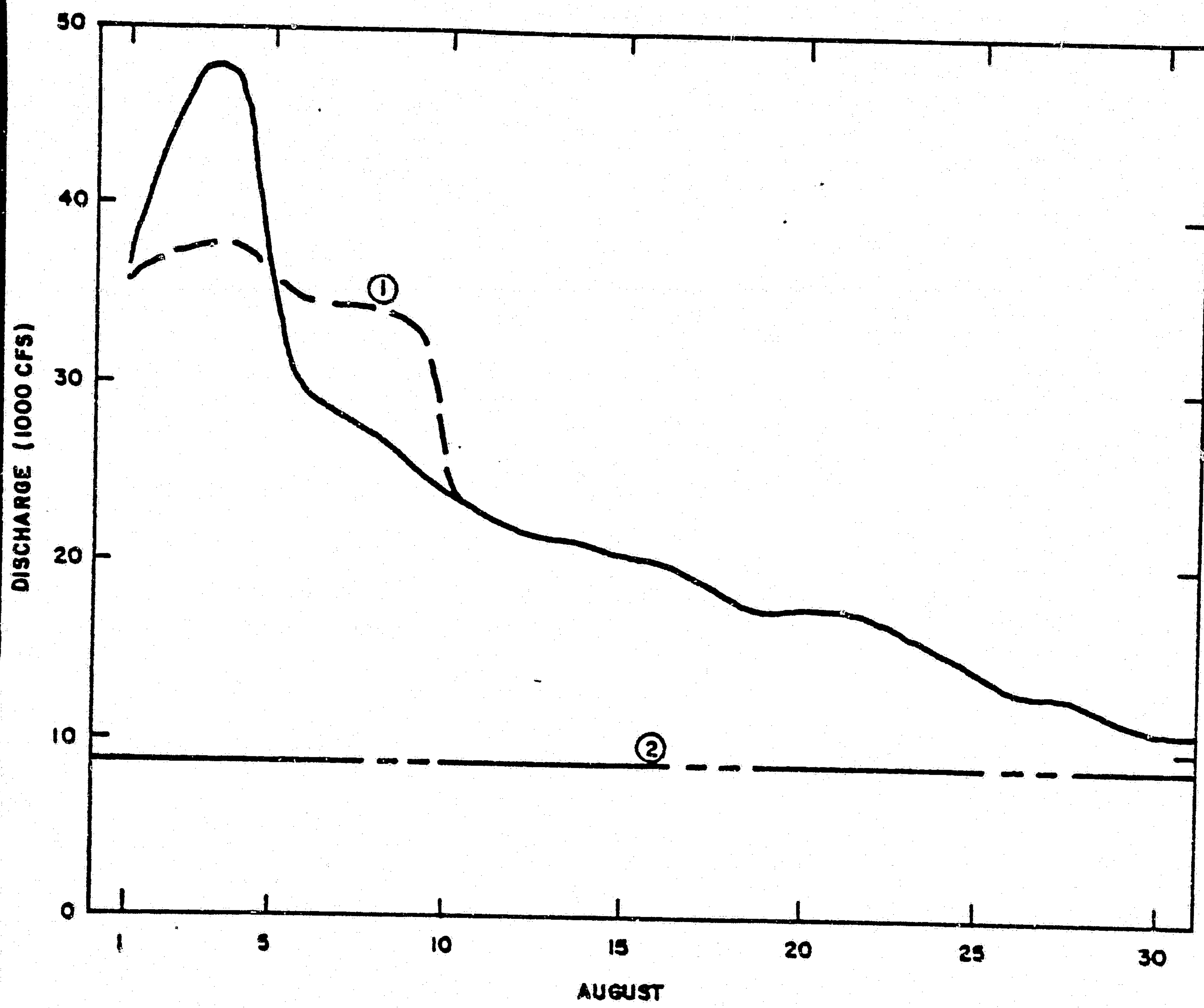
- Construction

No changes to river flooding characteristics in the middle Susitna River are expected during Stage I construction.

- Filling

Floods in the middle Susitna River will be damped due to the controlled Watana discharge. Using discharges measured during a typical August as an example (Figure 12), the daily natural and simulated with-project flows would be significantly different under normal operation. The amount of difference is dependent upon the reservoir level at the time of the flood, with the greatest difference associated with the lowest reservoir level.

In filling Sequence (1) in Figure 12, the reservoir is initially nearly full. While the peak of the flood is reduced by allowing the flood to surcharge the reservoir,



LEGEND:

- AUGUST 1958 FLOWS
- 1 FILLING SEQUENCE 1, AUGUST 1958 FLOWS – WATANA MINIMUM STORAGE CRITERIA VIOLATED
- 2 FILLING SEQUENCE 2, AUGUST 1958 FLOWS – WATANA CAPABLE OF ABSORBING HYDROGRAPH

NOTES:

1. WATANA FLOW ASSUMED TO BE 84 % OF GOLD CREEK FLOW.
2. RESERVOIR FILLING CRITERIA EXCEEDED WITH SEQUENCE 1
3. NEGLIGIBLE CHANGE IN DAM HEIGHT DURING FLOOD EVENT
4. MAXIMUM RELEASE AT WATANA 31,000 CFS (COMBINED POWERHOUSE AND OUTLET FACILITY DISCHARGE).

SOURCE: APA 1985c

FLOW VARIABILITY AT GOLD CREEK DURING WATANA FILLING

FIGURE 12

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outflow is greater than inflow on the receding limb of the hydrograph in order to reestablish the reservoir storage volume criterion. Hence, during this time period, the Gold Creek flow is greater than the natural flow.

In filling Sequence (2) illustrated in Figure 12, the reservoir level is near the minimum level and able to absorb the entire flood hydrograph. The Gold Creek flow would remain constant at 9,000 cfs as excess flows are stored in the reservoir.

- Operation

For the area upstream of the confluence of the Chulitna, Talkeetna, and Susitna Rivers, the largest annual floods generally occur in June as a result of snowmelt and rainfall-runoff. Thus the natural May-June series floods are larger than for the July-September series (Table 7). The project will delay flood peaks until later in the year as a result of storage. Project floods upstream of the confluence will also be reduced in magnitude from natural (Table 7).

(ii) Stage II

- Construction and Filling

The flood magnitude and frequency downstream of Devil Canyon will be the same as that described for Stage I operation.

- Operation

Flood flows will be less than for natural conditions in the middle reach due to Watana storage capacity. A small decrease in flood magnitude is expected for spring floods during Stage II operation as compared with Stage I

Table 7. Flood frequency and discharge (cfs) at Gold Creek during project operation.

Return Period (Years)	May-June Series				
				Stage III	
	Natural	Stage I	Stage II	Early	Late
2	42,500	19,800	17,300	18,000	19,700
5	56,200	26,800	24,300	25,000	26,700
10	66,300	30,600	28,100	28,800	30,500
25	80,500	33,900	31,400	32,100	33,800
50	92,100	37,900	35,400	36,100	37,800

Return Period (Years)	July-September Series				
				Stage III	
	Natural	Stage I	Stage II	Early	Late
2	37,300	36,500	36,500	35,500	15,700
5	49,800	43,100	43,100	43,100	21,300
10	59,400	44,000	45,000	45,000	24,000
25	73,200	44,000	45,000	45,000	26,500
50	84,800	46,600	47,000	47,300	29,500

Return Period (Years)	Annual Series				
				Stage III	
	Natural	Stage I	Stage II	Early	Late
2	48,000	Similar to July-September Series shown above			
5	63,300				
10	73,700				
25	87,300				
50	97,700				

operation. No significant change is expected for late summer floods (Table 7). Under natural conditions, the highest annual floods at Gold Creek generally occur in June. With Stage II operation, the annual flood peaks will generally occur in the July-September period rather than June (Table 7).

With Devil Canyon operational, a small amount of flood storage will be provided to prevent spillway releases during floods with return periods of less than 50 years. This will cause the maximum outflow for these events to be less than or equal to 42,000 cfs, the outlet works capacity.

Spring floods downstream of the project will be reduced by the discharged stored in Watana Reservoir. Devil Canyon Reservoir will generally be full during this period and would not provide any flood storage. Peak flows will generally be passed through Devil Canyon Reservoir without attenuation.

(iii) Stage III

- Construction and Filling

The discussion of flood flows for Stage II operation is applicable to the Stage III construction period before filling starts. Filling of Stage III will occur at the same time the dam crest is being raised, so construction and filling are not distinct phases.

Flood flows downstream will be only slightly reduced from Stage II operation levels due to increased storage in the reservoir. Sufficient storage will be maintained so that the structure is not endangered by floods.

- Operation

Spring floods downstream of the project will be reduced by the discharge stored in Watana Reservoir by a magnitude similar to those during Stage II operation (Table 7). Devil Canyon Reservoir will generally be full during this period and will not provide any flood storage. Peak flows will generally be passed through Devil Canyon Reservoir without attenuation. Late in Stage III, July-September flood flows become smaller than May-June flood flows as energy generation at Watana is increased, and flood storage capacity increases accordingly.

4.1.3 Flow Variability

Flow variability downstream of the damsites will be reduced from natural conditions following dam construction. Flow variations occurring upstream of Watana will be impounded in the reservoir, allowing a relatively steady flow to continue downstream. Variations in flow will become greater downstream because of natural inflow from tributaries. As the project progresses from Stage I to Stage III, flows will increase in stability as the reservoirs become more regulated to produce more constant powerhouse flows.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

No changes to downstream flows are expected as a result of Stage I construction.

- Filling

Under normal hydrologic conditions, flow from the Watana development will be totally regulated. The downstream flow will be controlled by the following criteria: downstream environmental flow requirements, minimum power demand, and reservoir operating rule curve. However, there can be significant variations in project discharge from one season to the next and for the same month from one year to the next.

Substantial changes in flow, which can occur daily under natural conditions, will be reduced during the filling process. Flow variations occurring upstream of Watana will be impounded in the reservoir, allowing a relatively steady flow to continue immediately downstream. Further downstream, the relative contribution of tributary and runoff flow increases such that flow variations become progressively more prominent.

- Operation

The Stage I discharge from Watana may be allowed to vary by ten percent above and below the mean weekly flow. The maximum variation in the mean weekly flow from one week to the next will be 20 percent.

Monthly flow duration curves have been prepared and presented in Chapter 2 of the FERC License Application Amendment (APA 1985c) to illustrate the variation in with-project flows as compared to natural variation. The Watana flows show little variability because of the high degree of reservoir regulation and the relatively constant powerhouse flow.

(ii) Stages II and III

During construction of the Stage II dam, flow variability in the Watana to Devil Canyon reach will remain unchanged from that during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna (Middle River)

(i) Stage I

- Construction

No changes in flows in the middle Susitna River are expected during Stage I construction.

- Filling

Stage I flow releases will provide a relatively steady flow immediately downstream of Watana. Large changes in the outflow rates at Watana will be virtually eliminated during filling. With increasing downstream distance, flow variations will become greater as tributary inflows provide a larger percentage of the mainstem discharge.

- Operation

Variations in flow at Gold Creek are greater than at Watana because of natural inflow in the reach between. This is graphically illustrated in the flow-duration curves presented in Chapter 2 of the FERC Application (APA 1985c); these curves show a diminishing difference between natural and with-project flow durations with increasing downstream distance. Another approach to illustrating the flow variability under natural and project flow regimes is to show the 10, 50, and 90 percent exceedance values of the percent change in discharge from one week to the next (Figure 13).

For the normal range of powerhouse discharges during Stage I, the expected range of stage fluctuations in the middle Susitna River for a daily change in discharge of 20 percent (10 percent $\pm$) would be from 0.2 to 0.7 ft.

(ii) Stage II

- Construction

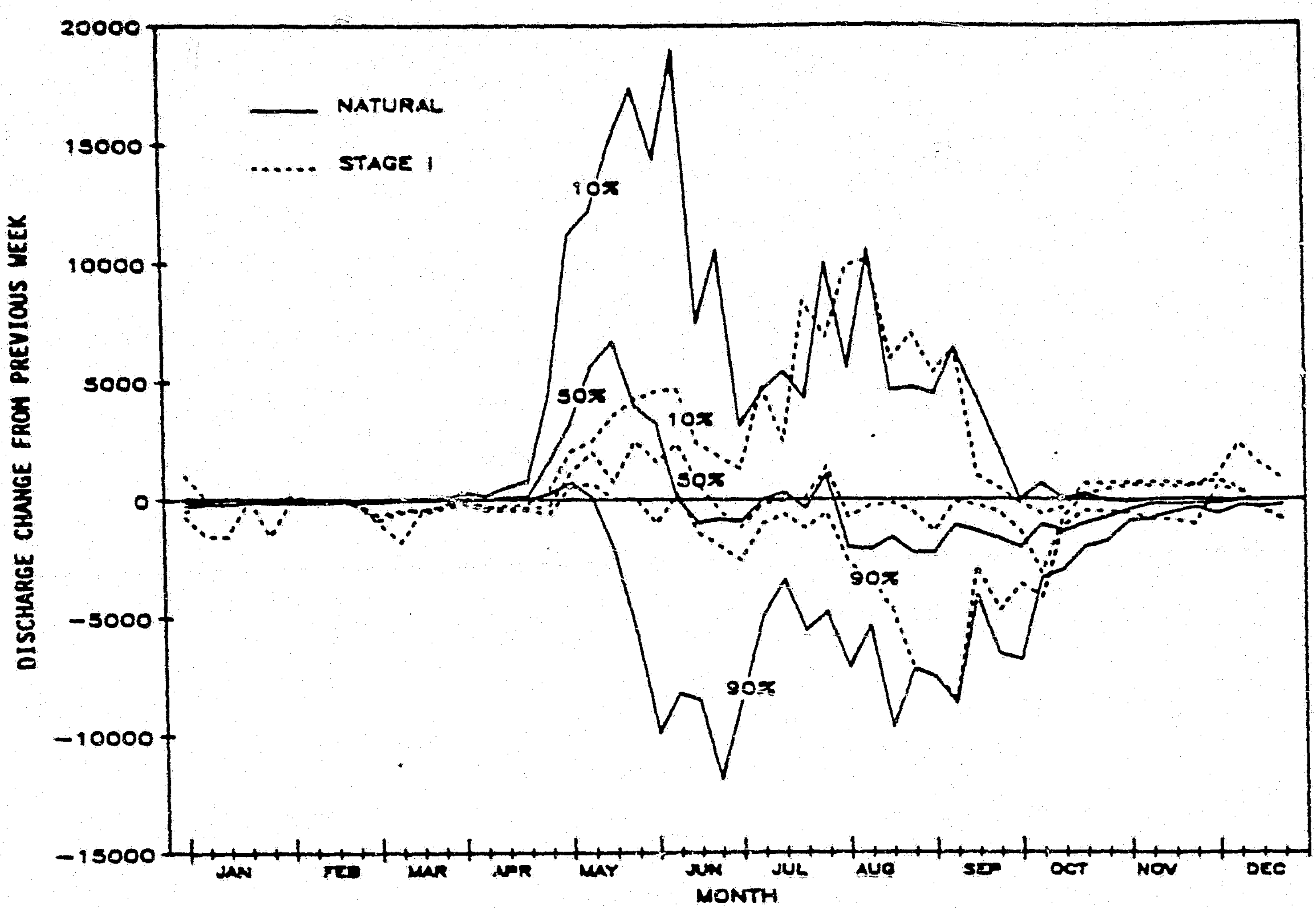
During the Devil Canyon construction phase, most differences in the flow variability from the natural conditions will be the result of the presence and operation of the Watana facility. Therefore, the conditions for Stage I operation will be applicable.

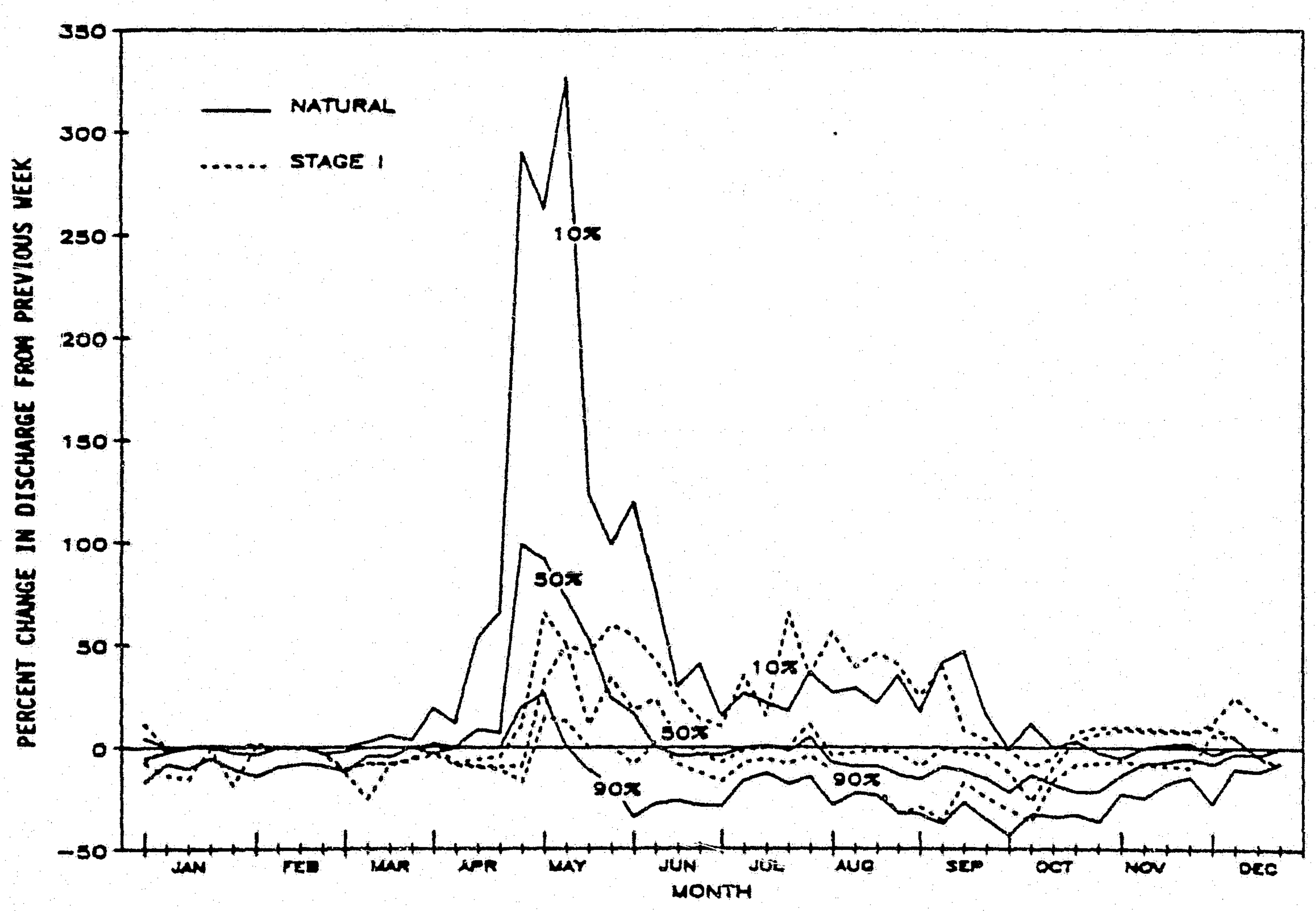
- Filling

Changes in flow during the short duration of Stage II filling will be similar to or slightly more stable than Stage I changes.

- Operation

Stage II operation outflows will have little variability because of the high degree of reservoir regulation and the relatively constant powerhouse flow. Gold Creek flows exhibit more variation because of the variability in local inflow. Flow duration curves show a diminished natural and with-project difference with distance downstream from Devil Canyon.





DISCHARGE AND PERCENT CHANGE OF NATURAL AND STAGE I MEAN WEEKLY FLOWS

FIGURE 13

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A series of charts of flow duration and variability at several middle Susitna River locations illustrate the improvement in flow stability for project conditions as compared to natural conditions (APA 1985c). Graphs of percent change in flow from one week to the next also illustrate the relative stability of project flows (Figure 14). Stage II flows are expected to be less stable in July and August as the reservoir becomes full and less storage capacity for floods is available.

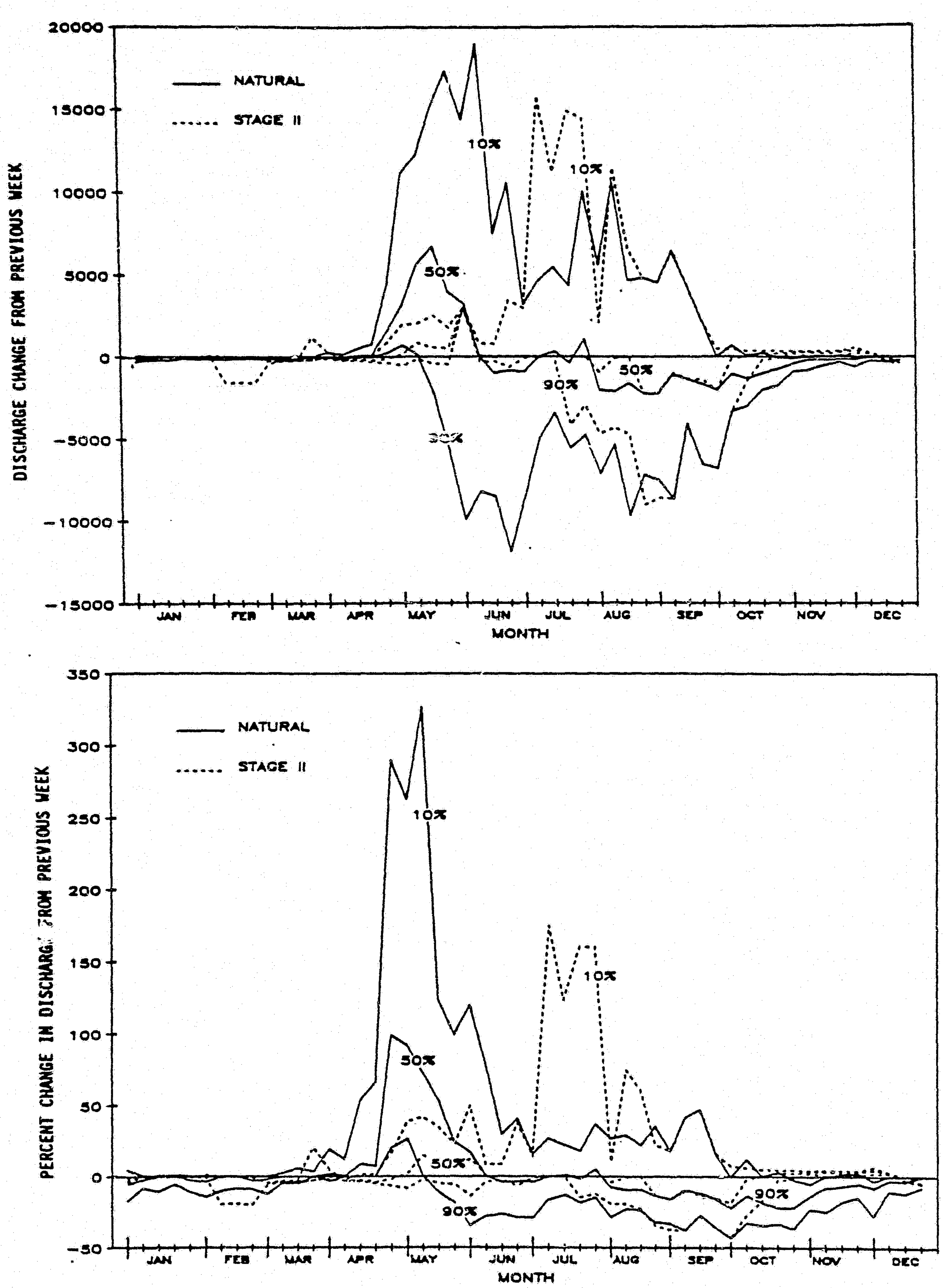
(iii) Stage III

- Construction and Filling

The discussion of flows and water levels for Stage II operation is applicable to the Stage III construction period before filling starts. Filling will occur simultaneously with raising the crest. Flow variations will be bracketed by Case E-VI requirements (minimum) and flood control filling criteria (maximum). Flow variations immediately below Devil Canyon will be minimized by controlled reservoir releases. Tributary inflow will contribute more to flow variability as downstream distance increases.

- Operation

While project flows will show little variability at the Devil Canyon dam, Gold Creek flows exhibit more variability because of local inflow between the dam and the Gold Creek gage site. Flow variability at Gold Creek for natural and Stage III operation is shown in the form of 10, 50, and 90 percent exceedance values for the percent change in weekly average discharge in Figures 15 and 16.



DISCHARGE AND PERCENT CHANGE OF NATURAL AND STAGE II MEAN WEEKLY FLOWS

FIGURE 14

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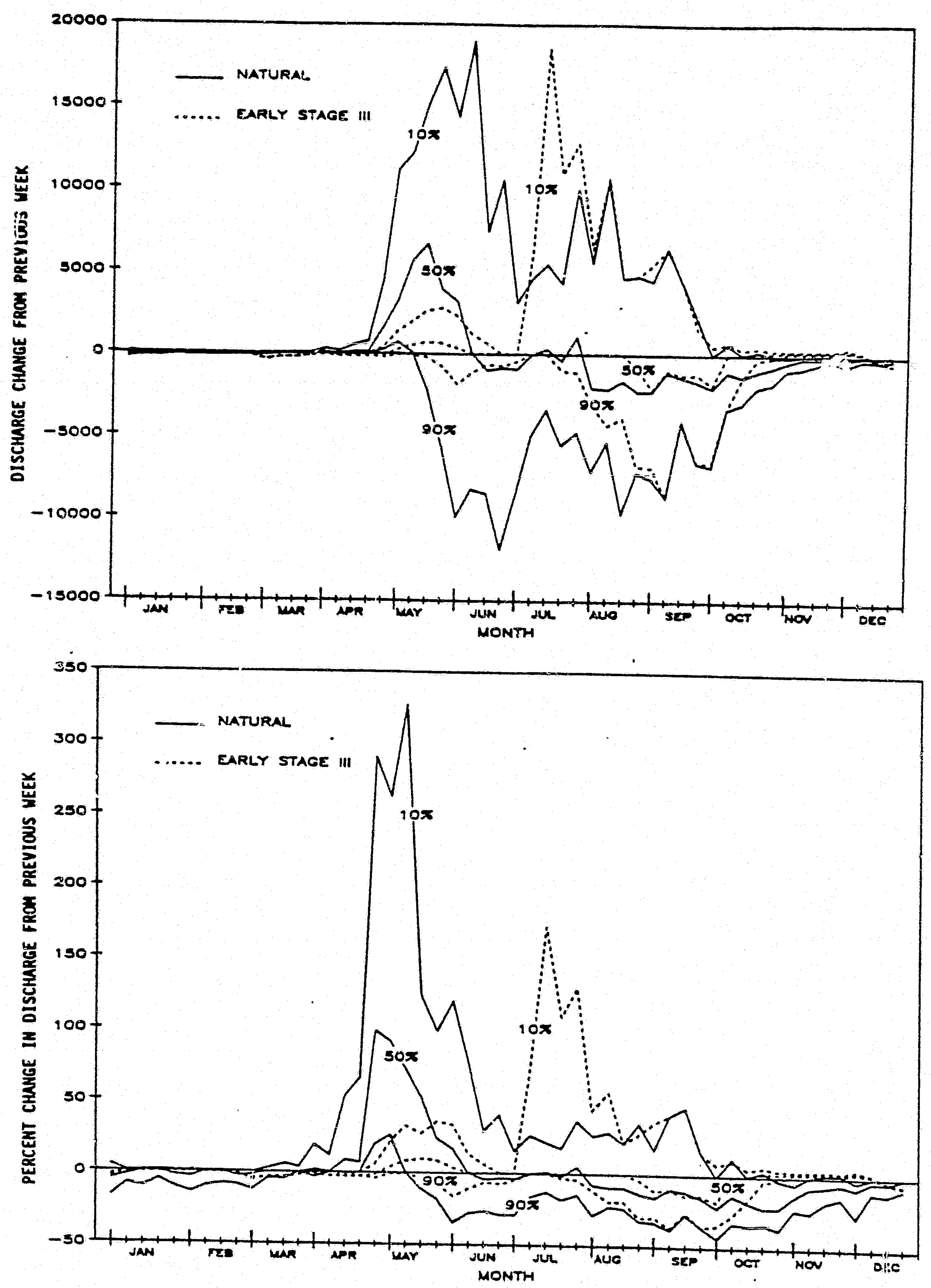

DISCHARGE AND PERCENT CHANGE OF NATURAL AND EARLY STAGE III MEAN WEEKLY FLOWS

FIGURE 15

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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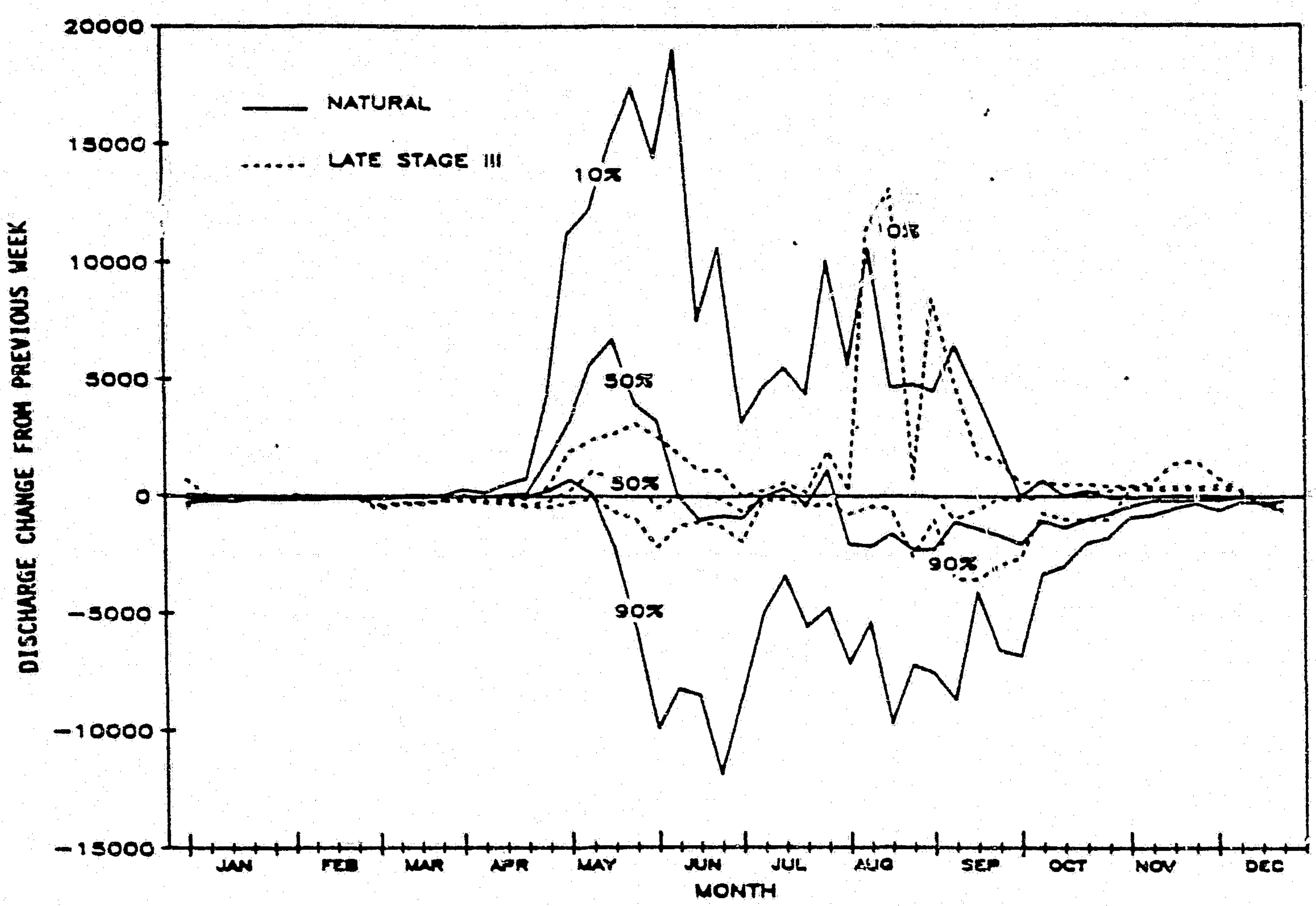
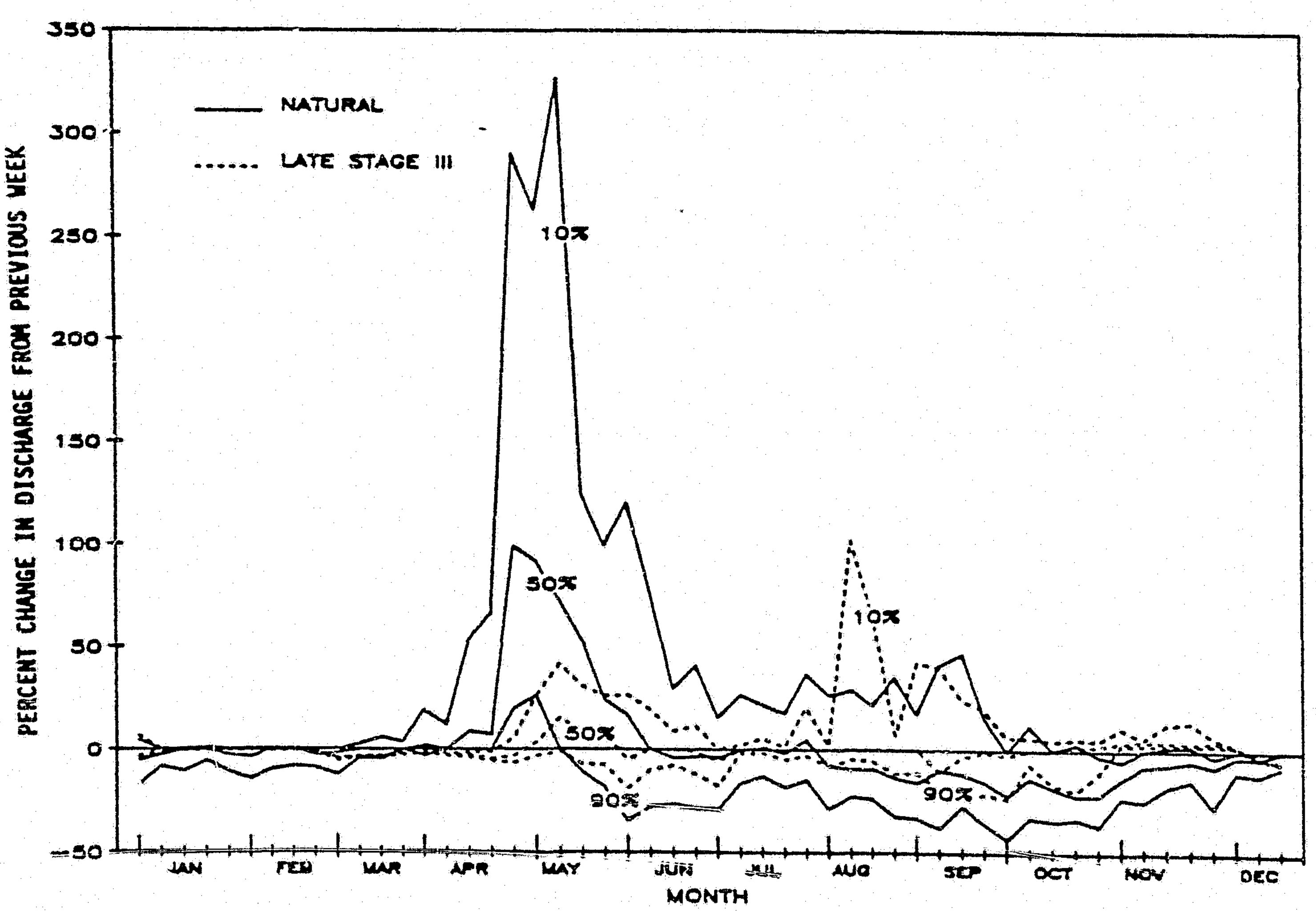
SUSITNA JOINT VENTURE





DISCHARGE AND PERCENT CHANGE OF NATURAL AND LATE STAGE III MEAN WEEKLY FLOWS

FIGURE 16

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

4.2 River Morphology

Changes in river morphology characteristics are expected to occur as a result of project operation. Summer flows and water levels during project operation are less than natural. Tributaries will downcut their beds to new equilibrium positions corresponding to the lower Susitna level, and vegetation will encroach on sloughs, on side channels, and on the narrower mainstem upstream of the ice front and to a lesser extent downstream of the ice front. Overtopping of slough berms will occur less frequently and for shorter duration during spring and summer. Sediment trapping in the reservoirs will decrease the downstream sediment suspended and bed loads, allowing the mainstem to erode the existing bed. Consequently, the river will narrow and deepen slightly, and the percentage of coarse material in the bed will increase as fines are picked up and carried downstream. Details of these changes are presented below and in Chapter 2 of the FERC License Application Amendment (APA 1985c).

4.2.1 Watana to Devil Canyon

(a) Stage I

(i) Construction

Since changes in flow will be negligible during Watana Stage I construction, impacts on morphology of the Susitna River will be confined to the dam and borrow sites. Borrow Site E will become a deep pond adjacent to the river.

(ii) Filling

The morphology of the river downstream will begin to change during filling of the Stage I reservoir due to changes in the sediment transport characteristics. Since filling the reservoir will require only one summer, changes in channel morphology will not become significant.

During filling, most flows in excess of the Case E-VI downstream requirements will be stored in the reservoir. At the end of the summer of filling, approximately 75 to 85 percent of the incoming sediment (particles larger than 5 to 10 microns) will be trapped. The reduced discharge volume, combined with the sediment trapping within the reservoir, will result in smaller downstream sediment loads than under natural conditions. Some degradation may occur, but it will not be significant because of the small discharge and the short period required to fill the reservoir. Reduced downstream water levels in the Susitna River during filling may also allow aggradation at the outlets of some downstream tributaries. Delta aggradation will also be minimal, however, because of the short filling period.

(iii) Operation

During operation of Watana Stage I, virtually all the bedload entering the reservoir would be trapped. Suspended sediments of about 0.004 mm and less will remain in suspension and pass through the reservoir (HE 1985, PND 1982). This sediment would be small enough in volume and particle size that it would not be deposited downstream. The river downstream of the dam will probably erode some bed material and therefore cause lowering of the streambed elevation (degradation) and possible coarsening of riverbed material (Section 4.2.2).

Reservoir operation will moderate downstream discharges. Peak flood flows will be reduced along with the volume and size of bed material transported during those flows, including that contributed to the mainstem by tributaries.

(b) Stage II and Stage III

During construction of the Stage II dam, river morphology in the Watana to Devil Canyon reach will remain unchanged from Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

4.2.2 Devil Canyon to Talkeetna (Middle River)

(a) Stage I

(i) Construction and Filling

Changes in river morphology are not expected during Stage I construction and filling. Some bed degradation will occur during filling since dam releases will contain little sediment, allowing the flow to erode more of the existing bed. Tributary delta aggradation will begin as mainstem flows decrease. Both bed degradation and delta aggradation will be minimal, however, because of the short filling time.

(ii) Operation

It is anticipated that the Susitna River between Devil Canyon and the confluence of the Susitna and Chulitna rivers would tend to become more defined with a narrower channel with the reduced Stage I operation summer flows. The main channel river pattern will strive for a tighter, better defined meander pattern within the existing banks. A trend of channel width reduction by encroachment of vegetation and sediment deposition near the banks is expected, especially upstream of the ice front. The tendency of the main channel to degrade and to be confined may cause the channel to recede from the heads of some sloughs and side channels.

The estimated bed degradation in the middle Susitna River may be as great as 0.8 to 1.3 ft during Stage I. Degradation tends to be greatest immediately downstream of the dam and to decrease further downstream although the amount of degradation at each site depends upon site-specific characteristics such as channel slope and bed material (Harza-Ebasco 1985a). Actual degradation in the mainstem is expected to be less than the estimated values as additional sediment will be contributed to the system from tributaries and bank erosion (Harza-Ebasco 1985a). In addition, sediments eroded upstream are likely to be redeposited downstream (R&M Consultants and WCC 1985). The rate of degradation may not allow equilibrium to become established during the scheduled period of Stage I operation.

Because of reduction in flow velocities in the main river, tributary streams, including Portage Creek, Indian River, Gold Creek, and Fourth of July Creek, may extend their alluvial fans into the river. Tributaries will either downcut their beds or remain perched above the Susitna (APA 1985c). If the tributary remains perched due to the presence of an erosion-resistant layer preventing downcutting, fish access to the tributary from the mainstem may be reduced. However, most of the tributaries will adjust to a new flow regime without detrimental effects to fish access, bridges, or the railroad bed. Depending on the hydraulic and sediment transport characteristics at the mouth of the tributaries, the adjustment may occur over a period of one wet season or a number of years (Trihey 1983, Harza-Ebasco 1985a, R&M Consultants 1982). Potential changes to specific tributaries are listed in Table 8. The relative amounts of change to physical characteristics in the Susitna drainage are shown in Table 9.

Overflow into most of the side channels and sloughs will be less frequent and of shorter duration during spring and summer as high flows will be attenuated by the reservoir. The effects of backwater from the mainstem to the sloughs also will be less during spring and summer because water levels in the mainstem will be lower. Thus, there will likely be some encroachment of vegetation to the upstream reach and periphery of some sloughs.

Table 8. Downstream tributaries potentially impacted by project operation[1/]

Name	River Mile	Bank of Susitna[2/]	Reason for Concern	Type of Assessment[3/]	Potential Impact[4/]
Portage Creek	148.9	RB	fish access	2	1
Jack Long Creek	144.8	LB	fish access	1	3
Indian River	138.5	RB	fish access	2	2
Gold Creek	136.7	LB	fish access	2	1
unnamed	132.0	LB	Railroad (RR)	1	6
4th of July Creek	131.0	RB	fish access	2	1
Sherman Creek	130.9	LB	RR/fish access	2	2
unnamed	128.5	LB	Railroad	1	6
unnamed	127.3	LB	Railroad	1	5
Skull Creek	124.7	LB	Railroad	2	7
unnamed	123.9	RB	fish access	1	3
Deadhorse Creek	121.0	LB	fish access	2	1
Little Portage Creek	117.8	LB	Railroad	2	6
Gash Creek	111.7	LB	RR/fish access	1	6,4
unnamed	110.1	LB	Railroad	1	5
Whiskers Creek	101.2	RB	fish access	1	4

1/ Source: APA 1985c

2/ Referenced by facing downstream (LB = left bank, RB = right bank)

3/ Type of Assessment: 1) Visual - bed material size not available
2) Comparison of transportable size vs. bed material size.

4/ Potential Impact

1. Potential fish access problems less likely than for category 2 since tributary bed material smaller than size transportable by mainstem.
2. Potential fish access problems more likely than for category 1 until tributary adjusts. Tributary bed material larger than size transportable by mainstem.
3. No data on tributary bed material. Visual assessment indicates potential for fish access problem for a period until tributary adjusts.
4. No data on tributary bed material. Visual assessment indicates no potential for fish access problem.
5. Visual assessment indicates potential for limited scour at RR bridge, potentially limited by geologic features. Depth of RR foundation may exceed scour depth.
6. Visual assessment indicates no potential for scour endangering RR bridge.
7. Comparison of tributary bed material size to transportable size by mainstem indicates potential for limited scour at bridge.

Table 9. Influence of mainstem flow and water quality on characteristics of aquatic habitat types.[1/]

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

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

1/ Source: APA 1985c

2/ Depth, velocity, wetted area, etc.

Sediment will deposit at the confluence of the Susitna, Chulitna, and Talkeetna rivers because of the large sediment discharge from the Chulitna River and the reduction in the peak flows of the Susitna River.

(b) Stage II

(i) Construction and Filling

Since operation of Watana Stage I will not be significantly affected by the construction or filling of the Devil Canyon Dam, the morphological processes discussed previously will continue to occur except at the Devil Canyon damsite. No impacts to the morphology of the Susitna River are anticipated from borrowing of construction materials because no borrow site is located within the river.

(ii) Operation

The mean of the annual maximum weekly discharges expected at Gold Creek during Stage II operation will be about 28,000 cfs. Resulting riverbed degradation may be as much as 1.0 to 1.5 ft (Harza-Ebasco 1985a). As described for Stage I operation, actual degradation may not be as great as estimated and may occur over a longer period of time. The extent of degradation will decrease to near zero at the confluence of the Susitna and Chulitna rivers due to aggradation at that location. Vegetation encroachment and tributary delta building in the reach will continue toward new equilibrium positions.

(c) Stage III

(i) Construction

Impacts on Susitna River morphology will be the same as those for Stage II operation.

(ii) Filling

The filling of Watana Reservoir for Stage III operation may take about five years under average flow conditions.

The impoundment will reduce the frequency of discharging large floods downstream; the additional impact on downstream morphology would be negligible. The potential for additional bed degradation from that described for Stage II will be insignificant.

(iii) Operation

Release of large flows in excess of meeting the energy and downstream requirement will be less frequent in Stage III than in Stage II. Reservoir operation studies indicate that the mean of the annual maximum weekly flows will be smaller than the mean of the annual maximum flows during Stage II operation. Therefore, the probability of further degradation (lowering of the bed level) beyond that under Stage II operating conditions will be reduced.

Sediment deposition near the confluence of the Susitna, Chulitna, and Talkeetna rivers will continue but the river will gradually stabilize with a better defined, narrower channel.

4.3 Water Quality

4.3.1 Water Temperature

River temperatures will be similar to but lag about 2 weeks behind natural conditions during Stage I operation. Winter temperatures between the upstream ice edge and the dam will be 0-2°C, whereas the natural temperature in this reach is 0°C. Water temperatures greater than 0°C will persist downstream longer into winter and arrive earlier in the spring than under natural flow conditions due to warmer project outflows.

Varying the depth of water withdrawal from the reservoir would have no significant impact on downstream river temperatures.

During Stage II, temperatures relative to Stage I are cooler from June through early August, warmer from mid-August to mid-April, and similar from mid-April through late May. Stage II summer temperatures lag natural conditions by one month. The use of a high-level intake to the Devil Canyon outlet works will increase the average river temperature at river mile 130 by 1 to $2^{o}C$ from natural conditions.

Summer temperatures simulated for Stage III are generally cooler than those during Stage II. Winter temperatures are somewhat warmer. Temperatures would lag behind natural conditions by approximately one month.

The procedures for developing downstream temperature regimes for project conditions is described in detail in other reports by the Applicant (APA 1985a, Harza-Ebasco 1985b, AEIDC 1983, 1984a, 1984b, 1984c, 1985). Briefly, the Watana reservoir outflow temperatures, which were simulated using DYRESM were input to the program SNTEMP to evaluate downstream water temperatures.

Temperature simulations using SNTEMP were carried out for open water reaches of the river between the dams and the Sunshine stream gaging station (RM 84). In summer, the entire reach was simulated. In winter, only the reach from the dams to the location of $0^{o}C$ was simulated. Temperatures for the three stage project were only simulated for the period May 1985 through September 1982. This represents a wet summer followed by an average temperature winter followed by an average flow summer.

Simulations for the three stage project were limited to the cases discussed above, in order to show the similarity between simulated temperatures for the original two stage and the proposed three stage project. Because the simulated temperatures for the three-stage project are similar to those for the two-stage project the simulations which have been made for the two stage project (APA 1984, Harza-Ebasco 1985c) may be used to determine the sensitivity of the river temperatures to various other hydrologic and meteorologic conditions. Simulations are also presented in other reports (AEIDC 1983, 1984a, 1984b, 1984c, 1985).

The simulation results presented below were developed using the policy of withdrawing water from the reservoir which has as close a temperature to natural as possible. This policy is known as "inflow temperature matching." Additional simulations have been carried out to evaluate whether other policies of multi-level intake operation would significantly affect temperatures. The policies considered were:

- warmest water - draw warmest water from the reservoir all year using the proposed multi-level intake

- lowest level - use lowest level of proposed intake in summer and winter regardless of outflow temperature to preserve reservoir heat in summer for use in winter

- warmest water with other possible intakes at el. 1636 ft and el. 1800 ft - draw warmest water from the reservoir all year but with the addition of intakes at el. 1636 ft and el. 1800 ft.

The effect of the various operating policies on summer river temperatures at RM 130 is minimal. The inclusion of intakes at el. 1636 and el. 1800 ft on the Watana outlet works does not appear to affect summer temperatures. The use of a high-level intake to the Devil Canyon outlet works has a noticable effect on river temperatures, generally increasing average temperatures during outlet works operation by 1°C to 2°C.

Slough and side channel surface water temperatures are generally dependent on the temperature of groundwater upwelling, climate conditions and the temperature of mainstem flow when the upstream berm is overtopped. Since the frequency of overtopping of the upstream berm will be reduced due to lower summer flows the slough and side channel surface water temperature will be more often solely a function of groundwater temperatures and climate, and thus independent of project stage. It has been determined that the temperature of the groundwater component of slough flow is generally equal to the mean annual temperature of the river. Since this will not change significantly during project operation, the only change in surface water temperatures in sloughs and side channels will be a function of the frequency of overtopping of the upstream berm.

When habitat areas in sloughs and side channels are not overtopped in summer their surface water temperatures are generally less than the mainstem reflecting the groundwater temperature and the climatic conditions. Therefore, a reduction in overtopping of habitat berms will generally cause slough surface water temperature in summer to be somewhat lower, on the average, than natural conditions, but higher than the groundwater temperature. The variation in surface water temperature resulting from intermittent overtopping of the berms will be reduced. Side channels will be affected less than sloughs because summer discharges during project operation will keep most side channel areas overtopped.

Surface water temperatures in tributary habitat areas are generally a function of tributary temperature and will not be affected by the project. The extent of the effect of the tributary temperature on the mainstem may change as a result of decreased summer mainstem flows.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

Since operation of the diversion structure will essentially be run-of-river, no impact on the temperature regime will occur downstream from the tunnel exit.

- <u>Filling</u>

The reservoir outlet temperatures during the first summer of filling should be similar to natural temperatures with short lags of about two weeks, being slightly cooler in May and June and slightly warmer in September (APA 1985c, APA 1984). During the filling period, water temperatures at Watana Dam will be as much as $7^{o}C$ cooler than normal during June, whereas in July and August outflow temperatures will be similar to the reservoir inflow temperatures. Downstream river temperatures during the summer of filling Watana Stage I are expected to be similar in magnitude to natural conditions with a similar lag time. Because river flows will be less than natural, heat exchange with the atmosphere and the river water will proceed more rapidly than under natural conditions and temperatures downstream are expected to be closer to natural than at the dam.

During the first winter after filling, the project will become operational when units one and two begin generating in October and January, respectively. The temperature of the water discharged from the dam will range from $2-4^{o}C$ depending upon which intake port is used to withdraw water from the reservoir and the air temperatures. Outflows are expected to be taken from near the surface of the reservoir, and since the reservoir will be stratified at this time, releases will have temperatures similar to operational conditions in later years. Since winter reservoir outflows would average 2,500 cfs to 3,500 cfs, the river water will cool down toward $0^{o}C$ more rapidly than when more units are operating. During this period, instream water temperature is expected to decrease rapidly from $2-4^{o}C$ at the Watana Dam to $0^{o}C$ in Devil Canyon because of the small volume of water to be discharged.

- Operation

The Stage I intake ports are located at five levels, and the discharge temperatures can be controlled to approximate the natural instream temperatures. The discharge temperatures would range from approximately 5°C to 12°C in the summer and approximately 0.5°C to 3°C in the winter depending on the meteorological condition, and energy demand level. In the summer, the inflows are more responsive to variations in the meteorological conditions than the reservoir due to the shallowness of the river. The river inflow warms up in the early summer and cools down in the late summer more rapidly than does the reservoir. Hence, the reservoir discharge water would be colder in the early summer and warmer in the early fall than the natural river conditions. However, in most of the summer months the discharge temperatures could be regulated to approximate inflow temperatures. During the winter months, discharge from the Watana Reservoir will be considerably greater under Stage I of the project than under natural conditions. At the dam, temperature of the water will be between 1°C and 3°C depending upon the water surface elevation in the reservoir relative to the port in the intake structure being utilized at the time. As the water surface is drawn down through the winter, discharge temperature will gradually decrease. However, when the water surface elevation is low enough to require use of the next lower intake port, the temperature of the discharge water will increase by approximately 1°C followed by another gradual decline.

Once the water is released from the reservoir, water temperature will decline to 0°C at a rate dependent upon the air temperatures. The water temperature is not expected to reach 0°C within the Watana to Devil Canyon reach.

(ii) Stages II and III

During construction of the Stage II dam, water temperatures in the Watana to Devil Canyon reach will remain unchanged from those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

- Construction

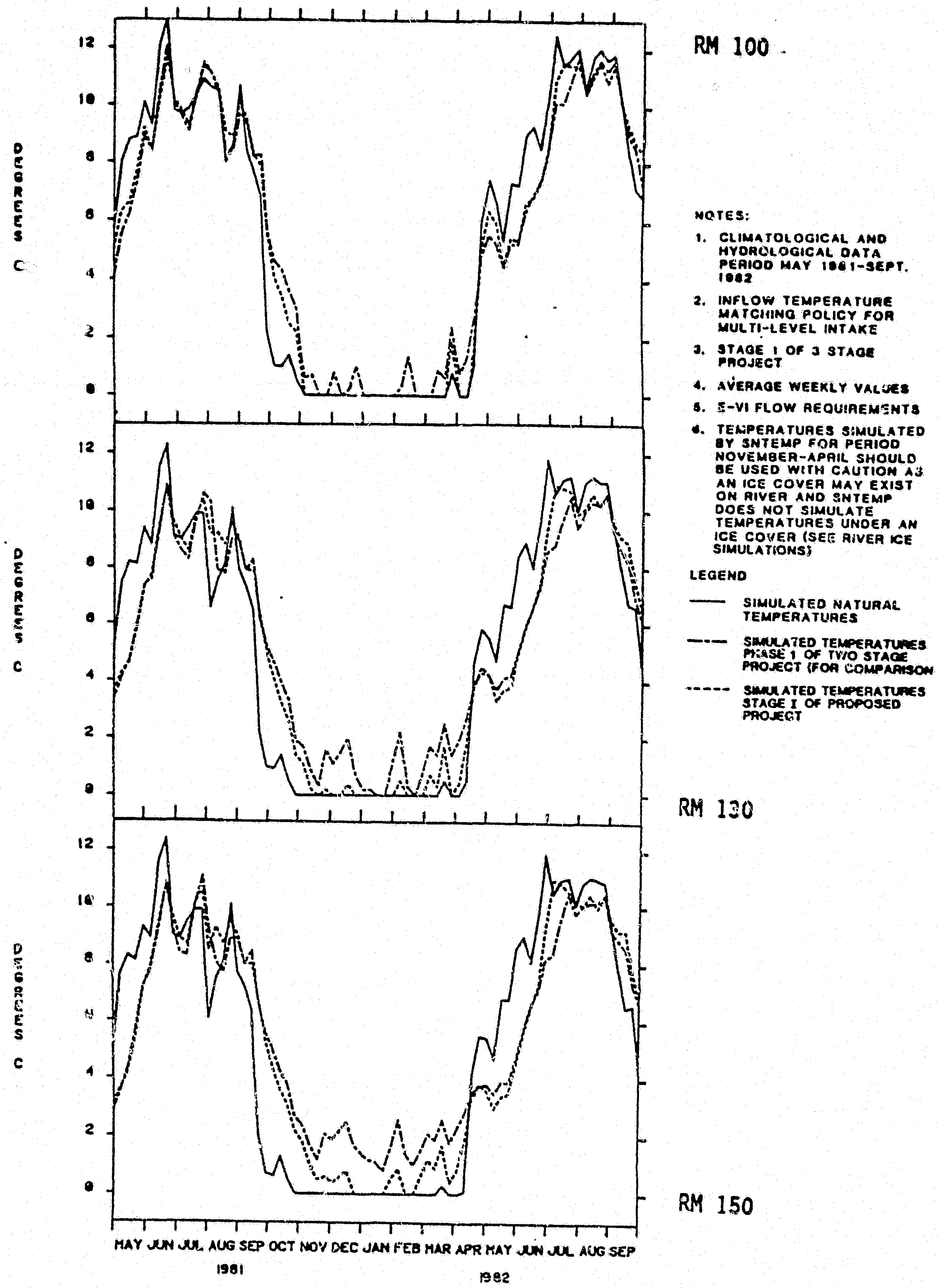
No changes in river temperature from natural conditions are expected from Devil Canyon to Watana during Stage I construction.

- Filling

Downstream river temperatures during summer of filling Stage I are expected to be similar in magnitude to natural conditions with a short lag of about two weeks. During the first winter after filling, the operation of two units with low flows will cause downstream river temperatures to be similar to but cooler than normal Stage I operating temperatures.

- Operation

Average weekly temperatures (natural and Stage I simulated) at RM 150, RM 130 and RM 100 are shown in Figure 17. Summer Stage I river temperatures exhibit a lag behind natural conditions of approximately 2 weeks. River temperature simulations were made at river mile 130 (between Devil



SOURCE: APA 1985c

NATURAL AND STAGE I TEMPERATURES

FIGURE 17

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SUSITNA JOINT VENTURE

Canyon and Talkeetna); the results are generally applicable to the Watana to Devil Canyon reach during Stage I operation. Simulated temperatures at river mile 130 are generally near 4°C in early May, peak at near 10°C in late June through early August and decrease to 0°C by mid-November. At RM 130, the water temperatures will be 2 to 3°C cooler in May and June, 0.3 to 0.9°C cooler in summer, and up to 3°C warmer in September through October compared to natural conditions. The mean annual temperature (time weighted) at river mile 130 has been calculated for the period May 1981 to April 1982 to be 3.7°C for natural conditions and 4°C for with-project conditions.

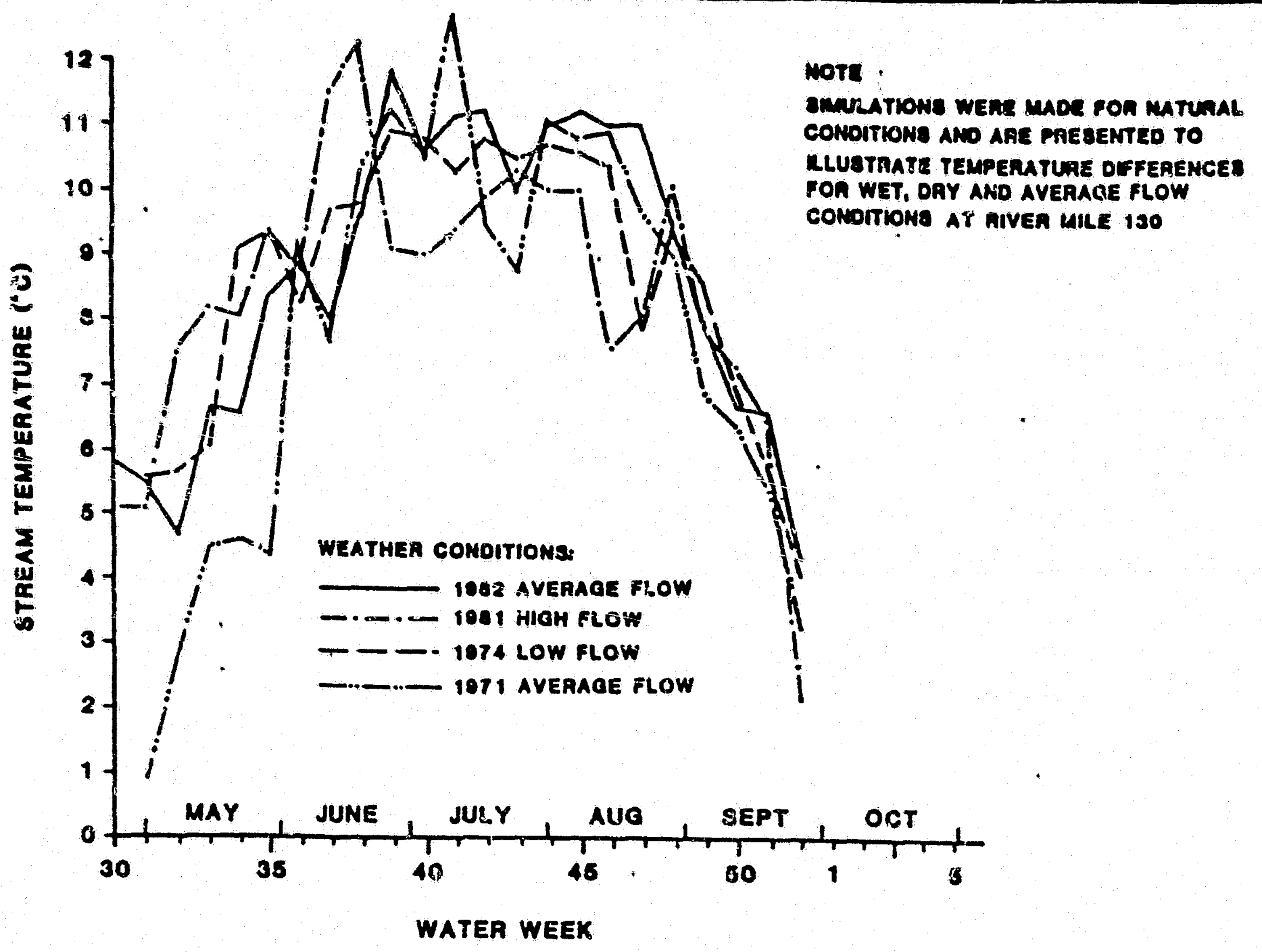
In wet years the reservoir fills by early July and thus the outlet works must be operated to pass flow. Because the outlet works draw from a lower elevation in the reservoir, its flows are generally cooler. This can cause a drop in river temperatures in early July (APA 1985c). The effect of annual flow variability on temperatures at River Mile 130 is shown for natural conditions and for simulated Stage I operation in Figure 18.

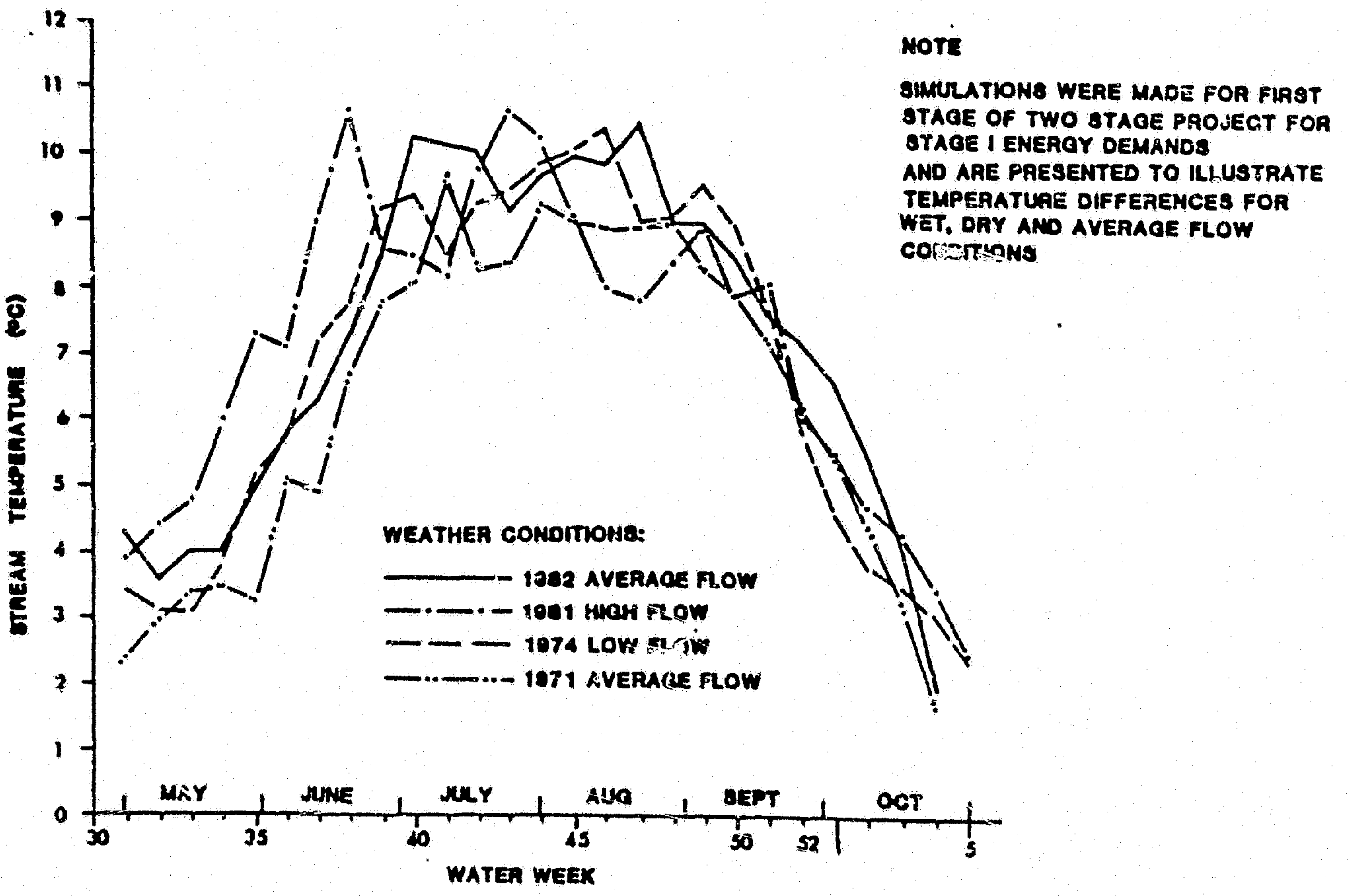
The temperature of the mainstem will remain above 0°C longer into the winter because of the warmer reservoir outflows. The temperature in the spring will warm up above 0°C sooner for the same reason. Between the upstream end of the ice cover and the dams the river temperature will generally be between 0°C and 2°C to 3°C, whereas the natural temperature in this reach is 0°C.

(ii) Stage II

- Construction and Filling

There will be little or no difference in water temperatures in the Devil Canyon to Talkeetna reach during Stage II





SOURCE: APA 1985c

NATURAL AND STAGE I TEMPERATURES AT RM 130

FIGURE 18

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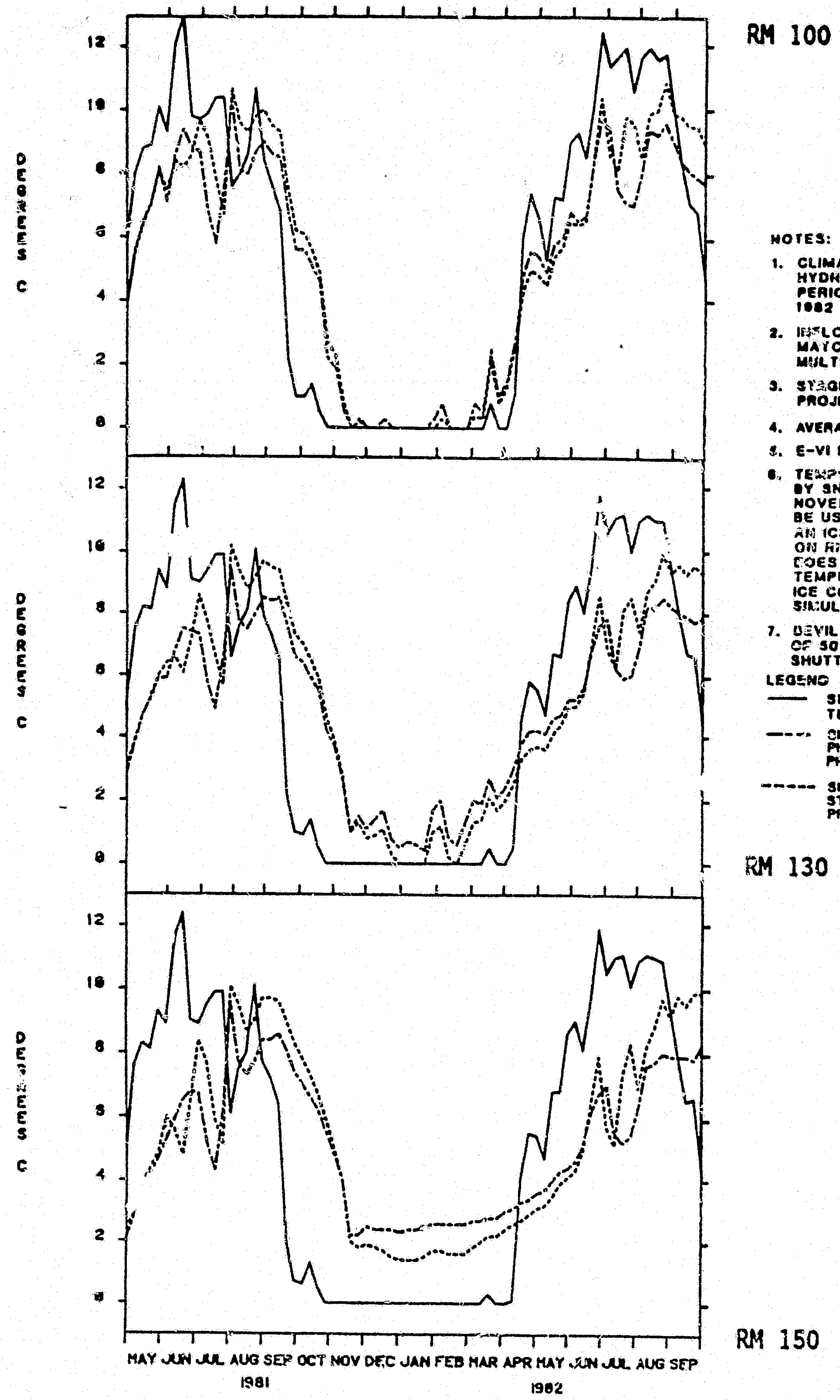
construction and filling as compared to those of Stage I operation.

- <u>Operation</u>

Differences between water temperatures under natural conditions and under Stage II project operation conditions are more pronounced than under Stage I operation at all locations within the middle Susitna River. Summer Stage II river temperatures exhibit a lag behind natural conditions of approximately one month. Simulated temperatures at RM 130 are generally near 4°C in early May, range from 6 to 8°C during the summer, peak at near 10°C in late August through late September, and decrease to 0°C by late December (Figure 19). Closer to the dam (RM 150) temperature effects of the reservoir releases are more pronounced, while downstream (RM 100) temperatures are close to natural (Figure 19).

In winter, the temperature of the mainstem will remain above 0°C longer than natural because of the warmer outflows from the project. The temperature in the spring will warm up above 0°C sooner for the same reason. Between the upstream end of the ice cover and the dams the river temperature will generally be between 0°C and 2°C to 3°C, whereas the natural temperature in this reach is 0°C. This change in winter temperatures is reflected in ice simulations discussed later.

From May through August, Stage II operation will result in water temperatures 2 to 4°C cooler than natural at RM 130. Fall water temperatures would be 2 to 6°C warmer. Through the winter, water temperatures are expected to be less than 1°C most of the time with occasional periods of 0°C temperatures. During Stage II operation, an ice cover may occasionally form at RM 130 (Section 4.4.2).



NOTES:

1. CLIMATOLOGICAL AND HYDROLOGICAL DATA PERIOD MAY 1981-SEPT. 1982
2. INFLOW TEMPERATURE MATCHING POLICY FOR MULTI-LEVEL INTAKE
3. STAGE 2 OF 3 STAGE PROJECT
4. AVERAGE WEEKLY VALUES
5. E-VI FLOW REQUIREMENTS
6. TEMPERATURES SIMULATED BY SNTEMP FOR PERIOD NOVEMBER-MARCH SHOULD BE USED WITH CAUTION AS AN ICE COVER MAY EXIST ON RIVER AND SNTEMP DOES NOT SIMULATE TEMPERATURES UNDER AN ICE COVER(SEE RIVER ICE SIMULATIONS)
7. DEVIL CANYON DRAWDOWN OF 50 FEET-7 LEVELS OF SHUTTERS

LEGEND

——— SIMULATED NATURAL TEMPERATURES

—-—- SIMULATED TEMPERATURES PHASE 2 OF TWO STAGE PROJECT (FOR COMPARISON)

------ SIMULATED TEMPERATURES STAGE 2 OF PROPOSED PROJECT

SOURCE: APA 1985c

NATURAL AND STAGE II TEMPERATURES

FIGURE 19

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In wet years the reservoir fills by early July and thus the outlet works must be operated to pass flow. Because the outlet works draw from a lower elevation in the reservoir, its flows are generally cooler. This will cause a drop in river temperatures in July in wet years.

Based on the simulations of natural conditions and project operation, the mean annual temperature (time weighted) at RM 130 for the period May 1981 to April 1982 was calculated to be 3.7^{o}C for natural conditions and 4.2^{o}C for Stage II project conditions. Simulations of other hydrological and meteorological conditions for other flow requirements also indicated that the mean annual temperature with-project would be similar to natural conditions.

The simulated Stage II operation results in a drawdown of Devil Canyon Reservoir in mid-June. This drawdown may be up to 50 feet in some years. When the water level decreases below the upper of the two levels, the lower level intake is opened. This intake, being relatively deeper in the reservoir, draws colder water for a short period until the water level decreases further. Thus, there is a simulated decrease in river temperatures in mid-June to early July depending on the year simulated. The effect of this drop is most noticeable near the dam, and because of climatic conditions, is not noticeable at RM 100. Two simulations were carried out with modifications to the operating policy of Devil Canyon and to the multi-level intake to attempt to improve temperatures. Because the effects of these two modifications on temperatures were minor, the Applicant maintained the Devil Canyon drawdown of 50 ft and the two level intake. The modifications which the Applicant considered are discussed below.

The first of these modifications was to hold the water level at Devil Canyon above the upper level intake which limits the drawdown at Devil Canyon to nine feet. This reduces project energy production somewhat since minimum flow requirements must be met from Watana storage rather than Devil Canyon. This modification policy generally eliminates the drop in temperatures resulting from lowered water levels. However, it also results in a noticeable increase in temperatures in mid-June and larger temperature decreases when the outlet works operate than for the 50-ft drawdown policy.

The second modification tested was to include a third level of ports between the two existing levels of ports at the Devil Canyon multi-level intake. This policy also eliminated the drop in temperatures resulting from lowered Devil Canyon water levels, and provides a smaller decrease when the outlet works operate and generally more uniform temperatures in June and July than the other two policies.

(iii) <u>Stage III</u>

- <u>Construction</u>

No change from Stage II operation is anticipated.

- <u>Filling</u>

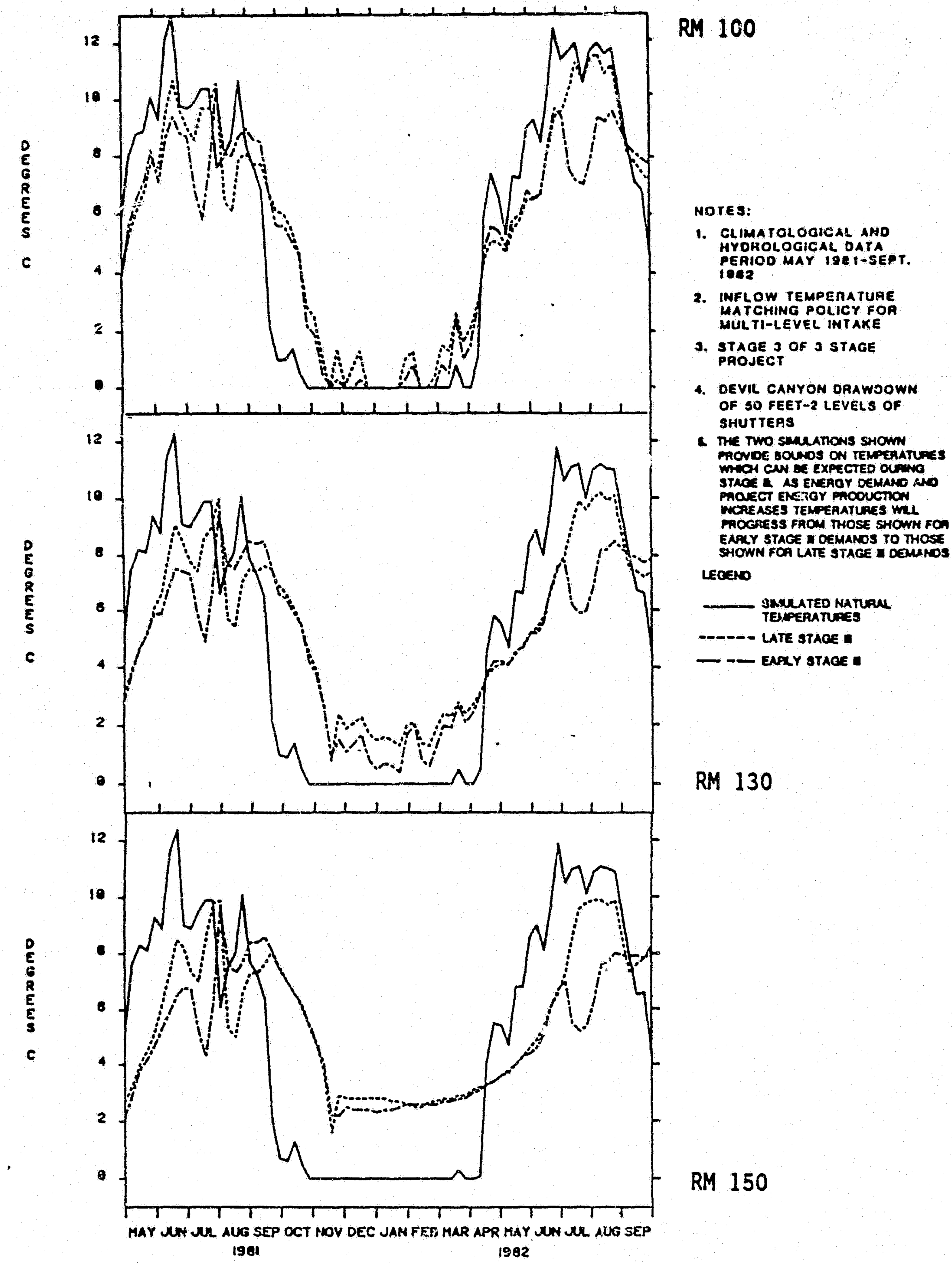
During the filling of Stage III Watana Reservoir, the capacity to select the water temperature to be discharged will be increased as more ports in the intake become available for use. The increased flexibility to select water temperature and the increased volume of water available at higher elevations will enable the release of water with temperatures more closely matched to the inflow temperature early and late in the summer months.

Outlet works releases during the July-September period of filling will be reduced. The intake to the outlet works is located in the hypolimnion and releases through the outlet works are generally colder than those through the powerhouse. Therefore, the reduction in these releases will result in temperatures in the river downstream of the dam being warmer than normal operation. Additionally, the reduced river flow in this period will result in greater river surface area per unit discharge and more heat transfer between the river and the atmosphere causing an increased rate of warming toward natural temperatures. Therefore, during the filling period, river temperatures are expected to be closer to natural than for normal operation of the project as described for Stages II and III.

- Operation

Stage III temperatures were simulated for early and late project energy demands. Summer temperatures simulated for early Stage III are generally cooler than for Stage II of the three-stage project. Thus, when Stage III begins operating, summer temperatures may be the same or decline slightly from those of Stage II. Summer temperatures will probably be below those experienced during stage III filling, since outlet works releases during Stage III filling will be minimal. As energy demands increase, the outlet works releases will decrease and summer temperatures will increase toward maximum energy demand levels.

Stage III temperatures for late project energy demands are generally warmer than early Stage III temperatures in May through July or early August and cooler than early Stage III temperatures from August through October (Figure 20). Summer Stage III (late) simulated temperatures are closer to natural than Stage II or early Stage III.



SOURCE: APA 1985c

NATURAL AND STAGE III TEMPERATURES

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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SUSITNA JOINT VENTURE

FIGURE 20

For late project energy demands, summer with-project river temperatures would exhibit a lag behind natural conditions of approximately one month. Simulated temperatures at RM 130 are close to 4°C in early May, peak near 10°C between July and August, and decrease to 1°C by late November. In wet years the reservoir fills by early August; thus, the outlet works must be operated to pass flow. Because the outlet works draw from a lower elevation in the reservoir, these flows are generally cooler. Outlet works releases due to a full reservoir causes the drop in simulated river temperatures in July 1981 and July 1982.

The open water temperatures in winter should not change much throughout Stage III. This is illustrated by river ice simulations undertaken for early and late Stage III energy demands (HE 1985b) which showed little difference in ice cover between these two energy demands. Open water temperatures in winter for all of Stage III are warmer than Stage II. Winter open water temperatures will increase gradually from Stage II operation through Stage III filling to Stage III operation.

In winter, the temperature of the mainstem will remain above 0°C longer than natural because of the warming outflows from the project. The temperature in the spring will exceed 0°C sooner than natural for the same reason. Between the upstream end of the ice cover and the dams, the river temperature will be between 0°C and 2°C to 3°C, whereas the natural temperature in this reach is 0°C.

The mean annual (time weighted) temperature at RM 130 has been calculated for the period May 1981 through April 1982 to be 3.7°C for natural conditions and 4.7°C for late Stage III conditions. Simulations of natural and with-project conditions for other meteorological and hydrological conditions for other flow requirements also indicates that mean annual with-project temperatures may be slightly greater than natural mean annual temperatures. Mean annual temperatures in dry year with-project simulations are generally closer to natural conditions than in wet years.

4.3.2 Ice

River ice conditions between Watana and Talkeetna during operation of the project were simulated with the ICECAL river ice model (HE 1985b). The primary objective of the ICECAL model is to simulate the timing and magnitude of river stage fluctuations resulting from ice processes.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

No downstream impacts on river ice are expected as a result of Stage I construction. The diversion tunnels are large enough to pass the largest ice floes that have been observed, so that no significant downstream effect during breakup is anticipated. During freezeup, some additional frazil ice may be formed in the diversion tunnels due to the high velocities and associated turbulence. The volume of frazil ice formed is not expected to affect downstream ice formation.

- Filling

During the winter after filling of the Stage I W tana Reservoir, reservoir releases would be warmer than natural and would, therefore, delay frazil ice generation and ice cover formation, compared to natural conditions. River ice conditions during the winter following the summer of filling are expected to be similar to the filling simulations presented in the "Instream Ice Simulation Study" (HE 1985b). Frazil ice generation and border ice growth would typically begin between 5 and 40 miles downstream of the dam, varying with weather conditions, being closer to the dam during colder periods and further downstream in warmer periods. In the reach approximately 30 miles immediately downstream of the dam, an ice cover is not expected to form.

River ice thicknesses and ice-induced stages would be somewhat less than those of natural conditions. Breakup of the ice cover would typically occur in May, similar in timing to natural breakup. Breakup is expected to be somewhat milder than natural, due to the warmer than natural reservoir releases which melt and weaken the ice cover.

- Operation

Based on the average winter weather conditions of 1981-82, the Case E-VI flow requirements, and the projected Stage I energy demand, frazil ice generation would begin downstream of the Watana to Devil Canyon reach. The ice front will advance a few miles upstream of RM 140 during a cold winter, but is not expected to extend to the Watana to Devil Canyon reach. Upstream of the ice cover, the river would remain open with some border ice and anchor ice expected within approximately 10 miles upstream of the cover. Depending on climate, during relatively cold periods a greater length of river would have border and anchor ice than in a warmer period. Maximum river stages upstream of the ice cover would be equivalent to or lower than those of natural conditions with an ice cover.

(ii) Stages II and III

During construction of the Stage II dam, ice conditions in the Watana to Devil Canyon reach will remain unchanged from those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) <u>Devil Canyon to Talkeetna</u>

(i) <u>Stage I</u>

- <u>Construction</u>

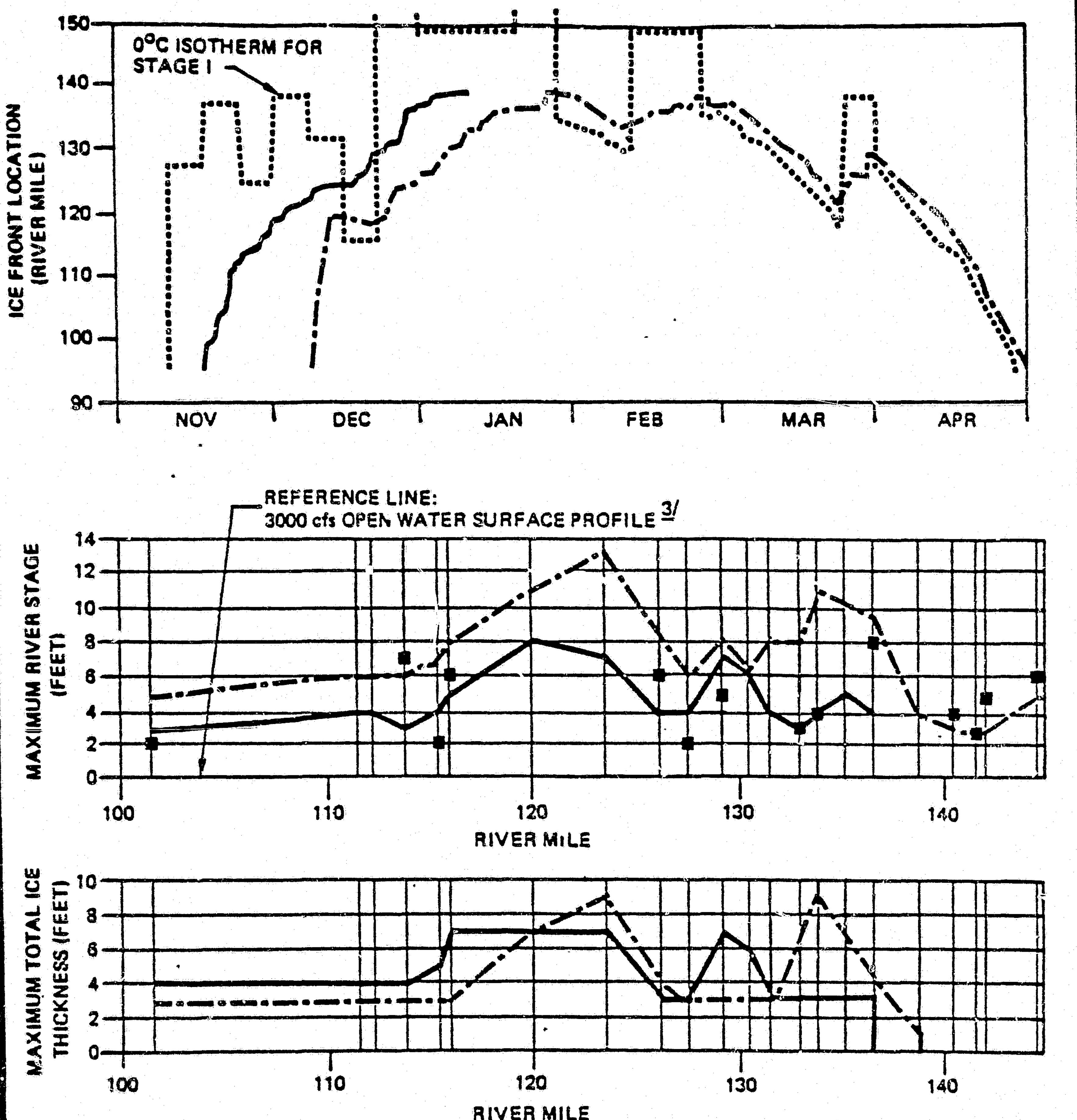
No impacts on ice regime are expected to occur during Stage I construction.

- <u>Filling</u>

During filling, the ice front is expected to advance upstream to RM 140 during an average winter, and upstream or downstream a few miles during cold and warm winters, respectively. River ice thicknesses and ice-induced stages will be slightly less than those of natural conditions.

- <u>Operation</u>

River ice model results during Stage I Watana operation are shown in Figure 21 based on the average winter weather conditions of 1981-82, and the Case E-VI flow requirements. For these conditions, frazil ice generation would begin where stream temperatures have cooled to $0^{o}C$, typically 35 to 65 miles downstream of the dam (RM 150 to 120) and would vary with daily weather conditions and reservoir release temperatures. Ice cover progression upstream of Talkeetna is expected to begin in mid-December, approximately 3 weeks later than for natural conditions. Progression of the ice cover would reach a maximum extent near RM 140 in late



NOTES:
1. STAGE I SIMULATION BASED ON CASE E–VI FLOWS. STAGE I ENERGY DEMAND, INFLOW MATCHING TEMPERATURE POLICY.
2. NATURAL CONDITIONS NOT SIMULATED UPSTREAM OF RM 140.
3. 3000 cfs REPRESENTS TYPICAL WINTER FLOW UNDER NATURAL CONDITIONS AT FREEZE UP.

LEGEND:
- NATURAL CONDITIONS
- STAGE I OPERATING
- ■ NATURAL SLOUGH BERM ELEVATION

SOURCE: APA 1985c

NATURAL AND STAGE I RIVER ICE CONDITIONS

FIGURE 21

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January. Maximum expected ice cover thicknesses range from 3 ft to 9 ft along the river, and are similar to those of natural conditions. Maximum river stages within the ice-covered reach (downstream of RM 140) would often be 2 to 6 ft higher than those of natural conditions (Figure 8) and a greater number of sloughs would be overtopped in this reach. A field program in the fall of 1985 collected topographic data along the perimeters of sloughs 8A, 9, 9A, 11, and 21. The topographic data were compared to the maximum ice stages predicted by the ice simulation (HE 1985b). The comparison suggests that the heads of sloughs 8A, 9, 9A, and 11 would be overtopped; a separate analysis of overtopping of sloughs under winter conditions in the FERC license application amendment (APA 1985c) confirmed these results. However, the islands separating the sloughs from the mainstem are not expected to be inundated under average winter weather conditions.

Flow in sloughs caused by overtopping may cause scouring in the sloughs. However, because of the increased backwater at the slough mouths due to mainstem staging, velocities at the downstream ends of the sloughs should be reduced, thereby reducing the chances of scouring in the lower reaches of the sloughs. Velocities upstream of the backwater effects may be as high as 3 fps (0.9 m/sec) under the ice cover, which are sufficient to cause erosion of finer material such as sands or small gravel. Currently, the bed material in the sloughs becomes coarser with distance upstream and is more resistant to flow, thus minimizing the potential for erosion.

Upstream of the ice cover, the river would remain open with some border ice and anchor ice expected within approximately 10 miles upstream of the cover. During relatively cold periods a greater length of river would have border and anchor ice than in a warmer period. Maximum river stages upstream of the ice cover would be equivalent to or lower than those of natural conditions with an ice cover. Slough 21 and Side Channel 21 are not expected to be overtopped (APA 1985c).

Colder winters will move the ice cover upstream and increase ice thicknesses up to 2 to 3 ft. A field program in 1985 collected topographic data along the islands between sloughs 8A, 9, 9A, 11 and 21 and the mainstem. These are considered to be the major salmon-spawning sloughs of the middle Susitna River (ADF&G 1985a). The topographic data were compared to the simulated maximum ice stages; the island at Slough 9A appears likely to be inundated under cold weather conditions. Conversely, during warm winters the ice cover will remain further downstream and ice thicknesses will be reduced by a few feet.

The ice cover upstream of Talkeetna is expected to substantially melt in place by the end of April. Mechanical break-up of the ice cover, which occurs during natural spring flow increases and results in ice jams and slough overtoppings, is expected to be substantially reduced or eliminated upstream of Talkeetna with Watana Stage I operating.

(ii) Stage II

- Construction and Filling

Ice processes will be unchanged from those discussed for Stage I operation.

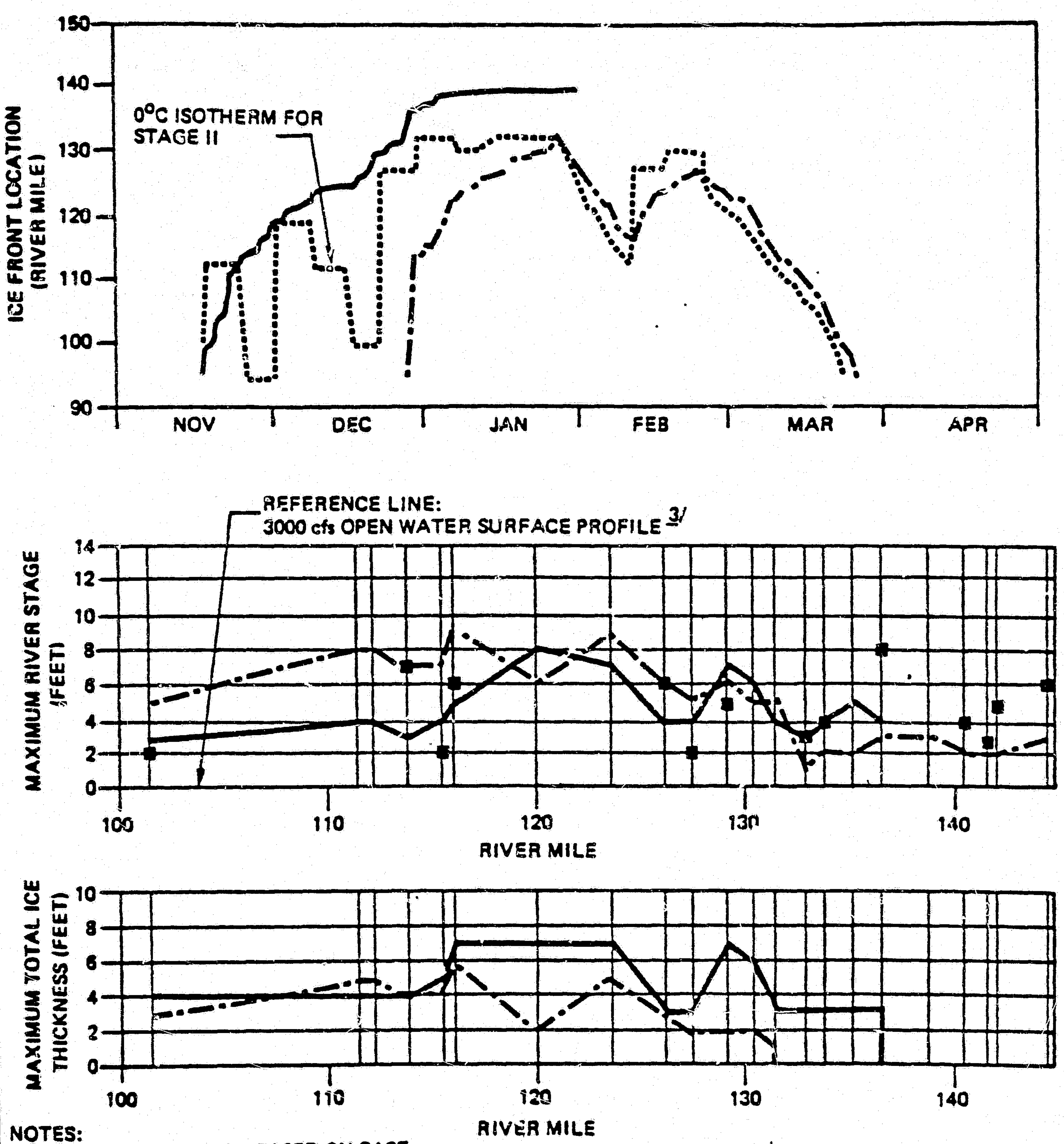
- Operation

Frazil ice generation would be limited to the reach downstream of RM 135 and would vary with daily weather conditions and reservoir release temperatures. At times, no frazil would be produced upstream of Talkeetna.

Ice cover progression at Talkeetna is expected to begin in late December and would reach a maximum extent near RM 133 in late January. This is approximately six miles downstream of the simulated Stage I maximum ice extent. Expected Stage II ice conditions are shown in Figure 22. Maximum expected ice cover thicknesses would range from 2 ft to 6 ft and would be generally similar to or less than those of natural conditions. Maximum river stages within the ice-covered reach would often be 1 ft to 4 ft higher than those of natural conditions (Figure 8) and greater overtopping of sloughs would therefore be expected in this reach if the mitigation measure of berm construction were not implemented. In general, river stages would be less than those during Stage I operation. Upstream of the ice cover, the river would remain open and maximum river stages would be equivalent to or slightly less than during natural conditions.

The ice cover upstream of Talkeetna is expected to substantially melt in-place by late March. Mechanical breakup and resulting ice jams and flooding events are expected to be substantially reduced compared to natural conditions.

With Stage II operating, the river ice effects of the alternative power intake designs and operating policies are expected to be less evident than those discussed for Stage I. Relative to the "inflow-matching" policy, the "warmest water" policy has essentially no effect on the simulated river ice conditions with both dams operating. Simulations for the final stage of the three stage project show that the simulated maximum extents of the ice front for both policies are within one mile of each other and maximum water levels



NOTES:
1. STAGE II SIMULATION BASED ON CASE E–VI FLOWS, STAGE II ENERGY DEMAND, INFLOW MATCHING TEMPERATURE POLICY
2. NATURAL CONDITIONS NOT SIMULATED UPSTREAM OF RM 140.
3. 3000 cfs REPRESENTS TYPICAL WINTER FLOW UNDER NATURAL CONDITIONS AT FREEZE UP'

LEGEND:
NATURAL CONDITIONS
STAGE II OPERATING
NATURAL SLOUGH BERM ELEVATION

SOURCE: APA 1985c

NATURAL AND STAGE II RIVER ICE CONDITIONS

FIGURE 22

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SUSITNA JOINT VENTURE

are within one foot of each other. The similarities between ice conditions for the two policies would be the same for Stage II as Stage III. Simulations with alternative low level intake ports showed only slight reductions in simulated river ice conditions.

For Stage II operation the maximum simulated ice thicknesses, river stages and ice front extent are substantially less than those for Stage I Watana operation. Slough overtopping events during Stage II operation are therefore expected to be milder and less frequent than those of Stage I operation.

(iii) Stage III

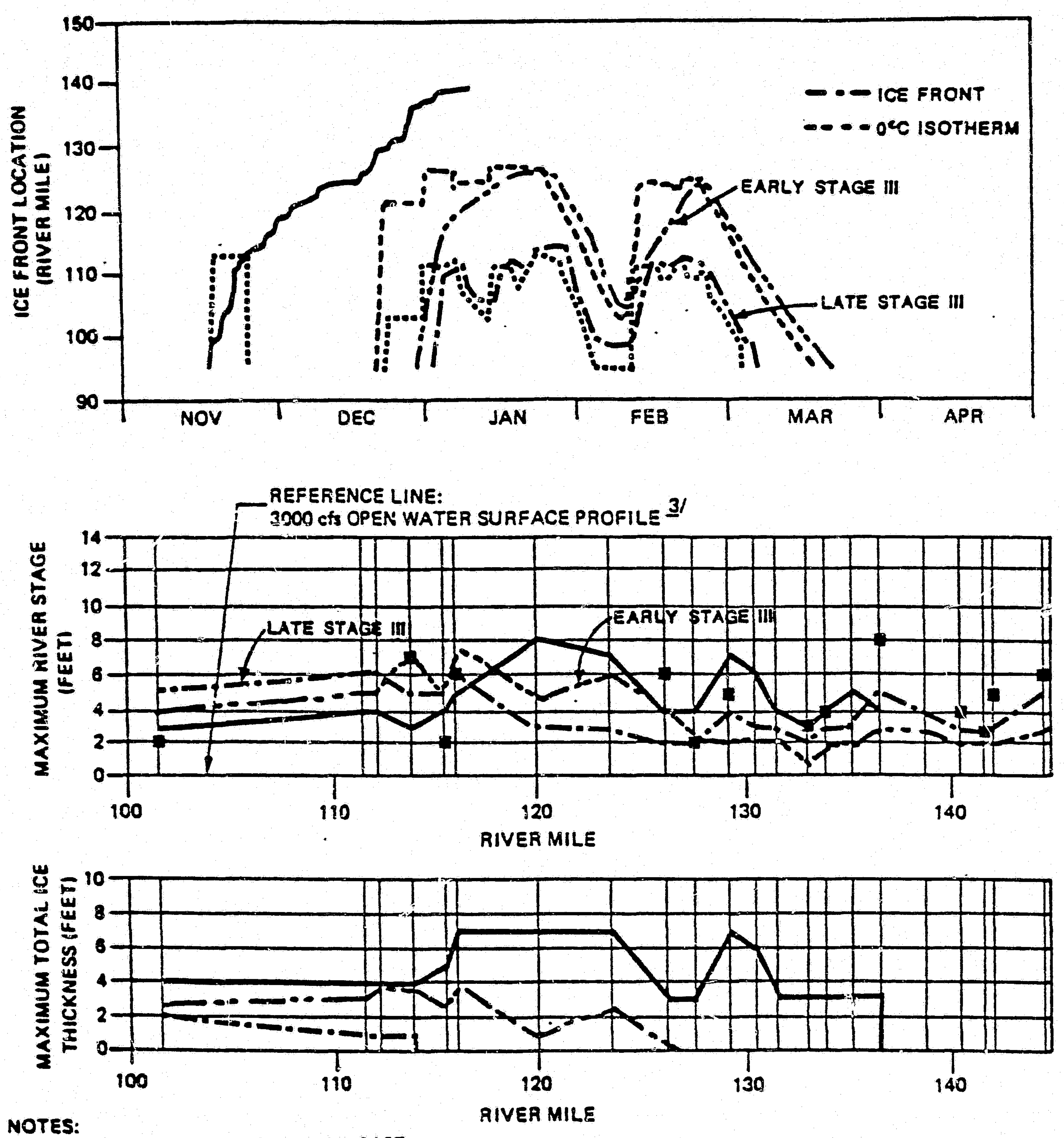
- Construction and Filling

The discussion of ice for Stage II operation is applicable to Stage III construction before filling commences. Conditions will gradually approach those discussed below for Stage III operation as the reservoir is being filled.

- Operation

Frazil ice generation would be limited to the reach downstream of RM 115 and would vary with daily weather conditions and reservoir release temperatures. For much of November and December, no frazil ice would be generated upstream of Talkeetna.

Ice cover progression at Talkeetna during Stage III operation is expected to begin in early January and would reach a maximum extent near RM 114 in late January. Maximum ice cover thicknesses of two feet are expected and would be several feet less than those of natural conditions (Figure 23). Maximum river stages within the ice-covered reach



NOTES:

1. STAGE III SIMULATION BASED ON CASE E-VI FLOWS, LATE STAGE III ENERGY DEMAND, INFLOW MATCHING TEMPERATURE POLICY
2. NATURAL CONDITIONS NOT SIMULATED UPSTREAM OF RM 140.
3. 3000 cfs REPRESENTS TYPICAL WINTER FLOW UNDER NATURAL CONDITIONS AT FREEZE UP.

LEGEND:

- NATURAL CONDITIONS
- LATE STAGE III OPERATING
- NATURAL SLOUGH BERM ELEVATION
- EARLY STAGE III OPERATING

SOURCE: APA 1985c

NATURAL AND STAGE III RIVER ICE CONDITIONS

FIGURE 23

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would be approximately two feet higher than those of natural conditions (Figure 8) causing somewhat greater than natural slough overtoppings in this reach. Overtopping would not be expected where berms are elevated as a mitigation measure. Upstream of the ice cover, maximum river stages would often be 1 to 3 ft lower than those of natural conditions with an ice cover, and fewer than natural slough overtoppings are expected.

The ice cover upstream of Talkeetna with Stage III operation is expected to be melted out by early March. As discussed for Stage I and Stage II, the ice cover is expected to substantially melt in place without major ice jamming or associated flooding.

The effects of differing winter weather conditions on river ice are expected to be generally similar to the trends discussed for Stage II operation. Relative to the river ice conditions for the average 1981-82 winter, ice front progression for other weather conditions may occur a few weeks earlier or later and may reach a maximum extent a few miles further upstream or downstream. Maximum ice cover thicknesses and river stages would also be expected to vary by a few feet among the various weather conditions.

The effects on Stage III river ice conditions due to alternative designs and operating policies for the multi-level power intakes is expected to be similar to that discussed for Stage II. The alternative designs and operating policies are not expected to substantially affect the river ice conditions.

4.3.3 Suspended Sediments/Turbidity/Vertical Illumination

Previous studies indicate that, with the project, there will be an overall reduction in the suspended sediment load of 80 to 90 percent from natural conditions. Turbidity levels will be measurably reduced from natural conditions in the summer (May through September) and increased in the winter (October through April).

Turbidity is a water quality parameter important to the fishery resources. It is a measure of the light transmitting characteristics of the water. Low values of turbidity indicate high light transmittance and vice-versa. Turbidity is influenced by the size, concentration and minerology of material suspended in the water including sediment, dyes, and other organic and inorganic material. In the Susitna River the turbidity levels are chiefly influenced by the concentrations and grain size of suspended sediment; the ratio of turbidity to suspended sediments appropriate for quiescent water bodies such as the reservoir is 2:1 (Figure 24). Vertical illumination is proportional to turbidity.

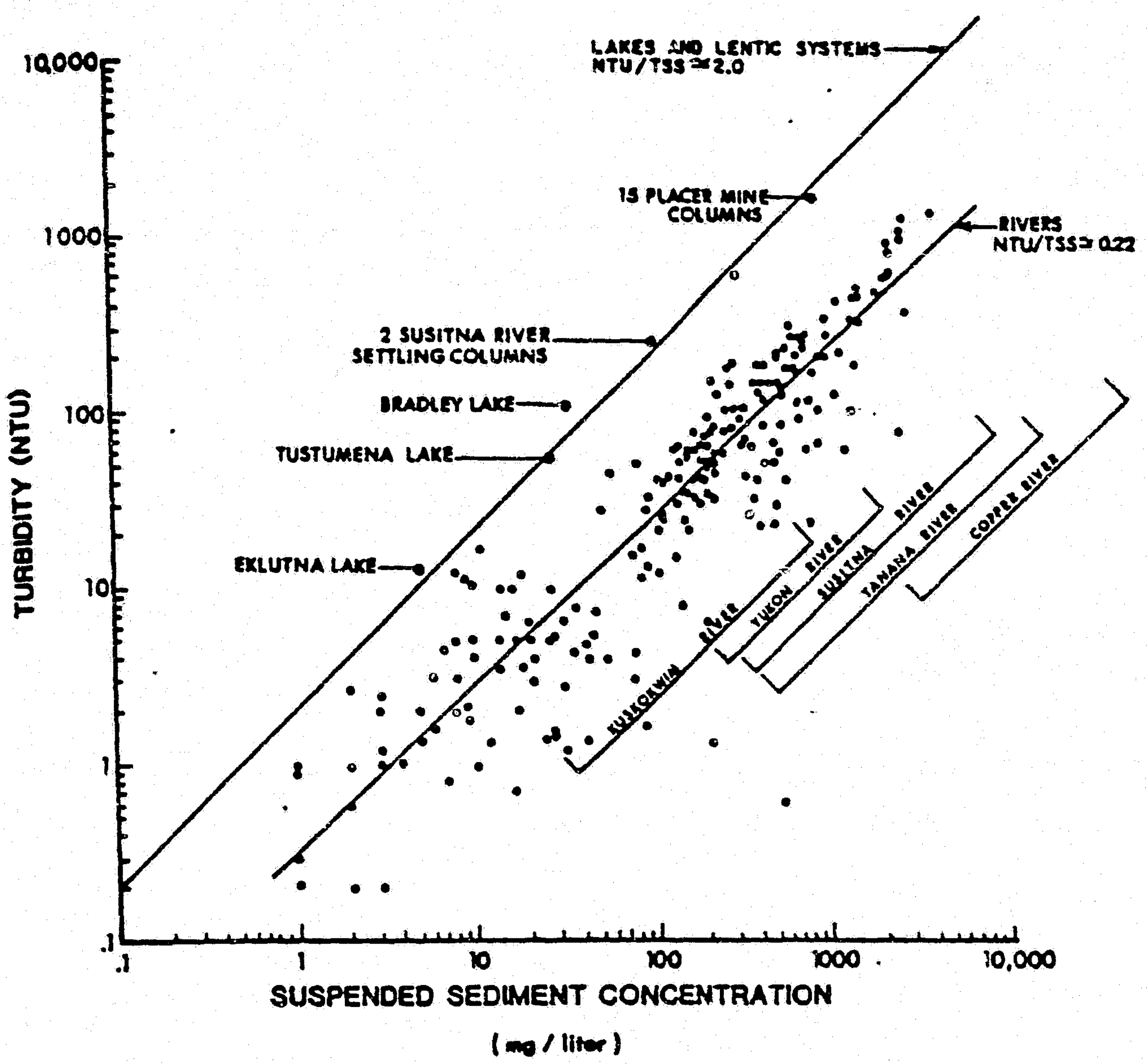
The DYRESM model was used to simulate the suspended sediments in the Watana Reservoir and in the project outflows (APA 1985c). Case E-VI flow requirements and 1970 and 1981-82 meteorological conditions were considered. Data on the suspended sediment concentration and size distribution in the Susitna River were available from USGS. Figure 25 shows the estimated relationship between discharge and suspended sediment load at the USGS gaging station on the Susitna River near Cantwell.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

During construction, suspended sediment concentrations and turbidity levels are expected to increase within the impoundment area and for some distance downstream. This will result from the necessary construction activities within and immediately adjacent to the river as described in



NATURALLY OCCURRING TURBIDITY VS. SUSPENDED SEDIMENT CONCENTRATION FOR RIVERS AND LAKES IN ALASKA (MODIFIED AFTER LLOYD 1985)

SOURCE: APA 1985c

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

FIGURE 24

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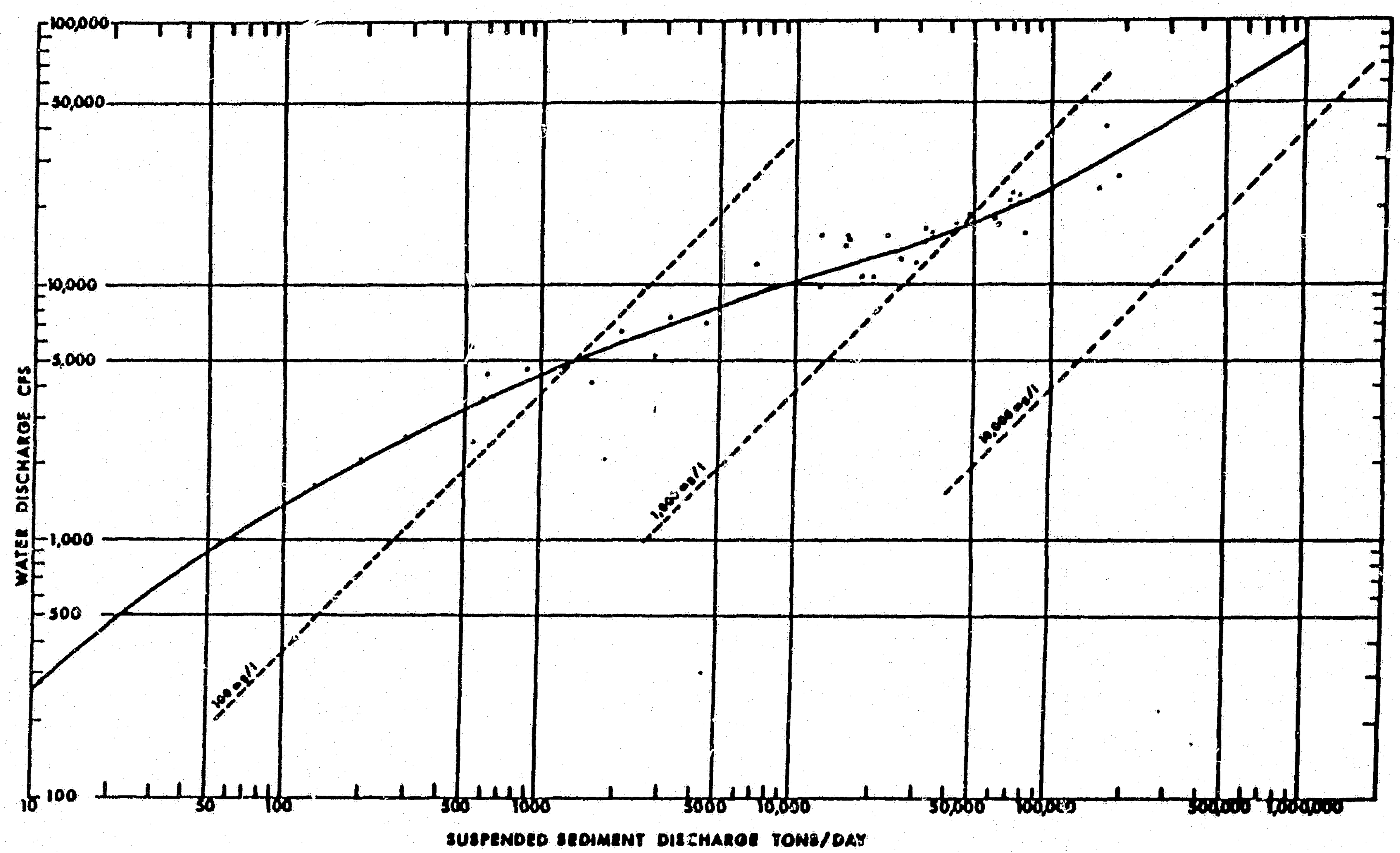


SUSPENDED SEDIMENT RATING CURVE AT USGS GAGING STATION SUSITNA RIVER NEAR CANTWELL, ALASKA

SOURCE: APA 1985c

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
ENTRIX, INC.	HARZA-EBASCO SUSITNA JOINT VENTURE

FIGURE 25

the Access Corridor, Construction Zone, and Transmission Corridor Impact Assessment and Mitigation Plan (Entrix 1985a).

The excavation of the diversion tunnels and construction of the first diversion cofferdam may cause temporary increases in suspended sediment and turbidity. Cofferdams will be constructed upstream and downstream of the diversion tunnels to enable tunnel construction. Material excavated from the tunnels will generally be confined within the cofferdams prior to disposal. This will minimize increases in suspended sediment and turbidity. The first diversion cofferdam will be located in the river. It will be constructed by dumping rock material into the river to divert flow to the diversion tunnels. During periods when rock is being placed, some sediment will be washed downstream. The amount of material introduced into the river in this manner is not expected to cause significant increases in sediment concentration since the total amount of material in the closure cofferdam is small relative to the existing river sediment load.

Summer flows will be passed through the diversion tunnel with no impoundment. Hence, little settling of naturally-occurring suspended sediments is expected to occur. Ponding is not expected upstream of the diversion tunnels in the winter, and so normally low winter sediment and turbidity levels will not be changed.

- Filling

In general, the suspended sediment concentration in the Watana to Devil Canyon reach will be reduced from natural conditions during summer and increased during winter.

As the reservoir begins to fill, water velocities in the river will be reduced and deposition of the larger suspended sediment particles will occur. Initially, all but the larger particles will pass through the reservoir but as more water is impounded, smaller diameter particles will settle before reaching the reservoir outlet. As the reservoir approaches normal operating levels, the percentage of particles settling will be similar to that occurring during normal reservoir operation. During the summer of filling, water will be passed through the low-level outlet. As a consequence, larger particles are expected to pass through the reservoir during the summer of filling than during operation. This will result in concentrations of sediment higher than those during operation. Maximum suspended particulate sizes passing downstream through the project area will decrease from about 500 microns during pre-project conditions to between 5 and 10 microns when the project becomes operational. During the winter following filling, concentrations would be similar to operation since units one and two will be on-line and releases will be through the multi-level intake. Maximum suspended sediment concentrations would occur during wet years with high suspended load influent to the reservoir. Minimum suspended sediment concentrations would occur during dry years with lower suspended load inflow. Because of the clear water tributary inflow in the Watana to Talkeetna reach, further dilution of the suspended sediment concentration may occur as the flow moves downstream.

During periods of high tributary flow, the same amount of suspended sediment will be added to the river by the tributaries as for natural conditions. Talus slides along the mainstem will also continue to contribute suspended sediment to the flow downstream from Watana. However, erosion of slide areas along the river should decrease due to increased flow stability and decreased flood frequencies and flows.

Summer turbidity levels will be reduced from natural levels ranging between 60 and 3,010 mg/l to an estimated value of 100-300 NTU. These values will persist until December and will decrease during winter to a minimum of between 20 and 40 NTU in early May prior to breakup. Because of the reduced turbidity in summer, the vertical illumination will be enhanced. Winter vertical illumination will be reduced from natural.

- Operation

Outflow suspended sediment concentration and turbidity level will be more uniform throughout the entire year than for natural conditions. The summer suspended sediment level will be decreased from about 60-3,010 mg/l to about 50-150 mg/l and the winter suspended sediment level will be increased from about 1-80 mg/l to about 20-100 mg/l, reaching a minimum between 10 mg/l and 40 mg/l in early May. Turbidities will average approximately 200 NTU from June through December and decrease to minimum values of 20-40 NTU by early May. Because of the reduced turbidity in summer, the vertical illumination will be enhanced while winter vertical illumination will be reduced.

The suspended sediment concentrations and hence the turbidity in the reach between Watana and Devil Canyon will be controlled by the concentration in the reservoir release, and any contribution from the reach. The contribution from the reach is not expected to be significant since the tributaries contain generally clear water and there is very little fine sediment or glacial flour present in the streambed or on the banks which might be entrained in the flow. During summer flood periods the contribution from the intervening areas may increase concentrations in the mainstem river as a result of erosion and bank sloughing. Talus slides along the mainstem may continue to contribute suspended sediment to the flow downstream from Watana as discussed for filling conditions.

(ii) Stages II and III

During construction of the Stage II dam, suspended sediments, turbidity, and vertical illumination in the Watana to Devil Canyon reach will remain unchanged from those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

- Construction

Increases in suspended sediment concentrations in this reach during construction will be quite small. Proper sediment control at the construction site will minimize additional sediment inputs. Any changes occurring during the summer are expected to be within the natural range of variation. Suspended sediment concentrations may be slightly increased during wet, warm winters.

- Filling

The trends will be the same as those in the Watana to Devil Canyon reach during Stage I filling (Section 4.3.3(a)(i)). Suspended sediment concentrations will be reduced from natural conditions during summer and increased during winter. Maximum and minimum concentrations will occur in wet years and dry years, respectively. Turbidity will be reduced to 100-300 NTU during summer and increased from natural conditions to 20-40 NTU by winter's end.

- Operation

In general, the trends described for the Watana to Devil Canyon reach during Stage I operation in Section 4.3.3(a)(i) are applicable. Summer concentrations of downstream suspended sediments will decrease from natural conditions of 60-2000 mg/l to project conditions of 60-150 mg/l. Conversely, TSS concentrations during winter will increase from 1-80 mg/l to 20-100 mg/l. Turbidity will correspondingly increase and decrease in proportion with TSS, while vertical illumination will vary inversely. Turbidity will average 200 NTU from June to December, then decrease to minimum values of 20-40 NTU by early May.

(ii) Stage II

- Construction

Construction of the Devil Canyon facility is expected to cause increased siltation and turbidity similar to increases anticipated during Watana construction, but of a smaller magnitude. Details of physical changes at the construction site are presented in the Access Corridor, Construction Zone, and Transmission Corridor Impact Assessment and Mitigation Plan (Entrix 1985a).

During winter, essentially all the suspended sediment concentrations and turbidity levels released from Watana are expected to pass downstream of the Devil Canyon construction site without significant change.

- Filling

As reservoir filling progresses, the Devil Canyon reservoir will provide settling capability in addition to the trapping of sediments by the Watana reservoir. The net result will be a slight decrease in suspended sediment and turbidity and a corresponding slight increase in vertical illumination downstream from Devil Canyon.

- Operation

As in the case of Watana Stage I reservoir outflows, the Devil Canyon reservoir outflow suspended sediment concentration and turbidity levels will be more uniform throughout the entire year than under the natural river conditions. As with Watana Stage I, the average summer suspended sediments concentration (90 mg/l) and turbidity level will be measurably reduced from natural conditions. The outflow suspended sediment concentration from Devil Canyon will reach its lowest level of about 20-30 mg/l in April or May and increase toward a maximum of about 130 to 150 mg/l in late July or early August. The corresponding turbidity level may vary from about 40 to 60 NTU in spring to a maximum of about 250 to 300 NTU in late July or early August.

During Stage II operation some of the suspended material in the Watana outflow would be trapped in the Devil Canyon reservoir. Simulations show that during Stage II the outflow concentration of suspended sediment from Devil Canyon would be about 10-20 percent less than in the outflow from Watana. Additionally, the Devil Canyon reservoir will tend to regulate the concentrations so that the abrupt changes in concentration resulting from changing multi-level intake port operations at Watana would not be apparent downstream of Devil Canyon. With Stage II the average

July-December outflow concentration would be approximately 80-100 mg/l. The maximum occurs in late July and would be about 150 mg/l, but the concentration would be relatively constant between July and December.

Between January and early May the concentration generally decreases to approximately 20-30 mg/l. For Stage II, suspended sediment concentrations were only simulated for an average year (1982). Based on the results for Stage I, low sediment (1970) and high sediment (1981) years would result in concentrations approximately 10-20 percent less and 10-20 percent greater than for an average year, respectively.

The suspended sediment concentration between Devil Canyon and the Chulitna-Susitna confluence will be similar to that in the outflow from the dam. Some sediment may be injected by tributaries during floods. However, the contribution from tributaries will normally be minimal. Thus the turbidity in the Devil Canyon to Chulitna confluence reach is expected to be slightly less than in Stage I or about 160-200 NTU on the average, between July and December decreasing to a minimum of 50 NTU in May. Vertical illumination will be increased slightly from Stage I conditions in the middle reach of the Susitna River.

(iii) Stage III

- Construction

Fluctuations in TSS downstream of Devil Canyon are not expected to change from Stage II operation. Additional impacts on TSS, turbidity, and vertical illumination due to Stage III construction will not be noticeable downstream of Devil Canyon dam. Sediment input will be minimized using best management practices developed for the project (APA

1985). Most sediment that does enter the watercourse between Watana and Devil Canyon will settle in the reservoir.

- Filling

Downstream river flows during this period will be less than during normal operation of the project in the July-September period because normal excess releases will be used to raise the water level. Thus, the ability of the downstream flow to pick up additional sediment will be reduced from normal operation.

The outflow concentrations of suspended sediment would gradually change from those described for Stages I and II normal operation to that described for Stage III normal operation; therefore, the suspended sediment/turbidity/vertical illumination conditions may be similar to the conditions described for those stages.

- Operation

As indicated in the Stage II studies, the Devil Canyon outflow suspended sediment concentration and turbidity level are expected to be more uniform throughout the entire year than the natural river condition. The outflow suspended sediment concentration of the Watana Reservoir in Stage III in July and August would be less than for the Watana Reservoir in Stages I and II. The reduction in concentration may be up to about 50 mg/l. This reduction is due to the larger and deeper Watana Reservoir formed in Stage III (retention time increases from 9 months to 20 months). The outflow suspended sediment concentration from Devil Canyon Reservoir is correspondingly less in Stage III than in Stage II.

The outflow suspended sediment concentration from Devil Canyon would reach its lowest level of about 10 to 20 mg/l in April or May and approach a maximum of about 90 to 100 mg/l in July or August. The average concentration between August and January would be about 70 mg/l.

Turbidity levels in this reach would be less than Stage I and II because of the reduced suspended concentrations. Turbidity in the summer would be reduced from natural conditions because of the trapping of material in the reservoir. Winter turbidity levels will be higher than natural because of the fine material which remains suspended in the reservoir. Summer turbidity levels are simulated to increase from values of 20-40 NTU in early May to maximums of 200 NTU in late July and to decrease to approximately 100 NTU by September. Turbidity would be relatively constant at 100-140 NTU through December and decrease to minimum levels in early May.

Vertical illumination would be greater than in Stages I or II.

4.3.4 Dissolved Oxygen

Dissolved oxygen concentrations downstream of the damsites are not expected to be substantially affected by the proposed project. Susitna River flow will likely remain high in dissolved oxygen concentrations.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

Changes in dissolved oxygen concentration are not anticipated during construction of Stage I.

- Filling

During the filling of Stage I, stratification of dissolved oxygen concentrations will begin to occur. Water will likely be released from water near the reservoir bottom and would likely contain lower dissolved oxygen levels than are normally found in the middle Susitna River. However, the oxygen deficit of the water near the bottom of the reservoir in Stage I is not expected to be high due to the small size of the reservoir, the volume of freshwater inflow, mixing effects caused by the low level outlet works, wind and waves, and the weaker stratification during filling than during normal operation. Moreover, additional reoxygenation of this water will occur naturally as it passes downstream through the turbulent rapids in the upper reaches of Devil Canyon.

- Operation

Susitna River flow from the reservoir during Stage I operation will continue to have both high dissolved oxygen concentrations and high percentage saturations. Dissolved oxygen changes are not anticipated since water will be drawn from the upper layer of the reservoir. The oxygen demand of the water entering the reservoir will be low.

A layer of organic matter at the reservoir bottom will be present and could create some localized oxygen depletion along the reservoir floor. However, the process of decomposition will be very slow because of the cold temperatures near the bottom. Any waters with low dissolved oxygen will be diluted by the large reservoir volume of water with relatively high dissolved oxygen content.

The stratification that is anticipated in the reservoir may limit the oxygen replenishment in the hypolimnion. The spring turnover, with its large inflow of freshwater containing relatively high concentrations of dissolved oxygen, will cause mixing; however, the depth to which this mixing will occur is unknown. It is anticipated that the upper 200 feet (60 m) of the impoundment should maintain high dissolved oxygen concentrations.

(ii) Stages II and III

The reach between Watana and Devil Canyon will be inundated following construction of the Stage II Devil Canyon dam. Dissolved oxygen conditions will remain similar to Stage I operation until inundation (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

Downstream dissolved oxygen conditions will remain similar to natural conditions as described for the Watana to Devil Canyon reach.

(ii) Stage II

- Construction

Construction of the Stage II dam is not expected to affect the dissolved oxygen concentration downstream.

- Filling

Prior to filling, all large standing vegetation in the reservoir area will be selectively harvested or cleared and burned, thereby eliminating some of the oxygen demand due to the long-term decomposition of vegetation following reservoir filling.

Because of the extremely short residence time, no hypolimnetic oxygen depletion is expected to develop either during the one year that the reservoir is held at el. 1,135 ft, or during the final period of reservoir filling.

- <u>Operation</u>

Within the upper layers (epilimnion) of the reservoir, dissolved oxygen concentrations will remain high. Inflow water to the impoundment will continue to have a high dissolved oxygen content and low BOD. Since water for energy generation is drawn from the upper layers of the reservoir, no adverse effects to downstream dissolved oxygen levels are expected.

Reduction of dissolved oxygen concentrations can occur in the lower levels of deep reservoirs. Stratification and the slow biochemical decomposition of organic matter will promote lower oxygen levels near the Devil Canyon Reservoir bottom over time. However, all large vegetation will have been selectively cleared and burned or buried prior to inundation thereby reducing the potential oxygen demand decomposition process. No estimates of the extent of oxygen depletion can be calculated.

During periods of release through the Devil Canyon outlet facilities, water with somewhat reduced oxygen levels may be discharged. Given the dynamic nature of the river, these reduced concentrations should quickly return to saturation levels. Quantitative estimates of these reduced oxygen levels are not possible.

(iii) Stage III

- Construction

The Devil Canyon reservoir will act as a buffer to stabilize any decreases in dissolved oxygen concentrations. No changes in downstream oxygen concentration are expected during Stage III construction.

- Filling

During the Stage III filling period, the reservoir stratification will be similar to that described for normal operation of Stages I, II and III. A significant biochemical oxygen demand is not anticipated. The timber in the reservoir area between the Stage II clearing level and the Stage III clearing level will be selectively cleared thereby eliminating some of the associated oxygen demand that would be created by the inundation and decomposition of vegetation. Further, the chemical oxygen demand of the Susitna River is low.

- Operation

Dissolved oxygen levels in Stage III would be similar to Stage II. In general, dissolved oxygen is expected to be similar to natural conditions because water will generally be withdrawn from near the reservoir surface. During periods when the Devil Canyon outlet works are operating, some water with lower than natural dissolved oxygen may be released from the reservoir. This water will be released as a diffused spray which will tend to increase its dissolved oxygen content. Additionally, exposure to the atmosphere and mixing with water released through the powerhouse will increase dissolved oxygen levels downstream. Continual operation of the Devil Canyon outlet works will cause replacement of water near the bottom of the Devil Canyon reservoir with water from near the surface of Watana. Thus, after a period of releases with potentially lower dissolved oxygen levels, the concentration in the water released through the outlet works is expected to increase.

4.3.5 Total Dissolved Gas

Total dissolved gas concentrations are expected to remain similar to natural concentrations as the outlet works would be designed to minimize gas supersaturation. A flip bucket would be installed on the low-level outlet works and fixed-vone valves would control flow from the outlet works at Watana.

The Devil Canyon rapids naturally entrain air and cause supersaturation of dissolved gas immediately downstream. Dissolved gas concentrations with-project are not expected to exceed naturally occurring concentrations.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

No changes to the total dissolved gas concentration is expected to be caused by Stage I construction.

- Filling

Changes in the concentration of total dissolved gas are not anticipated in the Watana to Devil Canyon reach. Water that is released during the filling of the reservoir to meet environmental flow requirements will pass through the low-level outlet. A flip bucket is provided on the low-level outlet works to disperse the flow and to prevent a hydraulic jump in order to minimize the potential for gas supersaturation. Gas concentrations in the river are expected to be similar to natural.

- Operation

Supersaturated dissolved gas (nitrogen) conditions can occur below high head dams as a result of flow releases. However, fixed-cone valves are planned to control flow from the outlet works at the Watana dam and will be used during project operation to release floods with return periods of less than 50 years. The amount of supersaturation in the Watana release is expected to remain constant between 100 and 105 percent for up to the 50-year event.

(ii) Stages II and III

During construction of the Stage II dam, dissolved gas concentrations will be unchanged from concentrations during Stage I operation. The reach between Watana and Devil Canyon will subsequently be inundated (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

- Construction

Construction activities are not expected to change dissolved gas concentrations downstream of Devil Canyon.

- Filling

Supersaturated dissolved gas conditions currently exist in the Susitna River below the Devil Canyon rapids due to the entrainment of air and pressurization due to the plunging action as the river flows through this reach. Filling will cause reduced downstream flows and result in lower summer dissolved gas concentrations below the Devil Canyon rapids. However, dissolved gas concentrations will be similar to concentrations occurring naturally at a similar flow. Based on observed pre-project conditions, August flows of 12,000 cfs at Gold Creek should result in total dissolved gas saturation levels of approximately 108 percent or less.

- <u>Operation</u>

During operation, dissolved gas concentrations downstream of Devil Canyon are expected to be similar to natural conditions under low fall flows.

As flows increase, flow in Devil Canyon would become more turbulent. The amount of supersaturation in Devil Canyon would increase so that the total gas concentration downstream of Devil Canyon would be approximately 115 to 125 percent for the 50-year flood. Gas concentrations have not been measured for natural conditions for flows exceeding 35,000 cfs, and a direct comparison of with-project and natural conditions is not possible for these floods. However, if the relation between flow and gas concentration developed for flows less than 35,000 cfs were extrapolated, gas concentrations for floods greater than the mean annual event for natural conditions would be higher than for with-project conditions.

Although no measurements of dissolved gas levels exist for the winter period for natural conditions, it is anticipated that average with-project flows (5,000 to 10,000 cfs) will cause levels of dissolved gas below Devil Canyon which exceed saturation. Concentrations are not expected to exceed the water quality standard of 110 percent (18 AAC 70.020) based upon the available natural condition measurements taken at slightly higher discharge conditions and higher ambient air temperatures.

(ii) Stage II

- Construction

During construction, dissolved gas concentrations will be similar to those occurring during Stage I operation.

- Filling

Dissolved gas supersaturation will not be a concern during the filling of the Devil Canyon reservoir. As the reservoir is filled, the rapids between the mouth of Devil Creek and the Devil Canyon damsite will be inundated and the turbulence that presently causes the supersaturation will thus be eliminated. Thus, dissolved gas concentrations in the reservoir area will be less than those for Stage I operation.

- Operation

Fixed-cone valves have been included in the design for the Devil Canyon dam. This will minimize the potential for gas supersaturation to exceed naturally occurring levels during floods with return periods of less than 50 years. Additionally, the inundation of the Devil Canyon rapids will eliminate a natural source of gas supersaturation. Gas concentrations downstream of Devil Canyon dam are expected to range from approximately 102 to 107 percent of saturation. This assumes that supersaturation occurring at Watana will not be reduced in Devil Canyon reservoir. The level of supersaturation will decrease downstream of Devil Canyon.

(iii) Stage III

- Construction

During construction of Stage III, the Devil Canyon dam operation will control the dissolved gas concentrations downstream.

- Filling

During filling of Watana Stage III the water normally released through the outlet works for flood control and dam safety purposes will be stored in the reservoir to raise the water level. Therefore, Watana outlet works use will be minimized during this period. Some water may be released through the Devil Canyon outlet works to meet environmental flow requirements and as a result of floods in the area between Watana and Devil Canyon. However, there is less likelihood that the outlet works or spillway will be used during this period than at any other time during project operation. Therefore, super-saturated gas concentrations are expected to be minimized during this period.

- Operation

As discussed for Stages I and II, the project operating policy and project design are planned to minimize the potential for downstream gas concentrations to exceed naturally occurring levels. Dissolved gas concentrations during Stage III operation would be similar to Stage II operation. Fixed cone valves are provided in the outlet works to disperse releases and minimize dissolved gas concentrations downstream. Floods with recurrence intervals of less than 50 years would be released without operating the spillway. Immediately downstream of the Devil Canyon dam, dissolved gas concentrations would not exceed 105 percent to 110 percent. Further downstream, gas concentrations would be reduced. Gas concentrations are expected to be less than natural for some floods with return periods of greater than 50 years also, due to the inundation of the Devil Canyon rapids and mixing of spillway, outlet works and powerhouse flows.

4.3.6 Nutrients and Organics

Concentrations of nutrients and organic compounds are expected to remain similar to natural concentrations. Initially, a slight increase in concentration may be caused by the leaching of minerals in the reservoir areas. However, the settling of sediments would likely precipitate nutrients from the water column. The magnitude of the net change is unknown, but concentrations are not expected to change substantially from natural levels.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

Potential increases in concentrations of nutrients and organic compounds in the river from construction activities will be minimized as described in the report describing potential impacts in the construction zone (Entrix 1985a).

Concentrations of waterborne nutrients and organic compounds downstream of the Watana damsite may be slightly increased from natural levels during construction (Entrix 1985a). A return to natural nutrient and organic compound levels is likely to occur within one summer (Entrix 1985a).

- Filling

Initial filling of Watana will likely cause an increase in nutrient concentrations due to leaching processes. However, this increase in nutrient concentration would be offset by the precipitation of the nutrients from the water column by settling of sediments transported into the impoundment. The magnitude of net change is unknown, but it is likely that nutrient concentrations will increase, especially in proximity to the reservoir floor for at least a short time during filling. Similarly the concentrations in release waters would be expected to increase.

- Operation

Concentrations of nutrients and organic compounds in the reservoir discharge are expected to be below natural levels. Within the reservoir, sedimentation will remove some of these constituents from the water column, making them unavailable for downstream use. Settling of suspended sediments within the reservoir will continue during project operation and will result in a sediment blanket that will reduce leaching and biological cycling of macro and micro nutrients, primary and secondary productivity, and organic detritus oxydation (Wetzel 1975, Campbell et al. 1975, Crawford and Rosenberg 1984, Wiens and Rosenburg 1984, Hicky and McCollough 1984). Development of small, low density biological communities in the reservoir is expected to occur. The anticipated trophic status of the Watana Reservoir has been developed in part by Peterson and Nichols (1982). The rate of removal is unknown, although it is expected to be small relative to the flow rate through the reservoir.

(ii) Stages II and III

During construction of the Stage II dam, nutrients and organics in the Watana to Devil Canyon reach will remain unchanged from those during Stage I operation. During filling of Stage II, the reach will be inundated. Impacts to this reach of river during filling and operation of Stage II and all phases of Stage III are discussed in the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

- Construction, Filling, Operation

The impacts on nutrient levels are similar to those in the reach from Watana to Devil Canyon, although they will be less distinct due to input from local tributary discharges.

(ii) Stage II

- Construction, Filling

During Stage II construction, nutrients and organics in the Devil Canyon to Talkeetna reach will remain unchanged from the levels described for Stage I operation. Also similar to Watana Stage I, two opposing factors will affect nutrient concentrations during the filling process. First, initial inundation will likely cause an increase in nutrient concentrations due to leaching. Second, sedimentation will remove some nutrients from the water column. Again, the magnitude of the net change in nutrient concentrations will increase in proximity to the reservoir floor during the filling process.

- Operation

Nutrient levels downstream will be slightly reduced due to sedimentation in the Devil Canyon reservoir.

(iii) Stage III

- Construction, Filling, Operation

Impacts will be similar to those for Stage II Operation. The additional impoundment in the Watana Reservoir is not expected to change the downstream nutrient and organic compound concentrations measurably.

4.3.7 Total Dissolved Solids, Conductivity, Significant Ions, Alkalinity, and Metals

Changes in the water quality in the Susitna River downstream of the damsite are expected to include slight increases in sediment, metal, and salt ion concentrations resulting from construction disturbances and from leaching of soil and rock in the reservoirs. The water quality should not be substantially changed from natural conditions.

(a) Watana to Devil Canyon

(i) Stage I

- Construction

The small increases in the concentration of trace metals resulting from construction disturbances to soils and rock on the river bank and in the riverbed are not expected to create adverse conditions in the ecosystem as the concentrations of many metals currently exceed established water quality criteria (APA 1985b).

- Filling

The initial filling of the reservoir will inundate rocks and soils in the reservoir that cause short-term increases in dissolved solids, conductivity, and most of the major ions by leaching processes (Peterson and Nichols 1982). Bolke and Waddell (1975) found the highest concentrations of all major ions, except magnesium, occurred immediately after dam closure. Symons (1969), also identified similar increases of alkalinity, iron, and manganese. These findings were all attributed to the initial inundation and leaching of rocks and soils in the reservoir. The magnitude of the expected changes cannot be quantified, but should not be significant (Peterson and Nichols 1982). Furthermore, Baxter and Glaude (1980) have found such effects are temporary and diminish with time.

The effects of leaching will diminish for two reasons. First, the most soluble elements will dissolve into the water rather quickly and the rate of leachate production will correspondingly decrease with time. Second, much of the inorganic sediment carried by the Susitna River will deposit in the Watana reservoir; the formation of an inorganic sediment blanket on the reservoir bed will retard the leaching process (Peterson and Nichols 1982).

Concentrations of leaching products will be highest near the reservoir bottom, but may be re-entrained into the upper levels during overturns. The products of leaching are not anticipated to be abundant enough to affect more than a small layer of water near the reservoir bottom (Peterson and Nichols 1982). Some leaching products may be distributed throughout the reservoir during the fall overturn following the summer of filling. Dilution by the large reservoir volume would make the resulting concentrations biologically insignificant. Since the power intakes are located in the upper levels of the reservoir, water released through the turbines should not be affected by leaching products. During the summer of filling, releases from the low-level outlets could increase downstream concentrations of the previously mentioned parameters but detrimental effects on freshwater aquatic organisms are not expected.

- Operation

During operation, the leaching process may result in slightly elevated concentrations of water quality parameters, especially near the reservoir bottom. As described for filling, leaching effects are expected to decrease over time.

Dissolved solids concentrations near the reservoir surface may also increase slightly due to evaporation in the summer months and rejection from freezing ice in the winter months. At no time, however, are these increases expected to be biologically significant in the reservoir. Changes in downstream water quality are not expected even during overflow spillway operation as the overflow spillway will not be operated except during a major flood (Section 2.1.4) when all other outlet facilities will also be in operation. Surface water will thus be diluted considerably and increases in concentration are expected to be below the detection limit.

Metal concentrations within the reservoir and consequently in the discharge may be reduced by metal precipitation. Metals have been observed to precipitate in reservoirs, particularly those which are oligotrophic with high pH and dissolved salt concentrations (APA 1985c). Although neither pH nor dissolved salts have excessively high concentrations in the Susitna River, the reservoir is expected to be oligotrophic (APA 1985c); a slight decrease in metal concentrations may occur.

(ii) Stages II and III

As the reach between Watana and Devil Canyon will be inundated following completion of the Devil Canyon dam, further physical changes in water quality are addressed within the impoundment impact assessment (Entrix 1985b).

(b) Devil Canyon to Talkeetna

(i) Stage I

- Construction

Disturbances to soil and rock adjacent to the river during Watana construction will increase dissolved and suspended materials in the river as described for the Watana to Devil Canyon reach. Although slightly elevated metal levels may result from construction activities, water quality should not be significantly changed.

- Filling and Operation

Changes in water quality are expected to be similar to those described for the Watana to Devil Canyon reach.

(ii) Stage II

- Construction, Filling, and Operation

Changes in water quality resulting from Stage II will be similar to those identified for Stage I. Leaching may occur over an extended period of time in the Devil Canyon reservoir as a blanket of glacial sediments will develop slower than in the Watana reservoir. However, changes in water quality due to the leaching process are expected to be diluted by the large volume of water in the reservoir and significant changes in downstream water quality are not expected.

(iii) Stage III

- Construction, Filling, and Operation

Water quality changes will be similar to those described for Stage II operation. The Devil Canyon reservoir will act as a construction buffer capturing increased trace metal concentrations, salts, or sediments released during Watana Stage III construction. The water quality released during filling and operation of Watana Stage III dam will be similar to the water quality during Stage II operation.

4.4 Groundwater Conditions

Changes in the groundwater conditions between Watana and Devil Canyon will be primarily limited to the floodplain of the Susitna River. Following construction of Stage I, the groundwater level adjacent to the mainstem is expected to decrease in the summer and increase during the winter in comparison to natural levels. The filling of the Devil Canyon reservoir will inundate the reach between Watana and Devil Canyon.

Project changes in the middle Susitna River affecting groundwater conditions will primarily consist of increases and decreases in groundwater levels adjacent to the mainstem. During the winter, groundwater levels and upwelling upstream of the ice front will be decreased from natural mid-winter conditions. Groundwater levels and upwelling downstream of the ice front will be increased. In the summer, groundwater levels at the streambank will be decreased about 2 ft from natural levels as described for the Watana to Devil Canyon reach.

4.4.1 Watana to Devil Canyon

(a) Stage I

(i) Construction

Substantial changes in groundwater conditions are not expected during construction of the dam as there will be no change in mainstem discharge or water level other than in the localized area of the project. In the immediate construction area, minor groundwater changes will likely result from the construction of the slurry cut-off trenches and the dewatering of the construction area (Section 2.1.1).

(ii) Filling

During the summer of filling, groundwater levels adjacent to the mainstem are expected to be reduced. Decreased summer flows will cause a decrease in the water levels in the mainstem of the river which will cause a reduction in groundwater levels in the river floodplain area. The average change in groundwater level during this period will be a reduction of about 2 ft near the streambank with less change occurring with increasing distance away from the river.

Winter groundwater levels are expected to be similar to natural levels as ice staging during the first winter following the summer of filling will be similar to natural conditions.

(iii) Operation

Groundwater changes during summer operation are likely to be similar to impacts during filling and will generally include a lowering of the groundwater levels in the floodplain. The river flows in the summer will be increased slightly from filling flows and will result in groundwater levels closer to but less than natural levels.

In the winter, ice staging will not occur between Watana and Devil Canyon as the flow will have warm temperatures. Groundwater levels are thus expected to be similar to the levels occurring under natural conditions in the early fall when natural river flows are approximately 10,000 cfs.

(b) Stage II and III

Following construction of the Devil Canyon dam, the reach between Watana and Devil Canyon will be inundated. Resulting changes in water levels are discussed in the Impoundment Zone Impact Assessment and Mitigation Plan (Entrix 1985b).

4.4.2 Devil Canyon to Talkeetna

(a) Stage I

(i) Construction

No changes to groundwater conditions in the middle Susitna River reach are expected as a result of Stage I construction.

(ii) Filling

- Mainstem

Changes in groundwater conditions of the middle Susitna River during filling will be similar to the changes described for the Watana to Devil Canyon reach.

- Sloughs and Peripheral Habitat

Lower groundwater levels in the river floodplain during the summer of filling will result in a dewatering of some of the seep areas in the sloughs, mainly in the higher, upstream portions. The reduced summer mainstem flows and resulting lower water levels will cause changes in the groundwater levels in various sloughs. Flows have been investigated in three sloughs (Sloughs 8A, 9, and 11), and equations derived that link mainstem stage to slough flow (APA 1985c). Based on these equations, a 2-ft reduction in mainstem stage will result in a reduction of 0.6 to 1.2 cfs in slough flows. This loss will mainly occur in the summer. The groundwater flow from the mainstem to other slough and side channel habitat areas will be affected in the same manner.

Groundwater recharge of slough aquifers will probably be reduced as overtopping of slough berms will occur less frequently due to reduced summer flows during filling.

Ice staging during the winter of filling will be similar to natural conditions and thus groundwater flow in sloughs will be similar to natural.

(iii) <u>Operation</u>

- <u>Mainstem</u>

Groundwater changes between Devil Canyon and Talkeetna during summer Stage I operation will be similar to those changes described between Watana and Devil Canyon. During winter, increased ice staging will occur during freeze-up and hence groundwater level will be increased from natural levels along ice covered sections of the mainstem. Groundwater levels upstream of the ice front will be less than those occurring in midwinter under natural conditions. However, groundwater levels will be greater than the minimum natural levels which occur in the fall prior to ice-staging.

- Sloughs and Peripheral Habitat

During winter in the Devil Canyon to Talkeetna reach, groundwater flow will be increased in sloughs and side channels downstream of Gold Creek adjacent to an ice-covered section of the river (Figure 8). As an ice cover forms at the project operation flows of about 9,000 cfs, the river will stage. The associated water level will be a few feet above normal winter water levels and will cause an increase in the groundwater table and thus an increase in groundwater flow.

Sloughs upstream of Gold Creek may be adjacent to open water sections of the river. Because monthly average flows will be between approximately 4,000 and 9,000 cfs in winter, the unstaged water level during project operation will be less than water levels during natural ice-staged conditions. Sloughs in this area may experience a decrease in groundwater flow in the winter compared to natural conditions. However, water levels upstream of the ice front will fluctuate less on an annual basis than during natural conditions, resulting in groundwater flows which will be more stable all year than for natural conditions.

In addition, the groundwater upwelling under project operation will be greater than the minimum natural upwelling rates which occur in the fall prior to ice-staging. Natural flows generally decline during the fall to near 5,000 cfs before an ice cover forms. This is the period of lowest groundwater flow. As Stage I discharges and water levels will remain higher than natural during this period, the minimum groundwater flow will be increased.

During summer, the mainstem-slough groundwater interaction will be similar to that during impoundment with the exception that the summer operational flows will be greater than the downstream flows during filling. Summer groundwater levels will thus be increased from filling levels.

(b) Stage II

(i) Construction

The construction of Devil Canyon will not modify the Watana operation or flows, and the groundwater conditions discussed under Watana operation will remain relevant during this period. Some local changes in groundwater levels in the immediate vicinity of the Devil Canyon damsite may occur due to dewatering of open and underground excavations.

(ii) Filling

No major groundwater changes are anticipated during the filling of the Devil Canyon reservoir; conditions are expected to remain similar to those identified for the filling of the Watana reservoir.

(iii) Operation

- Mainstem

Groundwater levels adjacent to the mainstem during Stage II operation will generally be less stable than for Stage I in summer (June through September), but more stable the rest of the year. During Stage II, higher mainstem flows will cause increased groundwater levels in late July to early September and late February to mid May. Groundwater level increases due to ice staging will not extend as far upstream as during Stage I as the river ice cover will form further downstream with Stage II. Groundwater levels adjacent to the ice-covered mainstem will also be slightly lower than for Stage I as winter flow releases will be less during Stage II.

- Sloughs and Peripheral Habitat Areas

Groundwater flows to sloughs and other peripheral habitat areas would reflect the flows and water levels in the mainstem as discussed for Stage I. Groundwater flow during the period when natural groundwater flow is the lowest (October) will generally be higher than Stage I and higher than natural (Figure 8). Winter ice cover will not extend as far upstream as in Stage I nor result in as high water levels. Therefore, groundwater flow in sloughs and side channels will be reduced from Stage I, but will still be higher than natural. Upstream of the ice front, the mainstem stage will be reduced from natural and will be similar to fall and spring levels, thus increasing the stability of groundwater flows.

(c) Stage III

(i) Construction

Groundwater changes from construction of Stage III will be similar to changes identified for Stage II operation as the mainstem flows for Stage II operation will be continued until Stage III filling commences.

(ii) Filling

- Mainstem

During filling, the groundwater levels along the mainstem will be reduced from July to September since excess flows normally released from Watana will be stored in the reservoir. Groundwater levels along the mainstem may be reduced by up to 2.5 ft near Gold Creek in August. Groundwater levels are expected to be more uniform during May to November as mainstem flows will be more stable during filling than during natural conditions.

- Sloughs and Peripheral Habitat Areas

The groundwater upwelling to sloughs will follow the same general pattern as the groundwater table along the mainstem. That is, groundwater upwelling will be more stable in the May-November period during filling of Stage III. Upwelling will be less than during normal operation in the July-September period. Groundwater upwelling during this period may be reduced by an average of 0.5 to 1.3 cfs based on relationships obtained for Sloughs 8A, 9, and 11.

(iii) Operation

Downstream groundwater level changes will be similar to those described for Stage I operation and will be confined to the river floodplain area. During winter, the extent of river covered with ice will be reduced from Stages I and II due to the warmer temperatures of the released water. Changes in groundwater conditions upstream and downstream of the ice front are discussed for Stage I operation.

5.0 IMPACT ANALYSIS

5.1 Altered Flow Regime

5.1.1 Summary of Physical Changes

(a) Stage I

(i) Filling

The changes in flow regime due to the filling of the Watana reservoir, Stage I, is discussed in Sections 2.1.2, 2.1.3, 4.1.1, and 4.4; key changes are summarized below:

- Flows at Gold Creek are expected to be at or slightly above the E-VI minimum flow requirements from May through September 1998.

- Minimum flows during the winter following the one summer of filling will be natural flows; flow levels may exceed natural flows during unit testing and commissioning.

(ii) Operation

Watana, Stage I operation and its effect on flow regime is discussed in Sections 2.1.4 and 4.1.1; major changes in flow regime are summarized below:

- The Stage I operational flow regime is scheduled to begin in the summer of 1999 and continue until the Devil Canyon dam is constructed and filling behind that dam begins.

- The Stage I operational flow regime will be more stable than natural flows, with lower flows and water levels than natural during summers and higher than natural flows (and water levels downstream of the ice front) during winters.

- The Stage I operational flows will normally exceed the flows during Stage I filling.

- Groundwater levels will be higher downstream of the ice front and similar upstream of the ice front compared to natural winter levels and lower than natural summer levels.

(b) Stage II

(i) Filling

The changes in flow regime due to the filling of the Devil Canyon reservoir are discussed in Sections 2.2.2, 2.2.3, and 4.1.1; key changes are summarized below:

- Filling of the Devil Canyon reservoir will be conducted in two distinct periods totaling 5 to 8 weeks in length.

- Downstream flows will be at or slightly above the E-VI minimum flow requirements during filling.

(ii) Operation

The changes in flow regime resulting from operation of the Devil Canyon reservoir are discussed in Sections 2.2.4 4.1.1, and 4.4; changes which cause impacts to fish resources are summarized below:

- Watana Stage I will be operated as a peaking plant and Devil Canyon operation will re-regulate Watana flows.

- Stage II operation will generally result in higher than natural winter flows and water levels and lower than natural summer flows and water levels; flood peaks will be considerably reduced.

- Stage II operation flows will be more uniform during the year than flows during Stage I operation.

- Groundwater levels will be higher in summer than Stage I although lower than natural summer levels; in winter, groundwater levels will be lower than Stage I and higher than natural levels downstream of the ice front.

(c) <u>Stage III</u>

(i) <u>Filling</u>

The changes in flow regime due to the filling of the Stage III Watana reservoir are discussed in Sections 2.3.1 and 4.1.1; changes which cause impacts to fish resources are presented below:

- Filling will take between three and seven years, beginning in 2011.

- filling flows will generally be near the minimum flow requirements during the summer.

(ii) <u>Operation</u>

The changes in flow regime due to the Stage III operation are discussed in Sections 2.3.4, 4.1.1, and 4.4; changes which cause impacts to fish resources are presented below:

- Watana will operated as a peaking plant and Devil Canyon as a baseloaded plant.

- The flow regime during early Stage III operation will be very similar to Stage II flow regime, with higher than natural winter flows and water levels and lower than natural summer flows and water levels; flood peaks will be considerably reduced.

- The flow regime will become more uniform as Stage III progresses.

- Groundwater levels will be higher than Stage II and lower than natural levels in summer; in winter, the groundwater levels will be higher than natural levels.

5.1.2 Effects on Species/Habitats

(a) Access and Passage

(i) Sloughs and Side Channels

Access and passage of fish into sloughs and side channels is provided through the interaction of channel morphology, mainstem flow, and local flow. The altered flow regime during project filling and operation may affect the channel morphology. Sloughs and side channels may degrade up to 0.3 ft; potential mainstem degradation may range between 1.0 and 1.5 ft in the middle Susitna River (Harza-Ebasco 1985a). This impact assessment has been prepared assuming that bed degradation will be minor. If the bed does degrade, a reevaluation will be done at that time as described in Section 5.2.

The project flows will be less than natural flows during the period of upstream migration of salmon adults. Access into sloughs and side channels will be reduced.

- Primary Evaluation Species

-- Chum Salmon Spawning Adults

. Stage I

.. Filling

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, Sautner et al. 1984). However, a quantitative assessment of the availability of passage conditions during reservoir filling using this information is not possible for average and wet years since the available flow data and 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 occurring naturally in August and September for average and wet weather conditions that the frequency of successful passage conditions would be reduced. In a dry year with 8,000 cfs E-VI minimum flows during the spawning period and assuming no precipitation (no variability around the minimum flow value), passage would be restricted beyond Passage Reach I in Slough 8A, Passage Reach IV in Slough 9A, Passage Reach I in Slough 11, and Passage Reach VI in Side Channel 21.

.. Operation

Passage conditions within sloughs and side channels will be restricted by the Stage I operation flow regime. Stage I - 1996 project flows during the spawning season for chum salmon (August 12 - September 15) would be less than natural flows (Section 4.1.1). 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 within sloughs and side channels 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 reaches of each slough was estimated for the specified time period by selecting the exceedance value associated with the minimum mainstem discharge that provided passage either through backwater, controlling breaching flows or local flow from groundwater infiltration (excluding direct surface runoff). The appendix presents the passage exceedance evaluation for each week and for the entire period from week 45 to 49 for the major chum producing sloughs. The results of these analyses are discussed for individual sloughs below.

... Slough 8A

Relative Utilization

During the 1981-1985 studies, the mean peak count of chum salmon in Slough 8A was 442 (range: 37-917). The mean estimated total escapements to the slough were 1,029 chum (range: 112-2383). Slough 8A mean estimated total chum escapement comprised 15.7 percent of the mean estimated total chum escapement (6,552) to all sloughs in the middle Susitna River.

Impact Mechanism

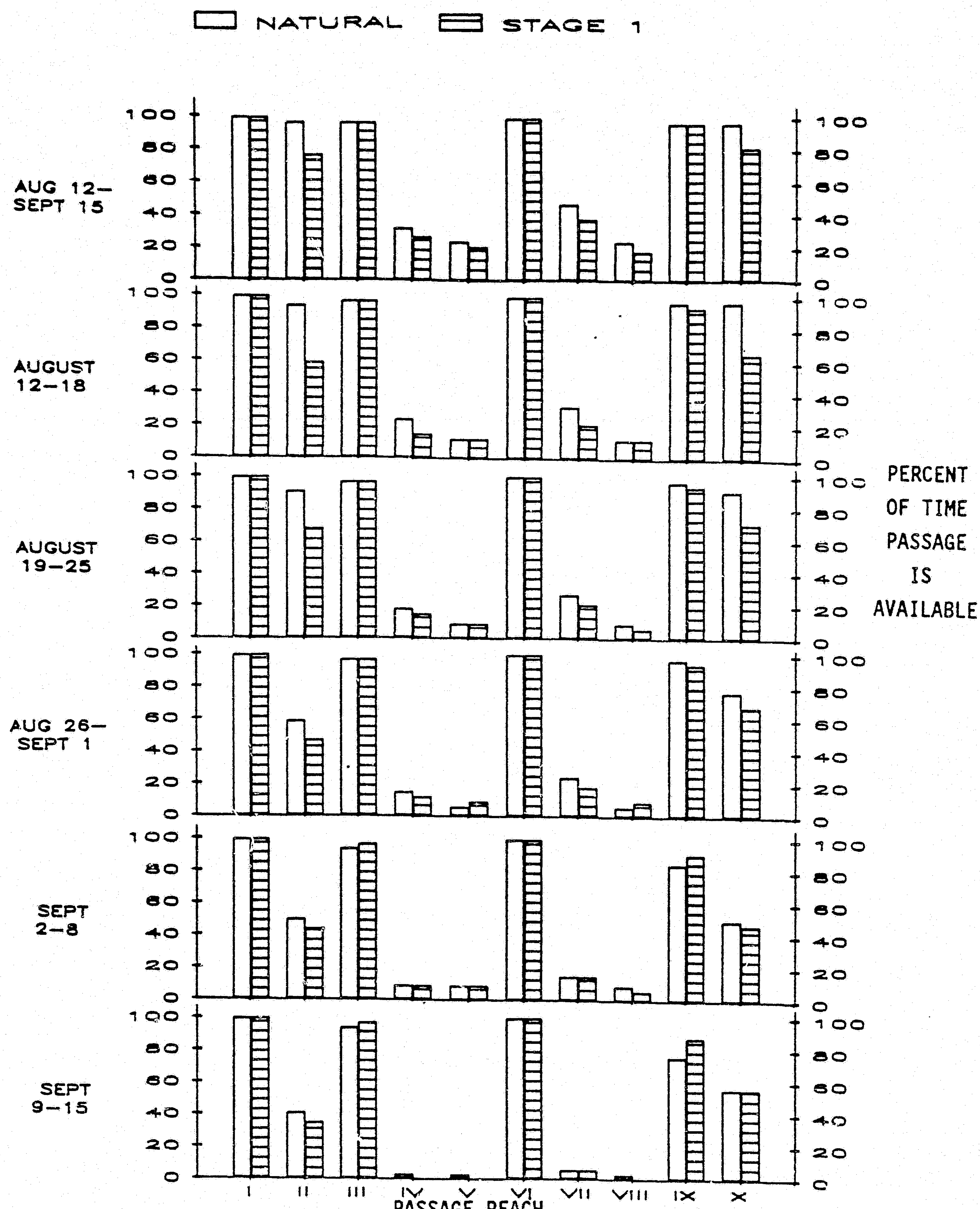
The frequencies of occurrence of successful passage conditions at each passage reach of Slough 8A under natural and Stage I flows are graphically depicted for each week and for all weeks combined of the spawning period in Figure 26. The mainstem discharges for passage considering backwater, local flow and breaching effects and the passage frequency values are listed for each week and for the entire period in Appendix Tables 1 to 6.

Under natural and Stage I 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 I 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 discharges required for successful passage at Slough 8A 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.

... Slough 9-9B

Relative Utilization

During the 1981-1985 studies, the mean peak count of chum salmon in Slough 9 (including 9B) was 269 (range: 94-423). The mean estimated total escapements to the slough was 449 chum (range: 118-645). Slough 9 and 9B mean estimated total chum escapement comprised 6.9



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Slough 8A.
FIGURE 26

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

percent of the mean estimated total chum escapement (6,552) to all sloughs in the middle Susitna River.

Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 9 under natural and Stage I flows are graphically depicted for each week and for all weeks of the spawning period combined in Figure 27. The mainstem discharges for passage and the 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 Stage I for each week and for the entire period would not likely be sufficient to alter present utilization patterns. The frequency of passage through passage reaches IV and V would be decreased slightly from natural conditions to Stage I conditions.

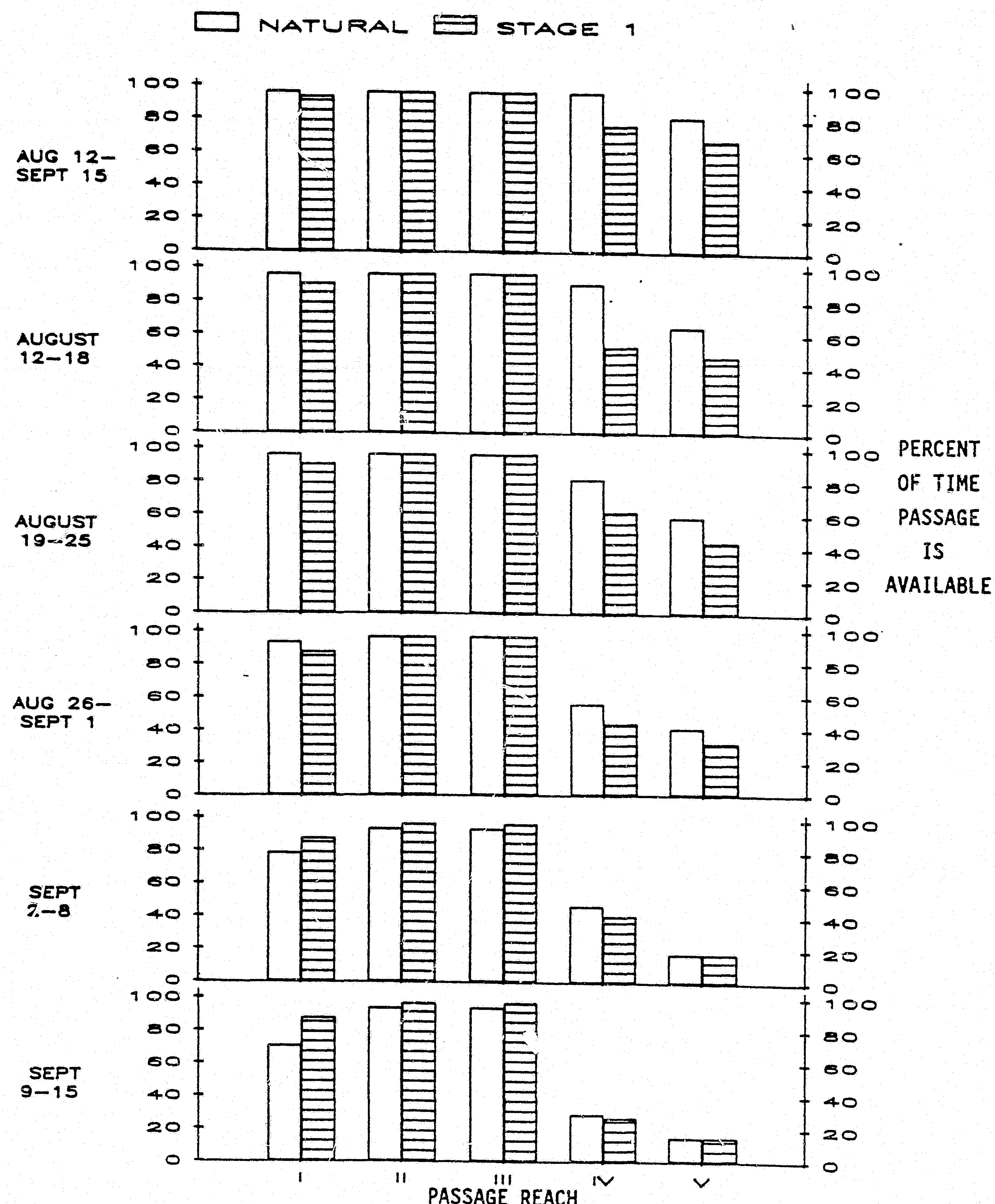
... Slough 9A

Relative Utilization

During the 1981-1985 studies, the mean peak count of chum salmon in Slough 9A was 168 (range: 105-303). The mean estimated total escapements to the slough were 227 chum (range: 86-528). Slough 9A mean estimated total chum escapement comprised 3.5 percent of the mean estimated total chum escapement (6,552) to all sloughs in the middle Susitna River.

Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Slough 9A under



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Slough 9.
FIGURE 27

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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natural and Stage I flows are graphically depicted for each week and for all weeks of the spawning period combined in Figure 28. The mainstem discharges for passage and frequency values are listed for each week and for the period in Appendix Tables 13 to 18.

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.

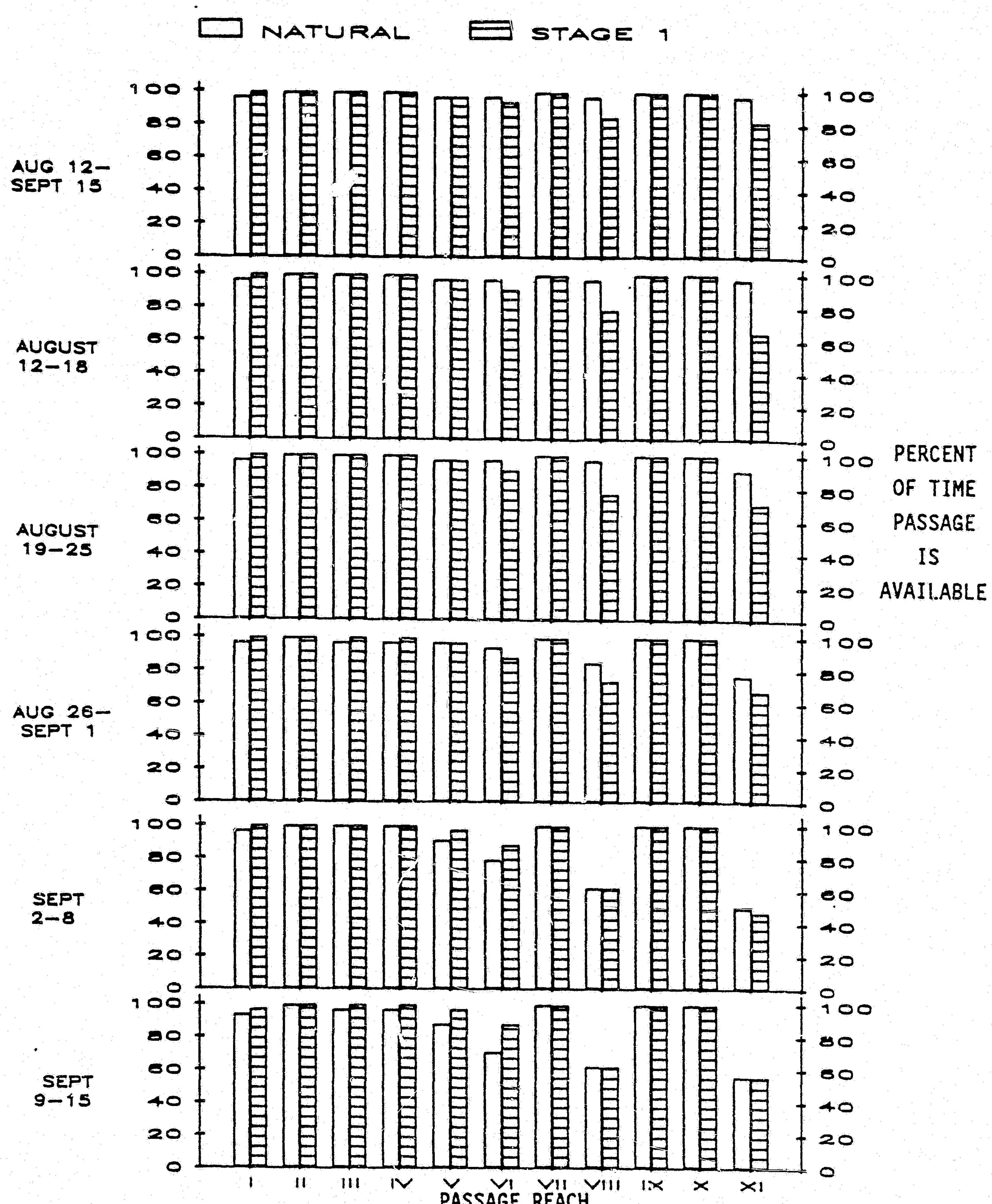
... Slough 11

Relative Utilization

During the 1981-1985 studies, the mean peak count of chum salmon in Slough 11 and Upper Side Channel 11 was 660 (range: 238-1,586). The mean estimated total escapements to the slough and upper side channel was 1,626 chum (range: 674-3,418). Slough 11 and Upper Side Channel 11 mean estimated total chum escapement comprised 24.8 percent of the mean estimated total chum escapement (6,552) to all 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 I flows are graphically depicted for each week and for all weeks combined of the spawning period in Figure 29. The mainstem discharges for passage and frequency values are listed for each week and for the period in Appendix Tables 19 to 24.



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Slough 9A.
FIGURE 28

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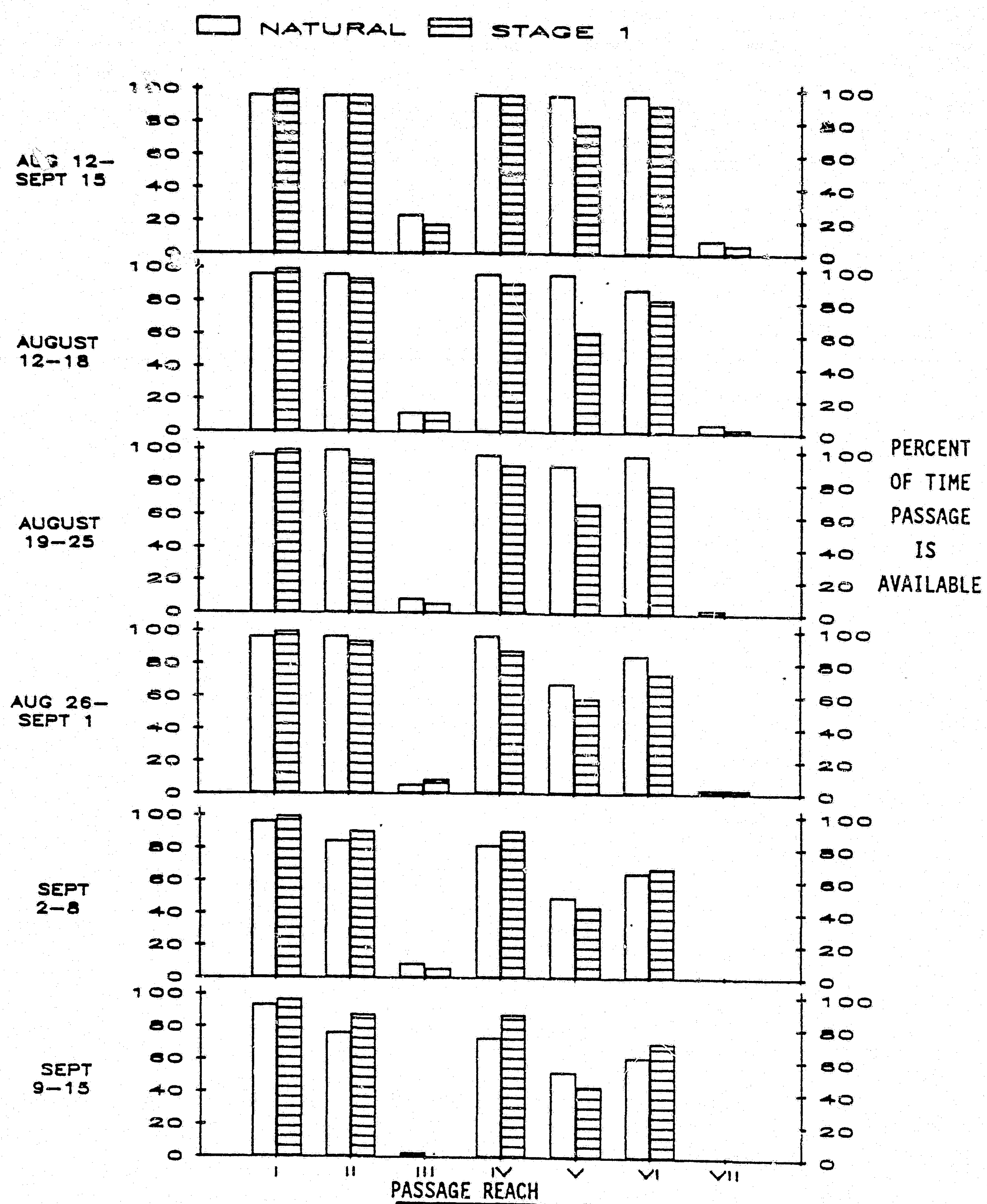

Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Slough 11.
FIGURE 29

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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. The local flows required for successful passage occur more frequently under natural conditions than under Stage I conditions especially early in the spawning season (week 45). Frequencies of passage during Stage I become more similar to natural frequencies later in the spawning season (week 49).

... Upper Side Channel 11

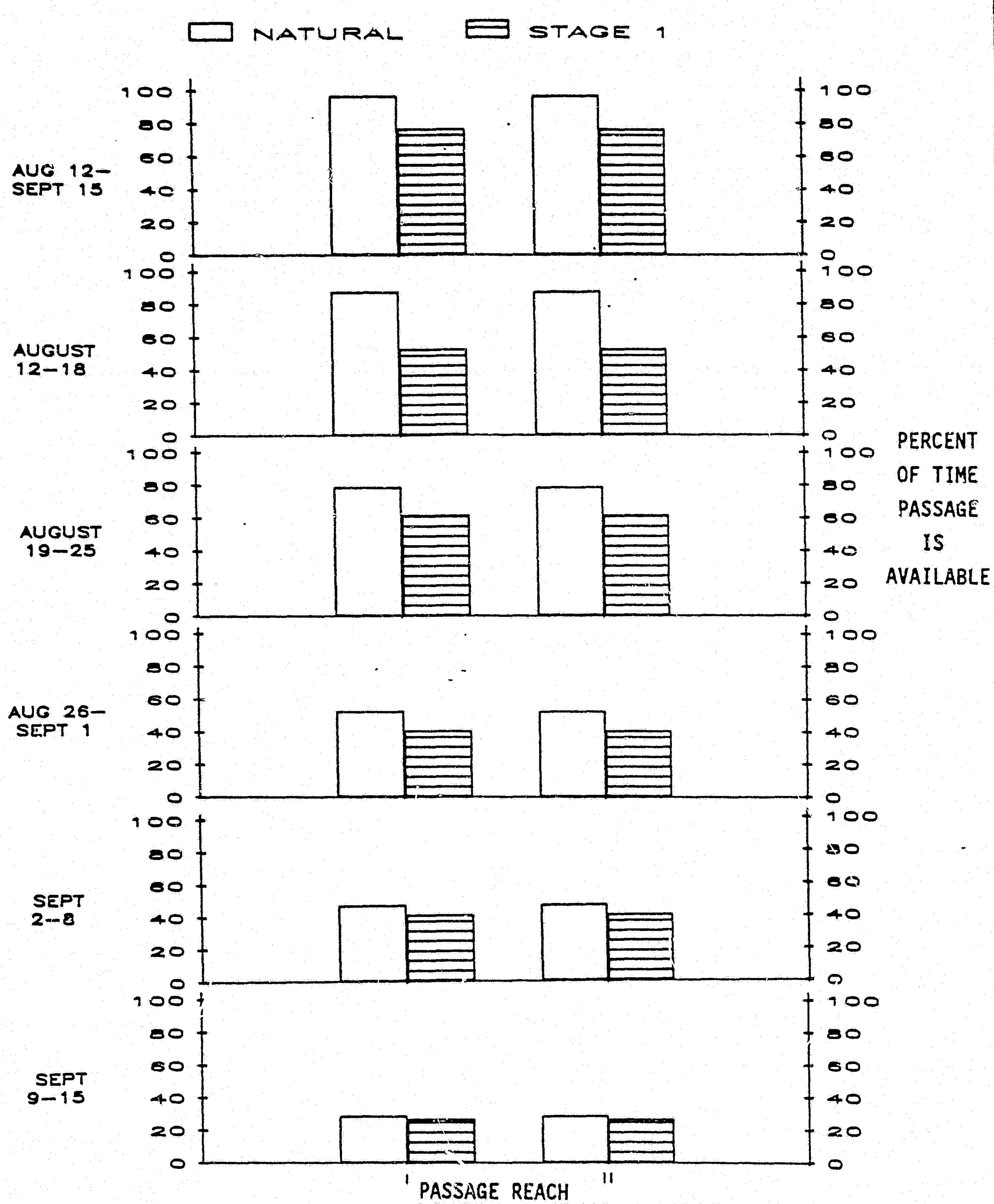
Relative Utilization

(See Slough 11)

Impact Mechanism

The frequencies of occurrence of successful passage conditions at each passage reach of Upper Side Channel 11 under natural flows and Stage I flow are graphically displayed for each week and all weeks of the spawning period in Figure 30. 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).

The difference in the percent of time passage is available under natural and Stage I project flows based on breaching flows would not likely affect the utilization of this site to a large degree.



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Upper Side Channel 11. FIGURE 30

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... Slough 21

Relative Utilization

During the 1981-1985 studies, the mean peak count of chum salmon in Slough 21 and Side Channel 21 were 792 (range: 274-2,354). The mean estimated total escapement to the slough and side channel was 1,612 chum (range: 481-4,245). Slough 21 and Side Channel 21 and Side Channel 21 mean estimated total chum escapement comprised 24.6 percent of the mean estimated total chum escapement (6,552) to all sloughs in the middle Susitna River.

Impact Mechanism

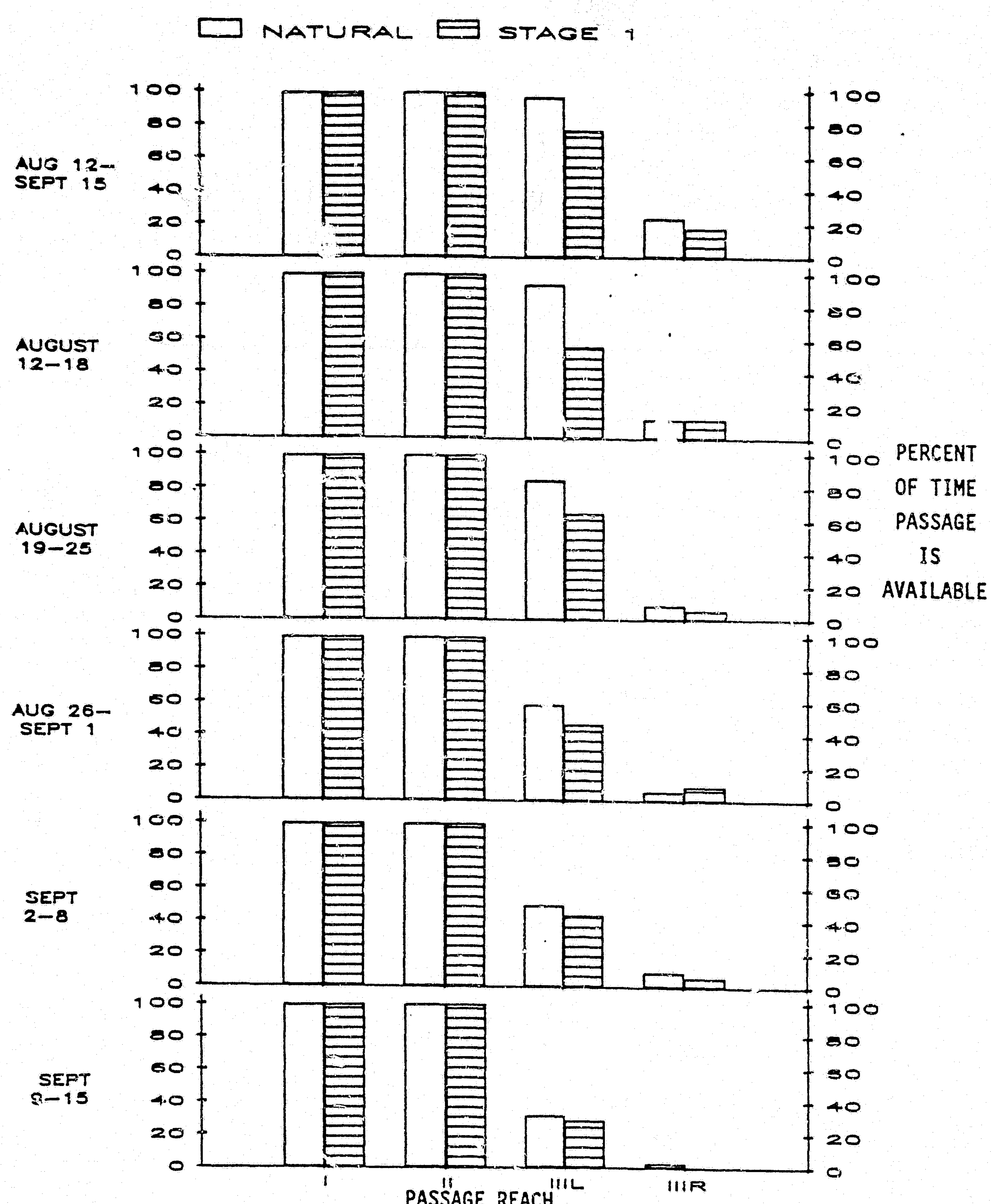
The frequencies of occurrence of successful passage conditions at each passage reach of Slough 21 under natural flows and Stage I flows are graphically displayed for each week and for all weeks combined of the spawning period in Figure 31. The mainstem discharges for passage and the frequency values are listed for each week and for the period in Appendix Tables 25 to 30.

Project flows would reduce the frequency of passage slightly at passage reaches IIIL and IIIR. Passage at other passage reaches would not be reduced from natural conditions due to project flows.

... Side Channel 21

Relative Utilization

(See Slough 21)



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Slough 21.
FIGURE 31

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Impact Mechanism

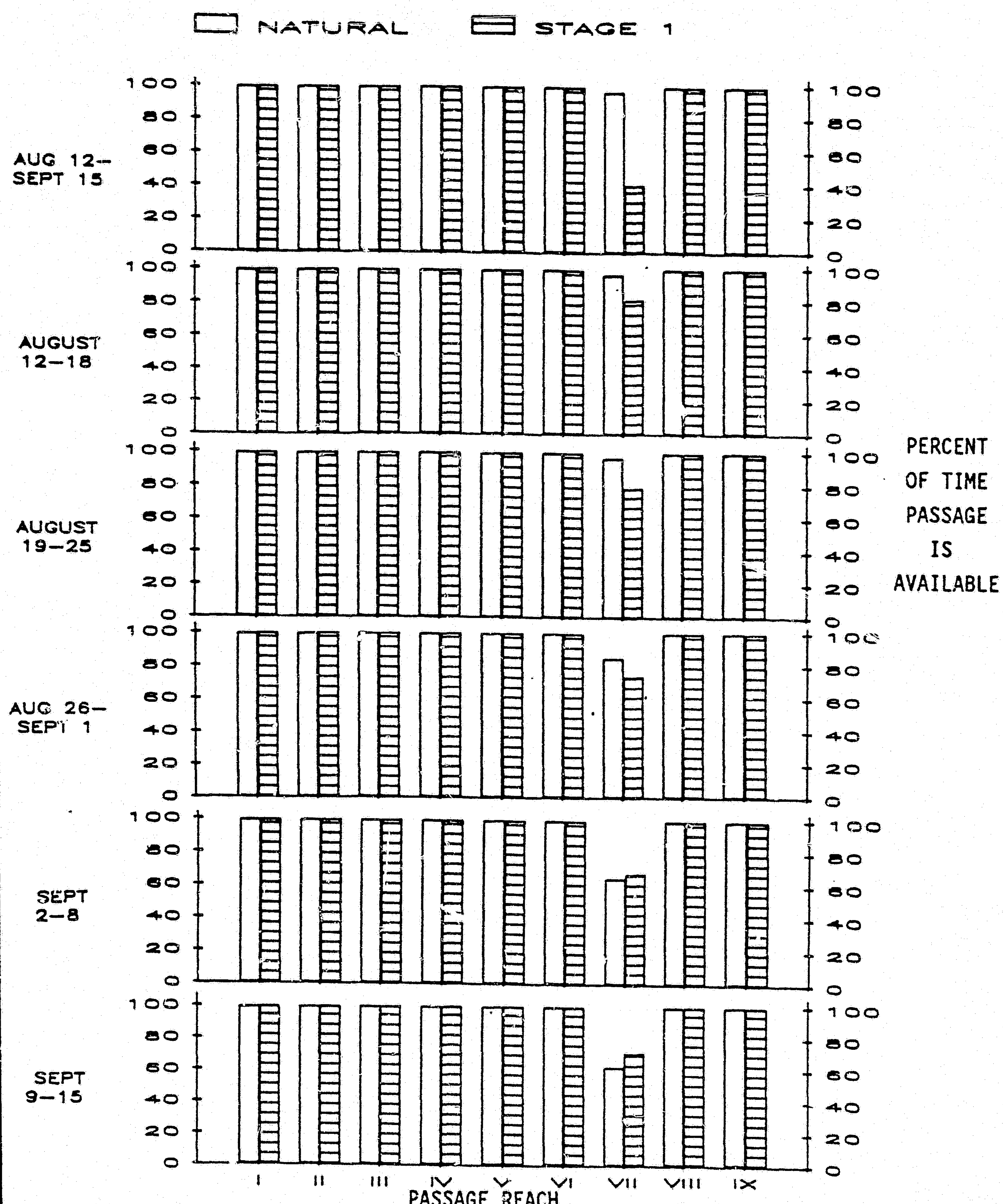
The frequencies of occurrence of passage conditions at each passage reach of Side Channel 21 under natural flow and Stage I flows are graphically displayed for each week and for all weeks combined of the spawning period in Figure 32. The mainstem discharges and the frequency values are also listed for 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 passage at Passage Reach VI although no other passage reach would be affected by project flows.

Stage II and III

If slough modification measures are implemented under Stage I, the natural conditions would be altered and consequently a comparison of the percent of time passage occurs under natural and Stage II and III flows is not feasible. The mitigation plan (Section 6.0) addresses the frequency of passage which would be available following slough modification.

There is also the possibility that the patterns of utilization of different habitat types may change during this time without a net decrease in productivity. Attempting to assess impacts for Stages II and III 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.



Percent of time passage is possible under natural and Stage I mainstem discharges for weeks between August 12 and September 15 at Side Channel 21. FIGURE 32

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-- Chinook Salmon Rearing Juveniles

. Stage I

Passage into sloughs and side channels is required for chinook salmon juveniles to access rearing habitat within the sloughs and side channels. The Case E-VI minimum flows are expected to provide adequate depths and velocities to allow passage of chinook salmon rearing juveniles.

. Stages II and III

Passage conditions into sloughs and side channels for chinook salmon rearing juveniles during Stages II and III are expected to remain similar to conditions during Stage I.

- Secondary Evaluation Species

-- Chum, Sockeye, Chinook, and Pink Salmon Outmigrant Juveniles

. Stage I

Flows during filling and operation would reduce the frequency and amplitude of spring runoff flows that can act as stimuli for outmigration for juvenile salmon in sloughs and side channels. These reductions are not expected to impact seaward migration because other factors such as photoperiod, water temperature, and physiological condition also stimulate outmigration.

. Stages II and III

No additional impacts are anticipated for Stages II and III as the flow regimes will be similar to Stage I.

-- Sockeye and Pink Salmon Spawning Adults

. Stage I

Sockeye and pink salmon are smaller and generally have better swimming performances than chum salmon (Bell 1973, Scott and Crossman 1973). Therefore, the analysis of passage conditions for chum salmon provides a conservative estimate of the passage conditions within sloughs and side channels for sockeye and pink salmon. Hence, under similar flow conditions it is expected that sockeye and pink salmon will have less difficulty gaining access to spawning areas in sloughs than chum salmon.

. Stages II and III

The flow regimes imposed by Stages II and III will not be substantially changed from Stage I. Access conditions are expected to be similar to those described for Stage I.

(ii) Tributaries

Access and passage of fish into tributaries is controlled by conditions at the confluence of the tributary and the mainstem. The altered flow regime during project filling and operation will affect the configurations of the tributary mouths. The lower mainstem stage resulting from reduced flows will initially perch the tributary mouths above the mainstem and inhibit the passage of fish into tributaries (WCC 1985b). Based on the analyses by R&M Consultants (1982), Trihey (1983) and Harza-Ebasco (1985a), most tributaries in the middle Susitna River will rapidly adjust to the lower mainstem flows without impeding fish access (WCC 1985b).

- Primary Evaluation Species

-- Chum Salmon Spawning Adults

. Stage I

Chum salmon access into important spawning areas within the tributaries may be slightly reduced by the perching of tributary mouths resulting from the lower than natural summer flows associated with project filling and operation. However, tributary mouths are expected to be downcut rapidly and an equilibrium condition will be reestablished. The flow regime will be more stable than previously and promote a rapid readjustment of tributary mouth configuration. The upstream passage of salmon is not likely to be restricted under the proposed project flow regime (Trihey 1983).

. Stage II and III

Passage conditions in tributary mouths are expected to be similar to conditions established during Stage I following the downcutting of triburary mouths.

- Secondary Evaluation Species

-- Chinook, Chum, Pink, and Coho Salmon Returning Adults

. Stages I, II, and III

Chinook, pink, and coho salmon spawn almost exclusively in tributaries. Passage of salmon into tributaries is not expected to be impeded as the tributary mouth configurations are likely to adjust rapidly to the lower mainstem stage as described for chum salmon.

-- Resident Salmonids

. Stages I, II, and III

Arctic grayling, Dolly Varden, and rainbow trout generally migrate from tributary habitats into mainstem overwintering habitat and return into tributaries in the spring for summer rearing and spawning. Access into tributaries is expected to be provided by naturally occurring high flow events in the spring. Tributary mouths will likely downcut rapidly during spring high flows and passage of resident salmonids is not expected to be restricted.

(iii) Mainstem

Minimum project flows at Gold Creek of 9,000 cfs, or 8,000 cfs in a dry year (Section 2.1.2), are expected to be sufficient to maintain fish passage in the mainstem. Under natural conditions, a discharge of 8,000 cfs occurs in the fall prior to the minimum natural flow of about 5,000 cfs (Section 4.4.1). A study of water elevations at several middle Susitna River cross sections found that depths in the mainstem typically remain in excess of 5 ft at a discharge of 8,000 cfs (R&M Consultants 1982).

- Primary Evaluation Species

-- Chum Salmon Spawning Adults

. Stages I, II, and III

The proposed minimum summer flows of 9,000 cfs (8,000 cfs in a dry year) for all stages of the project are expected to provide depths sufficient for adult chum salmon to access mainstem spawning areas.

-- Chinook Salmon Rearing Juveniles

. Stages I, II, and III

Passage in the mainstem is important to allow chinook salmon juveniles to move from natal tributaries downstream to other rearing or overwintering areas throughout the summer. Chinook salmon age 1+ juveniles outmigrate during the spring. Project flows will be sufficient in the spring and summer to maintain downstream passage of juveniles in the mainstem of the Susitna River.

- Secondary Evaluation Species

-- Chinook, Chum, Sockeye, Coho, and Pink Salmon Returning Adults

. Stage I

Minimum summer flows are not expected to impede the upstream migration of adult salmon in the mainstem of the middle Susitna River.

Adult salmon generally do not migrate upstream of the Devil Canyon rapids (RM 152). However, a few chinook salmon (approximately 20 spawning pairs) negotiate the rapids each year and spawn primarily in Cheechako and Chinook creeks (ADF&G 1985a). The upstream movement through the rapids occurs during July.

Based on a comparison of natural and simulated with-project flows at Gold Creek (RM 136.7) it is expected that the lower than natural with-project flows during July will facilitate the upstream movement of chinook salmon through the rapids. In 1982, 1983, and

1984 the mean monthly July flows at Gold Creek were 24,120 cfs, 21,150 cfs, and 23,400 cfs, respectively. Minimum daily flows in July of 1982, 1983, and 1984 were 16,600 cfs, 16,400 cfs and 18,600 cfs, respectively. Based on flow records since 1951, the average mean monthly July flow at Gold Creek is 24,390 cfs, with a minimum monthly flow of 16,100 cfs. In contrast, the estimated mean monthly July flow during Stage I filling will be 12,740 cfs, with a minimum flow of 9,000 cfs (8,000 cfs during dry years). During Stage I operation, the mean monthly July flow at Gold Creek is expected to be 14,490 cfs, with a minimum flow of 9,000 cfs (8,000 cfs during dry years). Because of the lower flows during Stage I filling and operation, velocities will also be reduced somewhat. This should increase the number of chinook salmon able to negotiate the rapids. In addition, it is probable that other salmon species may gain access to spawning habitats within and upstream of Devil Canyon. Hence, during Stage I filling and operation an expansion of the use of spawning habitats upstream of Devil Canyon is expected for all salmon species.

. Stages II and III

Minimum summer flows are not expected to impede the upstream movements of adult salmon in the middle Susitna River. Any gains in the amount of spawning habitat within and upstream of Devil Canyon (see previous section) will be lost due to construction of the Devil Canyon dam. Additionally, the present utilization of spawning habitat by chinook salmon within and upstream of Devil Canyon will be blocked by the Devil Canyon dam.

1984 the mean monthly July flows at Gold Creek were 24,120 cfs, 21,150 cfs, and 23,400 cfs, respectively. Minimum daily flows in July of 1982, 1983, and 1984 were 16,600 cfs, 16,400 cfs and 18,600 cfs, respectively. Based on flow records since 1951, the average mean monthly July flow at Gold Creek is 24,390 cfs with a minimum monthly flow of 16,100 cfs. In contrast, the estimated mean monthly July flow during Stage I filling will be 12,740 cfs, with a minimum flow of 9,000 cfs (8,000 cfs during dry years). During Stage I operation, the mean monthly July flow at Gold Creek is expected to be 14,490 cfs, with a minimum flow of 9,000 cfs (8,000 cfs during dry years). Because of the lower flows during Stage I filling and operation, velocities will also be reduced somewhat. This should increase the number of chinook salmon able to negotiate the rapids. In addition, it is probable that other salmon species may gain access to spawning habitats within and upstream of Devil Canyon. Hence, during Stage I filling and operation an expansion of the use of spawning habitats upstream of Devil Canyon is expected for all salmon species.

. <u>Stages II and III</u>

Minimum summer flows are not expected to impede the upstream movements of adult salmon in the middle Susitna River. Any gains in the amount of spawning habitat within and upstream of Devil Canyon (see previous section) will be lost due to construction of the Devil Canyon dam. Additionally, the present utilization of spawning habitat by chinook salmon within and upstream of Devil Canyon will be blocked by the Devil Canyon dam.

-- Chum, Pink, Coho, and Sockeye Salmon Outmigrant Juveniles

. Stages I, II, and III

Project flows will be sufficient to provide passage for outmigrating juveniles in the mainstem.

-- Resident Salmonids

. Stages I, II, and III

During overwintering of Arctic grayling, Dolly Varden, and rainbow trout, in the mainstem, project flows will be greater than natural winter flows. The higher flows will provide depths greater than those occurring naturally. Although velocities in the mainstem will be correspondingly greater, passage is not expected to be restricted by velocity requirements as the flows will not exceed natural spring flows when resident salmonids migrate to tributaries.

-- Burbot

. Stages I, II, and III

Burbot primarily utilize mainstem and mainstem associated habitats. Passage within the mainstem is not expected to be restricted for burbot.

(b) Spawning/Incubation

(i) Mainstem

Mainstem habitat is comprised of those portions of the middle Susitna River that normally convey streamflow throughout the year. Few salmon spawn in the mainstem. Of those that do, chum salmon predominate. Mainstem spawning appears to be limited by the armored streambed, high velocities, and infrequent areas of upwelling.

- Primary Evaluation Species

-- Chum Salmon Spawning Adults

The amount of available mainstem spawning habitat for chum salmon remains relatively unchanged over a wide range of mainstem discharge, except for a slight increase in habitat at mainstem discharges of approximately 14,000 to 15,000 cfs (Figure 33). Hence, as some areas of spawning habitat are lost due to changing mainstem discharges, others are usually gained.

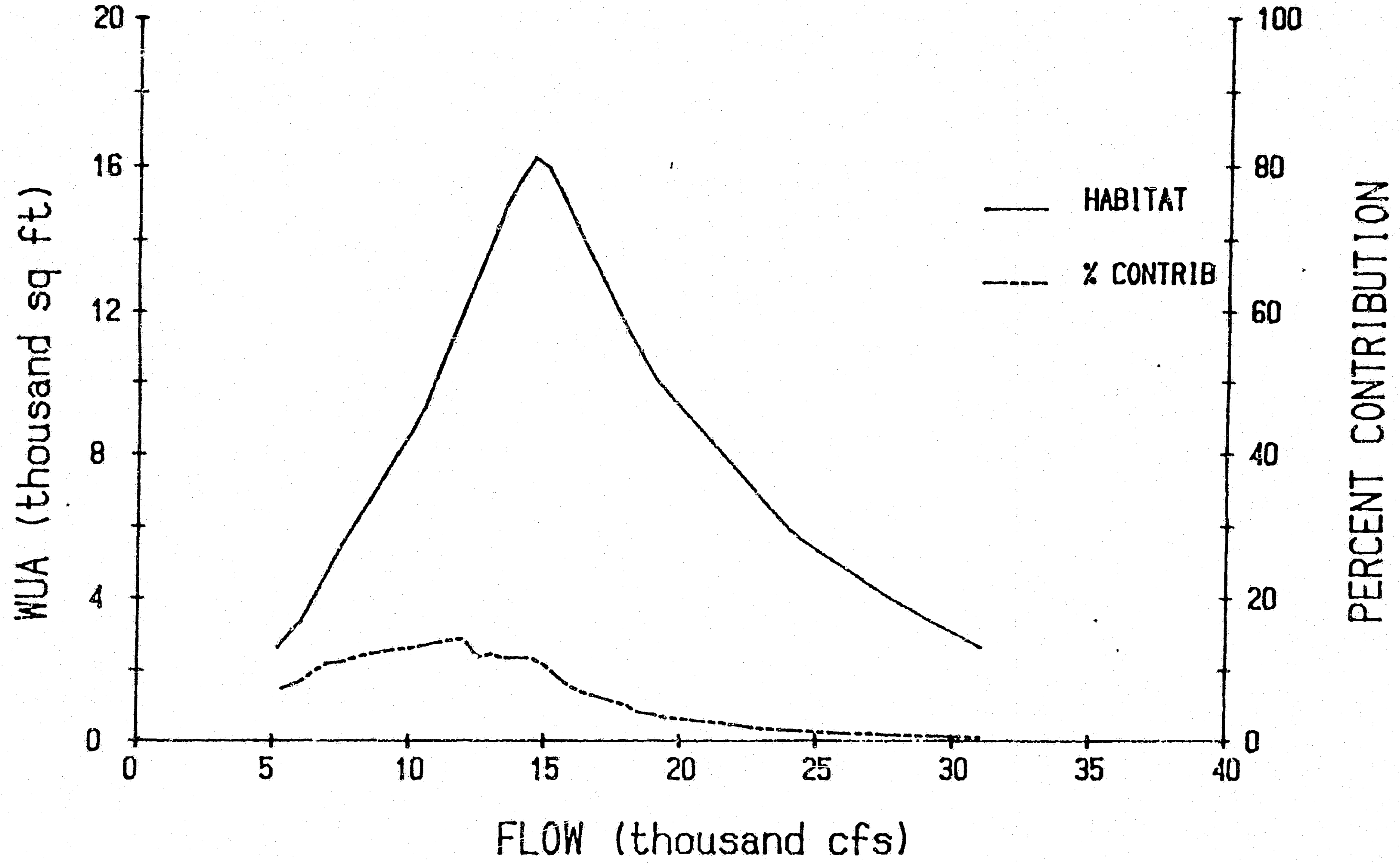
. Stage I

.. Filling

The available spawning habitat in mainstem margins for dry, average, and wet years during Stage I filling is presented in Table 10. If a dry year occurs during the filling period, spawning habitat will be reduced by approximately 50 percent in August and 65 percent in September. If an average year occurs during the filling period, spawning habitat will be increased by about 75 percent in August, but decreased by almost 70 percent in September. An increase in available spawning habitat in August and subsequent decrease in September is expected if a wet year occurs during filling.

.. Operation

Habitat availability in mainstem margins under natural and Stage I flows is compared in seasonal habitat



Chum salmon spawning habitat response curve and percent contribution to total available habitat of mainstem areas in the middle Susitna River.

FIGURE 33

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Table 10. Estimated change in chum spawning habit-´ (WUA) in mainstem margins due to filling of the Watana - Stage I Reservoir.

Month	Discharge (cfs) Natural	Discharge (cfs) Filling	Chum Spawning WUA (sq ft) Natural	Chum Spawning WUA (sq ft) Filling	Chum Spawning WUA (sq ft) % Change
Dry Year					
August	17,392	8,000	12,379	6,120	-50.56
September	10,422	5,800	9,171	3,181	-65.31
Average Year					
August	22,228	12,415	7,362	12,929	75.62
September	13,221	6,800	14,466	4,484	-69.00
Wet Year					
August	25,236	15,505	5,207	15,285	193.55
September	15,124	6,800	15,797	4,484	-71.61

duration curves and weekly habitat time series plots (Figures 34 and 35). During Stage I operation, a slight increase in available spawning habitat will occur throughout much of the spawning season.

The contribution of mainstem margins to the habitat availability provided by all groups for natural and Stage I operation is shown in Figure 36. A slight increase in percent contribution is expected during August, whereas, the range of percent contribution is expected to be similar to natural conditions during September.

. Stage II

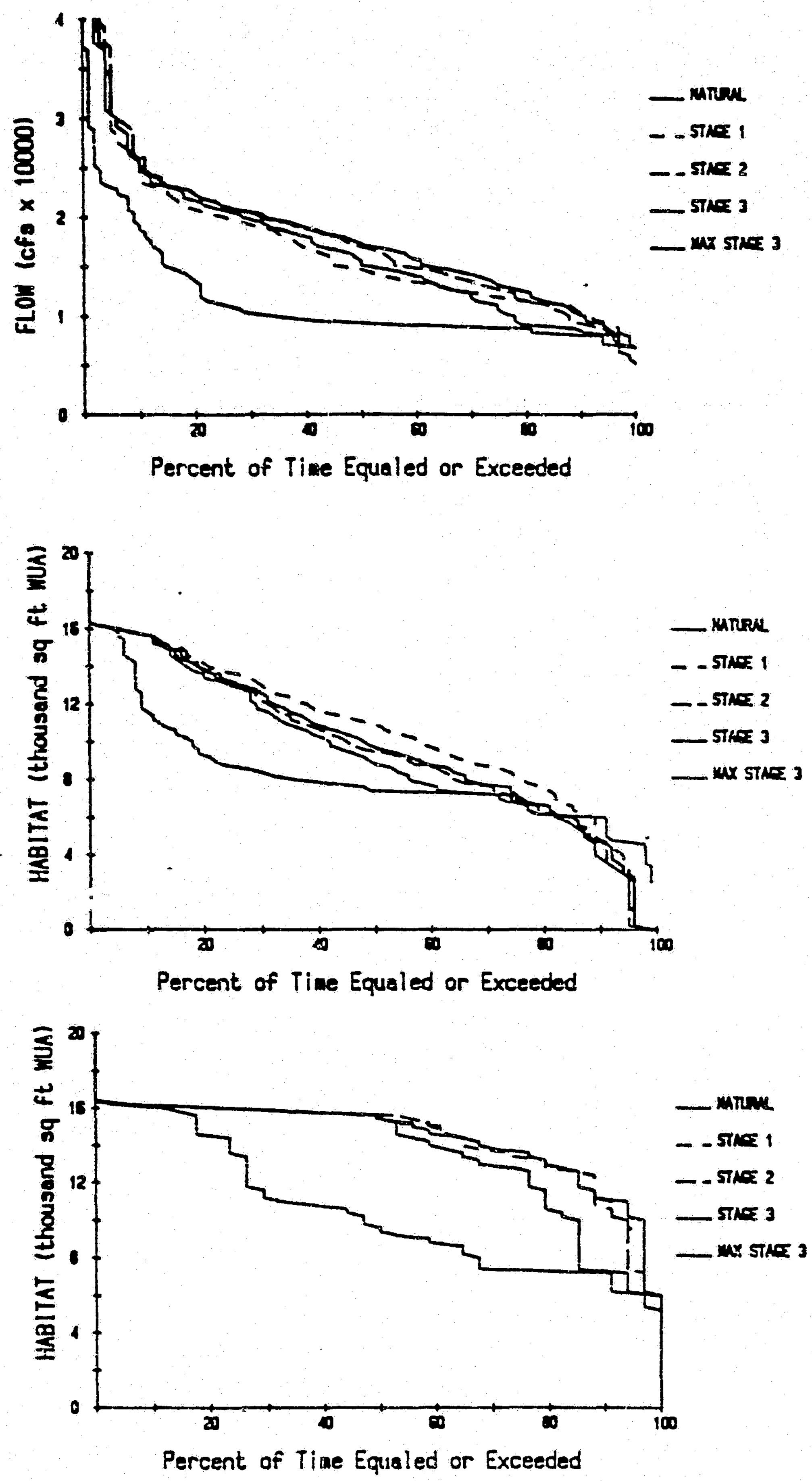
.. Filling

Filling flows for Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

.. Operation

Habitat availability in mainstem margins under natural and Stage II flows is compared in seasonal habitat duration curves and weekly time series plots (Figure 34 and 37). During mid-August a slight increase in available spawning habitat is expected 50 percent of the time, while in late August a decrease of up to 40 percent in available spawning habitat is expected. During the remainder of the spawning season, habitat availability is expected to be similar to natural.

The contribution of mainstem margins to the habitat availability provided by all groups for natural and Stage II operation is shown in Figure 38. The range of



Flow duration curve (upper) and seasonal (middle) and maximum weekly (lower) chum spawning habitat duration curve for mainstem.

FIGURE 34

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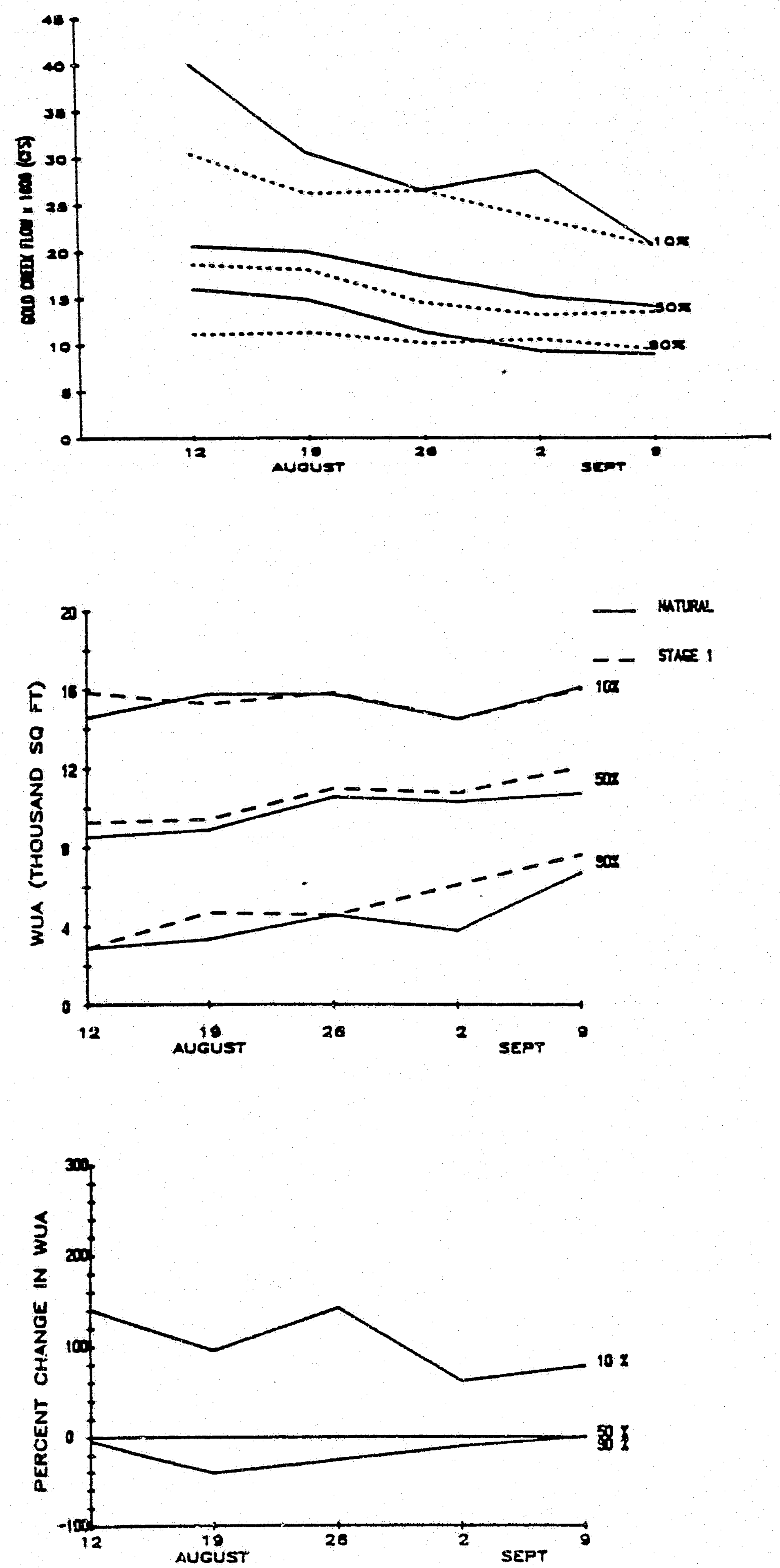

Mean weekly discharge (upper), chum spawning WUA for mainstem (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 35

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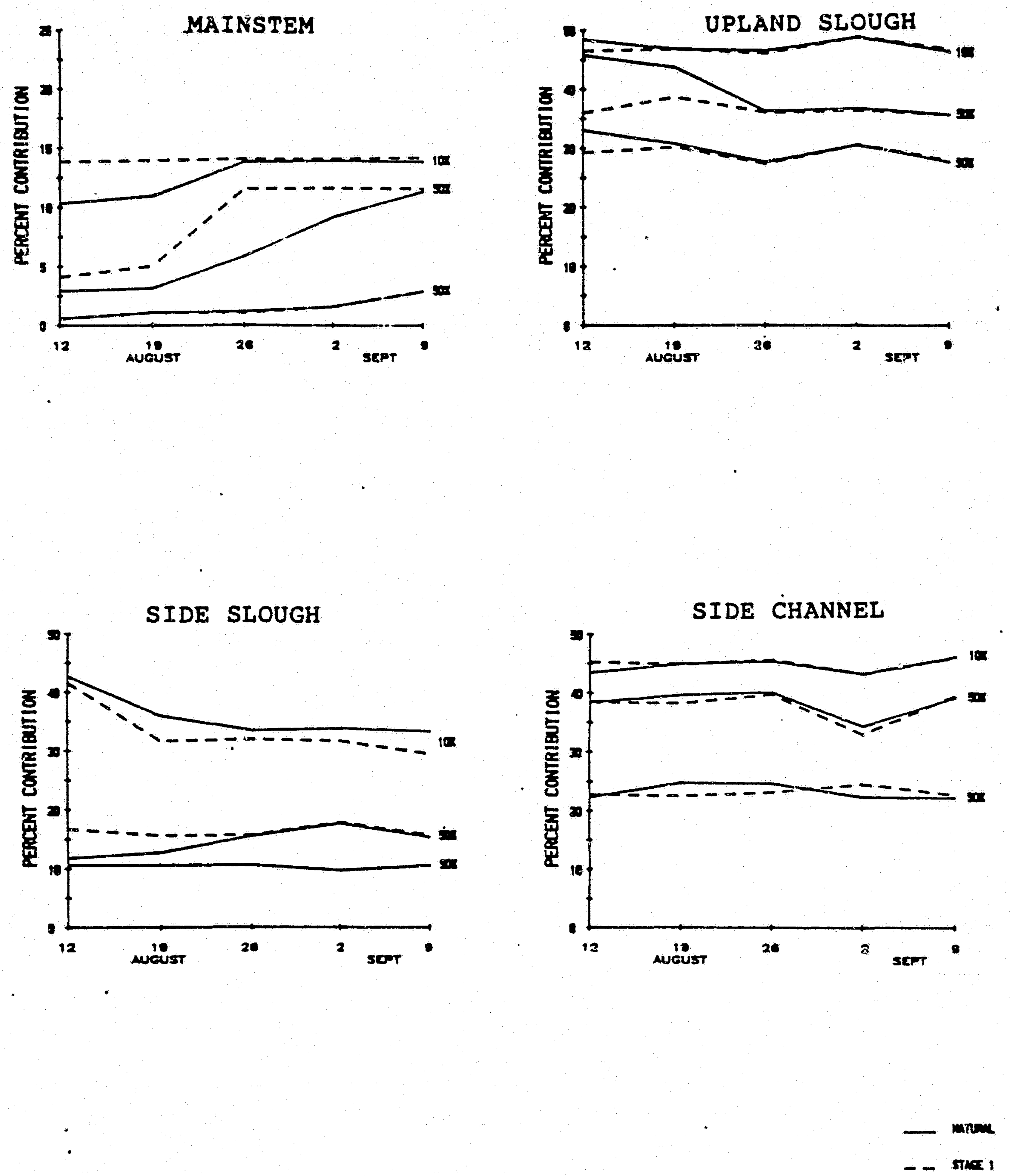

Percent contribution of chum spawning habitat in mainstem, side channels, side sloughs, and upland sloughs to total habitat during Stage I exceeded 90, 50 and 10 percent of the time.

FIGURE 36

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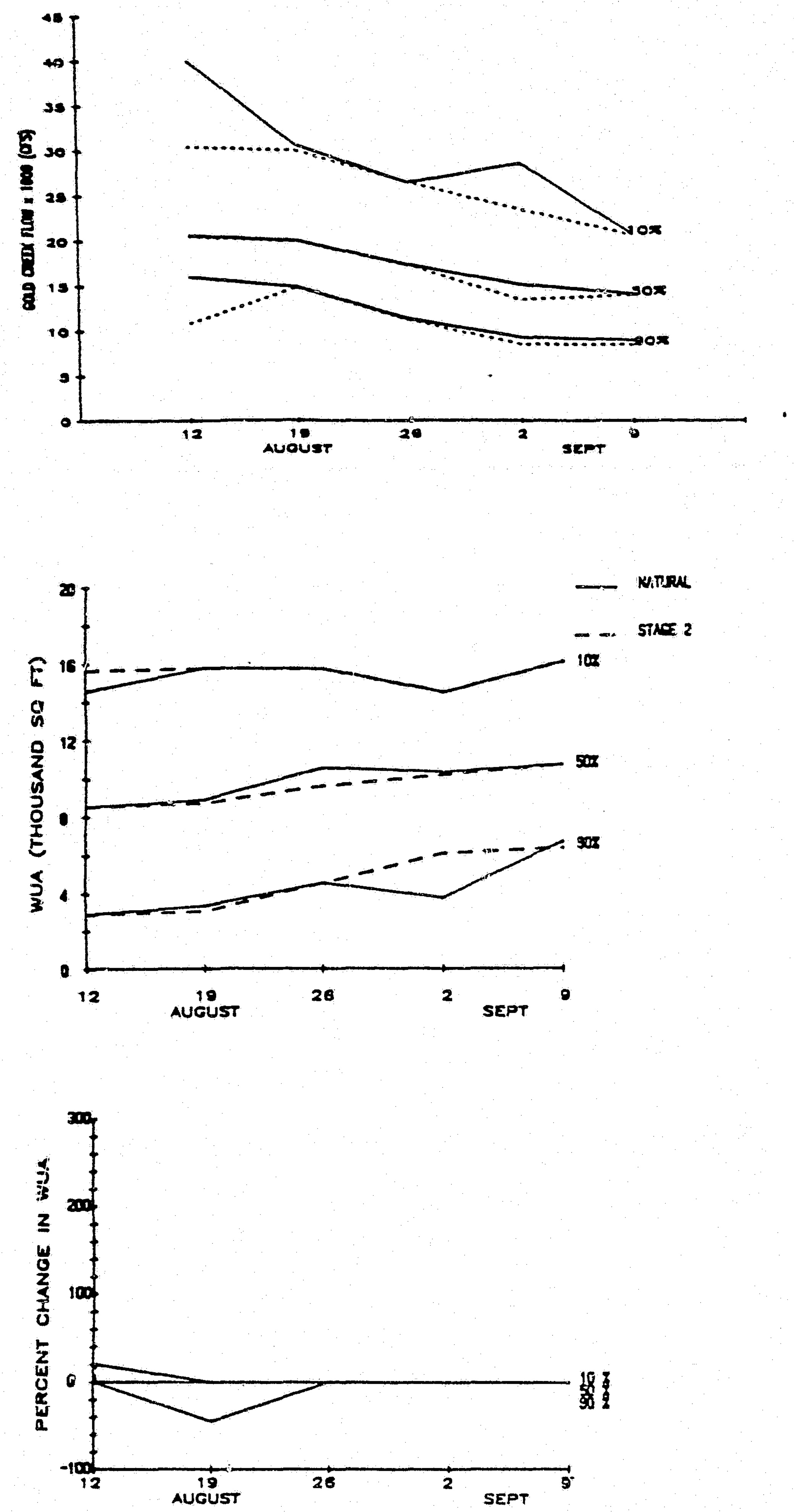

Mean weekly discharge (upper), chum spawning WUA for mainstem (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 37

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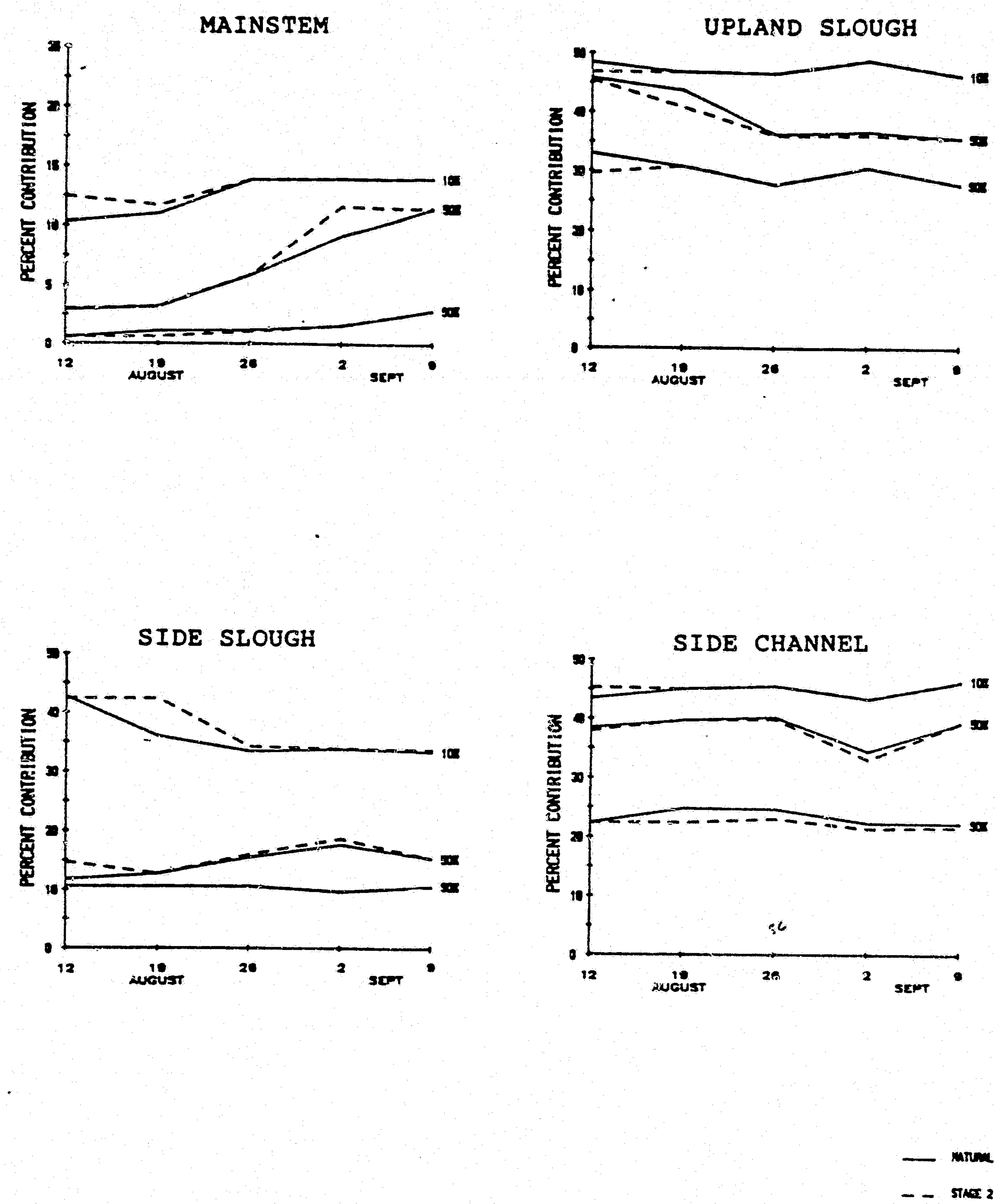

Percent contribution of chum spawning habitat in mainstem, side channels, side sloughs, and upland sloughs to total habitat during Stage II exceeded 90, 50 and 10 percent of the time.

FIGURE 38

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percent contribution during Stage II is expected to be similar to the range of contribution under natural conditions.

. Stage III

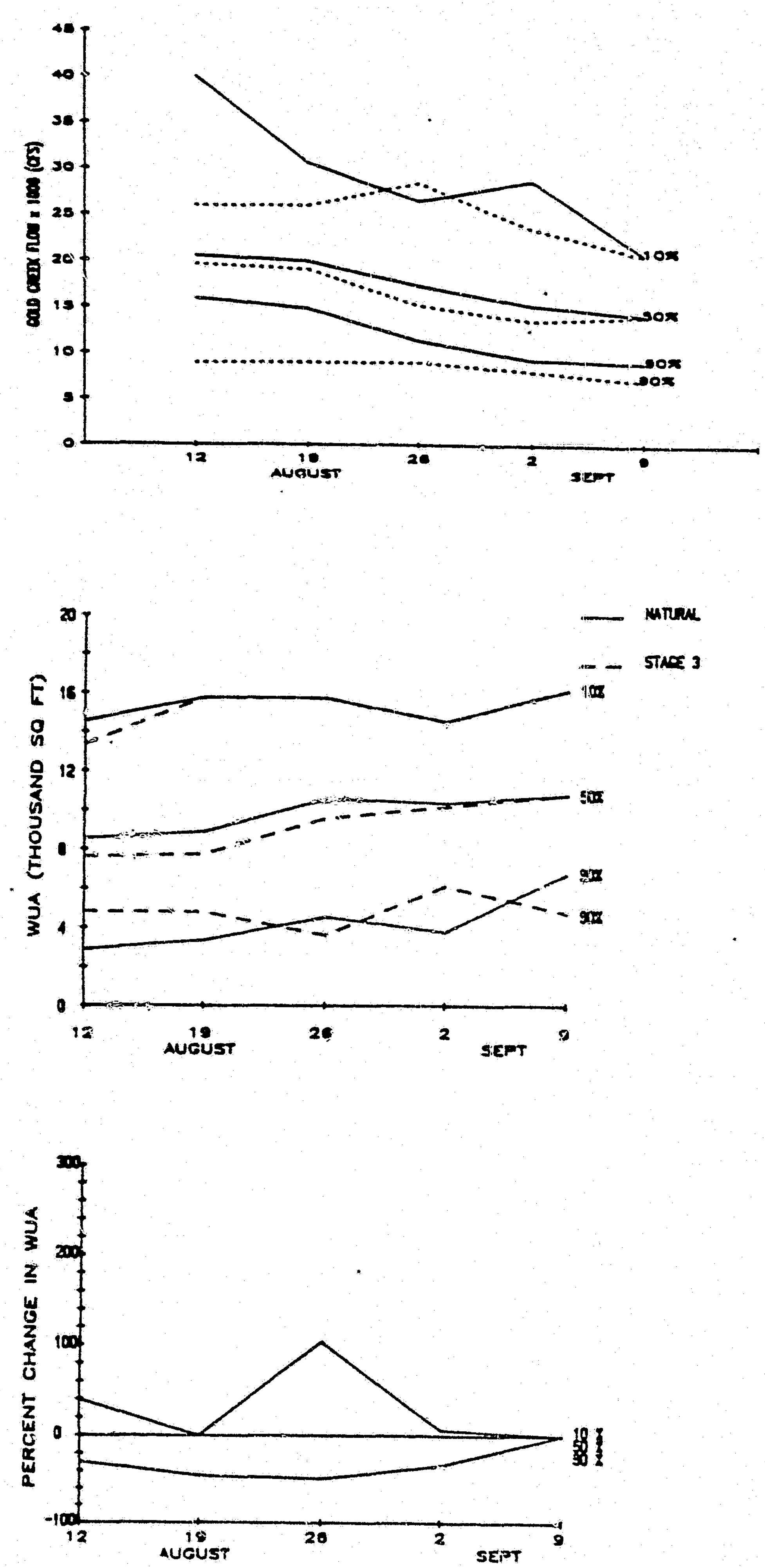
.. Filling

Filling of Watana during Stage III would occur over several years and consequently discussion of habitat availability relating to this process are more appropriately addressed under operation.

.. Operation

Habitat availability in mainstem margins under natural, early Stage III operation, and late Stage III operation is compared in seasonal habitat duration curves and weekly time series plots (Figures 34, 39 and 40). During early and late Stage III operation there is a 50 percent chance or greater that available spawning habitat in mainstem margins will be reduced. However, during much of the spawning season there is a 50 percent likelihood that available spawning habitat will increase. Moreover, the percent increase in habitat peaks during water week 48. This is of particular importance since water week 48 coincides with the peak activity of the spawning season. Thus, although available spawning habitat is likely to be reduced during most of the spawning season, available spawning habitat would likely increase above natural during the peak of the spawning season.

The contribution of mainstem margins to the habitat availability provided by all groups for natural, early Stage III operation, and late Stage III operation is



Mean weekly discharge (upper), chum spawning WUA for mainstem (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 39

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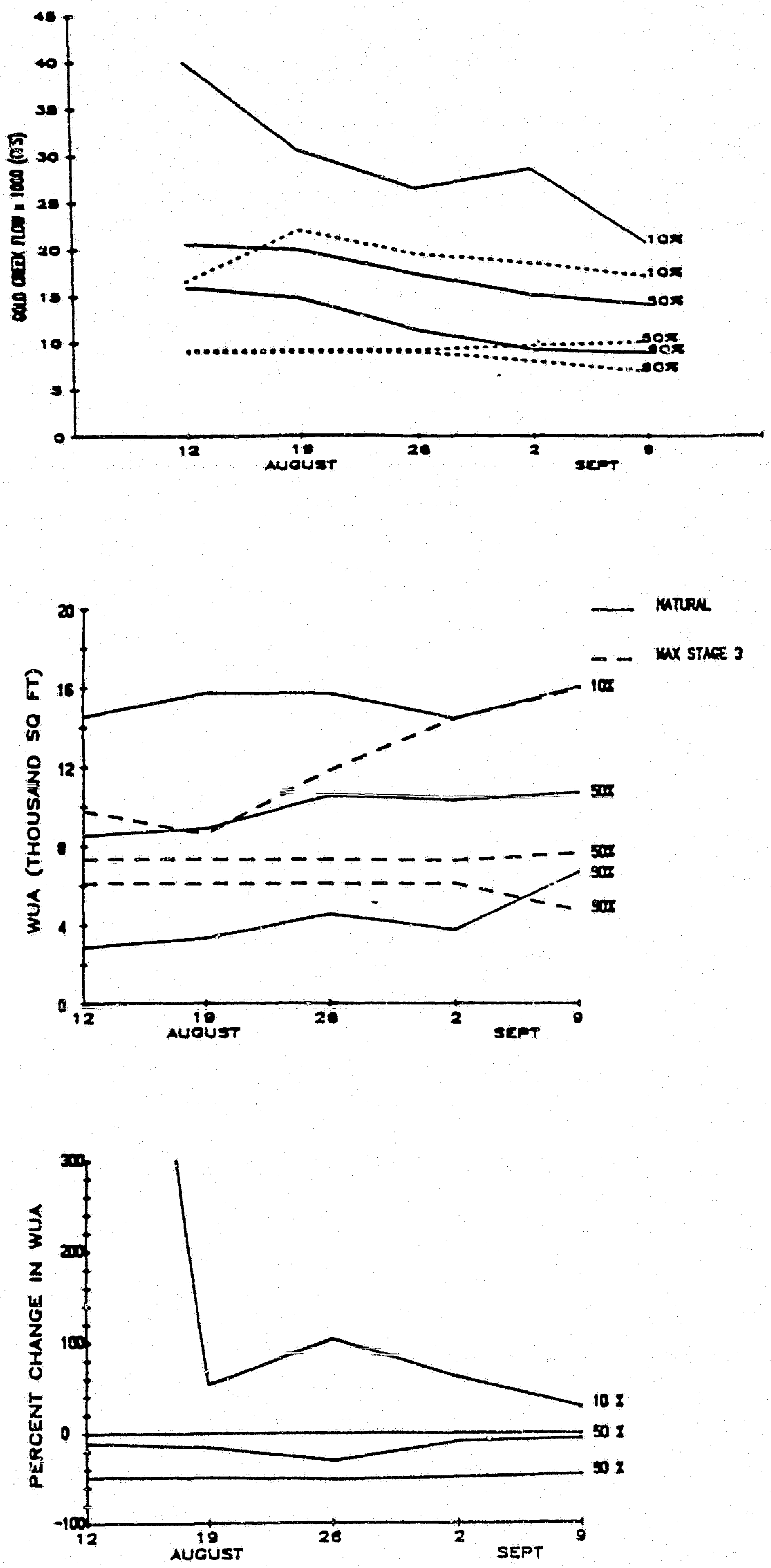

Mean weekly discharge (upper), chum spawning WUA for mainstem (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 40

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shown in Figures 41 and 42. In late Stage III operation, mainstem margins would usually contribute a higher percentage of available spawning habitat to the total available habitat provided by all groups, because of substantial reductions in available spawning habitat for other groups.

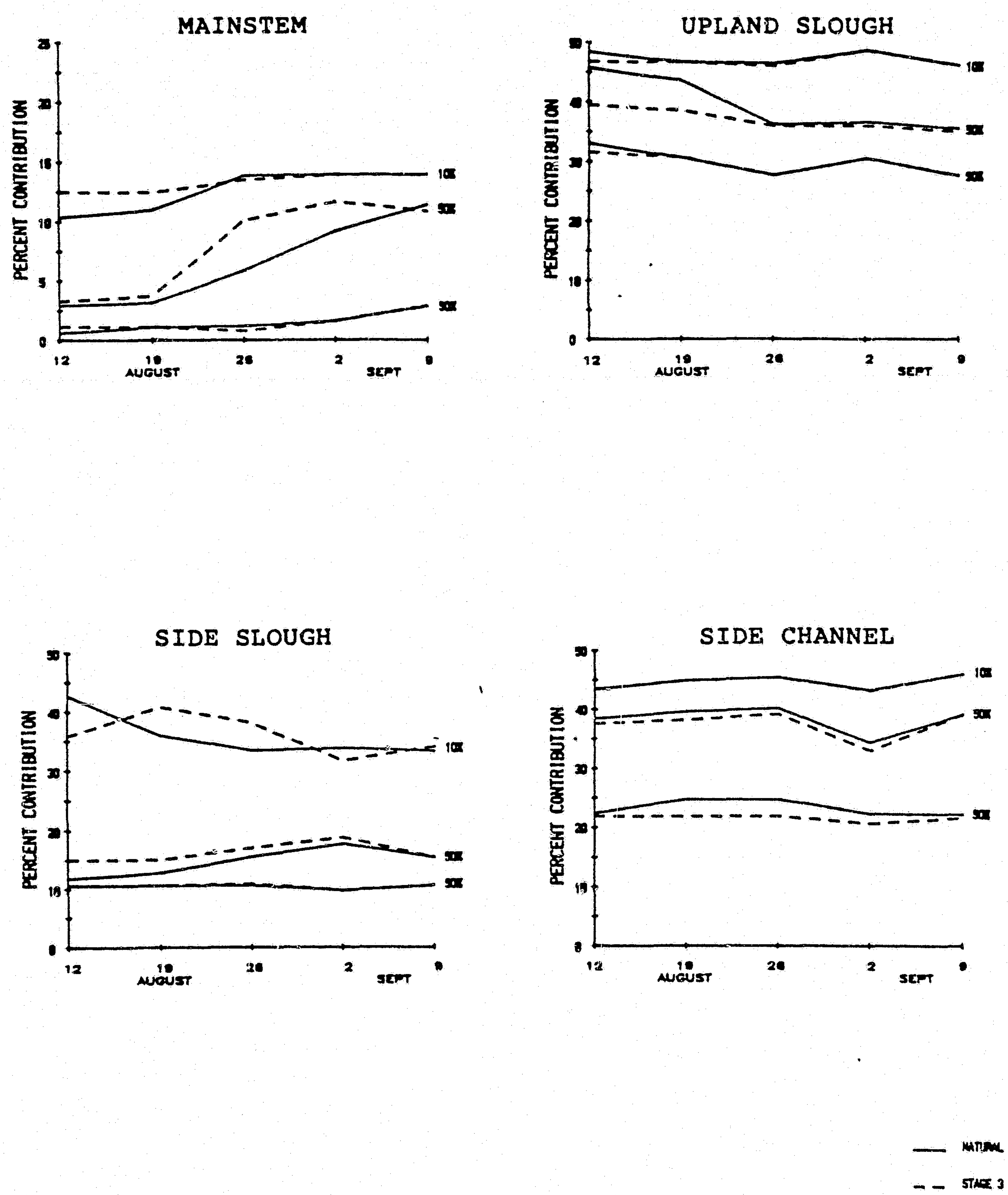
-- Chum Salmon Embryos and Pre-Emergent Fry

. Stage I Filling

Flows during the fall and winter after the summer of filling Stage I are expected to be similar to natural. Thus, conditions for incubating embryos are expected to be similar to natural.

. Stage I, II, III Operation

Chum embryos in mainstem-influenced areas are subject to dessication and freezing as a result of reduced discharge in the river during the October and November period prior to ice cover formation. Under Stage I project operation, discharge in the middle river would be maintained at a considerably greater discharge than under natural conditions as indicated in Section 4.1.1. As a result, embryos deposited in the spawning areas are not expected to be as subject to dessication and freezing. In fact, water depths and velocities in the spawning areas will be maintained at higher than natural levels. This will increase the effective spawning area over natural conditions. Hence, conditions for incubation are expected to be maintained or improve during project operation because of the higher, stable flows in the fall and winter.



Percent contribution of chum spawning habitat in mainstem, side channels, side sloughs, and upland sloughs to total habitat during early Stage III exceeded 90, 50 and 10 percent of the time.

FIGURE 41

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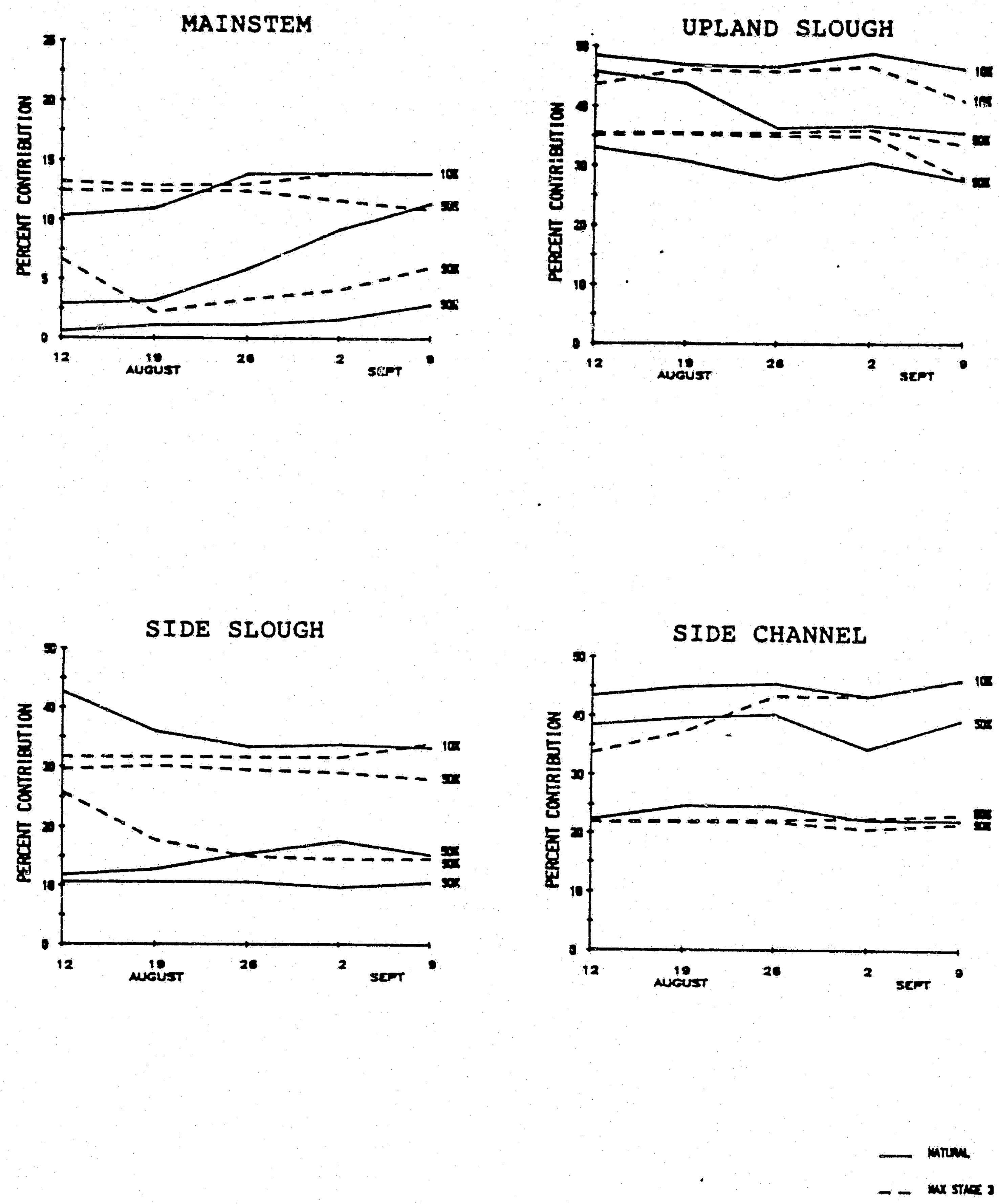

Percent contribution of chum spawning habitat in mainstem, side channels, side sloughs, and upland sloughs to total habitat during late Stage III exceeded 90, 50 and 10 percent of the time.

FIGURE 42

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- Secondary Evaluation Species

-- Burbot

. Stage I Filling

Stage I filling will not affect burbot spawning and incubation. Filling will be completed by early fall, whereas burbot spawn during mid-winter. Thus, project effects on burbot spawning and incubation are more appropriately discussed under Stage I operation.

. Stage I Operation

Within the middle Susitna River, the population of burbot is relatively low and because of this, spawning locations in this reach of river have not been identified. Burbot are thought to inhabit relatively low-velocity deep-water areas in the mainstem of the middle Susitna River during winter.

Stage I operation will substantially increase flows during winter. Mid-winter mean monthly flows, which typically range from 750 to 3,000 cfs (mean of approximately 1,500 cfs), will range from 5,000 to 11,500 cfs with an average of about 8,000 cfs during Stage I operation. This higher in flow is expected to increase the amount of low-velocity, backwater areas. If this occurs, burbot in the middle Susitna River are not expected to be adversely affected by the project flow regime.

. Stages II and III

Because the project flow regime during Stages II and III will be similar to Stage I operation, no significant effects on spawning burbot due to the filling or operation of Stages II and III are expected.

(ii) Side Channels

In general, side channels convey less than 10 percent of the total discharge in the river, but convey mainstem discharge more than 50 percent of the time during the summer high flow months (EWT&A 1984, 1985). Relatively few salmon spawn in side channels of the middle Susitna River. Of those which do, chum salmon predominate.

- Primary Evaluation Species

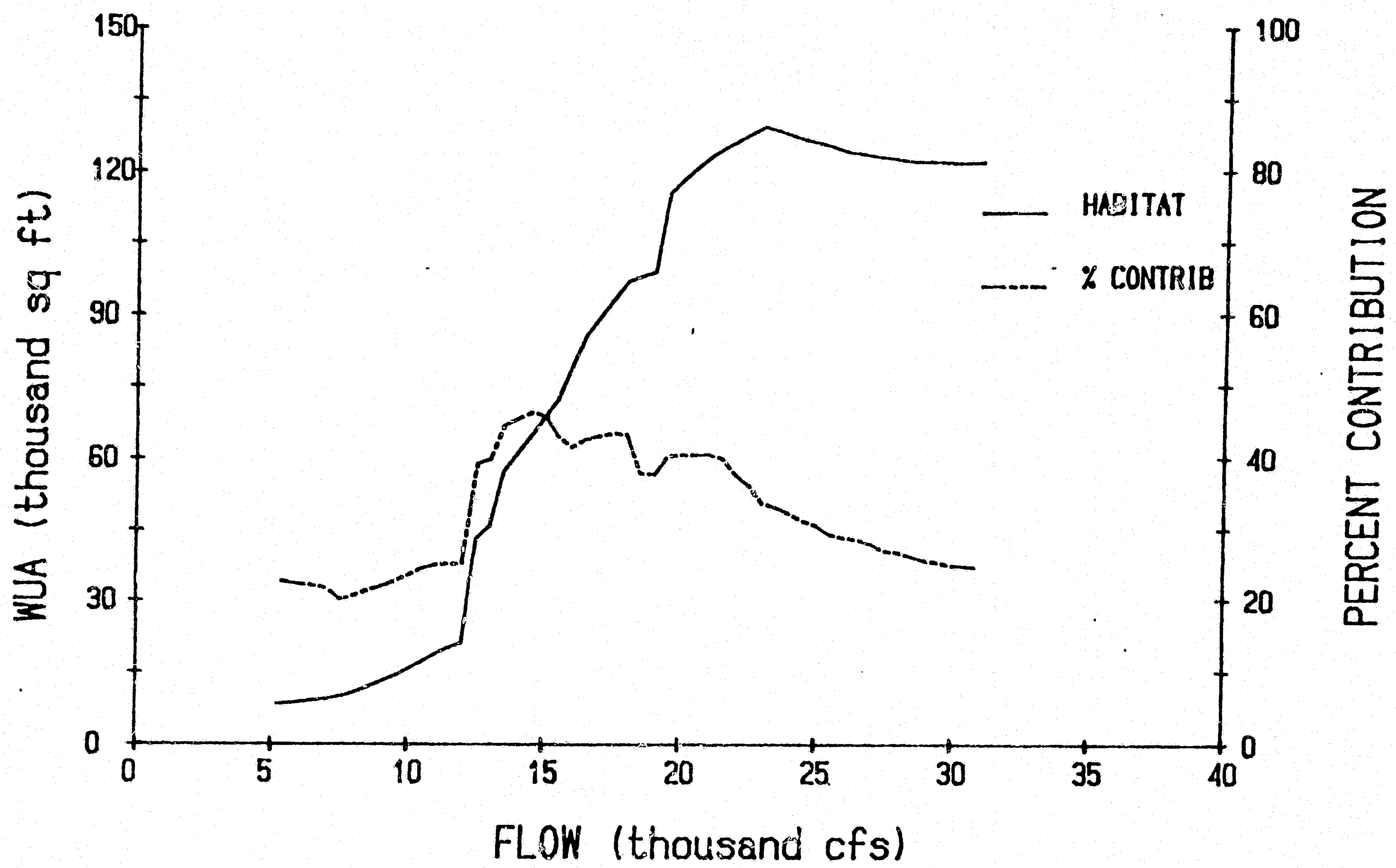
-- Chum Salmon Spawning Adults

The amount of available side channel chum salmon spawning habitat remains relatively constant at mainstem discharges greater than 20,000 cfs (Figure 43). As mainstem discharge falls below 20,000 cfs the available spawning habitat in side channels decreases substantially. This is primarily a result of receding backwater effects at the mouths of side channels.

. Stage I

.. Filling

The available spawning habitat in side channels for dry, average, and wet years during Stage I filling is presented in Table 11. If a dry year occurs during the filling period, spawning habitat will be reduced by approximately 90 percent in August adn 50 percent in September. If an average year occurs during the filling period, spawning habitat will be decreased by about 70 percent in August and by 80 percent in September. A



Chum salmon spawning habitat response curve and percent contribution to total available habitat of side channel areas in the middle Susitna River.

FIGURE 43

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Table 11. Estimated change in chum spawning habitat (WUA) in side channels due to filling of the Watana - Stage I Reservoir.

Month	Discharge (cfs)		Chum Spawning WUA (sq ft)		
	Natural	Filling	Natural	Filling	% Change
Dry Year					
August	17,392	8,000	84,027	18,869	-77.54
September	10,422	5,800	23,985	14,087	-41.27
Average Year					
August	22,228	12,415	160,644	33,642	-79.06
September	13,221	6,800	35,486	14,600	-58.86
Wet Year					
August	25,236	15,505	186,379	57,734	-69.02
September	15,124	6,800	46,174	14,600	-68.38

decrease in available spawning habitat in August of 40 percent and of 85 percent in September is expected if a wet year occurs during filling.

.. Operation

Habitat availability in side channels under natural and Stage I flows is compared in a seasonal habitat duration curve and a weekly habitat time series plot (Figures 44 through 47). During Stage I operation, a reduction in available spawning of 0 to 80 percent could occur throughout the spawning season. However, in September available habitat could increase by up to 60 percent.

The contribution of side channels to the habitat availability provided by all groups for natural and Stage I operation is shown in Figure 36. The range of percent contribution is expected to be similar to natural conditions during August and September.

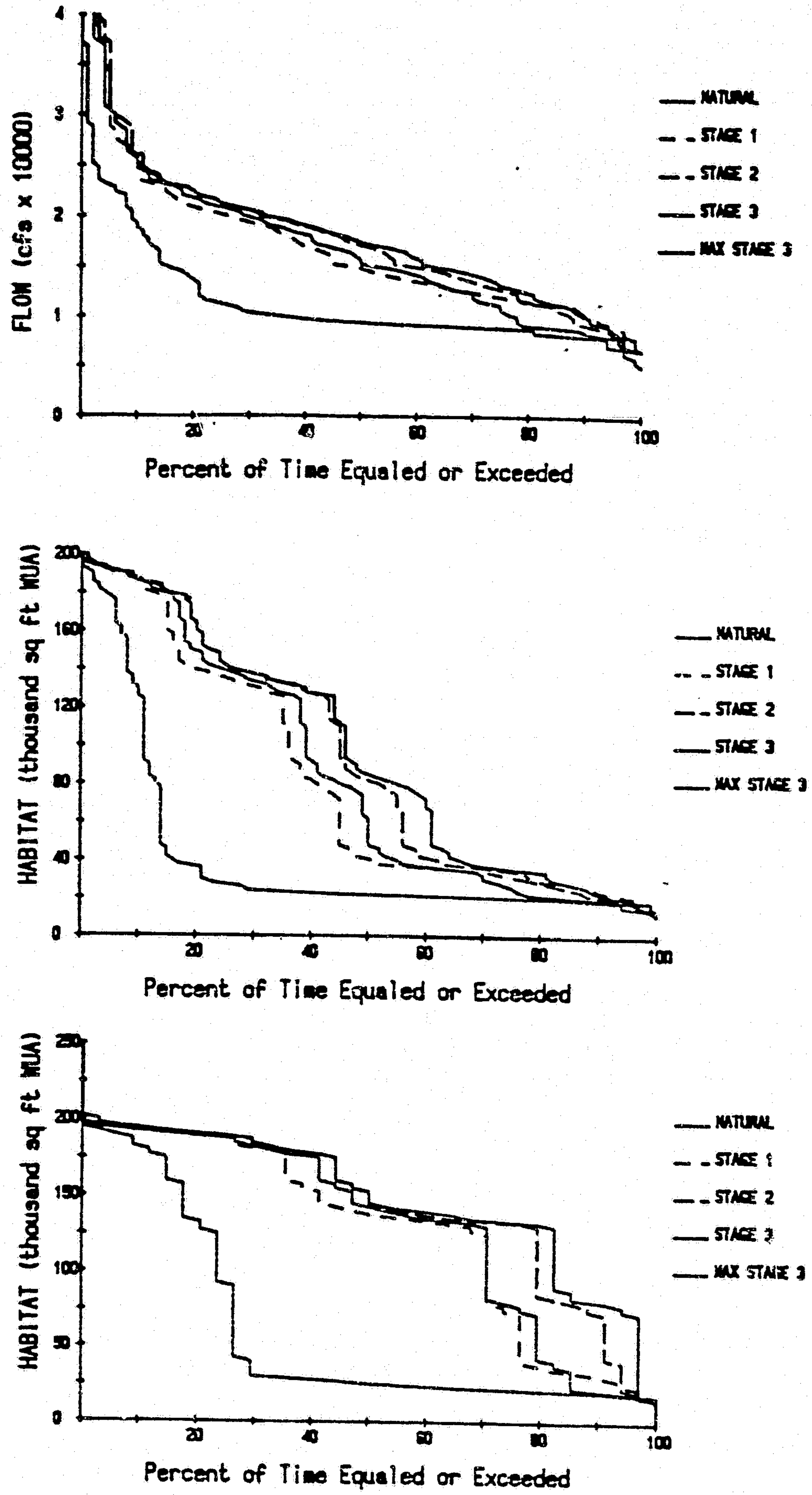
. Stage II

.. Filling

Filling flows for Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

.. Operation

Habitat availability in side channels under natural and Stage II flows is compared in a seasonal habitat duration curve and a weekly time series plot (Figures 44 and 46). During mid-August a decrease of up to 50 percent in available spawning habitat could occur.



Flow duration curve (upper) and seasonal (middle) and maximum weekly (lower) chum spawning habitat duration curve for side channels.

FIGURE 44

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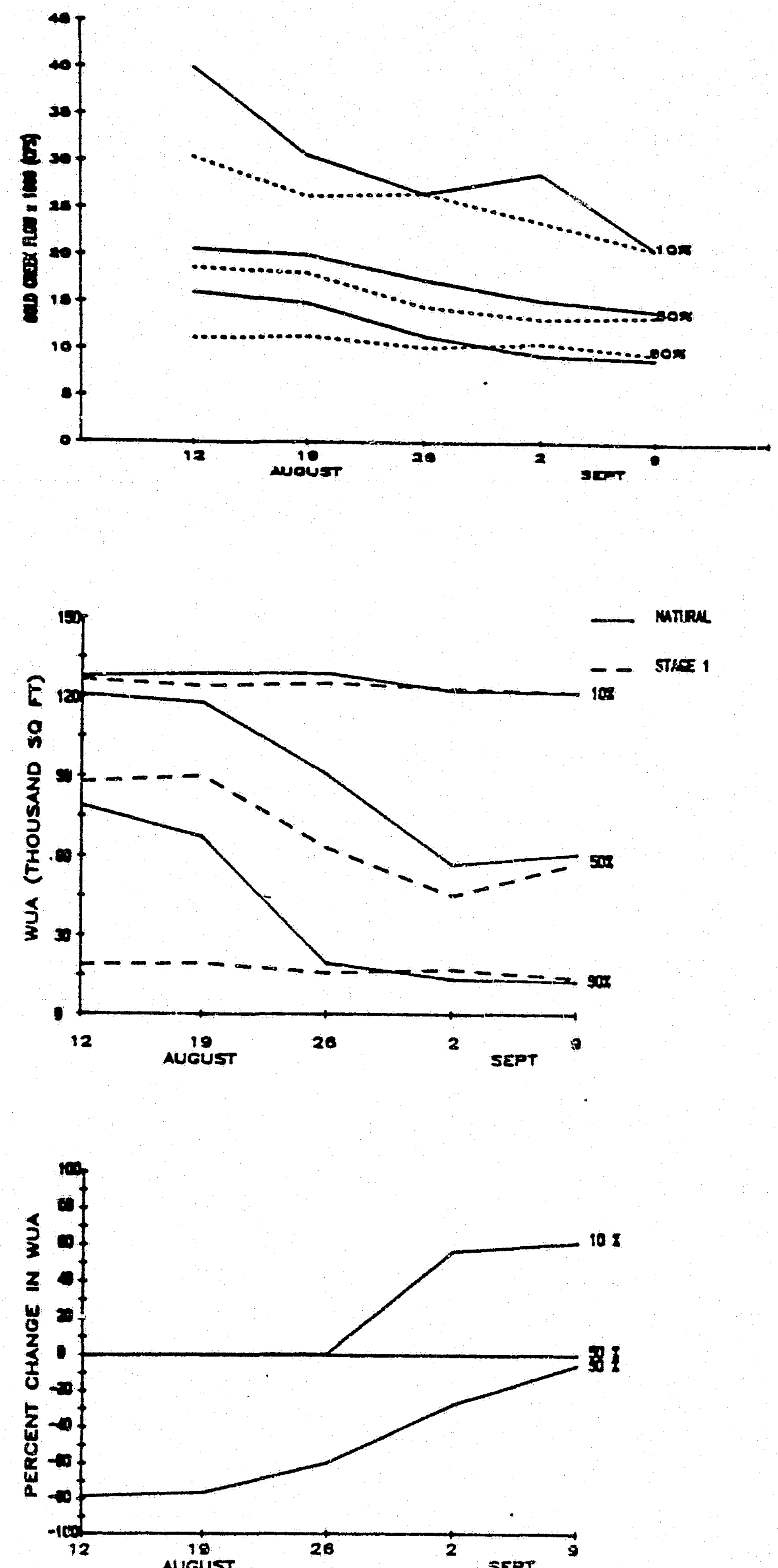

Mean weekly discharge (upper), chum spawning WUA for side channels (middle) and percent change in WUA (lower) exceeded 70, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 45

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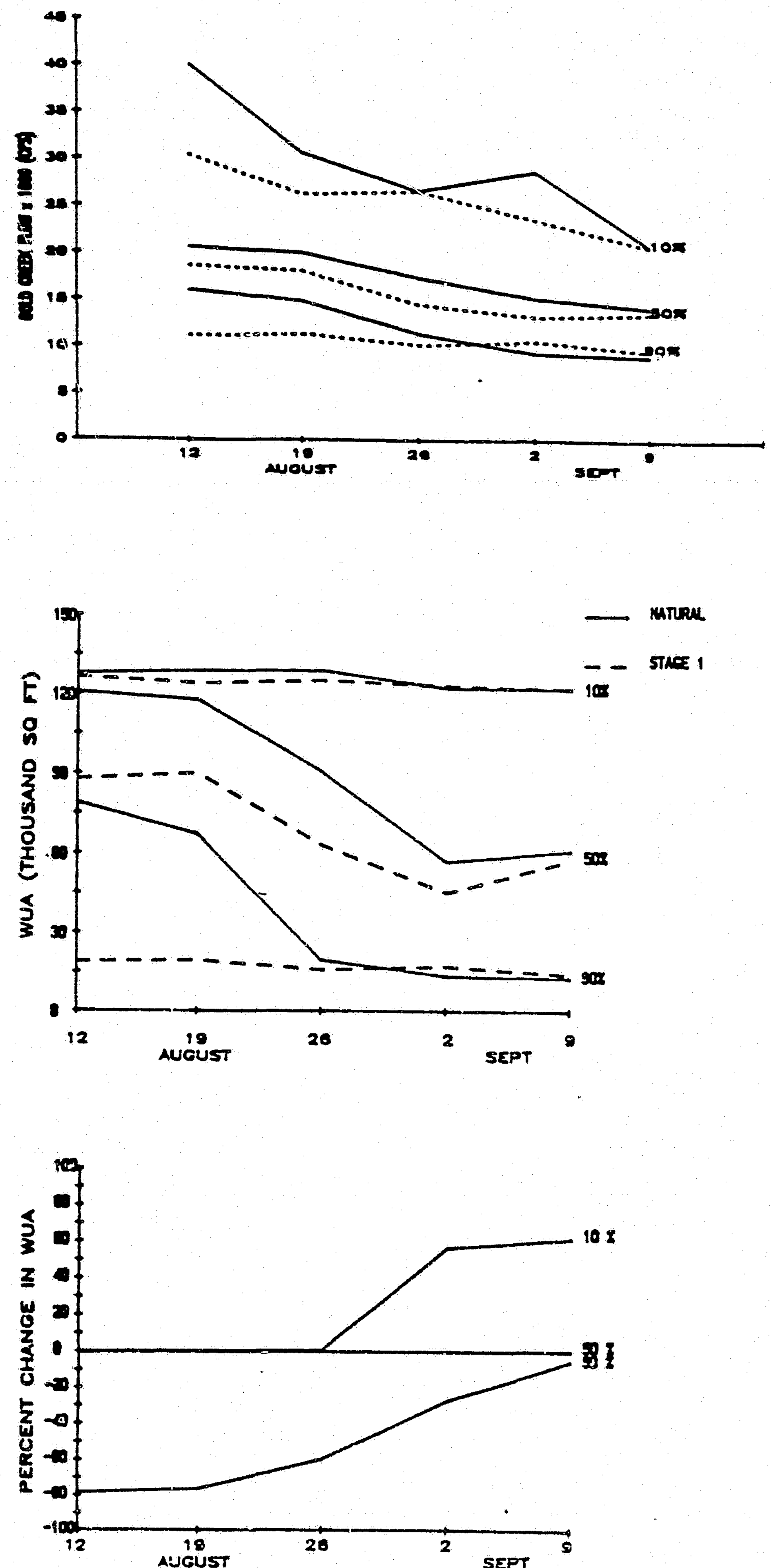

Mean weekly discharge (upper), chum spawning WUA for side channels (middle) and percent change in WUA (lower) exceeded 70, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 45

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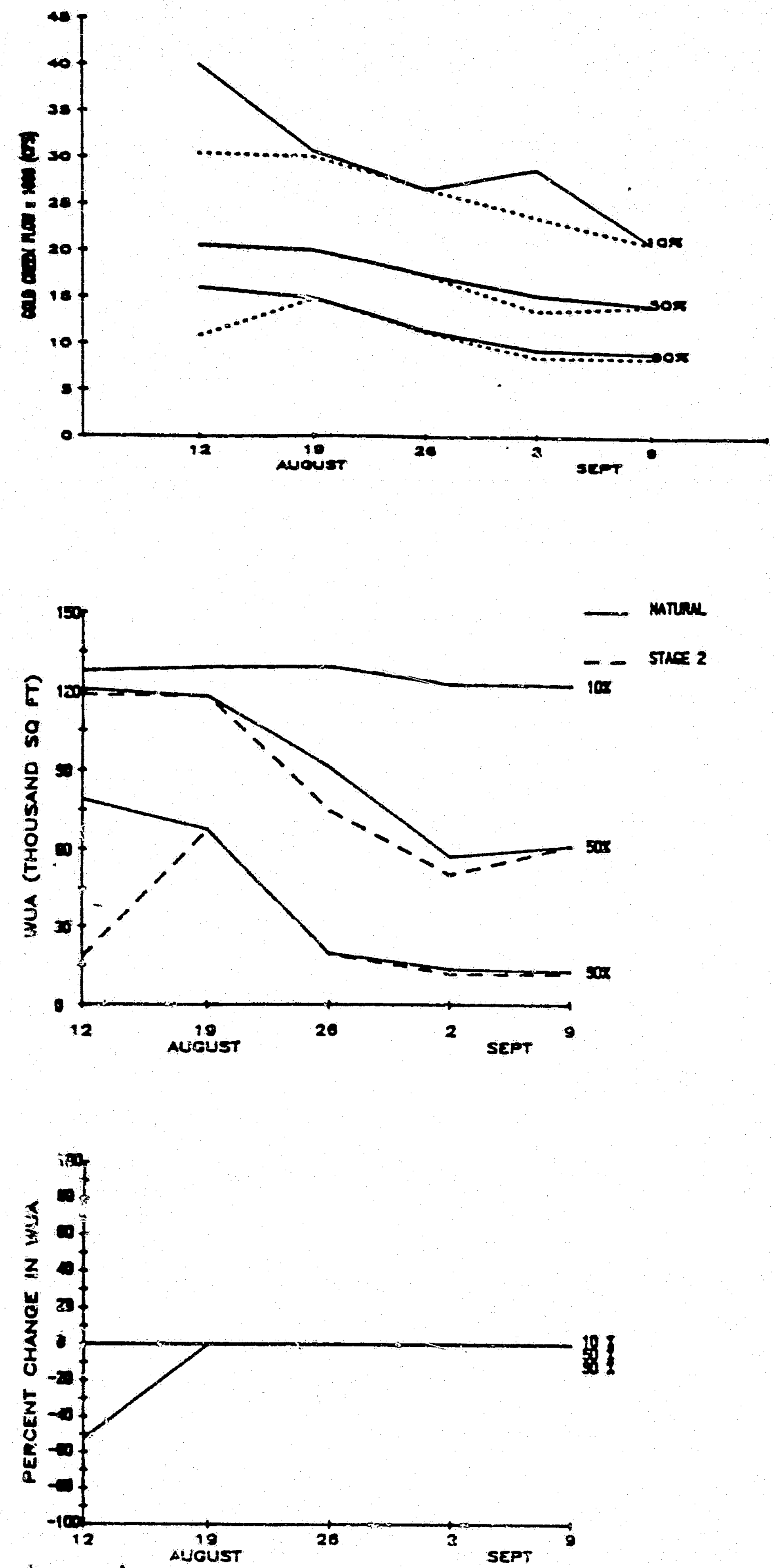

Mean weekly discharge (upper), chum spawning WUA for side channels (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 46

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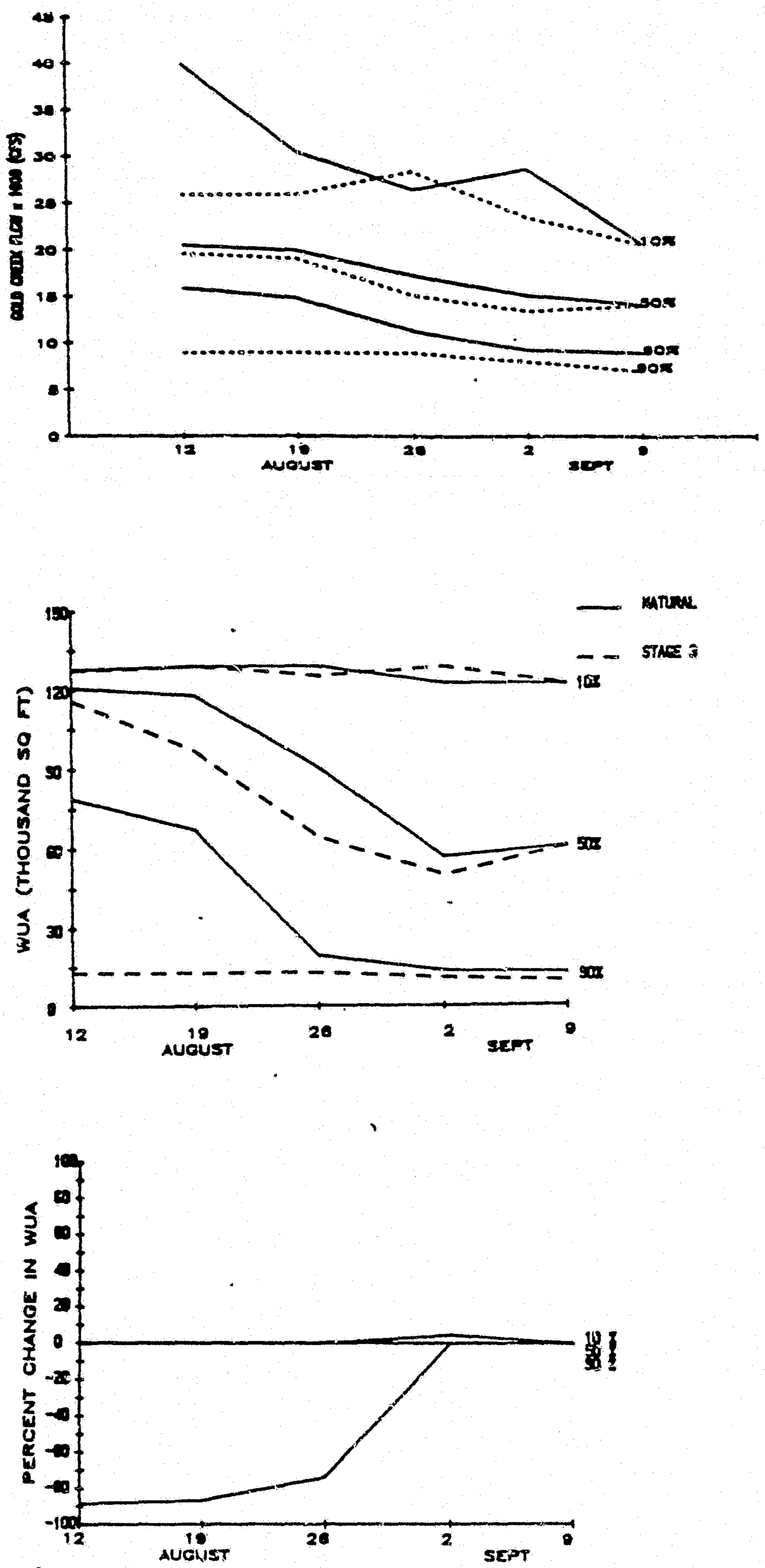

Mean weekly discharge (upper), chum spawning WUA for side channels (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 47

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During the remainder of the spawning season, habitat availability is expected to be similar to natural.

The contribution of side channels to the habitat availability provided by all groups for natural and Stage II operation is shown in Figure 38. The range of percent contribution during Stage II is expected to be similar to the range of contribution under natural conditions.

- <u>Primary Evaluation Species</u>

-- <u>Chum Salmon Embryos and Pre-emergent Fry</u>

. <u>Stage I Filling</u>

Flows during the fall and winter after the summer of filling Stage I are expected to be similar to natural. Thus, conditions for incubating embryos are expected to be similar to natural.

. <u>Stage I, II, III Operation</u>

As mentioned previously, conditions for incubation in mainstem-influenced areas are expected to be maintained or improved during project operation because of the higher, stable flows in the fall and winter.

- <u>Secondary Evaluation Species</u>

Side channels in the middle Susitna River do not provide any known significant spawning habitat for the secondary evaluation species.

- Stage III

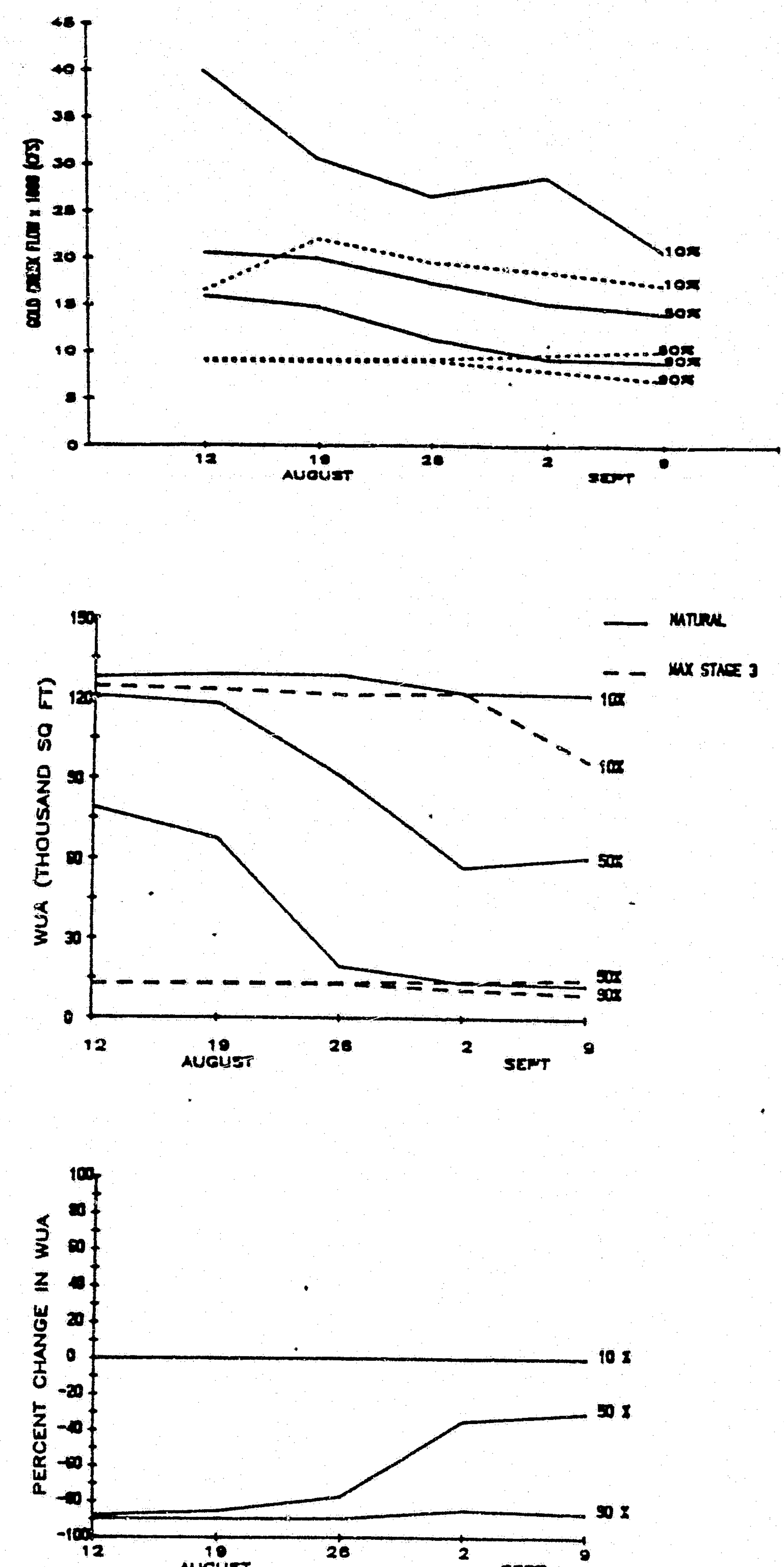
.. Filling

Filling of Watana during Stage III would occur over several years and consequently discussion of habitat availability relating to this process are more appropriately addressed under operation.

.. Operation

Habitat availability in side channels under natural, early Stage III operation, and late Stage III operation is compared in seasonal habitat duration curves and weekly time series plots (Figures 44, 47 and 48). During early Stage III operation there is a 50 percent chance that available spawning habitat in side channels will be reduced by up to 80 percent during the first half of the spawning season. There is a 50 percent chance that available spawning habitat will be reduced by at least 50 percent during late Stage III operation.

The contribution of side channels to the habitat availability provided by all groups for natural, early Stage III operation, and late Stage III operation is shown in Figures 41 and 42. During early Stage III operation the range of percent contribution will be similar to natural. Percent contribution would likely be substantially reduced during late Stage III operation. Percent contribution would approach natural conditions at the lower end of the range of contributions throughout the season and at the higher end of the range during late September.



Mean weekly discharge (upper), chum spawning WUA for side channels (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 48

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-- Chum Salmon Embryos and Pre-emergent Fry

. Stage I Filling

Flows during the fall and winter after the summer of filling Stage I are expected to be similar to natural. Thus, conditions for incubating embryos are expected to be similar to natural.

. Stage I, II, III Operation

As mentioned previously, conditions for incubation in mainstem-influenced areas are expected to be maintained or improved during project operation because of the higher, stable flows in the fall and winter.

- Secondary Evaluation Species

-- Sockeye Salmon Spawning Adults

Side channels in the middle Susitna River provide significant spawning habitat for sockeye salmon. Slough 11 provides habitat for almost 70 percent of the spawning sockeye in the middle Susitna River.

(iii) Side Sloughs

Side sloughs are morphologically similar to side channels, but the upstream ends of side sloughs are breached by mainstem discharges of 20,000 cfs or greater (EWT&A and AEIDC 1985). Hence, side sloughs convey mainstem water less than 50 percent of the time during the summer high flow months. A substantial portion of the chum spawning and much of the sockeye spawning in the middle Susitna River occurs in side sloughs. Some pink salmon use side sloughs for spawning, mostly in even-numbered years.

- Primary Evaluation Species

-- Chum Salmon Spawning Adults

The amount of side slough spawning habitat for chum salmon remains relatively unchanged below 20,000 cfs (Figure 49). However, spawning habitat in side sloughs substantially increases as mainstem discharges exceed 20,000 cfs. This is a result of side channels transforming to side sloughs at various discharges above 20,000 cfs.

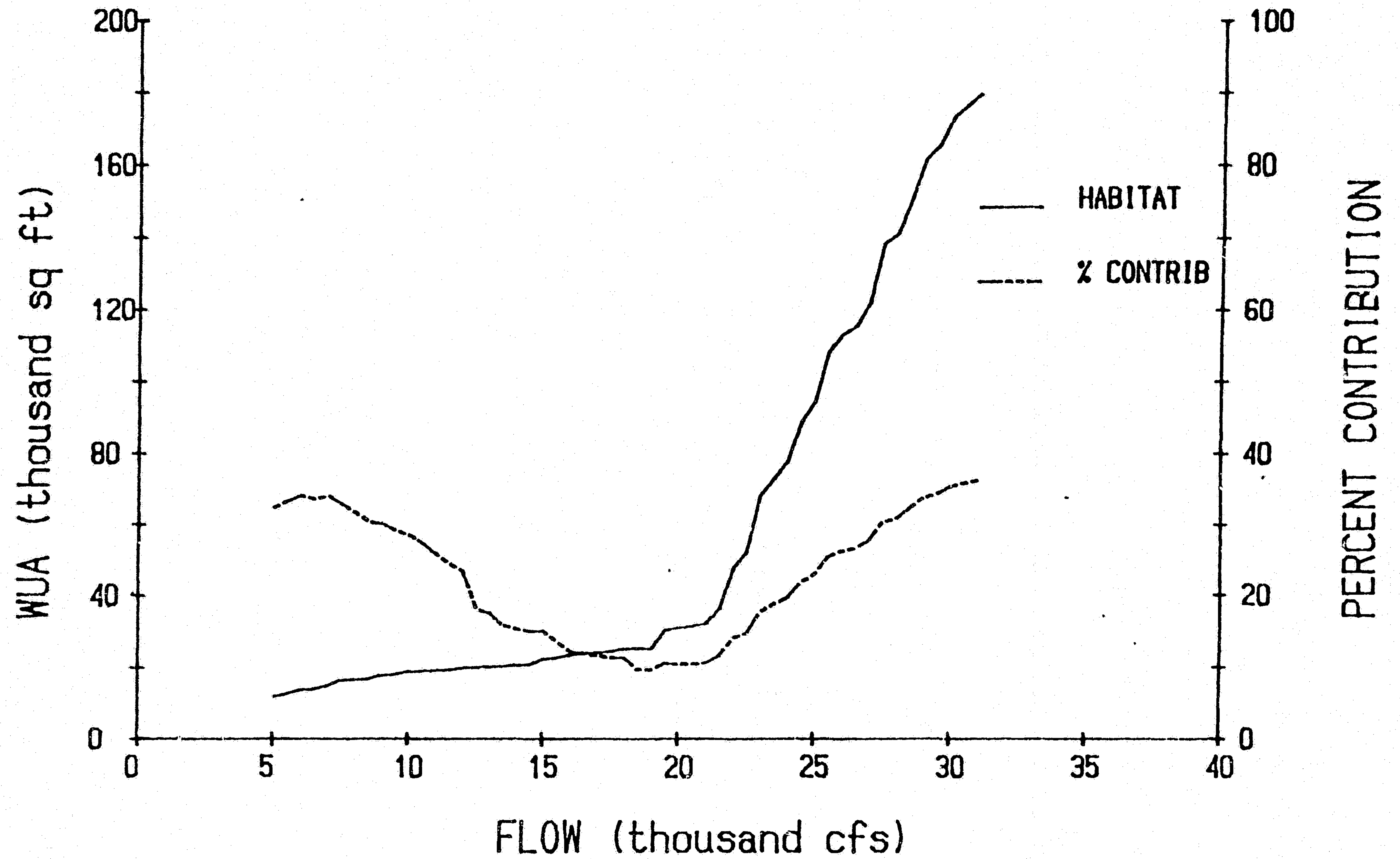
. Stage I

.. Filling

The available spawning habitat in side sloughs for dry, average, and wet years during Stage I filling is presented in Table 12. If a dry year occurs during the filling period, spawning habitat will be reduced by approximately 30 percent in August and September. If an average year occurs during the filling period, spawning habitat will be decreased by about 60 percent in August and by almost 30 percent in September. A decrease in available spawning habitat of almost 80 percent in August and 35 percent in September is expected if a wet year occurs during filling.

.. Operation

Habitat availability in side sloughs under natural and Stage I flows is compared in seasonal habitat duration curves and weekly habitat time series plots (Figures 50 and 51). Reductions in available spawning habitat of between 10 and 60 percent are expected 40 percent of the time throughout the spawning season, while increases of



Chum salmon spawning habitat response curve and percent contribution to total available habitat of side slough areas in the middle Susitna River.

FIGURE 49

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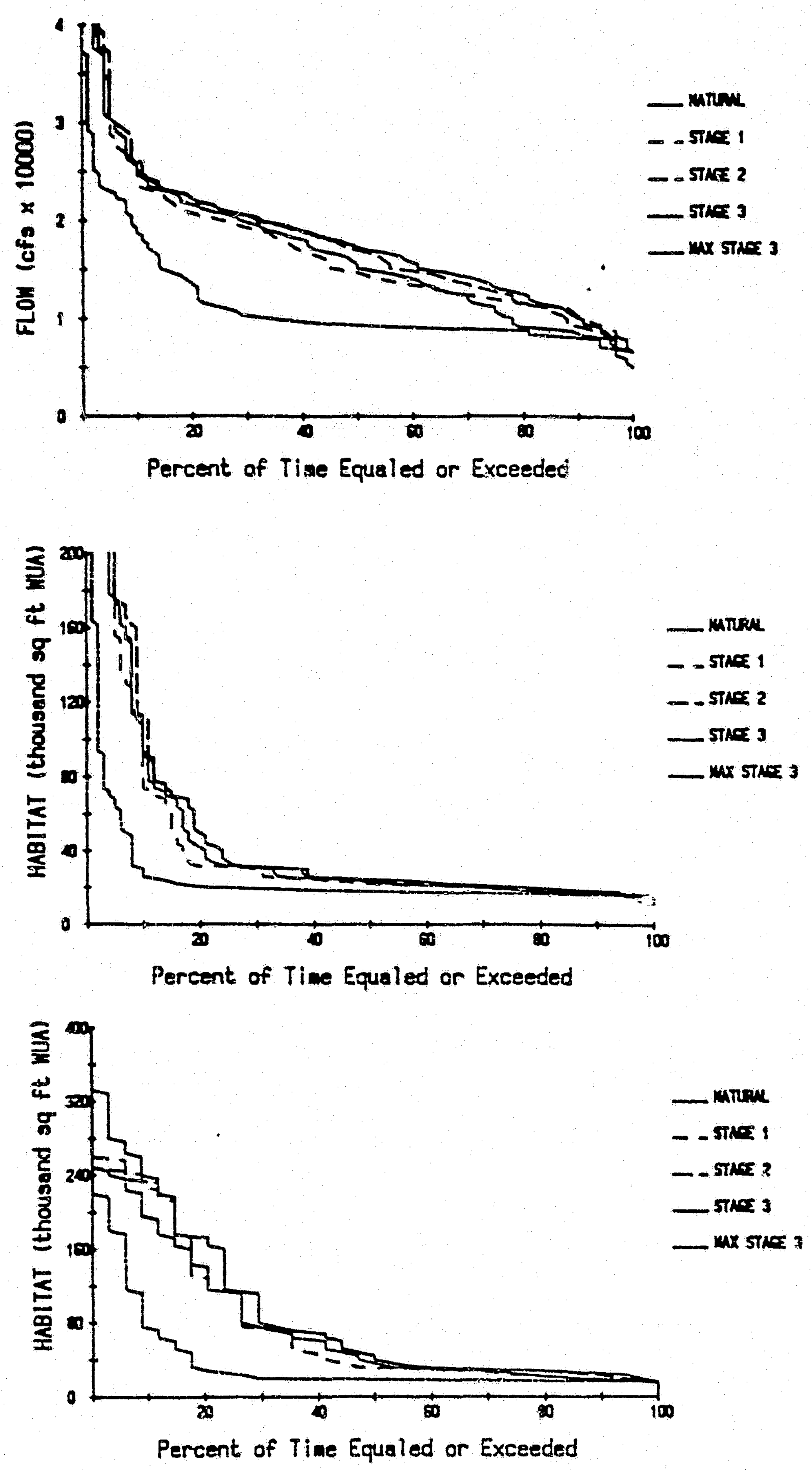
Table 12. Estimated change in chum spawning habitat (WUA) in side sloughs due to filling of the Watana - Stage I Reservoir.

Month	Discharge (cfs		Chum Spawning WUA (sq ft)		
	Natural	Filling	Natural	Filling	% Change
Dry Year					
August	17,392	8,000	24,385	16,595	-31.95
September	10,422	5,800	18,982	13,287	-30.00
Average Year					
August	22,228	12,415	49,721	19,559	-60.66
September	13,221	6,800	20,241	14,594	-27.90
Wet Year					
August	25,236	15,505	100,845	22,812	-77.38
September	15,124	6,800	22,547	14,594	-35.27



Flow duration curve (upper) and seasonal (middle) and maximum weekly (lower) chum spawning habitat duration curve for side sloughs.

FIGURE 50

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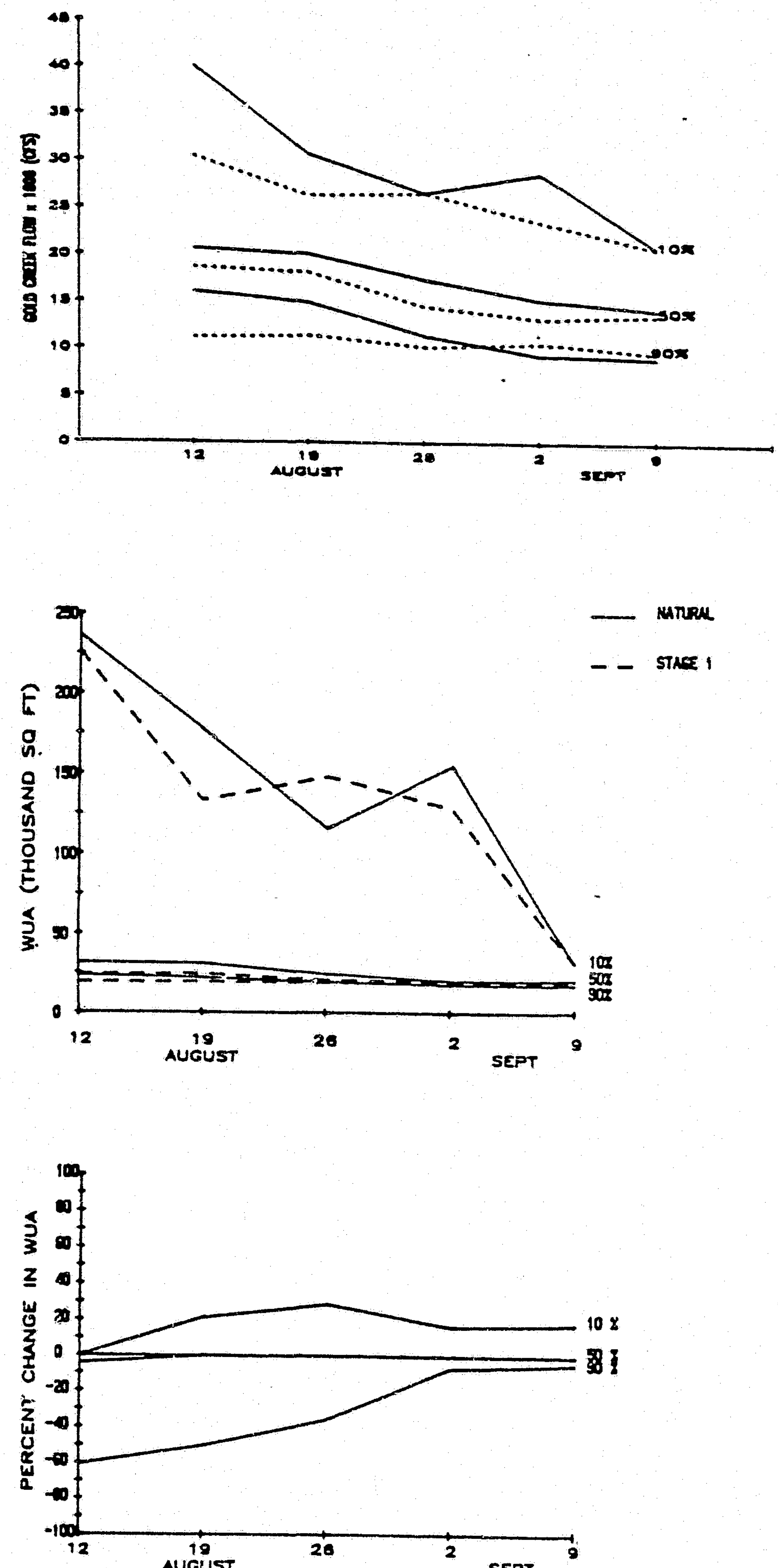

Mean weekly discharge (upper), chum spawning WUA for side slough (middle) and percent change in WUA (lower) exceeded 70, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 51

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between 0 and 30 percent are expected 40 percent of the time throughout the spawning period.

The contribution of side sloughs to the habitat availability provided by all groups for natural and Stage I operation is shown in Figure 36. At the lower range of contribution, the percent contribution during Stage I operation is expected to be similar to natural conditions, whereas, at the upper end of the range percent contribution is expected to slightly decrease under Stage I operation.

. <u>Stage II</u>

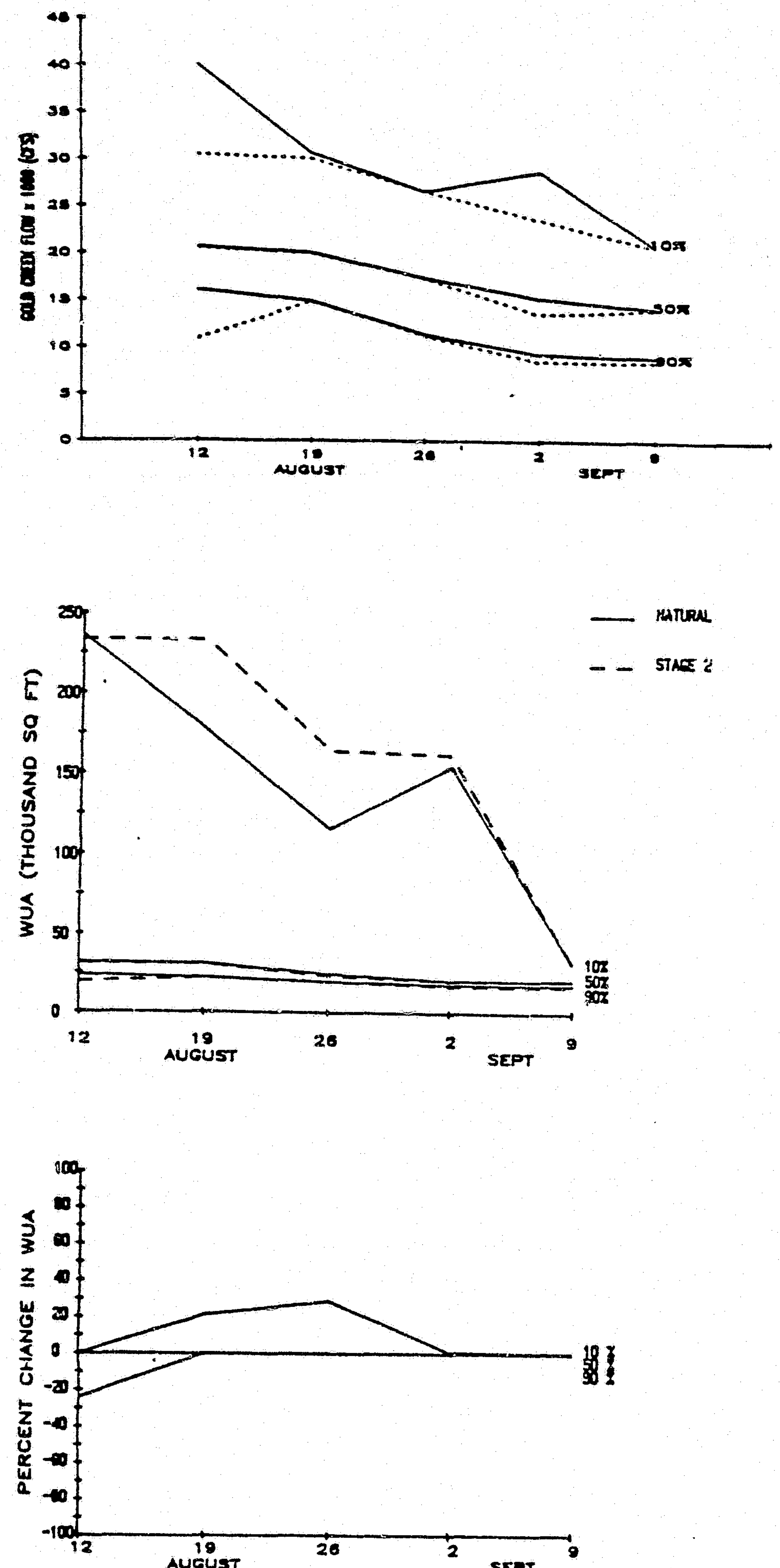
.. <u>Filling</u>

Filling flows for Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

.. <u>Operation</u>

Habitat availability in side sloughs under natural and Stage II flows is compared in seasonal habitat duration curves and weekly time series plots (Figures 50 and 52). During the first two weeks of the spawning season, available habitat may decrease up to 25 percent. However, increases of up to 30 percent are expected in late August coinciding with the peak spawning activity.

The contribution of side sloughs to the habitat availability provided by all groups for natural and Stage II operation is shown in Figure 38. The range of percent contribution during Stage II is expected to be similar to the range of contribution under natural conditions.



Mean weekly discharge (upper), chum spawning WUA for side slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 52

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- Stage III

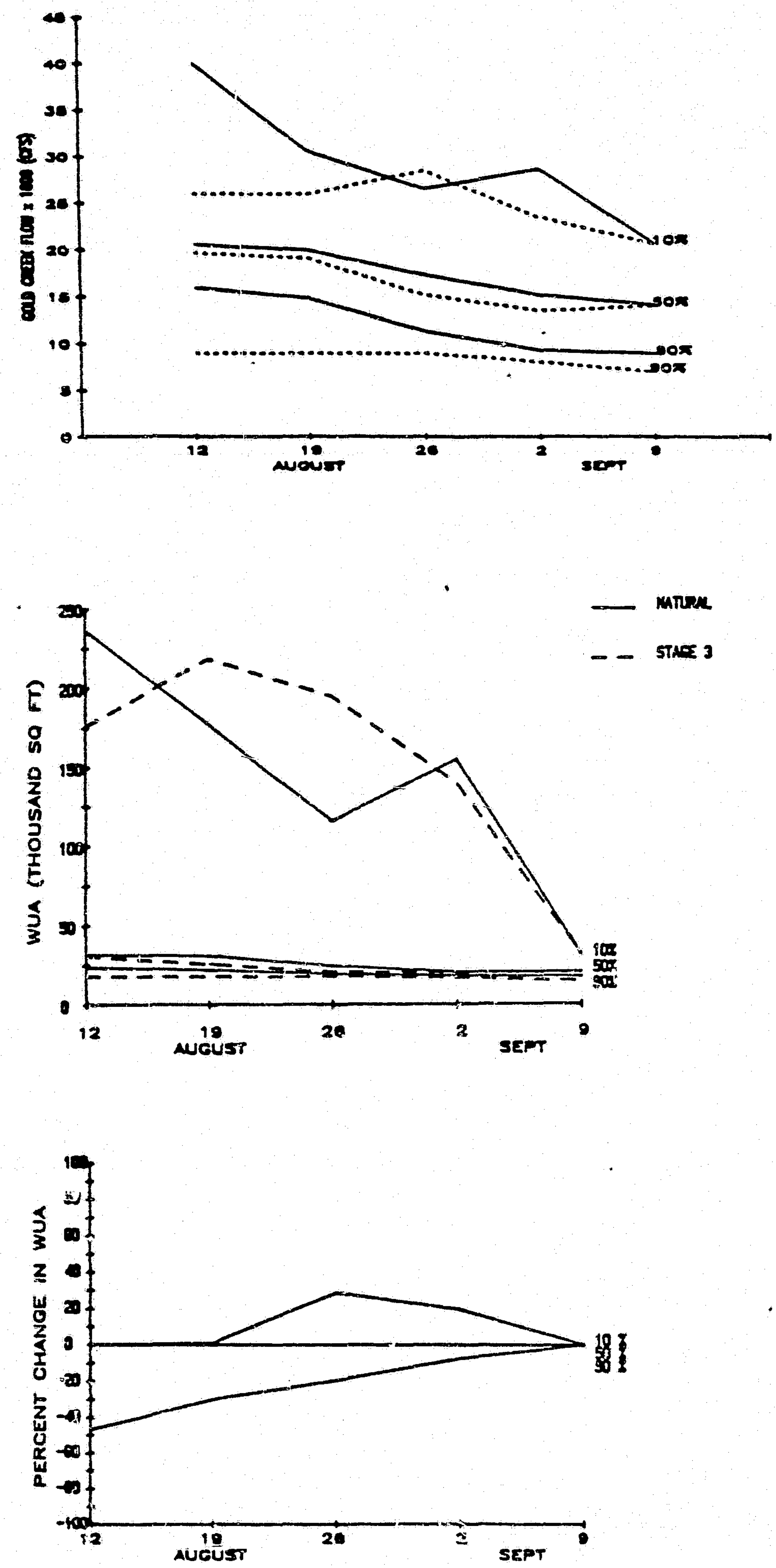
.. Filling

Filling of Watana during Stage III would occur over several years and consequently discussion of habitat availability relating to this process are more appropriately addressed under operation.

.. Operation

Habitat availability in side sloughs under natural, early Stage III operation, and late Stage III operation is compared in seasonal habitat duration curves and weekly time series plots (Figures 51, 53 and 54). During early Stage III operation, reductions in available spawning habitat from 0 to almost 50 percent could occur early in the spawning season. However, during the middle and later portions of the spawning period increases of up to 20 or 30 percent could occur. In late Stage III operation, reductions in available spawning of up to 50 percent or greater could occur throughout the spawning season.

The contribution of side sloughs to the habitat availability provided by all groups for natural, early Stage III operation, and late Stage III operation is shown in Figures 41 and 42. In late Stage III operation, the range of percent contribution would be more narrow, particularly early in the spawning season.



Mean weekly discharge (upper), chum spawning WUA for side slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows. FIGURE 53

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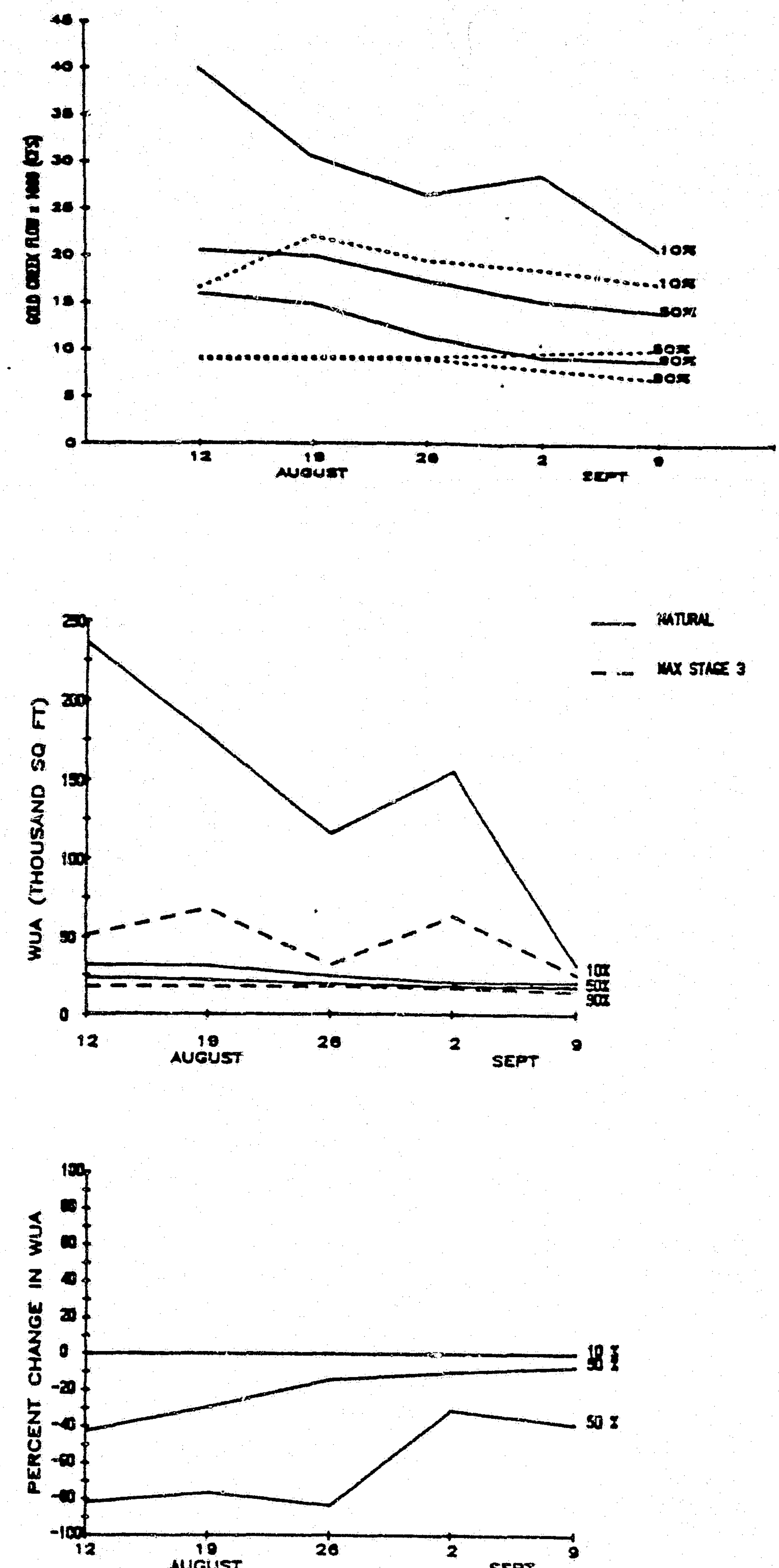

Mean weekly discharge (upper), chum spawning WUA for side slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 54

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-- Chum Salmon Embryos and Pre-emergent Fry

. Stage I Filling

Flows during the fall and winter after the summer of filling Stage I are expected to be similar to natural. Thus, conditions for incubating embryos are expected to be similar to natural.

. Stage I, II, III Operation

As mentioned previously, conditions for incubation in mainstem-influenced areas are expected to be maintained or improved during project operation because of the higher, stable flows in the fall and winter.

- Secondary Evaluation Species

-- Sockeye Salmon Spawning Adults

. Stage I Filling and Operation

In the middle Susitna River, sockeye salmon spawn in side sloughs, with two side sloughs (8A and 21) providing habitat for 25 percent of the sockeye spawning.

The habitat requirements of spawning sockeye salmon are similar to those of chum salmon. Thus, the habitat modeling developed for spawning chum salmon (see above) can be applied to sockeye salmon. The habitat modeling for chum salmon provides a conservative estimate of available spawning habitat for sockeye salmon, because sockeye are able to negotiate more shallow passage reaches than chum salmon. Hence, at a selected flow, sockeye salmon will likely have access to more spawning habitat than the model predicts because of their ability to negotiate more shallow depths than the minimum depth criteria for successful chum salmon passage.

. Stages II and III

Habitat availability for sockeye would be similar to chum salmon.

-- Pink Salmon Spawning Adults

. Stage I Filling and Operation

In the middle Susitna River, pink salmon spawn primarily in tributaries, and to a lesser extent in sloughs. In odd years, when the run strength is low, few pink salmon spawn in sloughs (ADF&G 1985a). During years of high pink escapements (even years), pink salmon spawn in sloughs more frequently. Sloughs 8A and 20 were areas utilized for slough-spawning pink salmon during 1982 and 1984 (ADF&G 1985a).

Since habitat requirements of spawning pink salmon and chum salmon are dissimilar (pink salmon tend to use areas with higher velocities and smaller substrate), the analysis of available habitat for spawning chum salmon cannot be applied to pink salmon.

(section on pink spawning and incubation to be added upon completion of IFR secondary species evaluations in March 1985)

. Stages II and III

(section on pink spawning and incubation to be added upon completion of IFR secondary species evaluations in March 1985)

(iv) Upland Sloughs

Upland sloughs are analogous to small tributaries since their upstream ends are only breached by mainstem water at extremely high mainstem discharge (greater than 40,000 cfs). Chum, sockeye, and pink salmon spawn in upland sloughs, with Slough 11 containing most of the utilization in this habitat type.

- Primary Evaluation Species

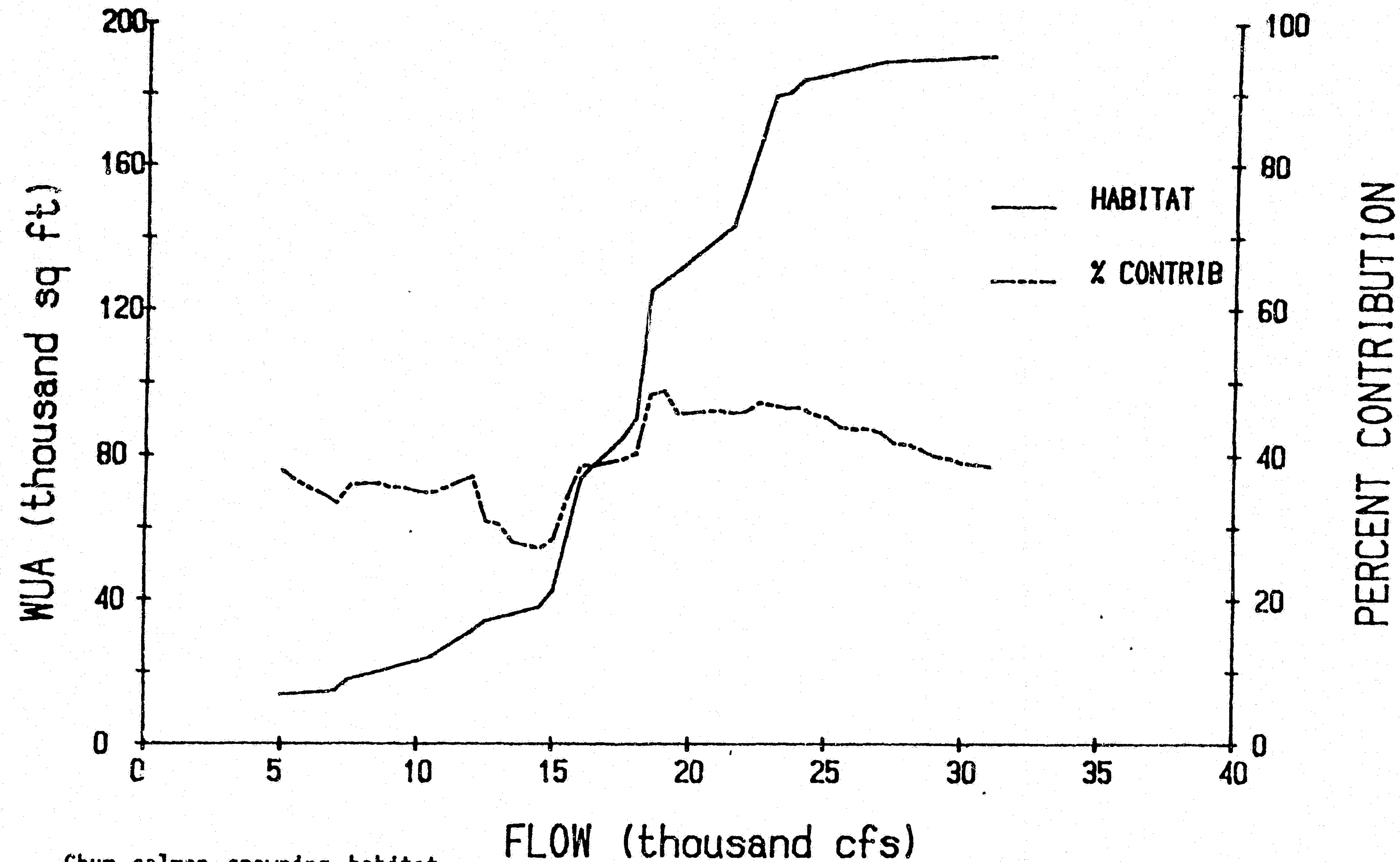
-- Chum Salmon Spawning Adults

- The amount of available upland slough spawning for chum salmon in the middle Susitna River increases substantially between mainstem discharges of 12,000 to 20,000 cfs (Figure 55). At discharges below 12,000 cfs and above 20,000 cfs there is little change in the amount of available upland slough spawning habitat.

. Stage I

.. Filling

The available spawning habitat in upland sloughs for dry, average, and wet years during Stage I filling is presented in Table 13. If a dry year occurs during the filling period, spawning habitat will be reduced by approximately 75 percent in August and 40 percent in September. If an average year occurs during the filling period, spawning habitat will be reduced by



Chum salmon spawning habitat response curve and percent contribution to total available habitat of upland slough areas in the middle Susitna River.

FIGURE 55

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Table 13. Estimated change in chum spawning habitat (WUA) in upland sloughs due to filling of the Watana - Stage I Reservoir.

Month	Discharge (cfs		Chum Spawning WUA (sq ft)		
	Natural	Filling	Natural	Filling	% Change
Dry Year					
August	17,392	8,000	92,581	10,828	-88.30
September	10,422	5,800	16,755	8,798	-47.49
Average Year					
August	22,228	12,415	127,335	39,526	-68.96
September	13,221	6,800	50,922	9,380	-81.58
Wet Year					
August	25,236	15,505	125,723	72,374	-42.43
September	15,124	6,800	69,518	9,380	-86.51

approximately 75 percent in August and 40 percent in September. If an average year occurs during the filling period, spawning habitat will be decreased by about 75 percent in August and by almost 60 percent in September. A decrease in available spawning habitat of almost 70 percent is expected in both August and September if a wet year occurs during filling.

.. Operation

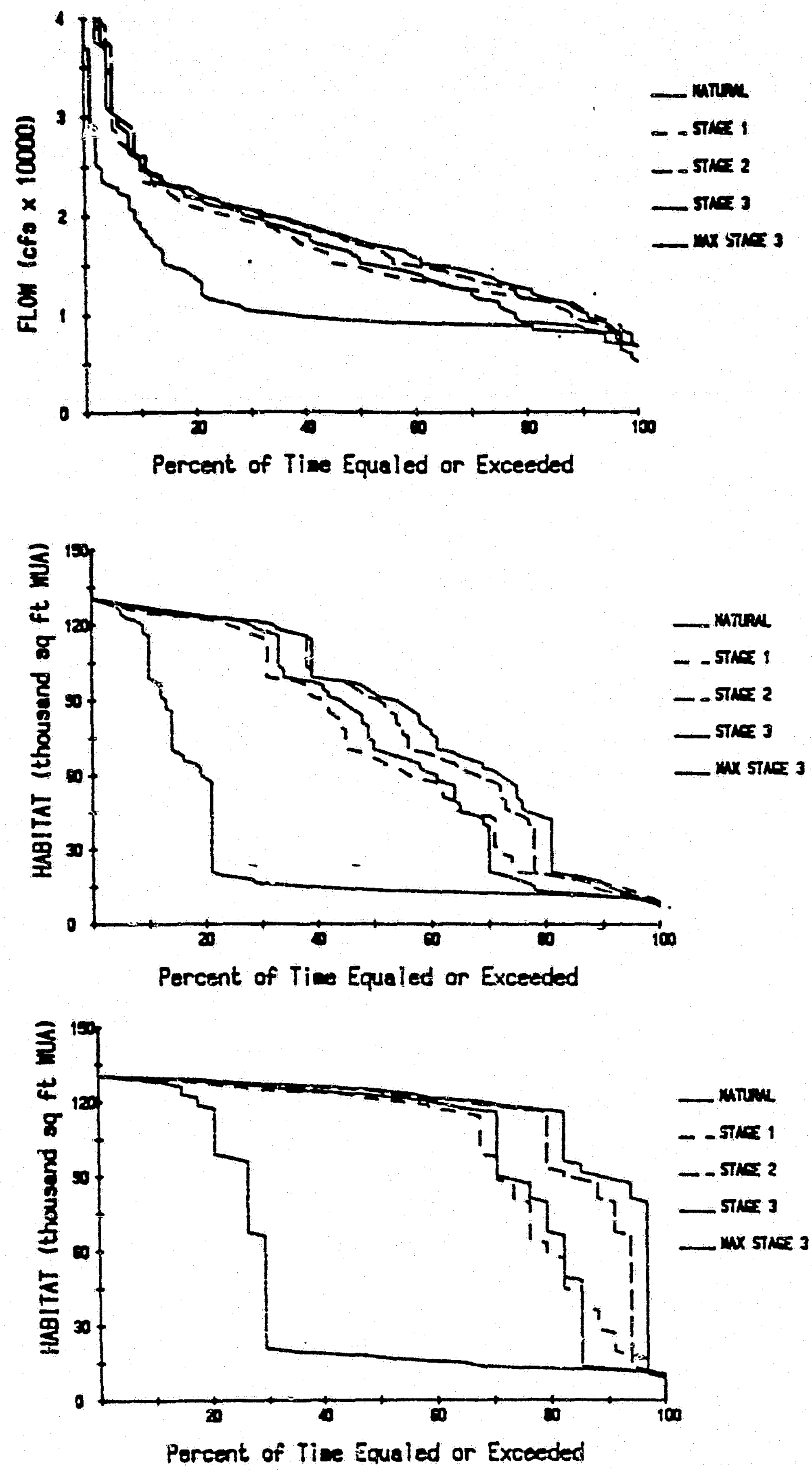
Habitat availability in upland sloughs under natural and Stage I flows is compared in seasonal habitat duration curves and weekly habitat time series plots (Figures 56 and 57). During August a reduction of up to 70 to 80 percent of the available spawning habitat is expected 50 percent of the time. However, in September reductions in the available habitat will be less and there would be a 50 percent chance that available habitat would increase by up to 50 percent.

The contribution of upland sloughs to the habitat availability provided by all groups for natural and Stage I operation is shown in Figure 36. A slight decrease in percent contribution is expected during August, whereas, percent contribution is expected to be similar to natural conditions during September.

. Stage II

.. Filling

Filling flows for Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.



Flow duration curve (upper) and seasonal (middle) and maximum weekly (lower) chum spawning habitat duration curve for upland sloughs.

FIGURE 56

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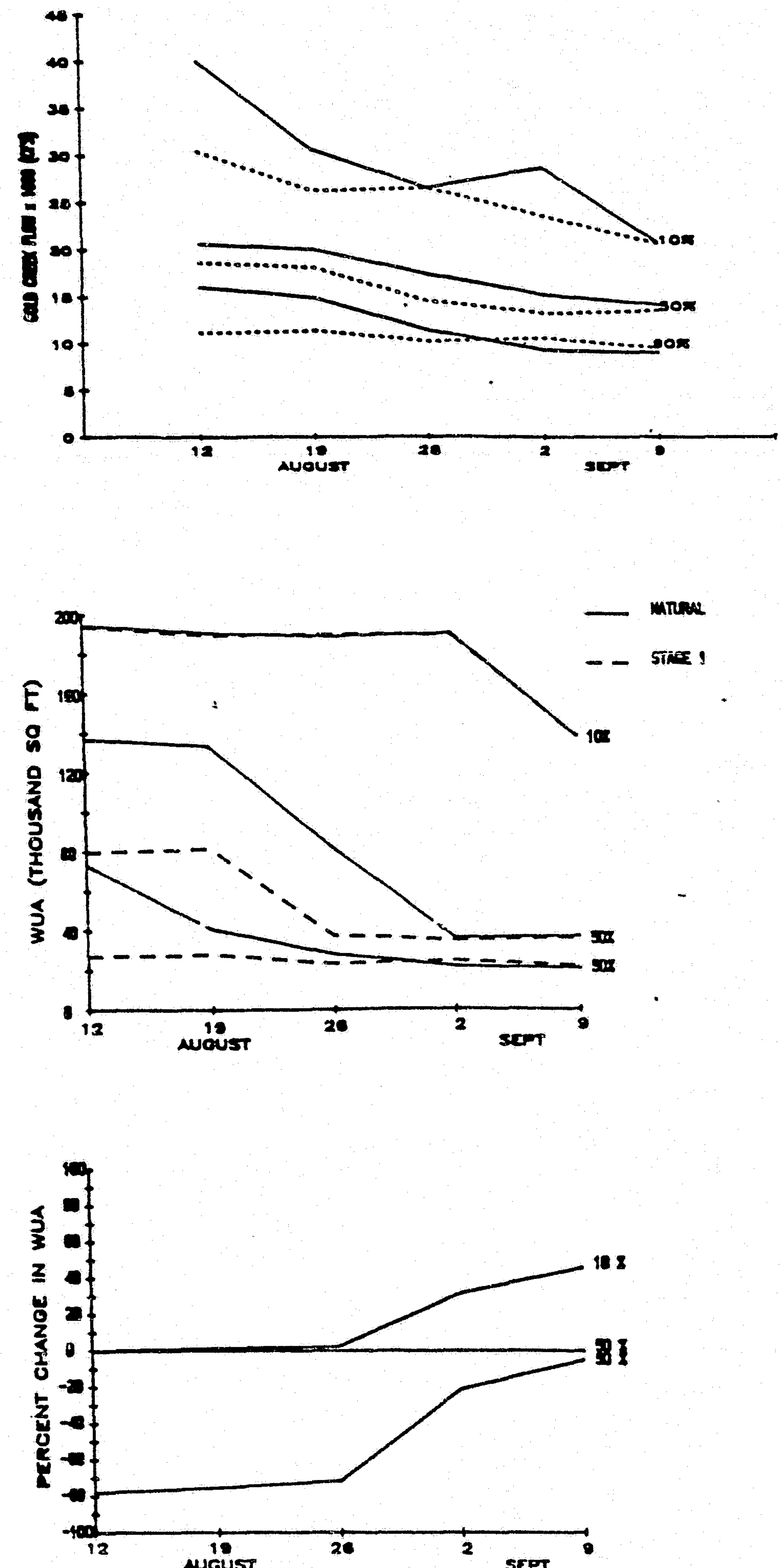

Mean weekly discharge (upper), chum spawning WUA for upland slough (middle) and percent change in WUA (lower) exceeded ?0, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 57

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.. Operation

Habitat availability in upland sloughs under natural and Stage II flows is compared in seasonal habitat duration curves and weekly time series plots (Figure 56 and 58). During the early part of the spawning season, available spawning habitat could be decreased by up to 70 percent. However, available spawning habitat is expected to be similar to natural conditions during the rest of the spawning period.

The contribution of upland sloughs to the habitat availability provided by all groups for natuarl and Stage II operation is shown in Figure 36. The range of percent contribution during Stage II is expected to be similar to natural conditions, except early in the spawning season when the contribution is expected to be slightly less than natural.

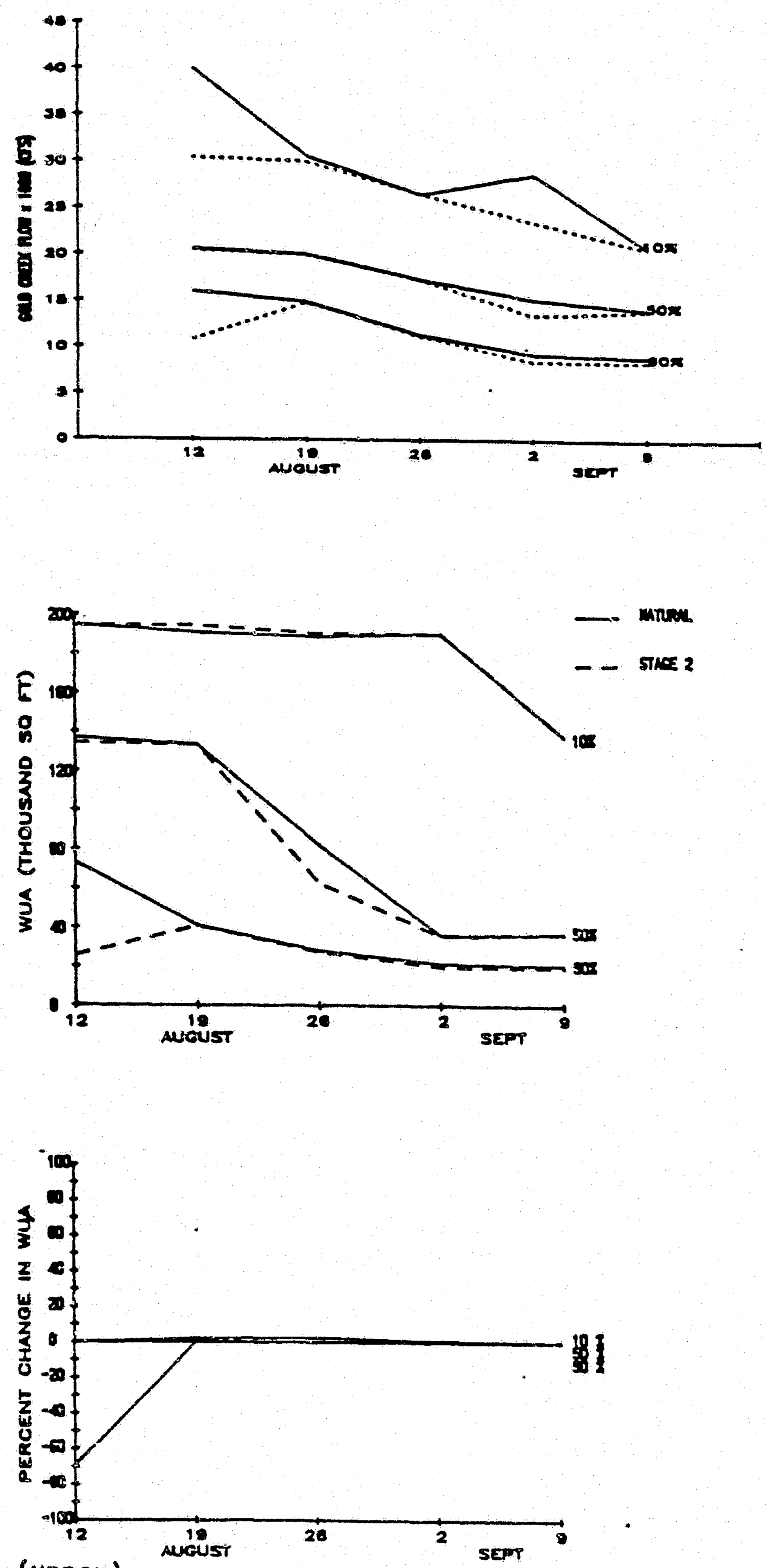
. Stage III

.. Filling

Filling of Watana during Stage III would occur over several years and consequently discussion of habitat availability relating to this process are more appropriately addressed under operation.

.. Operation

Habitat availability in upland sloughs under natural, early Stage III operation, and late Stage III operation is compared in seasonal habitat duration curves and weekly time series plots (Figures 56, 59 and 60). During early Stage III operation there is a 50 percent chance or greater that available spawning habitat in



Mean weekly discharge (upper), chum spawning WUA for upland slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 58

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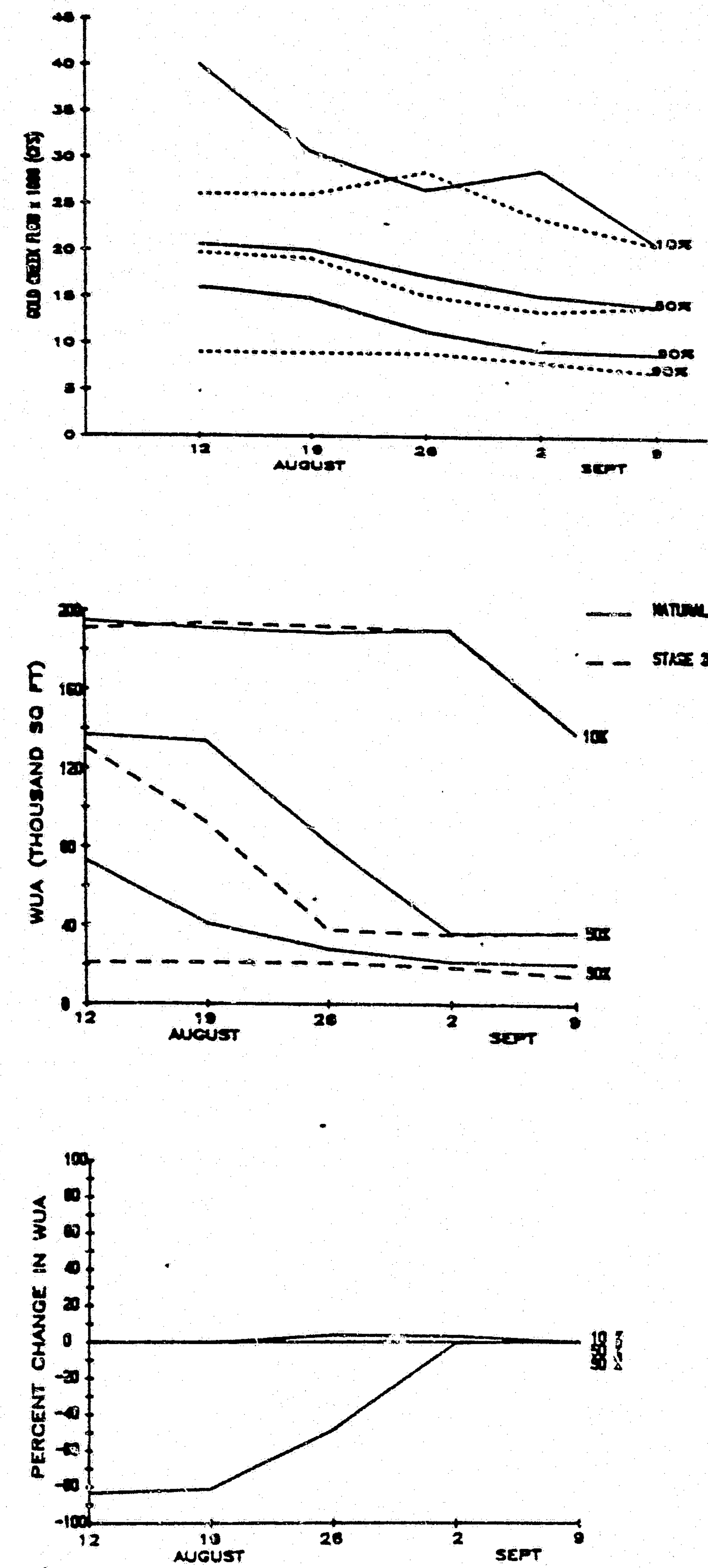

Mean weekly discharge (upper), chum spawning WUA for upland slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 59

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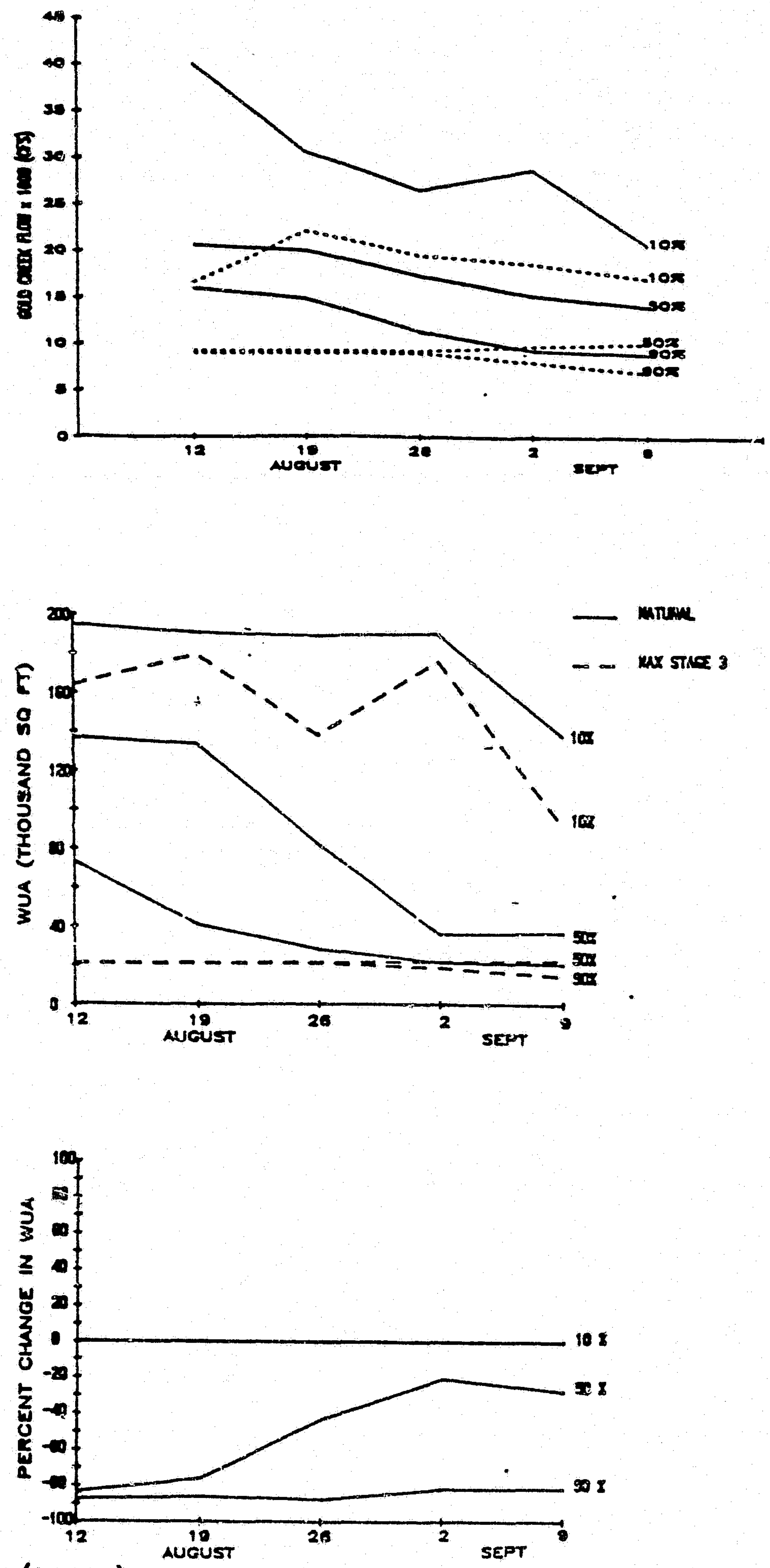

Mean weekly discharge (upper), chum spawning WUA for upland slough (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 60

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upland sloughs would be reduced by up to 80 percent. However, in September of early Stage III, available habitat would be similar to natural conditions. During late Stage III operation substantial reductions in available habitat would occur throughout the spawning season in most years.

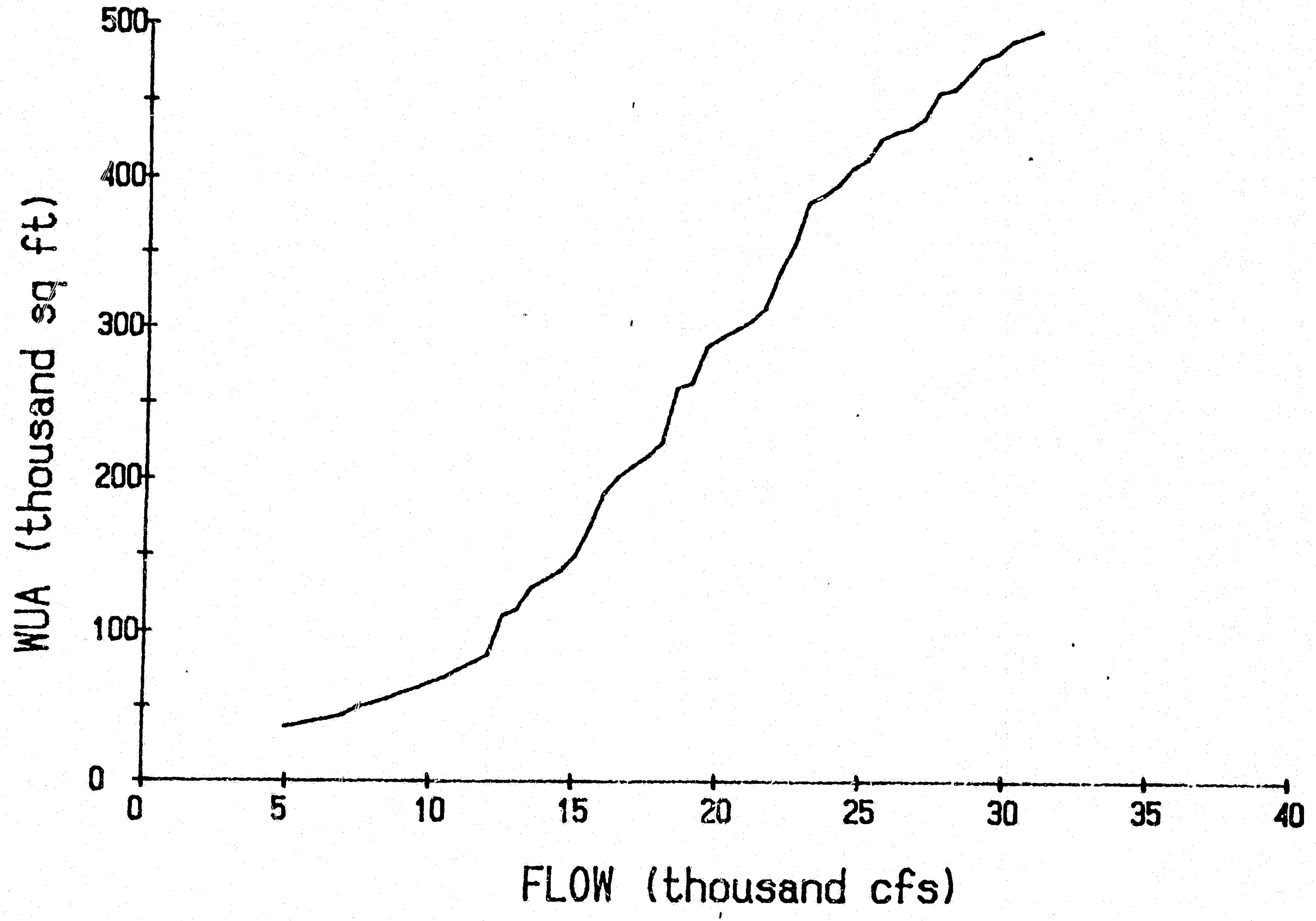
The contribution of upland sloughs to the habitat availability provided by all groups for natural, early Stage III operation, and late Stage III operation is shown in Figures 41 and 42. During early Stage III operation a slight decrease in percent contribution is expected in August, whereas in September percent contribution will approach natural conditions. During late Stage III operation, the range of percent contribution will be more narrow than under natural conditions and percent contribution will usually be less than natural.

(v) <u>All Groups</u>

- <u>Primary Evaluation Species</u>

-- <u>Chum Salmon Spawning Adults</u>

The amount of available chum salmon spawning habitat in all groups increases with increasing mainstem discharge over the range of 5000 to 35,000 cfs (Figure 61). All groups show increases in available habitat between 5000 and 20,000 cfs. However, side slough is the only group that shows an increase in available habitat in response tomainstem discharges greater than 20,000 cfs.



Chum salmon spawning habitat response curve for all habitat types in the middle Susitna River.

FIGURE 61

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. Stage I

.. Filling

The available spawning habitat in all groups for dry, average, and wet years during Stage I filling is presented in Table 14. If a dry year occurs during the filling period, spawning habitat will be reduced by approximately 75 percent in August nad 45 percent in September. If an average year occurs during the filling period, spawning habitat will be decreased by about 70 percent in August, by almost 65 percent in September. A decrease in available spawning habitat in August of 60 percent and in September of 70 percent is expected if a wet year occurs during filling.

.. Operation

Habitat availability in all groups under natural and Stage I flows is compared in seasonal habitat duration curves and weekly habitat time series plots (Figures 62 and 63). During Stage I operation, there is a 40 percent chance that available spawning habitat in all groups would decrease from 0 to almost 70 percent during August and from 0 to 20 percent during September. However, there is an equal chance that available habitat in all groups would slightly increase in August and be up to 40 percent higher in September.

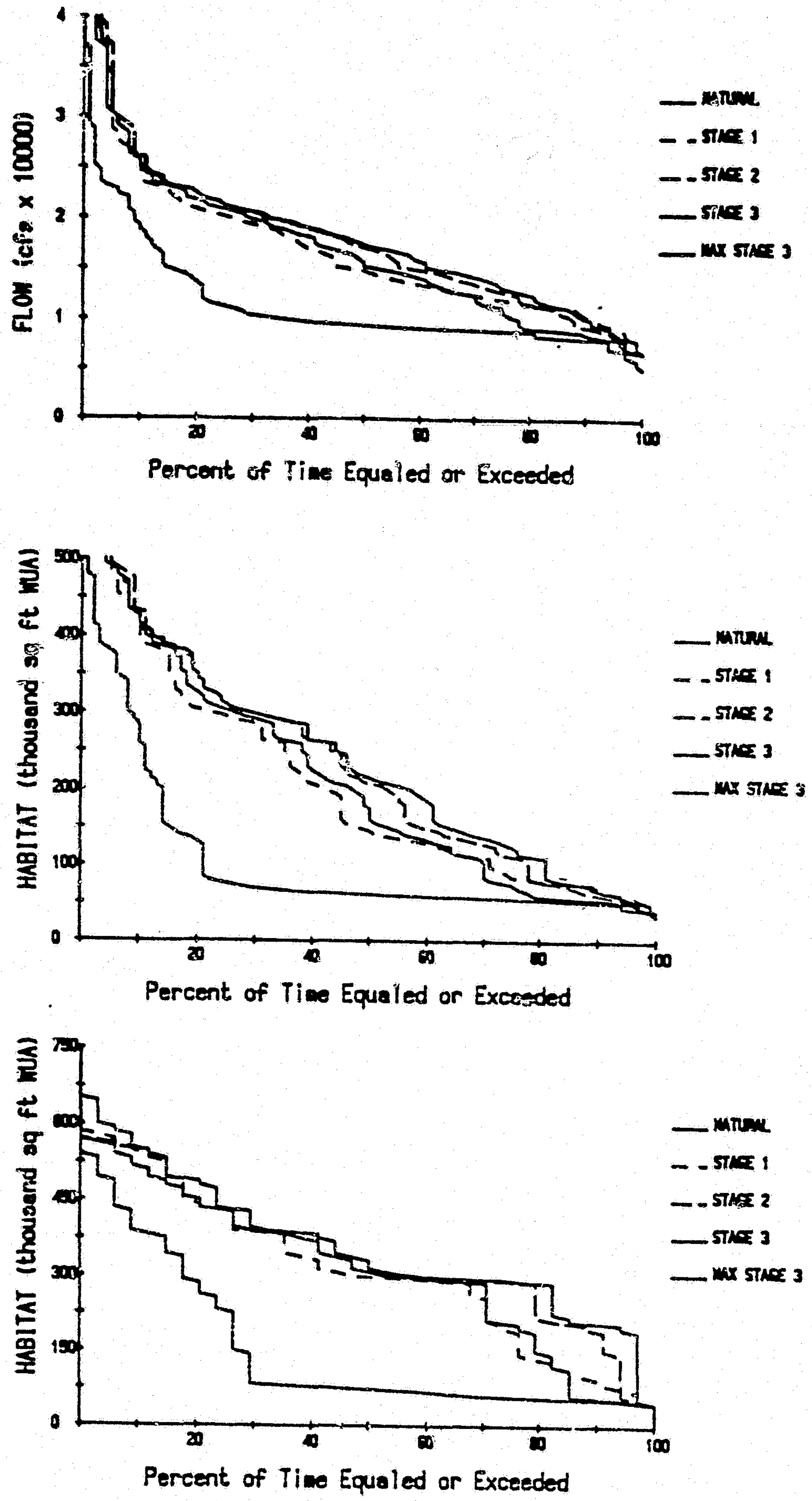
. Stage II

.. Filling

Filling flows for Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

Table 14. Estimated change in chum spawning habitat (WUA) in all habitats due to filling of the Watana - Stage I Reservoir.

Month	Discharge (cfs)		Chum Spawning WUA (sq ft)		
	Natural	Filling	Natural	Filling	% Change
Dry Year					
August	17,392	8,000	213,372	52,412	-75.44
September	10,422	5,800	68,893	39,353	-42.88
Average Year					
August	22,228	12,415	345,063	106,056	-69.26
September	13,221	6,800	121,116	43,057	-64.45
Wet Year					
August	25,236	15,505	418,154	168,206	-59.77
September	15,124	6,800	154,036	43,057	-72.05



Flow duration curve (upper) and seasonal (middle) and maximum weekly (lower) chum spawning habitat duration curve for all habitat types.

FIGURE 62

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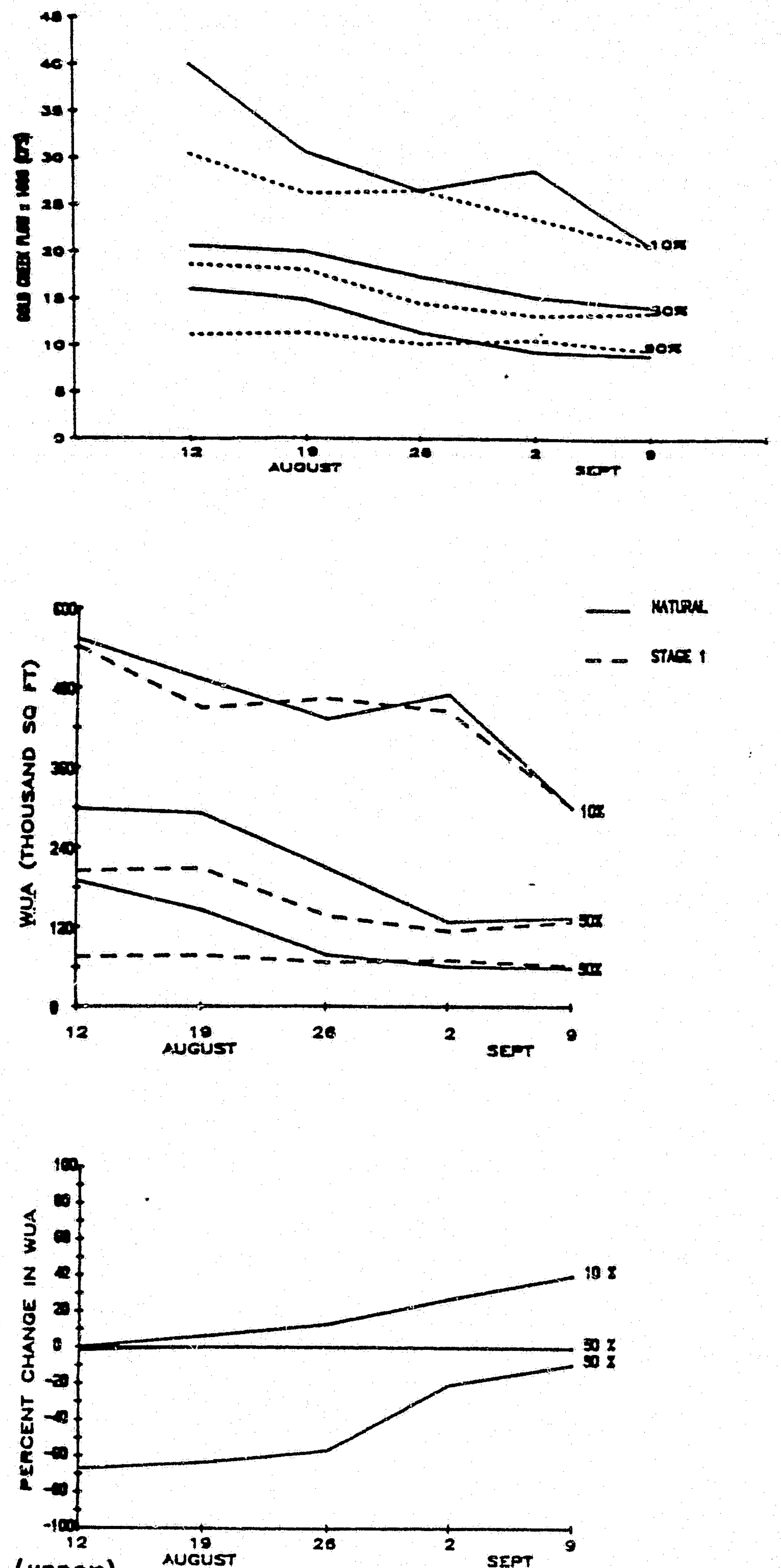

Mean weekly discharge (upper), chum spawning WUA for all habitat types (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 63

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.. Operation

Habitat availability in all groups under natural and Stage II flows is compared in seasonal habitat duration curves and weekly time series plots (Figures 62 and 64). During mid-August there is a chance that available spawning habitat may be reduced by up to 50 percent. However, during the remainder of the spawning season available habitat is expected to be similar to or slightly greater than natural.

. Stage III

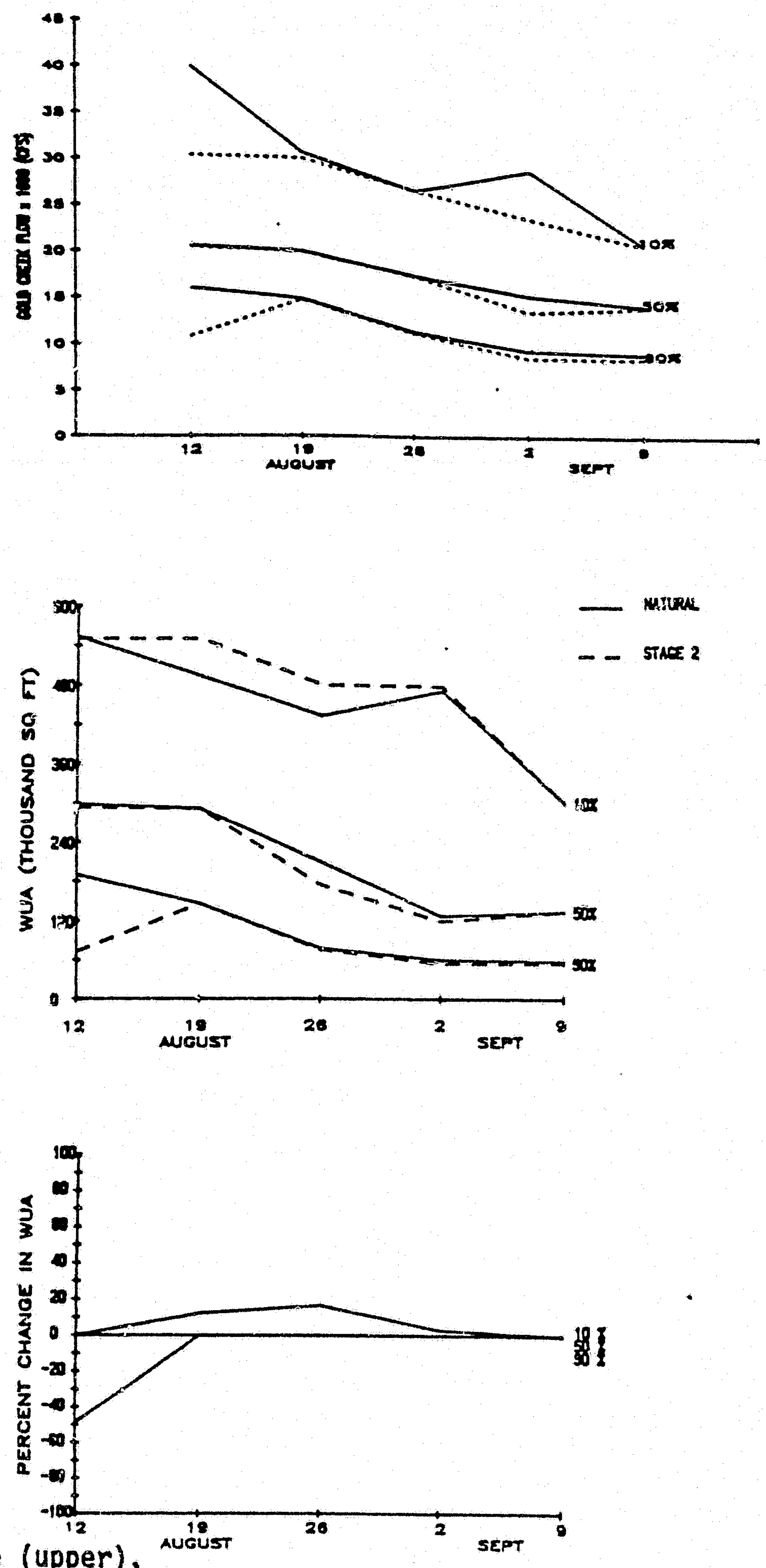
.. Filling

Filling of Watana during Stage III would occur over several years and consequently discussion of habitat availability relating to this process is more appropriately addressed under operation.

.. Operation

Habitat availability in all groups under natural, early Stage III operation, and late Stage III operation is compared in seasonal habitat duration curves and weekly time series plots (Figures 62, 65, and 66). During early Stage III, available spawning habitat could be substantially reduced in August (up to 80 percent) and slightly reduced in September. A gain in available habitat of up to 30 percent could occur during late August.

Under late Stage III operating conditions available spawning will be substantially reduced. A loss of 20 to 80 percent is expected throughout the spawning season 40



Mean weekly discharge (upper), chum spawning WUA for all habitat types (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 64

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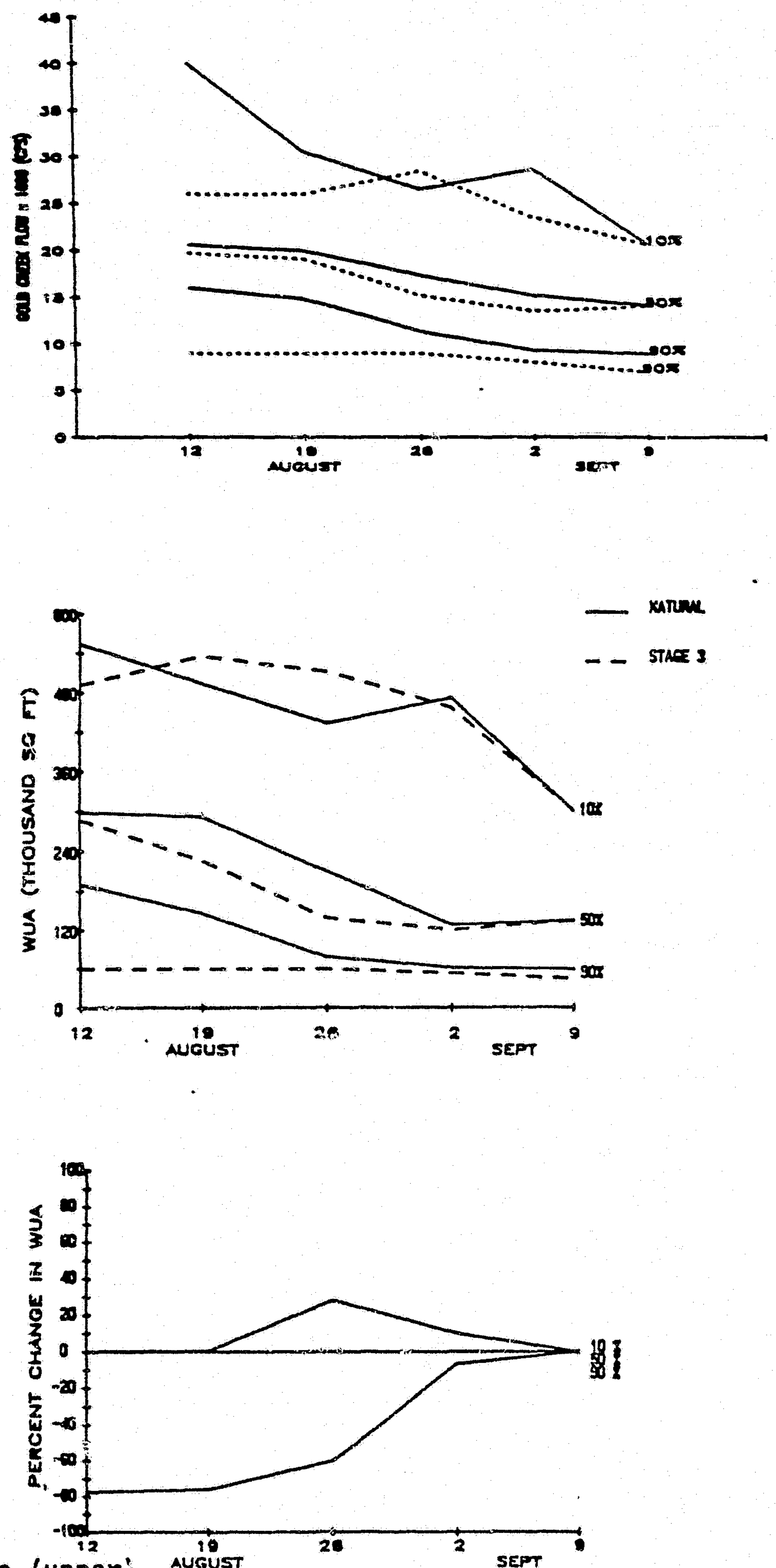

Mean weekly discharge (upper), chum spawning WUA for all habitat types (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 65

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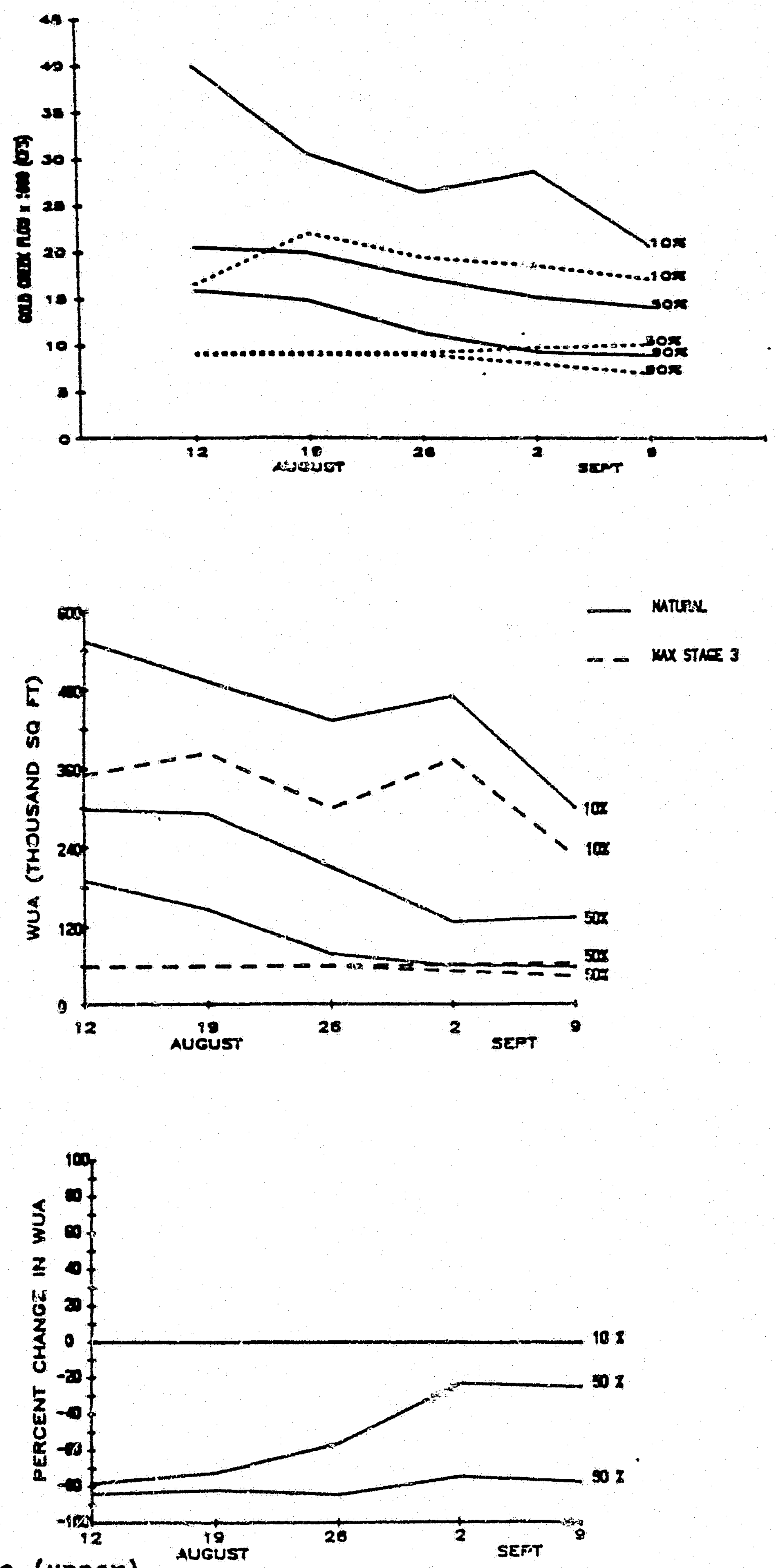

Mean weekly discharge (upper), chum spawning WUA for all habitat types (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 66

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percent of the time. Available habitat will be similar to natural conditions only 10 percent of the time.

(c) Rearing

The principal effort in assessing impacts to the rearing life stage of fish species in the middle Susitna River has focused on chinook salmon juveniles, the designated primary evaluation species/life stage. In order to describe the dynamic and site-specific response of juvenile chinook rearing habitat to flow-related changes in this reach of the Susitna River, a set of distinct subenvironments was defined (Aaserude 1985). This set of subenvironments consisted of nine groups considered to be representative of the range of habitats present in the middle Susitna River. The habitat for each group as a function of mainstem flow was then modeled (Steward et al. 1985). Response of rearing habitat to project conditions within each of the representative groups and for all groups combined are discussed in Sections 5.1.2(c)(i) below.

The low abundance of rearing life stages of the secondary evaluation species in the middle Susitna River has precluded establishing definitive seasonal utilization patterns and habitat response functions necessary for a quantitative impact analysis. The response of the rearing life stage of secondary evaluating species are discussed in a qualitative fashion for each of the traditional habitat types (mainstem, side channel, side slough and upland slough) in Section 5.1.2(c)ii.

(i) Representative Groups

- Representative Group I

This group includes upland sloughs, which are highly stable areas connected to the main channel at their downstream end, except in times of high flow events, when they may be overtopped by turbid mainstem waters. The habitat response curve and percent contribution of this group to total middle Susitna habitat are shown in Figure 67a.

-- Stage I

. Filling

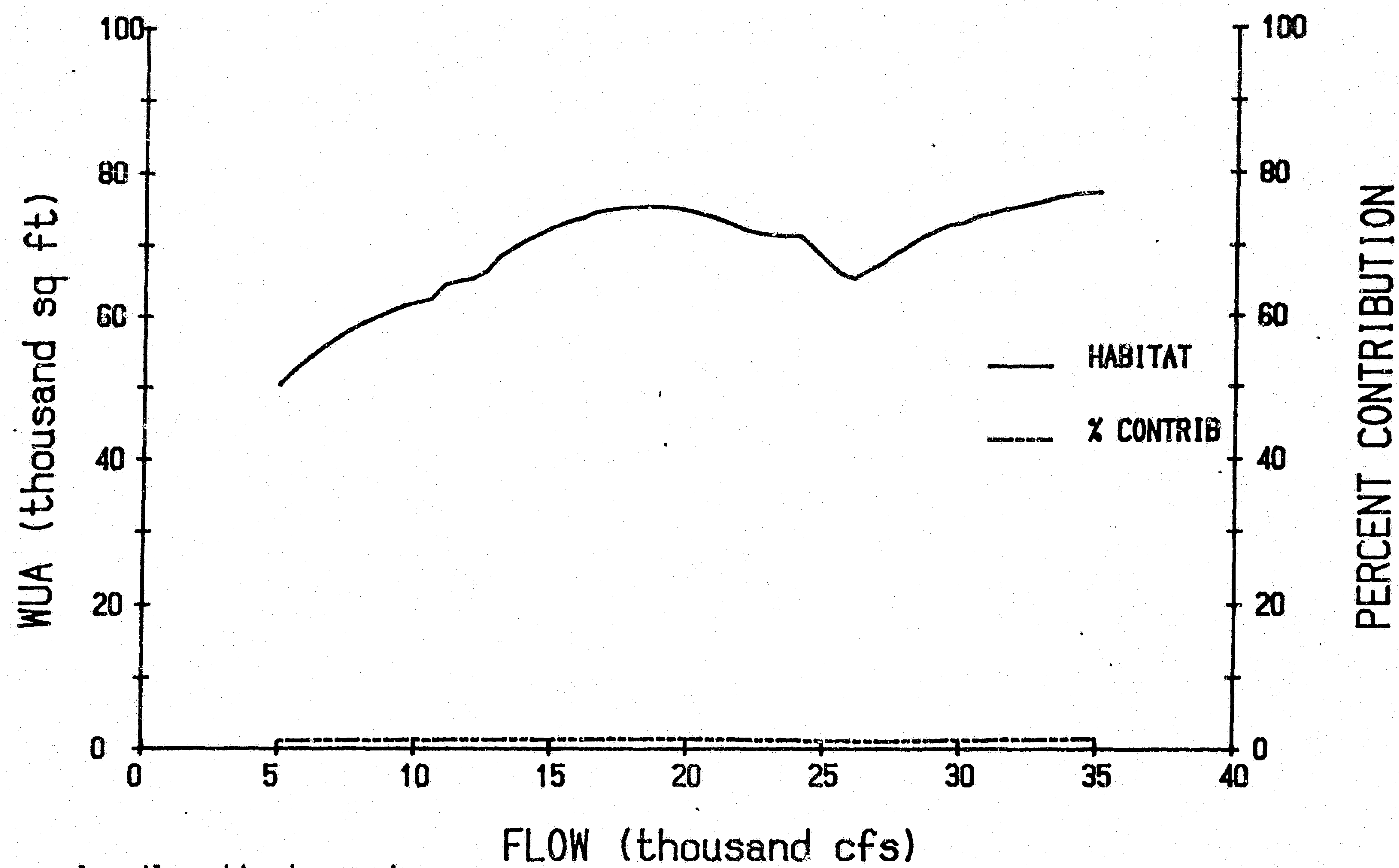
Weekly simulations of Gold Creek flows during the first summer of filling were not undertaken, however estimates of monthly flows during June and September indicate levels to be at or near E-VI minimum levels. Flow levels during July and August would depend on the hydrologic conditions of that year. Under dry conditions flow releases in July and August would be at the E-VI dry year minimum of 8,000 cfs. In an average year July and August flows would be about 12,700 and 12,400 cfs and in a wet year about 20,500 and 15,500 cfs.

The rearing habitat available during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below the flows that provide the maximum habitat levels for this group.

Habitat associated with monthly flow estimates for June through September would be reduced 14 to 22 percent in a dry year, 3 to 18 percent in an average year, and 7 to 23 percent in a wet year (Table 15).

. Operation

Habitat availability under natural and Stage I flows is compared in a weekly habitat time series and a seasonal habitat duration curve (Figure 67b and 68). The rearing habitat provided by Stage I operational flows would be



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 1 areas in the middle Susitna River.

FIGURE 67A

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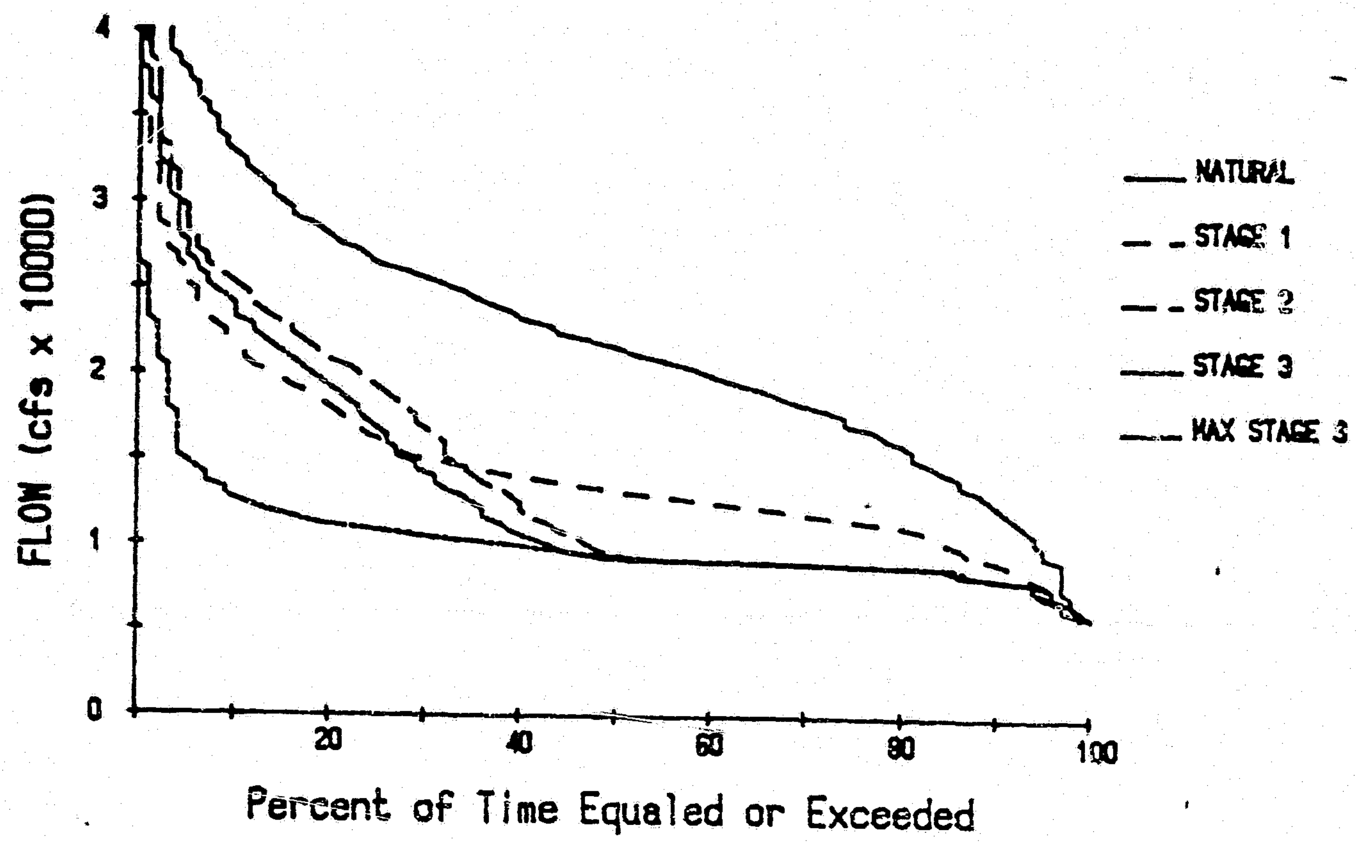
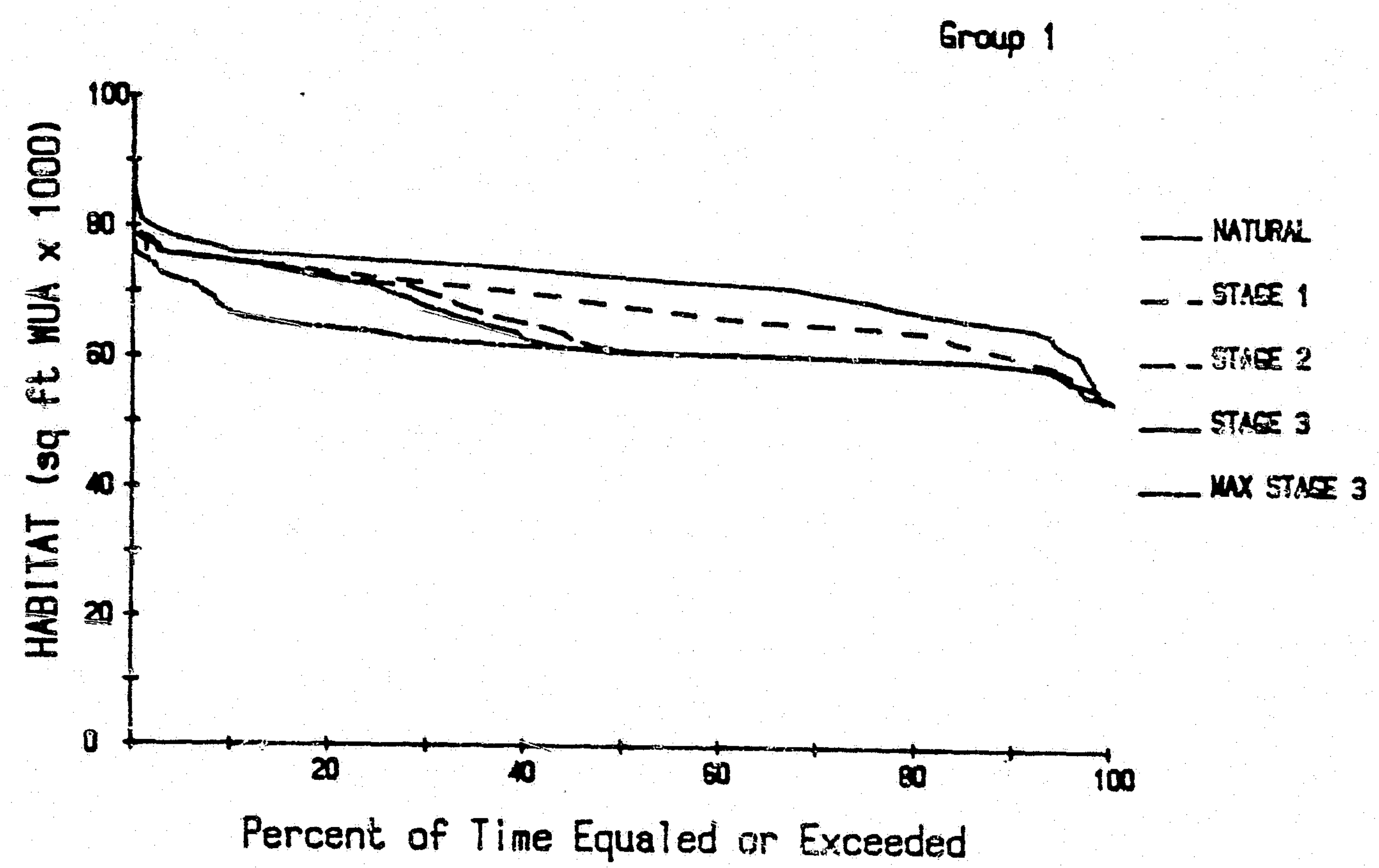
Table 15. Estimated change in chinook rearing habitat in Group 1 due to filling under dry, average and wet conditions.

Month	Discharge (cfs)		Rearing Habitat (sq ft WUA)		
	Natural	Filling	Natural	Filling	Change
Dry Year					
June	21,763	7,800	72,419	58,605	-19.08
July	19,126	8,000	75,179	59,016	-21.50
August	17,392	8,000	75,075	59,016	-21.39
September	10,422	5,800	62,424	53,439	-14.39
Average Year					
June	27,815	8,800	69,495	60,403	-13.08
July	24,445	12,740	69,735	67,365	-3.40
August	22,228	12,415	71,846	66,153	-7.92
September	13,221	6,800	69,020	56,314	-18.41
Wet Year					
June	31,580	10,752	74,925	63,531	-15.21
July	27,753	20,547	69,345	74,160	6.94
August	25,236	15,505	66,822	73,238	9.60
September	15,124	6,800	72,727	56,314	-22.57





Flow duration curve and chinook rearing habitat duration curve for Group 1.

FIGURE 67 B

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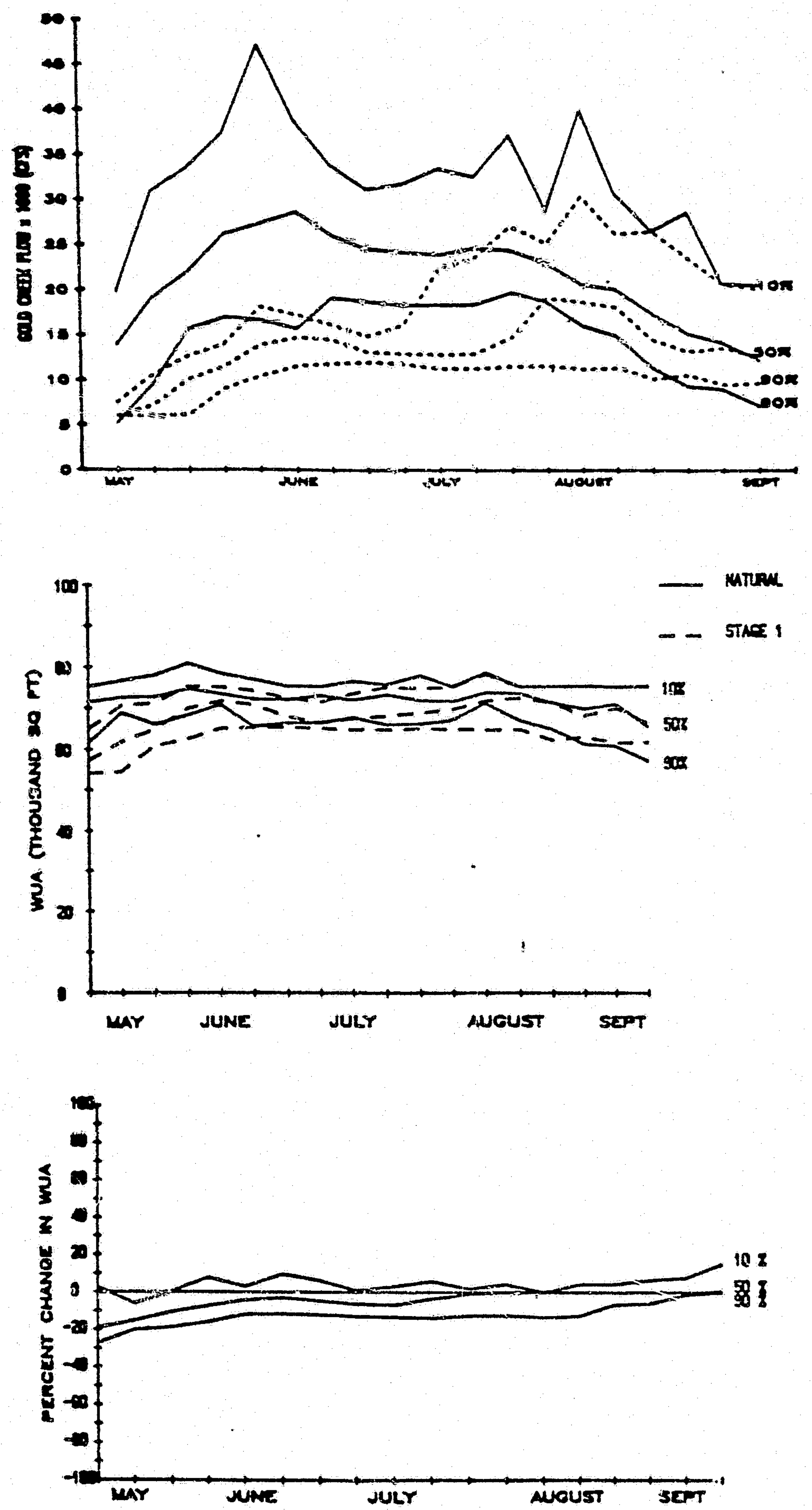

Mean weekly discharge (upper), chinook rearing WUA for Group 1 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 68

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reduced as much as 28 percent in late May and gradually increase throughout the season. By early August approximately half the time there would be an increase in habitat and half the time a decrease. The magnitude of the decreases, however, would be greater than the increases. By mid-September rearing habitat in upland sloughs would be greater under natural conditions.

The habitat within sloughs in Group I would have about the same stability in June and July during Stage I as natural and have less stability than that provided under natural conditions during July through September (Figure 69).

The percent contribution of Group I to the total habitat available would exhibit less variability than levels but would remain about the same (Figure 70).

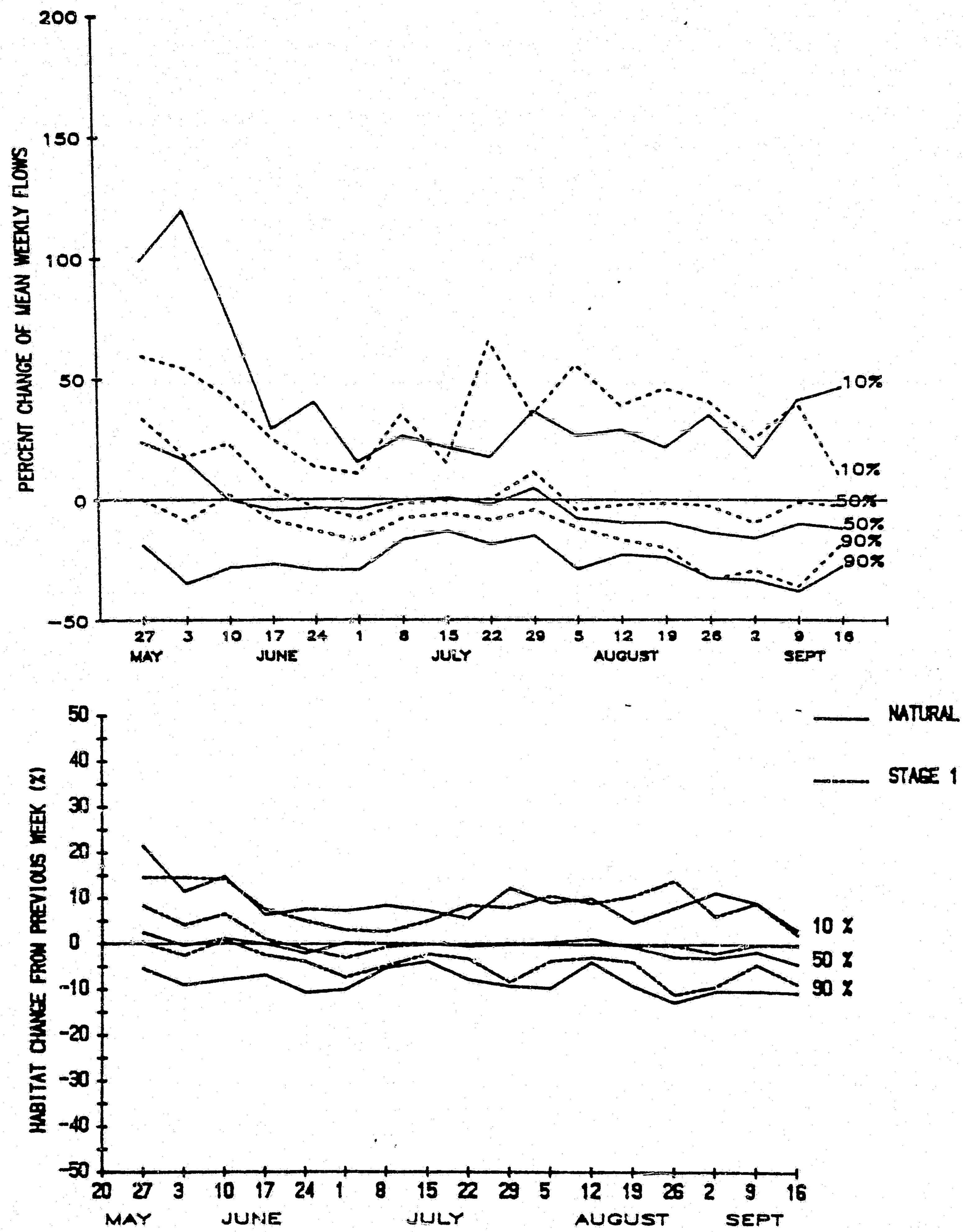
-- Stage II

. Filling

Filling flows under Stage II would be of short duration and discussion of habitat availability are deferred to Stage II operation.

. Operation

Habitat availability under natural and Stage I' flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figures 67 and 71). Reductions in rearing habitat during Stage II operation would be of greater magnitude and frequency than under Stage I and natural flows for the rearing period through mid-August. From mid-August to mid-September the habitat available would be similar to that under natural



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 1 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 69

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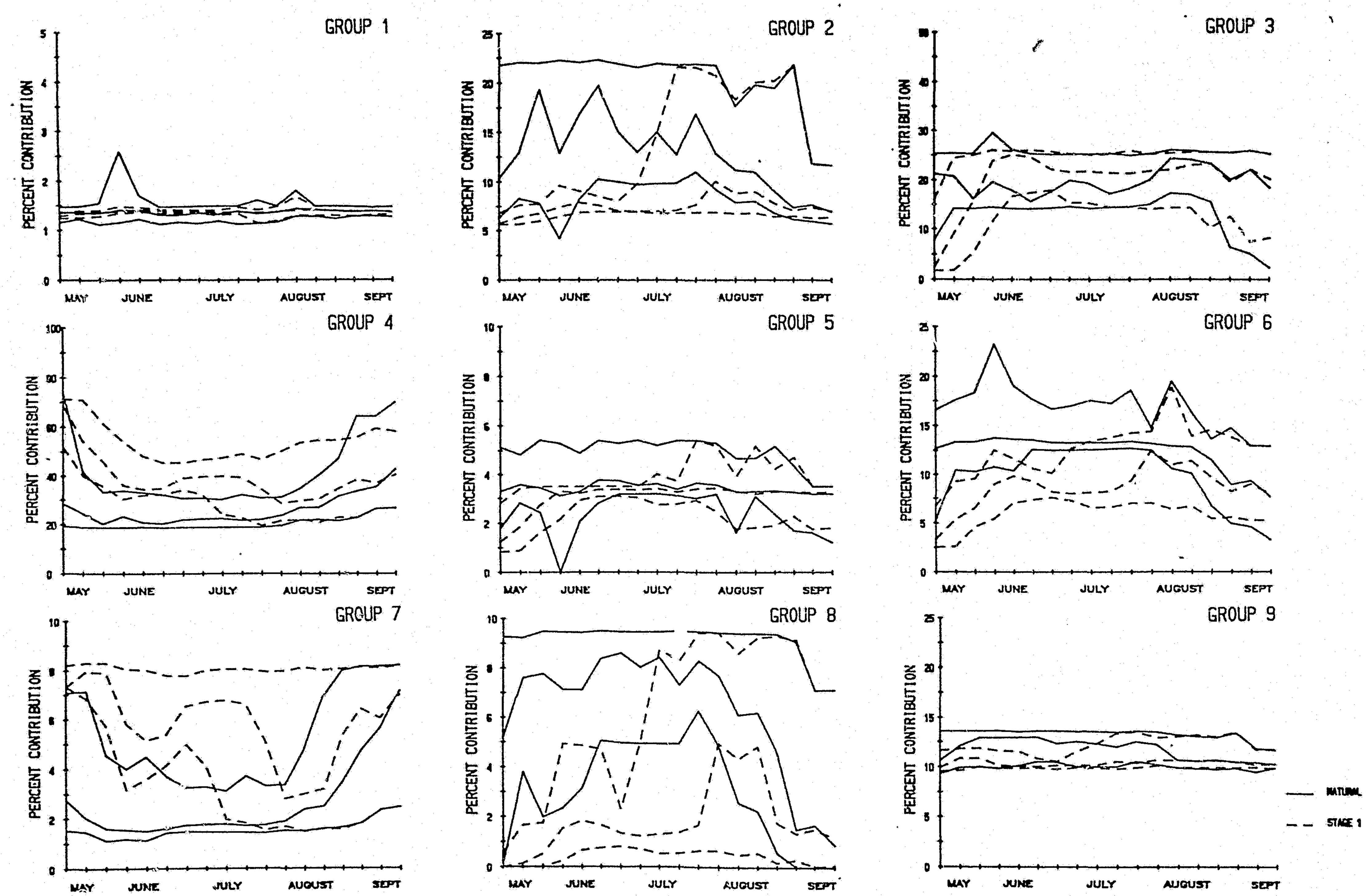

Percent contribution of chinook rearing habitat in Groups 1-9 to total habitat during Stage I.

FIGURE 70

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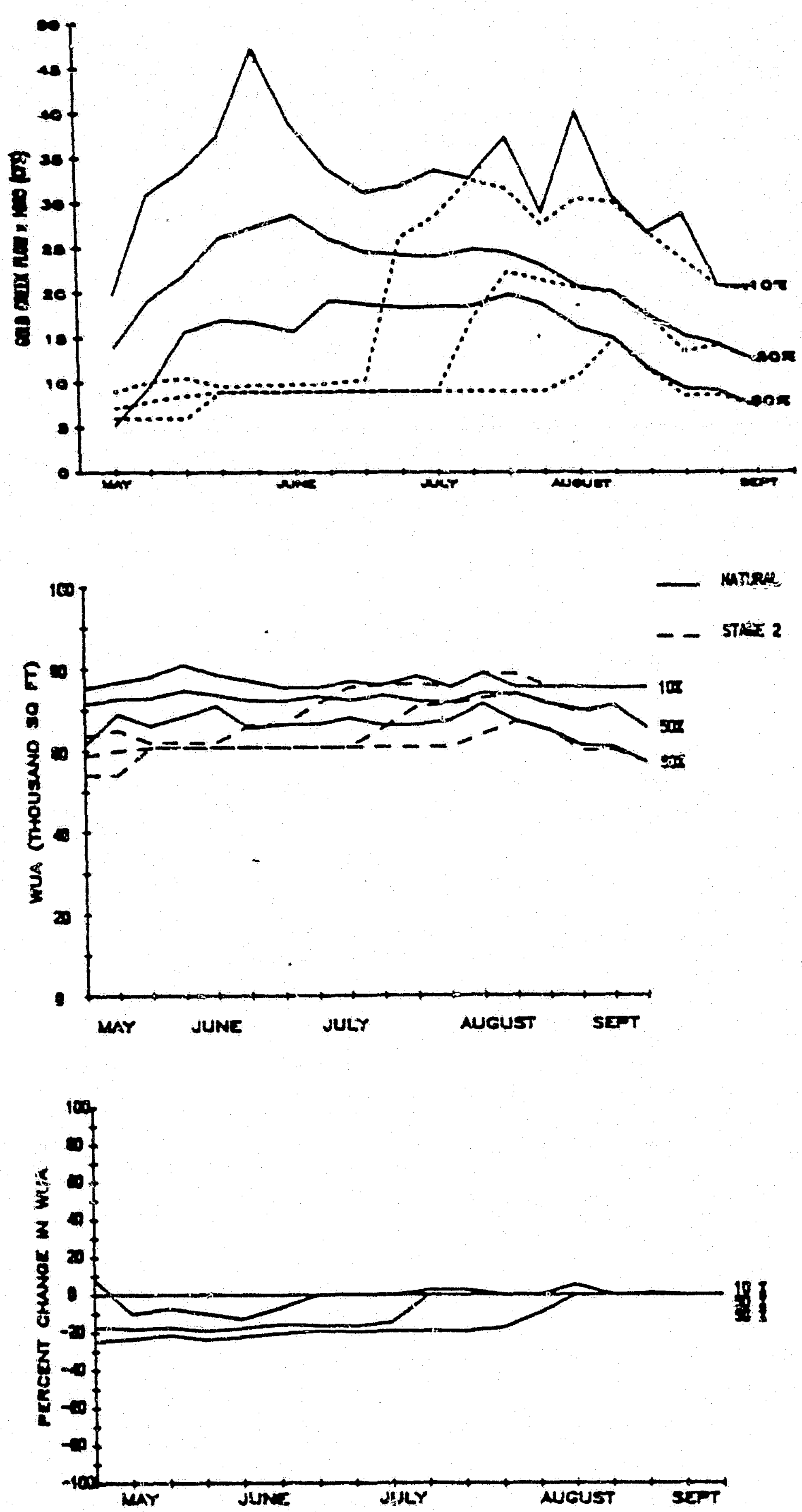

Mean weekly discharge (upper), chinook rearing WUA for Group 1 (middle) and percent change in WUA (lower)exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 71

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conditions but decreased somewhat from Stage I operational flows.

The highly stable nature of the habitat within the group as measured by week to week changes in availability is depicted in Figure 72.

The contribution of habitat within this group to the total middle Susitna River rearing habitat is quite small, a little over 1 percent for both natural and project conditions (Figure 73). Consequently reductions in habitat amounting to 20-30 percent represent only a fraction of the overall habitat.

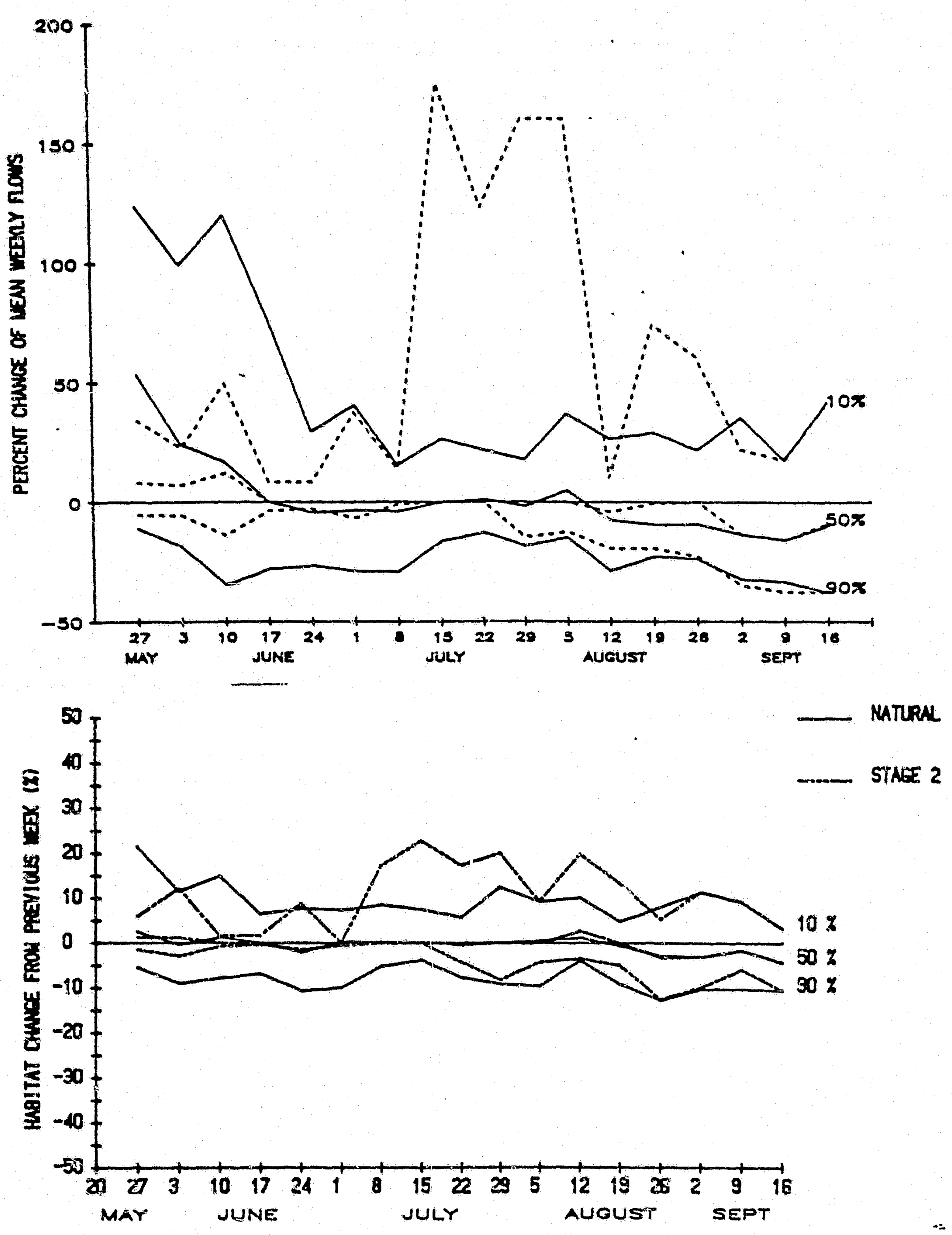
-- Stage III

- Filling

Filling flows during Stage III would be similar to those during operation and therefore juvenile chinook habitat-flow relationships are discussed in that section.

- Operation

Habitat availability under natural and early and late Stage III flows is compared in weekly habitat time series and seasonal habitat duration curves (Figures 67, 74 and 75). The rearing habitat provided by early Stage III operational flows would be about 10-20 percent less than natural in June, 0-20 percent less than natural in July to mid-August, and by mid-September would be similar to that provided by natural flows. In late Stage III, reduction in habitat would be similar to early Stage III through June; however, in contrast to



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 1 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 72

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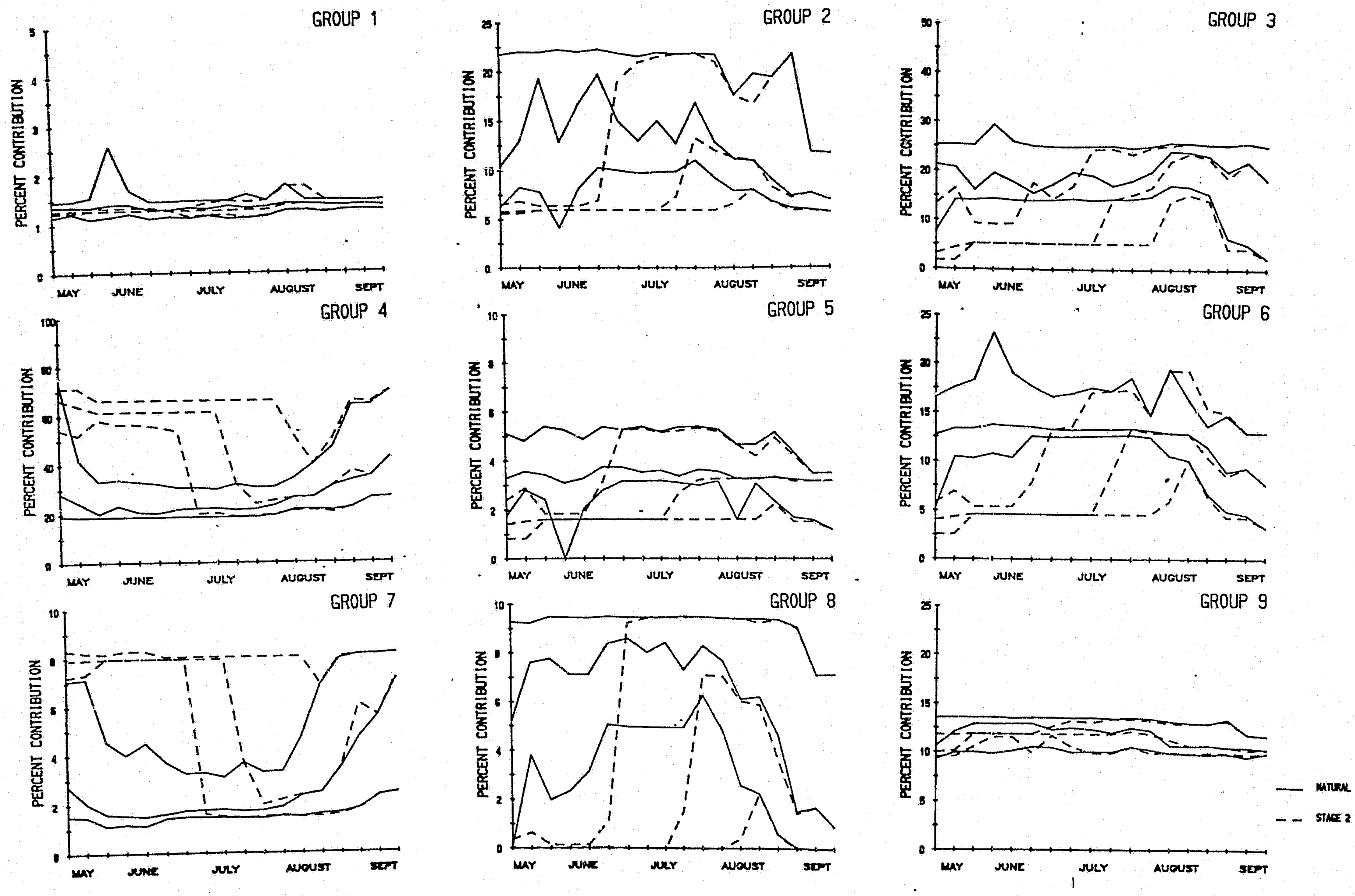

Percent contribution of chinook rearing habitat in Groups 1-9 to total habitat during Stage II.

FIGURE 73

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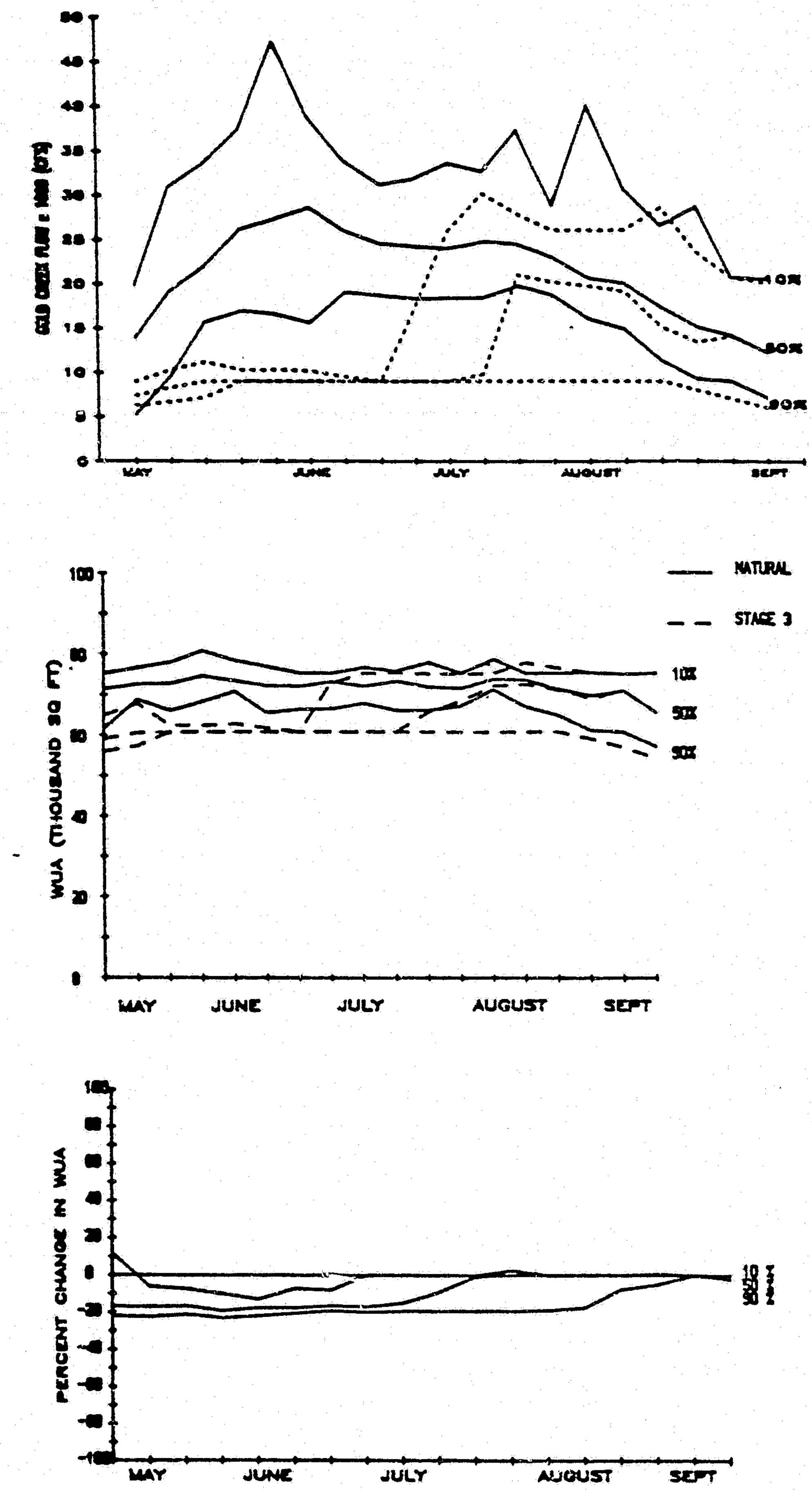

Mean weekly discharge (upper), chinook rearing WUA for Group 1 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 74

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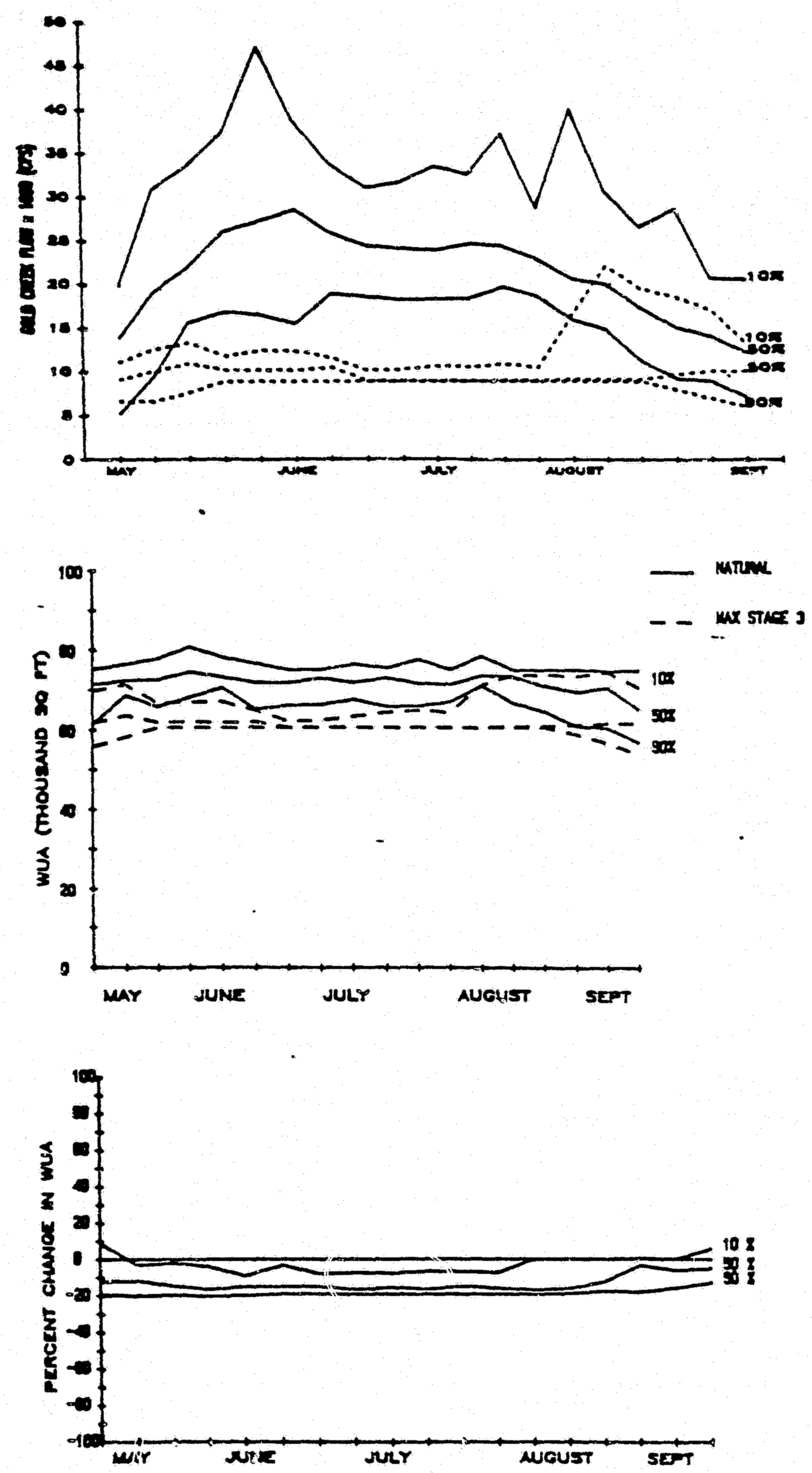

Mean weekly discharge (upper), chinook rearing WUA for Group 1 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 75

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early Stage III, rearing habitat in late Stage III would remain at depressed levels through mid-September.

With-project stability of upland slough habitat in both stages would increase early in the season during the annual filling process. Later, during July and August, the weekly percent change in habitat would increase under early and late Stage III flows (Figures 76 and 77).

The percent contribution of upland sloughs to total habitat available would be similar for both natural and Stage III flows, about 1 to 1.5 percent, although the variability would be somewhat less with project (Figures 78 and 79).

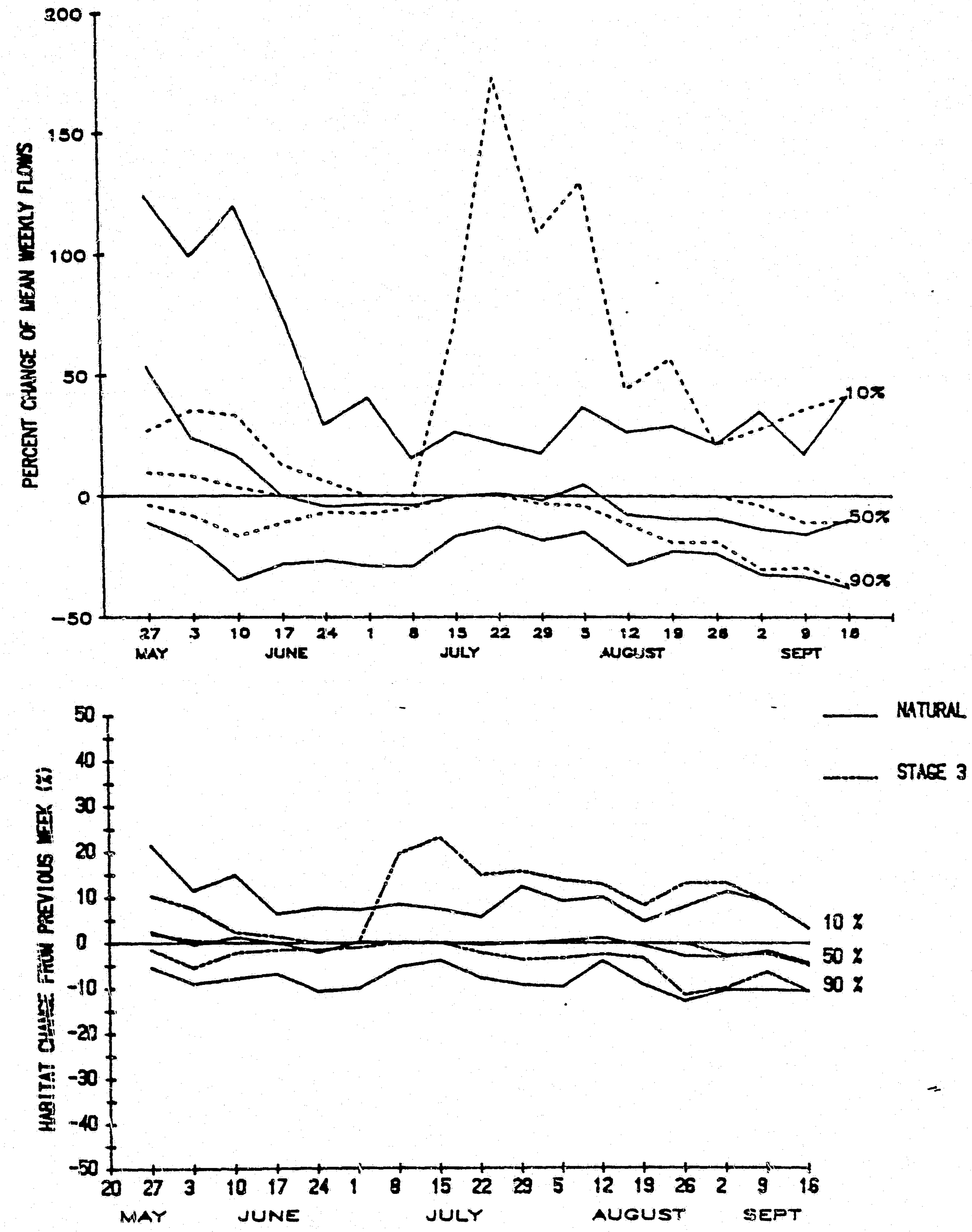
- <u>Representative Group 2</u>

This groups consists of side sloughs with with moderately high breaching flows (>20,000 cfs) and enough upwelling groundwater to keep portions of the sites ice free during the winter months. During the summer rearing season, the sites within the group are some of the more heavily utilized ones by chinook juveniles, particularly in the breached state. The habitat response and percent contribution of this group to total middle Susitna River habitat is shown in Figure 80.

-- <u>Stage I</u>

. <u>Filling</u>

The rearing habitat available during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below the natural



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 1 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 76

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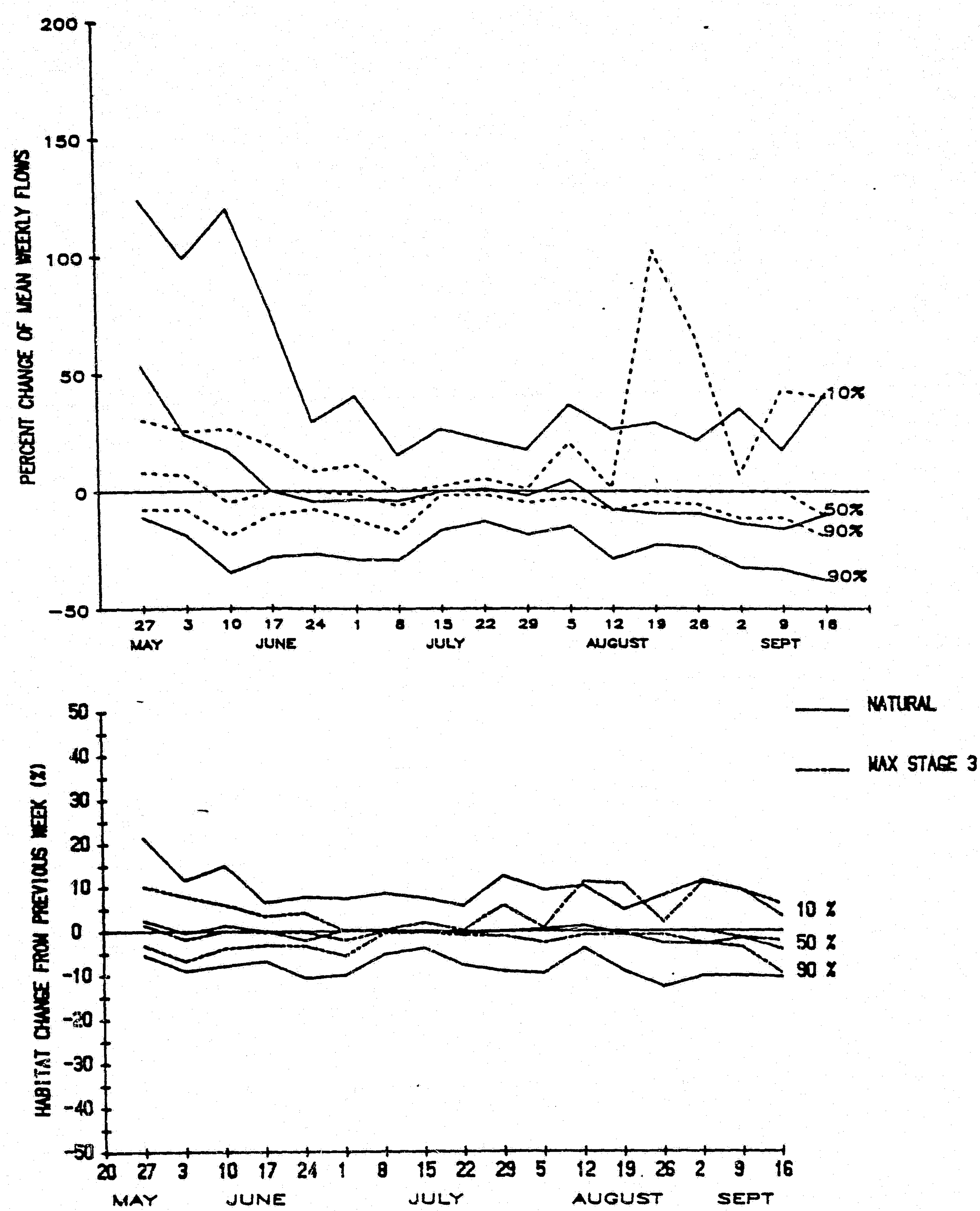

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 1 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 77

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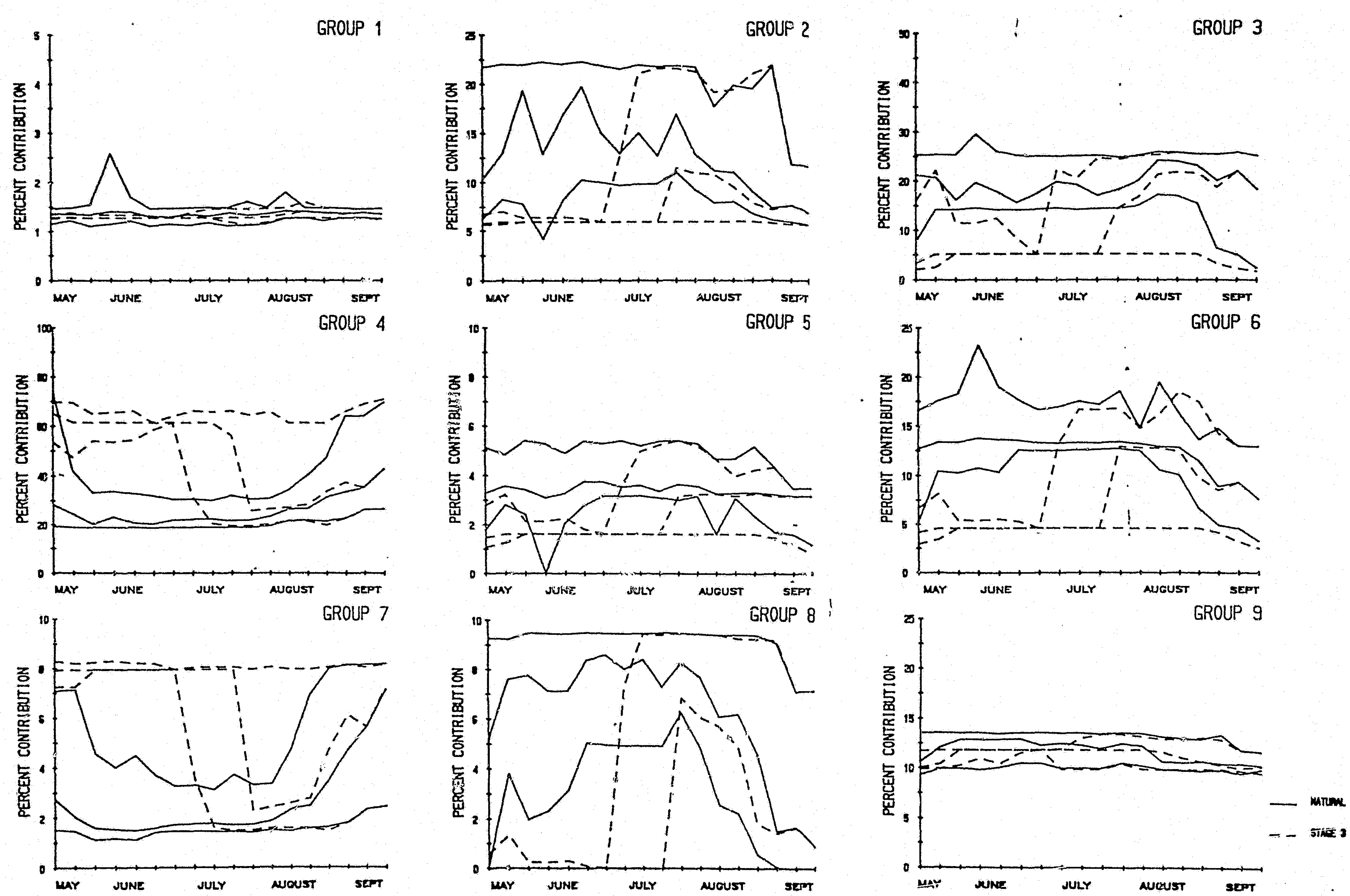

Percent contribution of chinook rearing habitat in Groups 1-9 to total habitat during early Stage III.

FIGURE 78

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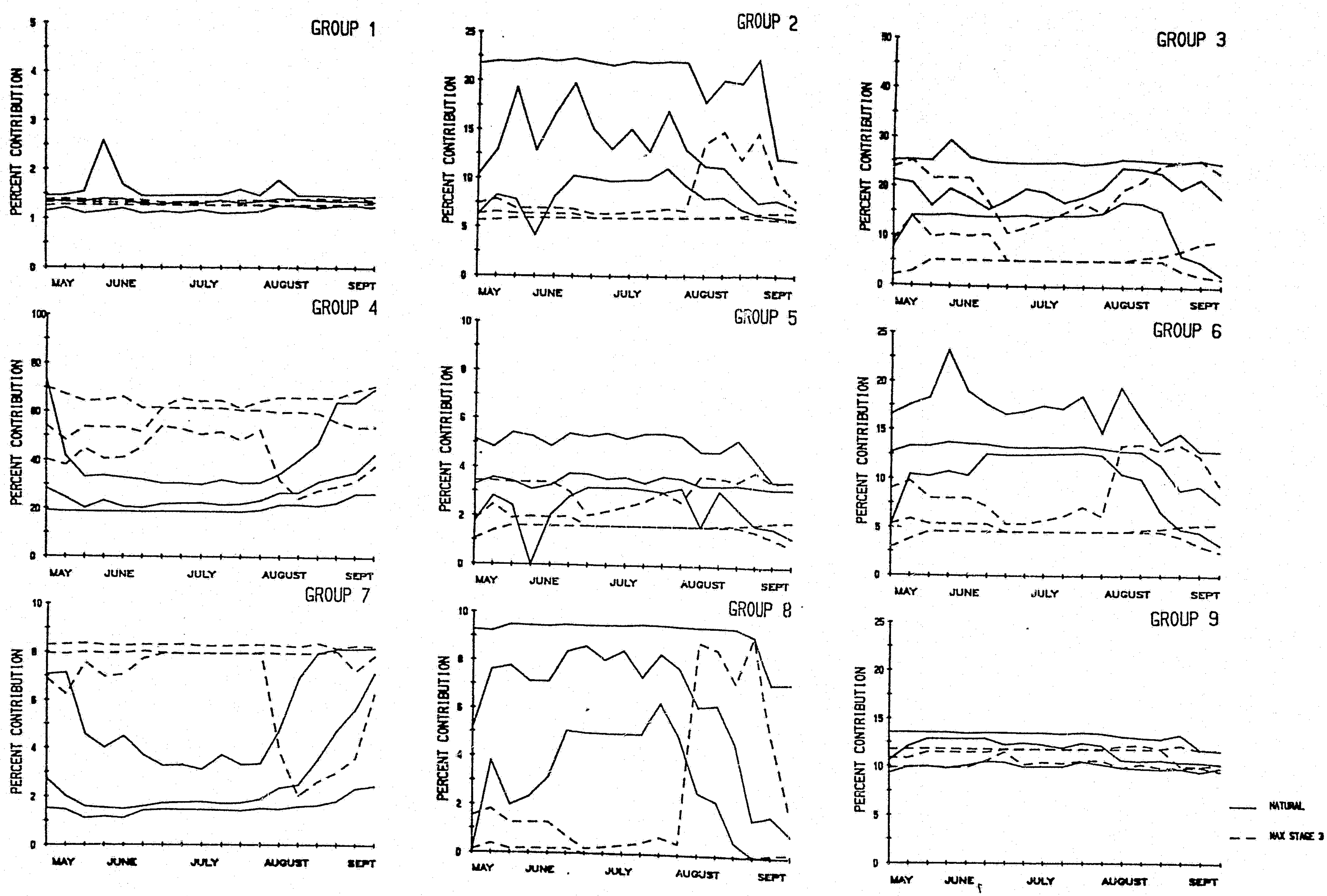

Percent contribution of chinook rearing habitat in Groups 1-9 to total habitat during late Stage III.

FIGURE 79

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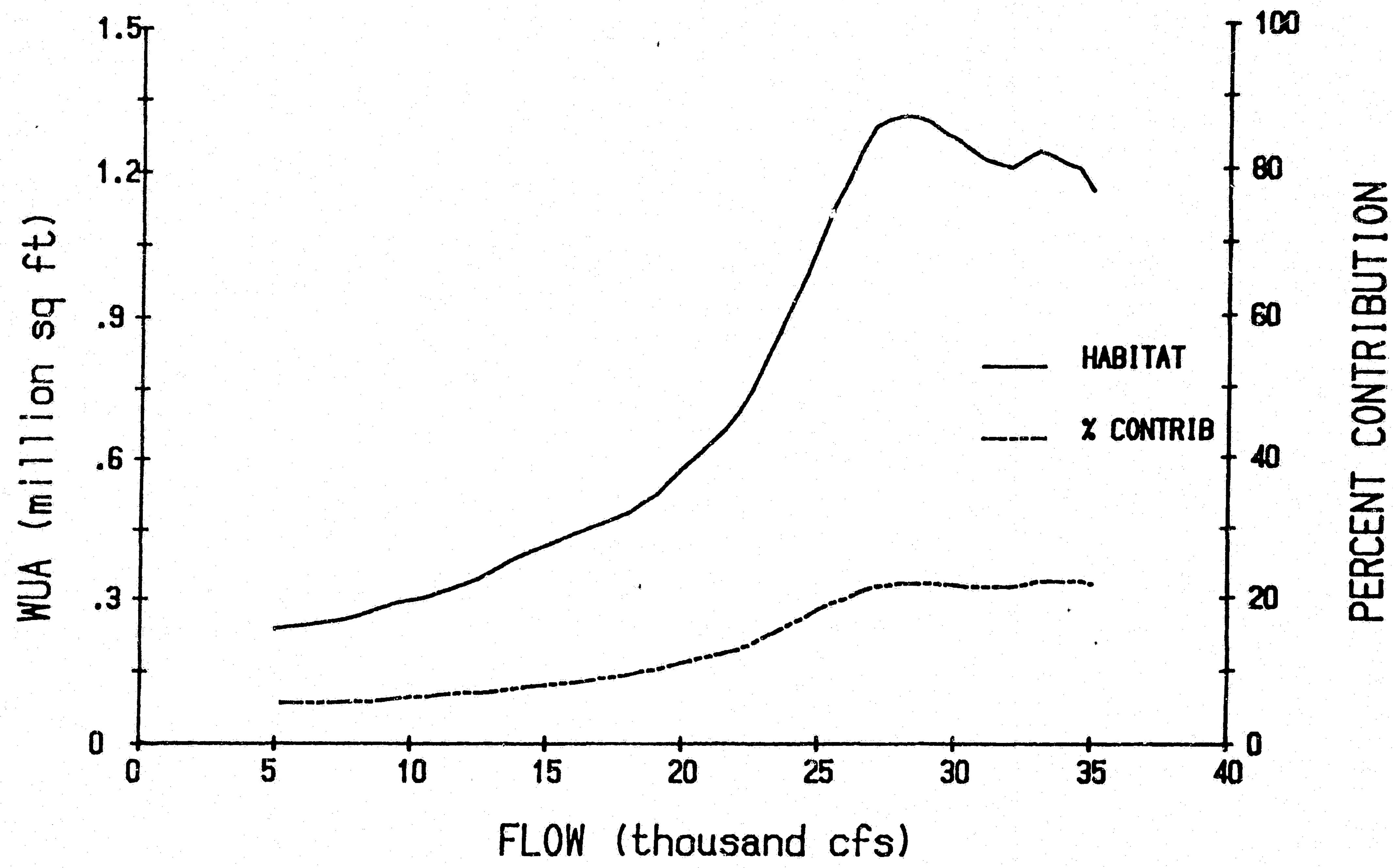

Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 2 areas in the middle Susitna River.

FIGURE 80

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flows that provide the higher habitat levels for this group.

Habitat associated with monthly flow estimates for June through September would be reduced 19 to 61 percent in a dry year, 31 to 71 percent in an average year, and 40 to 75 percent in a wet year (Table 16).

.. <u>Operation</u>

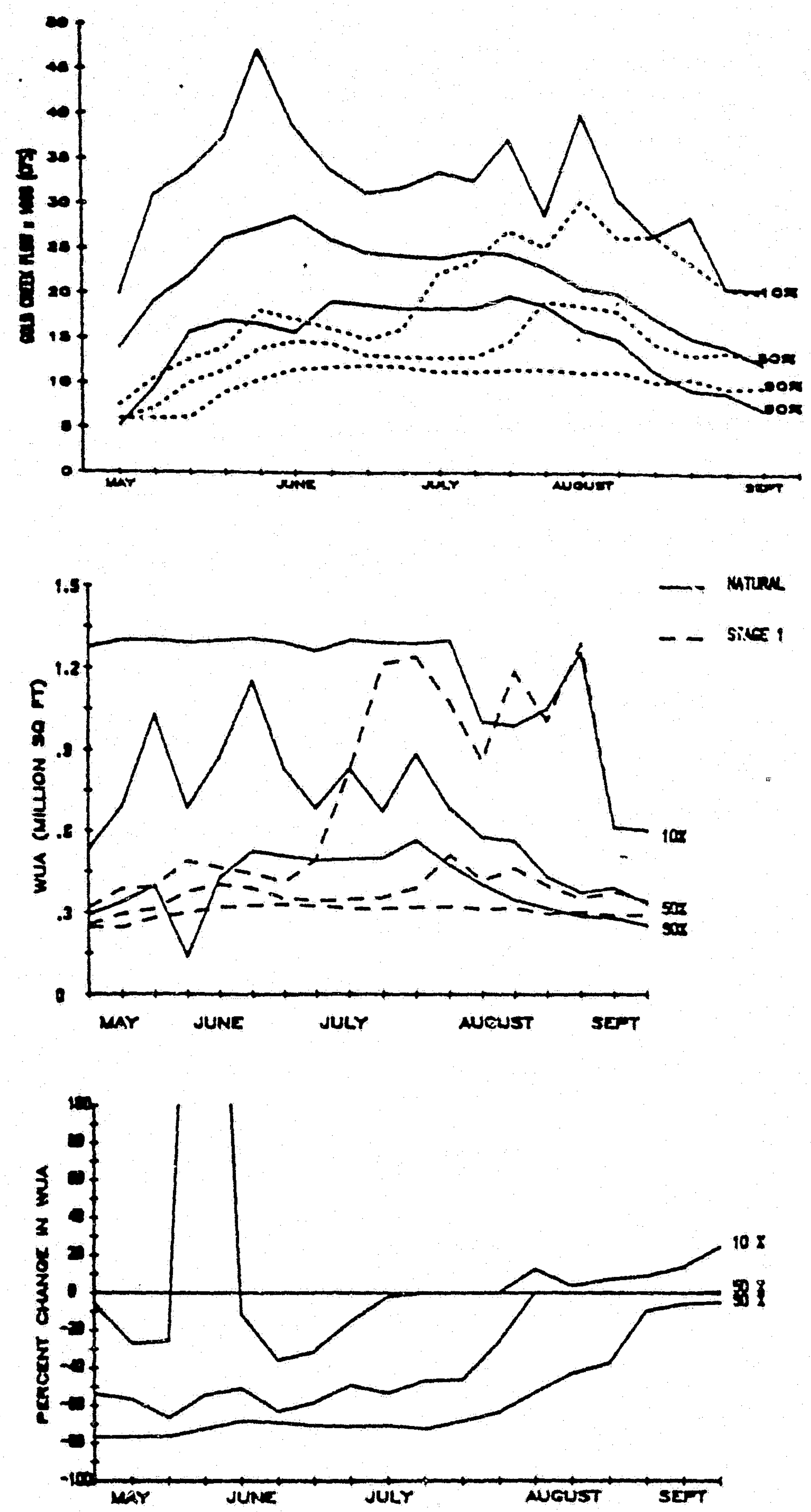
Habitat availability under natural and Stage I flows is compared in a weekly habitat time series and a seasonal habitat duration curve (Figure 81 and 82). Stage I flows would result in habitat reductions of approximately 20 to nearly 80 percent through early August. During August and September about half the time there would be a decrease in habitat and half the time an increase over natural conditions.

The habitat within sloughs in Group 2 would be more stable in June and July during Stage I and have about the same stability as that provided under natural conditions during July through September (Figure 83).

The percent contribution of Group 2 to the total habitat available would decrease from natural levels of approximately 10 to 23 percent to Stage I values of 6 to 9 percent from the end of May to mid July. The percent contribution of Group 2 would increase through the remainder of the season and by the end of August approximate natural level (Figure 70).

Table 16. Estimated change in chinook rearing habitat in Group 2 due to filling under dry, average and wet conditions.

Month	Discharge (cfs)		Rearing Habitat (sq ft WUA)		
	Natural	Filling	Natural	Filling	Change
Dry Year					
June	21,763	7,800	678,304	261,826	-61.40
July	19,126	8,000	528,973	264,810	-49.94
August	17,392	8,000	469,579	264,810	-43.61
September	10,422	5,800	301,335	244,373	-18.90
Average Year					
June	27,815	8,800	1,306,241	279,140	-78.63
July	24,445	12,740	978,032	350,286	-64.18
August	22,228	12,415	717,305	341,036	-52.46
September	13,221	6,800	366,080	251,124	-31.40
Wet Year					
June	31,580	10,752	1,209,072	306,904	-74.62
July	27,753	20,547	1,305,358	605,570	-53.61
August	25,236	15,505	1,087,103	428,237	-60.61
September	15,124	6,800	419,100	251,124	-40.08



Mean weekly discharge (upper), chinook rearing WUA for Group 2 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 81

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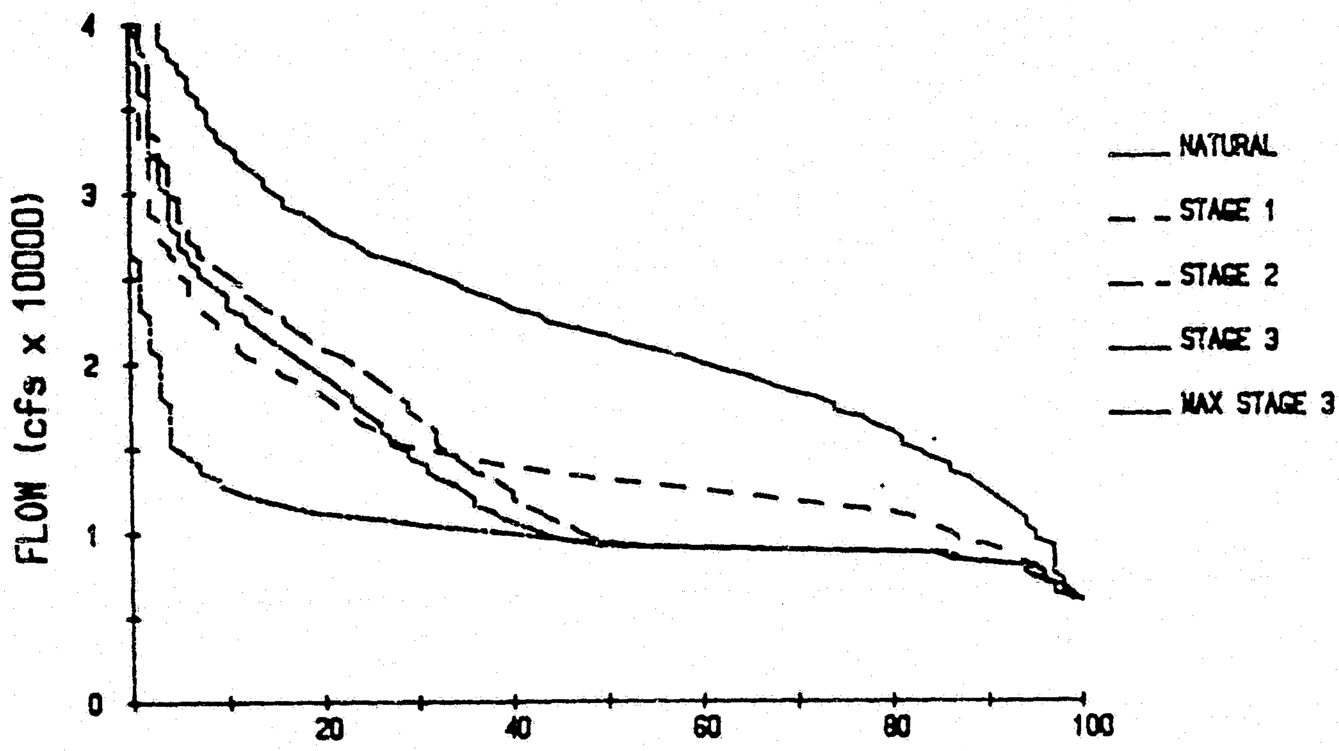
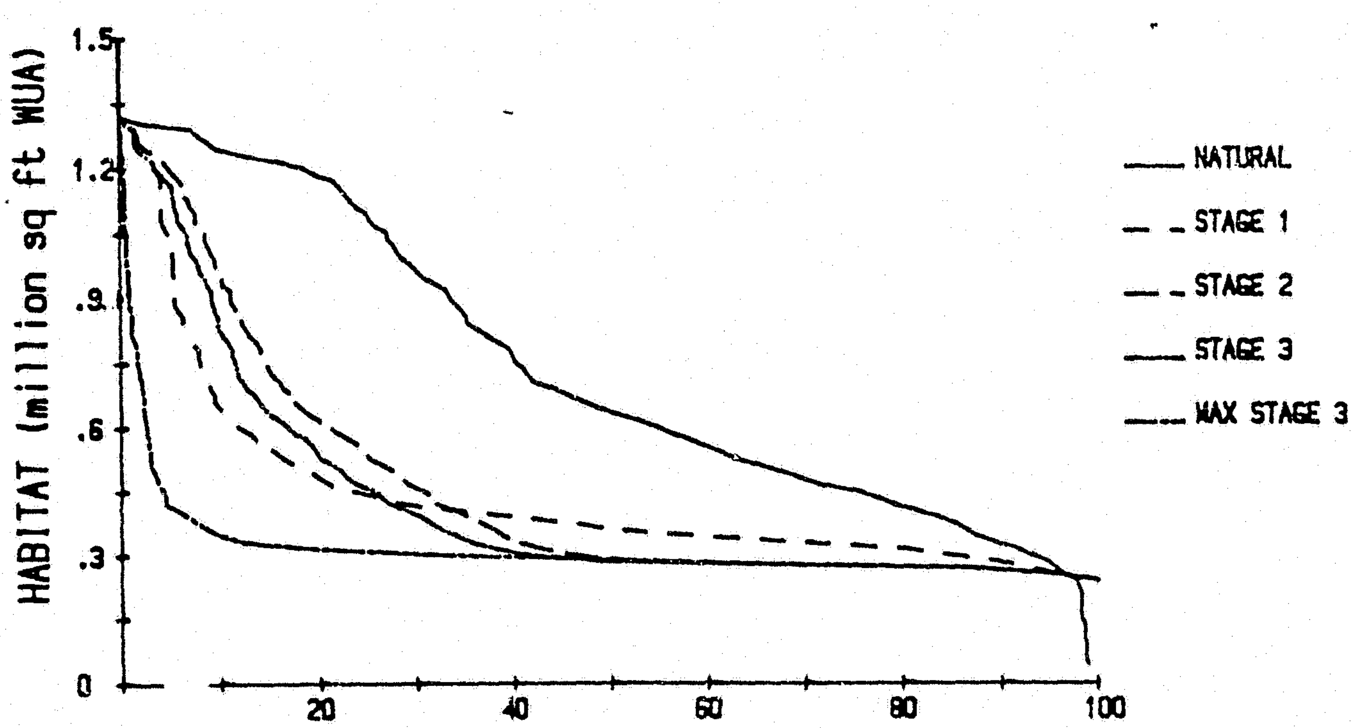


Group 2



Flow duration curve and chinook rearing habitat duration curve for Group 2.

FIGURE 82

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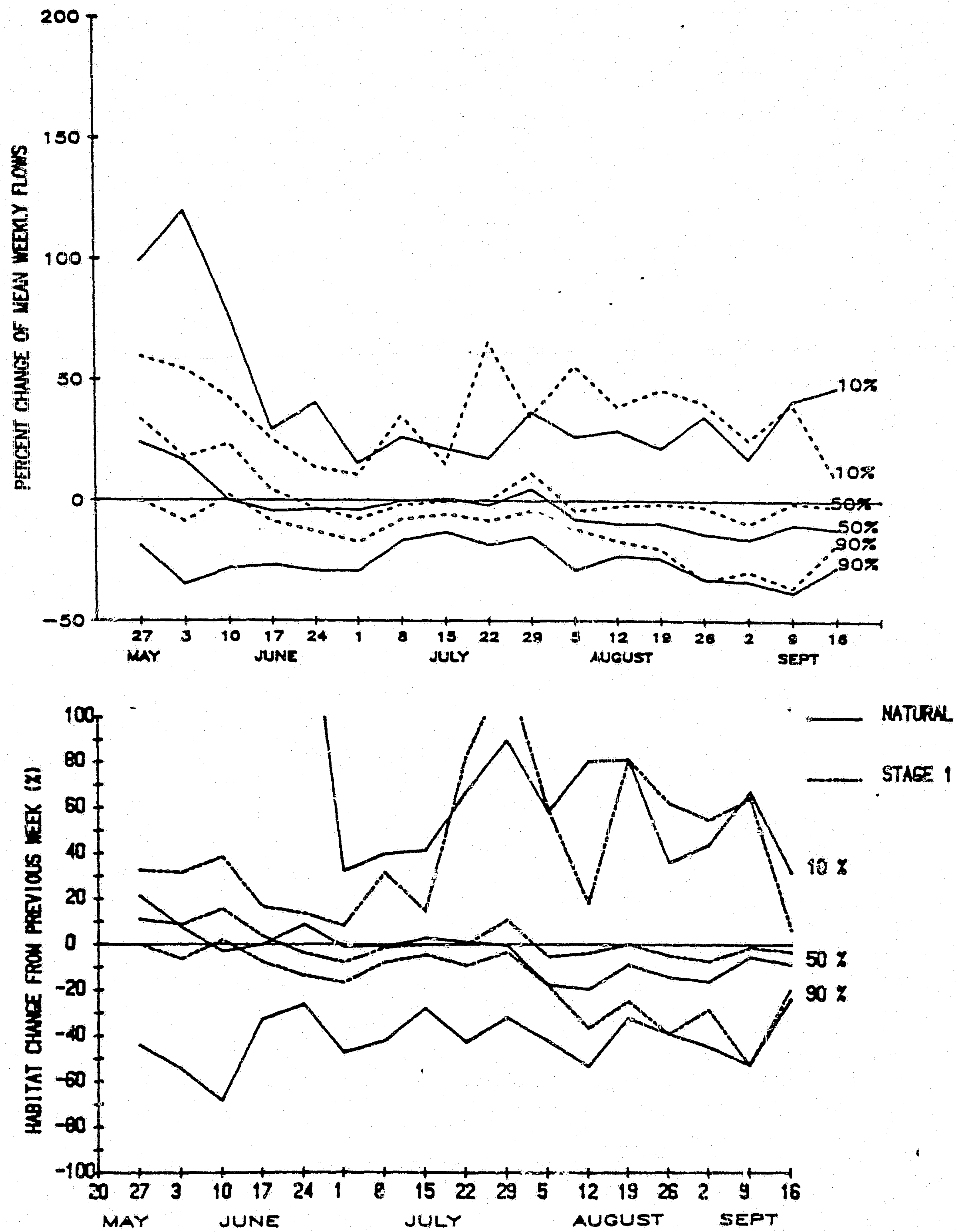

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 2 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 83

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SUSITNA HYDROELECTRIC PROJECT

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SUSITNA JOINT VENTURE

. Stage II

.. Filling

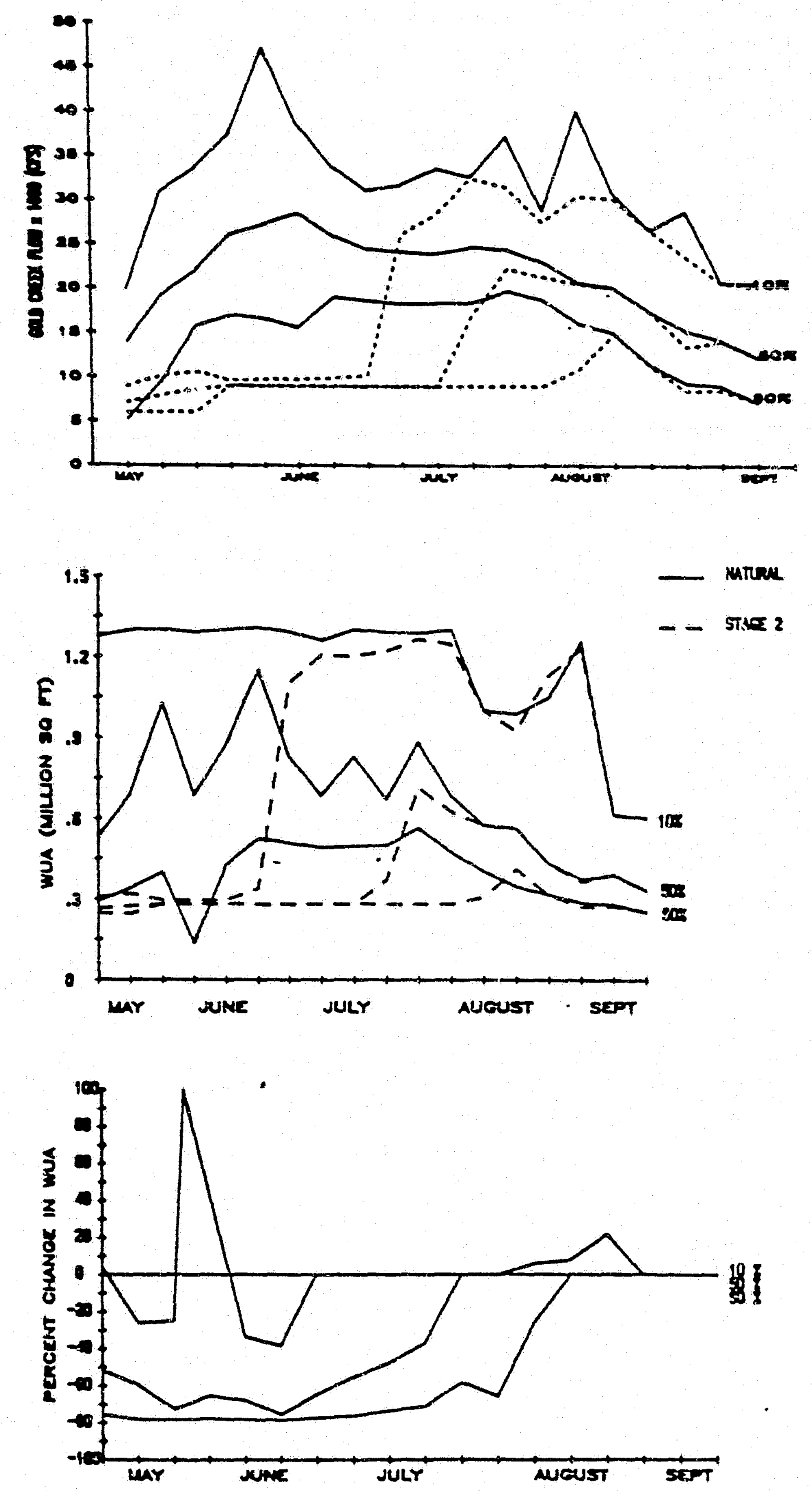
Filling flows under Stage II would be of short duration and discussion of habitat availability are deferred to Stage II operation.

.. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figure 84 and 82). Stage II operational flows would result in habitat reductions while May and June ranging from 20 to 80 percent with over half the reduction being greater than 60 percent. Beginning in July the magnitude of the reductions would decrease until mid-August at which time the rearing habitat under Stage II would be equal to or greater than that available with natural flows. This pattern would continue through mid-September.

The stability of Group 2 would increase with-project during June; however by July week-to-week changes would increase substantially, sometimes exceeding 100 percent. Stability at the end of August through mid-September would be similar to natural conditions (Figure 85).

The percent contribution of Group 2 to the total available habitat would decrease from a range of 6 to 22 naturally to about 6 percent with-project during late May and June. The contribution of Group 2 would increase through mid-summer and by mid August and through mid-September would be similar to natural conditions (Figure 73).



Mean weekly discharge (upper), chinook rearing WUA for Group 2 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 84

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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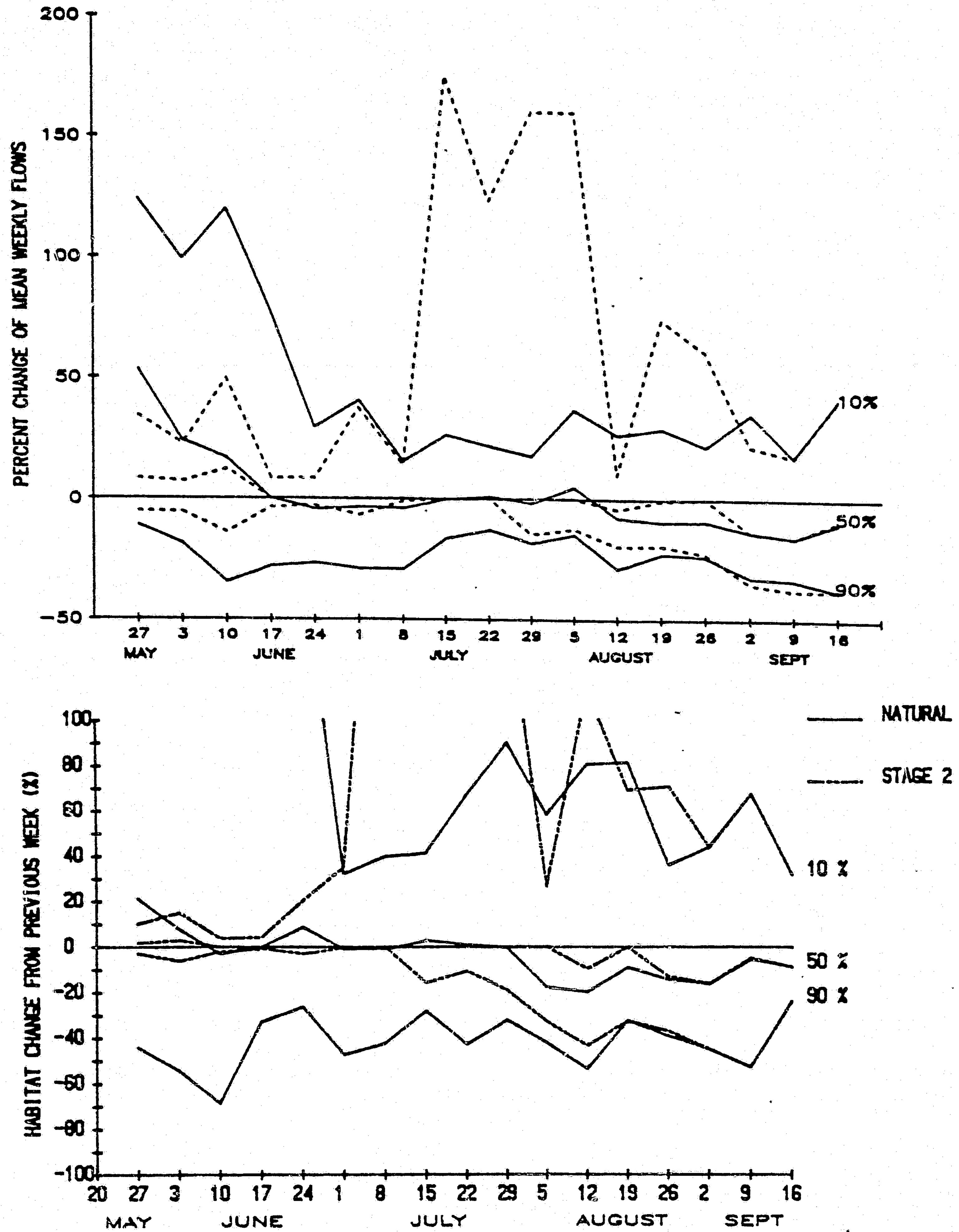

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 2 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 85

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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° **Stage III**

.. **Filling**

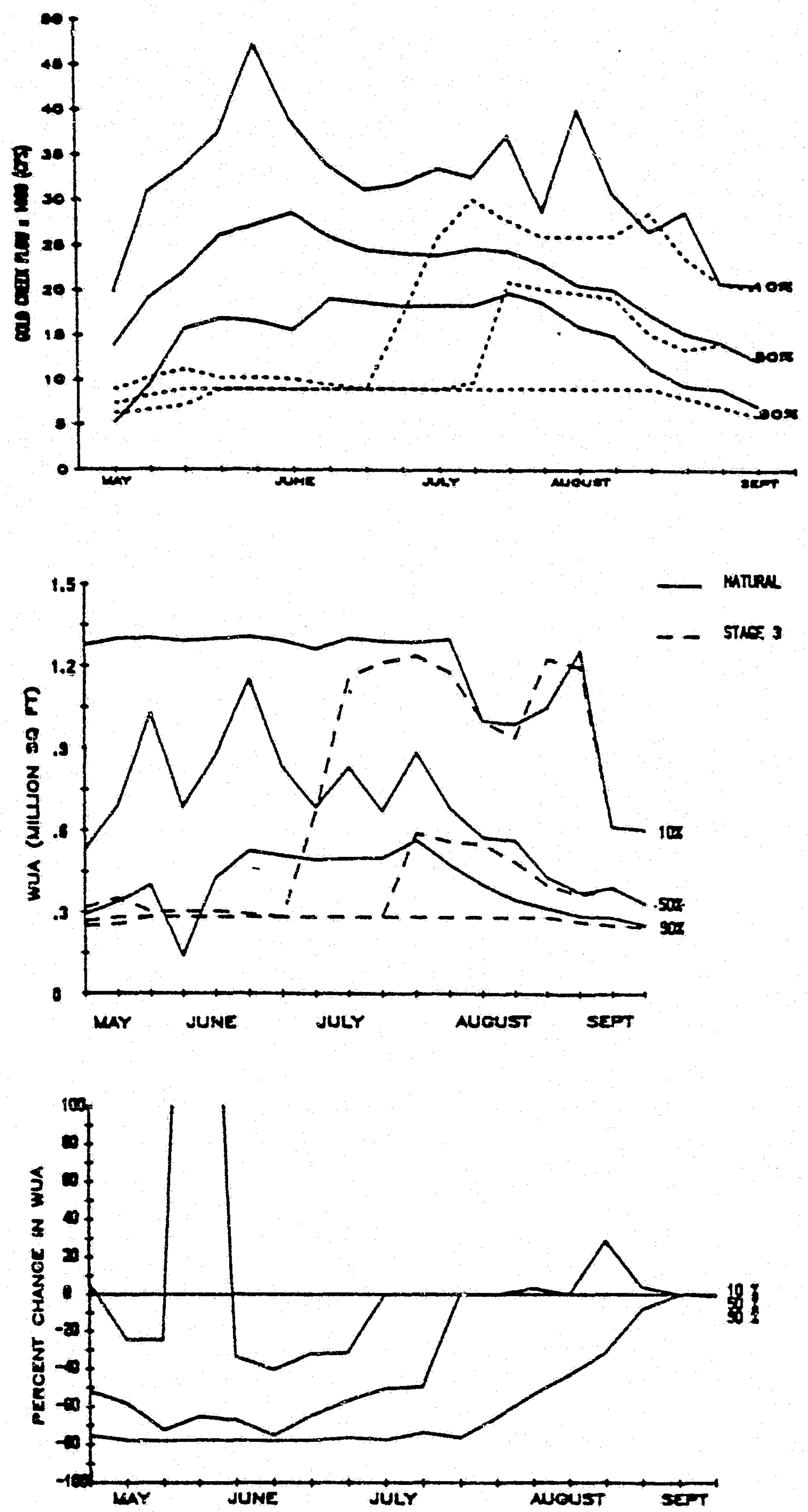
Filling of high Watana would occur over a period of several years and therefore rearing habitat availability is more appropriately discussed under Stage III operation.

.. **Operation**

Habitat availability under natural and Stage III flows is compared in weekly habitat time series plots and seasonal habitat duration curves (Figures 86, 87 and 82). Stage III operational flows would result in habitat reductions similar to Stage II, 20 to 80 percent in late May and June with over half the reductions greater than 60 percent. In July the magnitude of reductions would decrease and continue this trend through August. By September the habitat availability would approximate natural conditions. In the late Stage III, the annual filling process would continue in July extending the period of habitat reductions through that month. In August through September, habitat would increase by remain below that available for natural, Stage II and early Stage III conditions.

The stability of Group II would increase during late May and June of early Stage III (Figure 88). In late Stage III this increased stability would extend through July and August as flows are maintained at or above E-VI minimum constraints (Figure 89).

The contribution of Group 2 to the total available habitat would decrease from a range of 6 to 22 percent maturity to about 6 percent in early Stage III during



Mean weekly discharge (upper), chinook rearing WUA for Group 2 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 86

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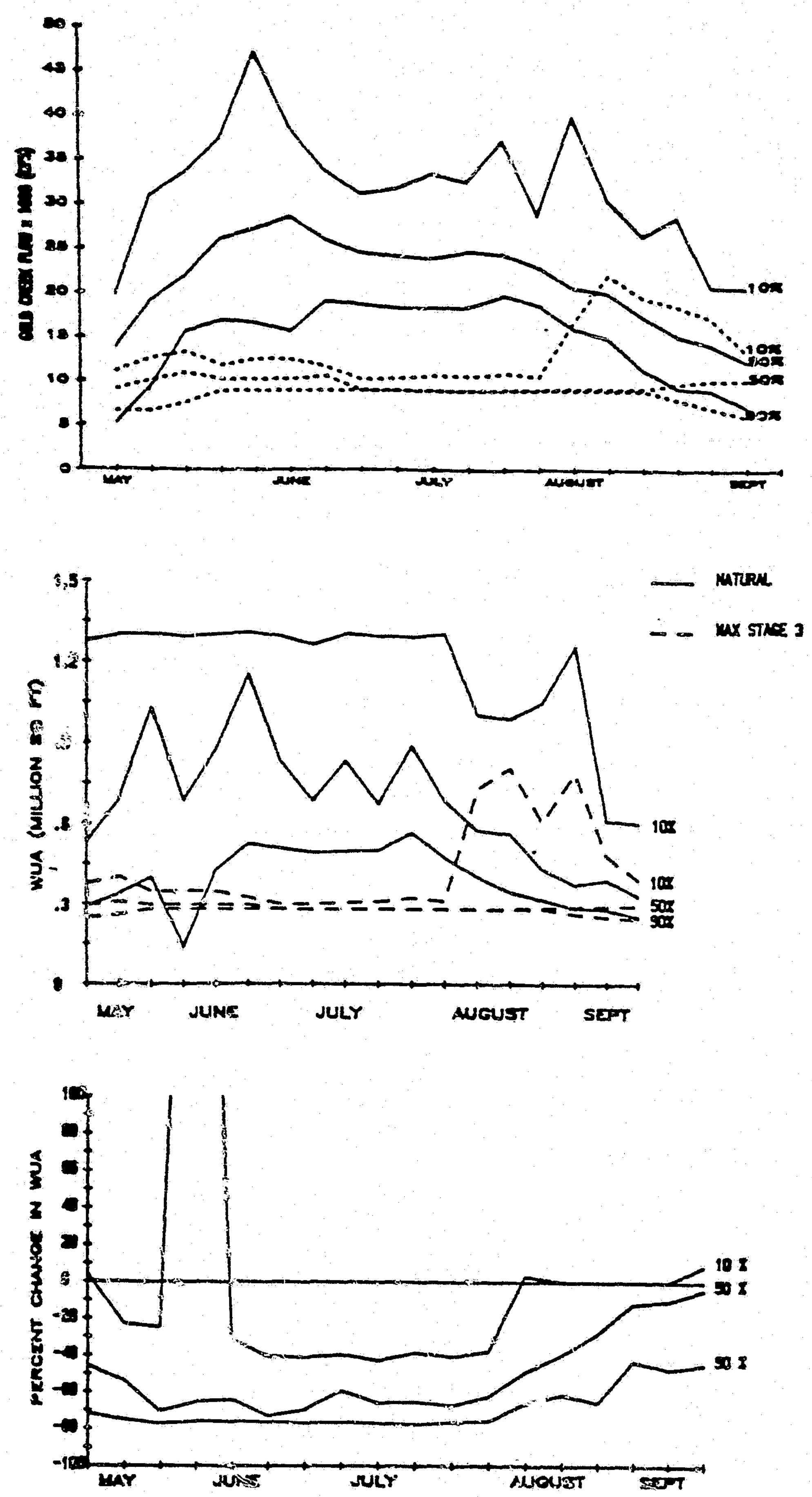

Mean weekly discharge (upper), chinook rearing WUA for Group 2 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 87

ALASKA POWER AUTHORITY
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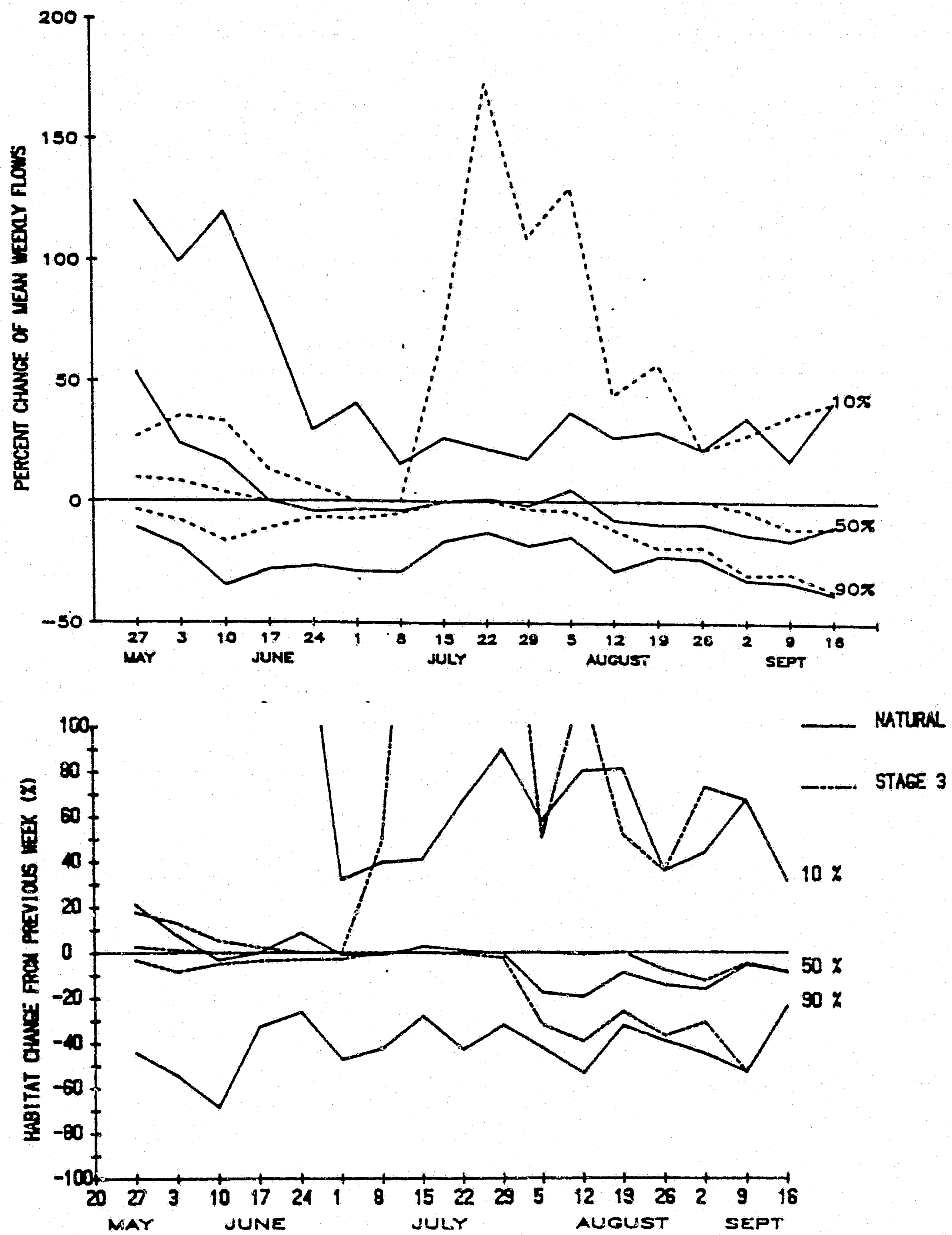

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 2 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 88

ALASKA POWER AUTHORITY
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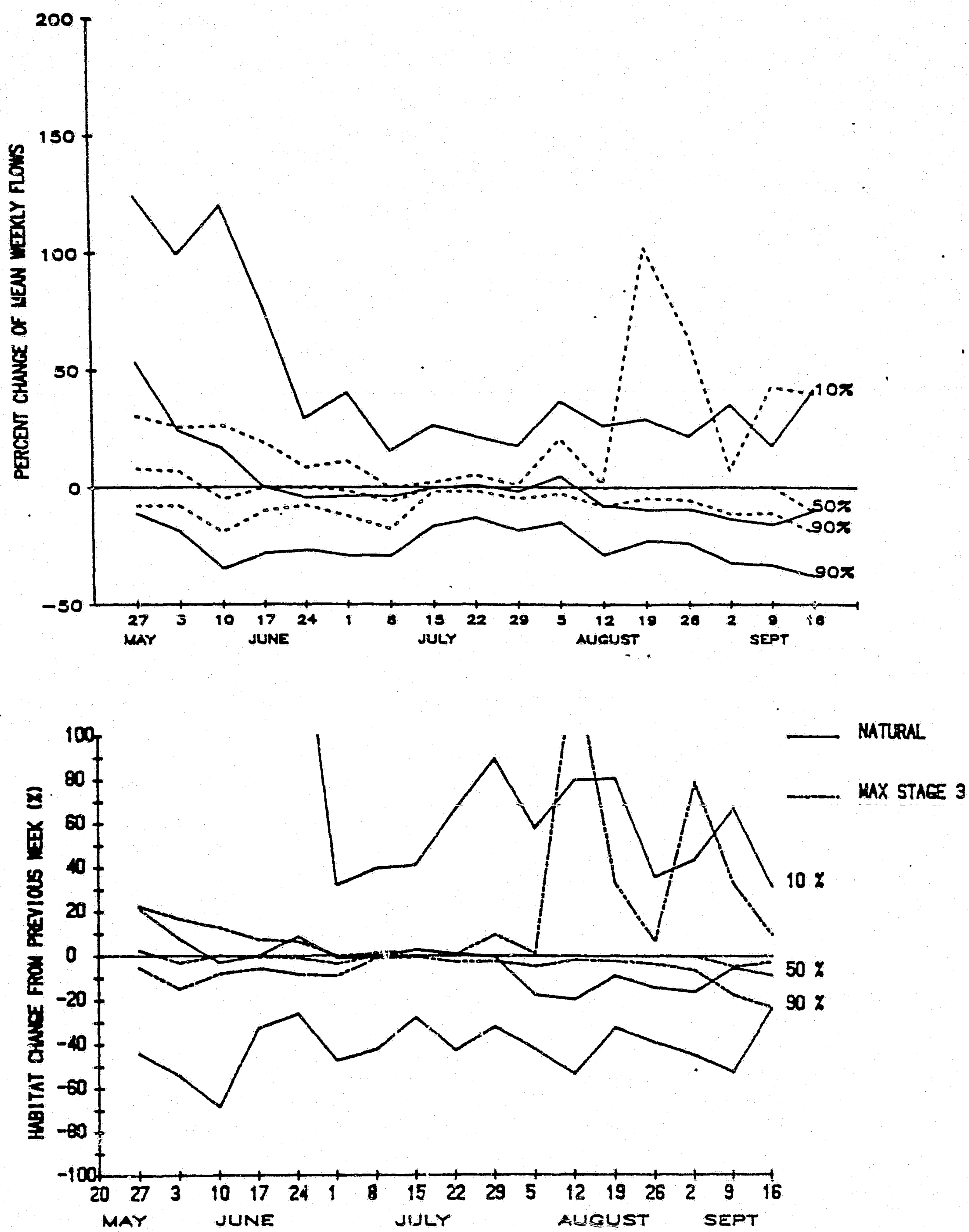

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 2 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 89

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late May and June. Increases in July would bring the Stage III contribution to natural levels around August (Figure 78). In late Stage III the 6 percent contribution level would extend through July with some increase in August and early September but natural levels would not be reached (Figure 79).

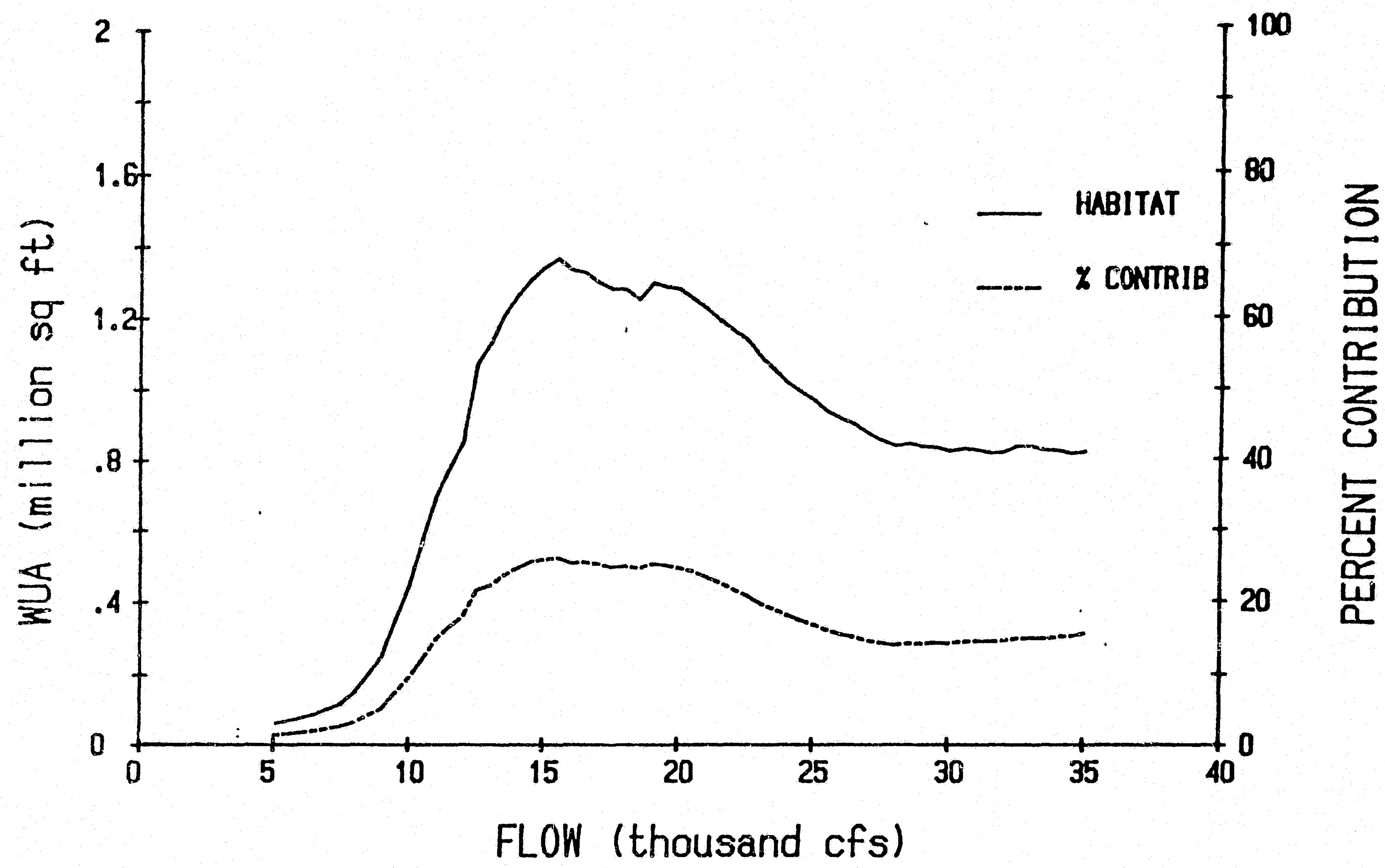
- Representative Group 3

This group consists of side channels which breach at intermediate mainstem discharges (8,000 to 16,000 cfs) and transform into side slough at lower discharge. In contrast to Group 2 side channels, sites within this group are larger and convey greater volumes of water when breached. In addition, sites comprising this group represent some of the most heavily utilized rearing areas in the middle Susitna River under breached conditions. The habitat response and percent contribution to overall habitat availability of this group is portrayed for the range of natural and with-project flows in Figure 90.

-- Stage I

. Filling

The rearing habitat during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below the flows that provide the higher habitat availability for this group. Habitat associated with monthly filling flow estimates for June through September would be reduced by 87-88 percent in a dry year, 10-92 percent in an average year, and 22 to 93 percent in a wet year (Table 17).



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 3 areas in the middle Susitna River.

FIGURE 90

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Table 17. Estimated change in chinook rearing habitat in Group 3 due to filling under dry, average and wet conditions.

Month	Discharge (cfs)		Rearing Habitat (sq ft WUA)		
	Natural	Filling	Natural	Filling	Change
Dry Year					
June	21,763	7,800	1,178,308	137,604	-88.32
July	19,126	8,000	1,293,441	150,046	-88.40
August	17,392	8,000	1,284,701	150,046	-88.32
September	10,422	5,800	553,277	73,345	-86.74
Average Year					
June	27,815	8,800	843,033	229,381	-72.79
July	24,445	12,740	993,691	1,101,905	10.89
August	22,228	12,415	1,153,420	1,035,368	-10.23
September	13,221	6,800	1,166,589	96,193	-91.75
Wet Year					
June	31,580	10,752	816,422	635,484	-22.16
July	27,753	20,547	844,924	1,250,440	47.99
August	25,236	15,505	951,618	1,365,033	43.44
September	15,124	6,800	1,347,903	96,193	-92.86

. Operation

Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figure 91 and 92). Stage I flows would result in increases in habitat about half the time and decreases in habitat about half the time throughout the summer rearing period. From the end of August through mid-September, the magnitude of habitat increases would greatly exceed the habitat decreases.

The stability of habitat in Group 3 sites would be less in May and early June than naturally and about the same for the remainder of the season (Figure 93).

The contribution of Group 3 to the habitat availability provided by all groups would be slightly less than natural in late May and about the same as natural for the rest of the season (Figure 70).

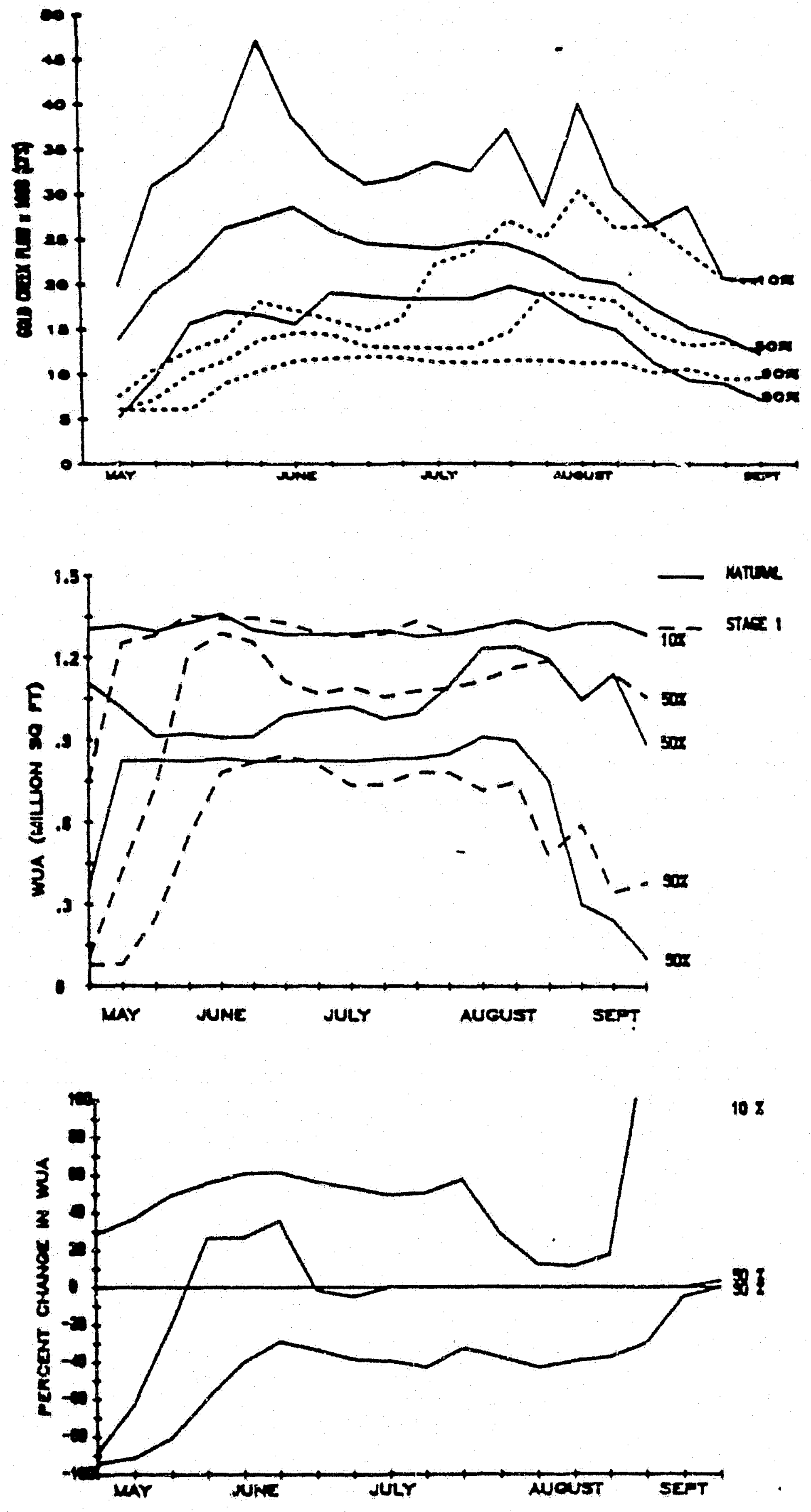
-- Stage II

. Filling

Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figures 94 and 92). Stage II operational flows would result in habitat reductions from 0 to 80 percent with refraction of 70



Mean weekly discharge (upper), chinook rearing WUA for Group 3 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 91

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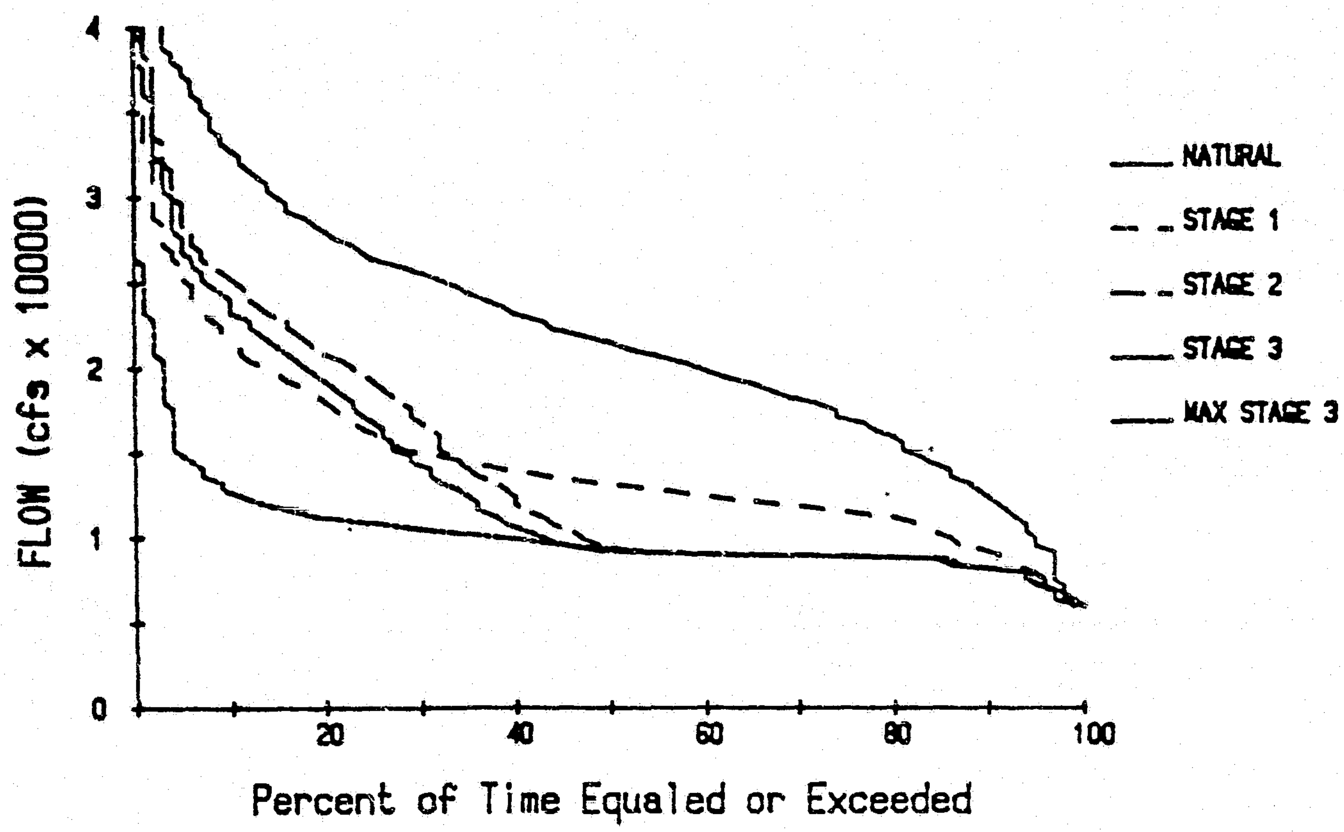

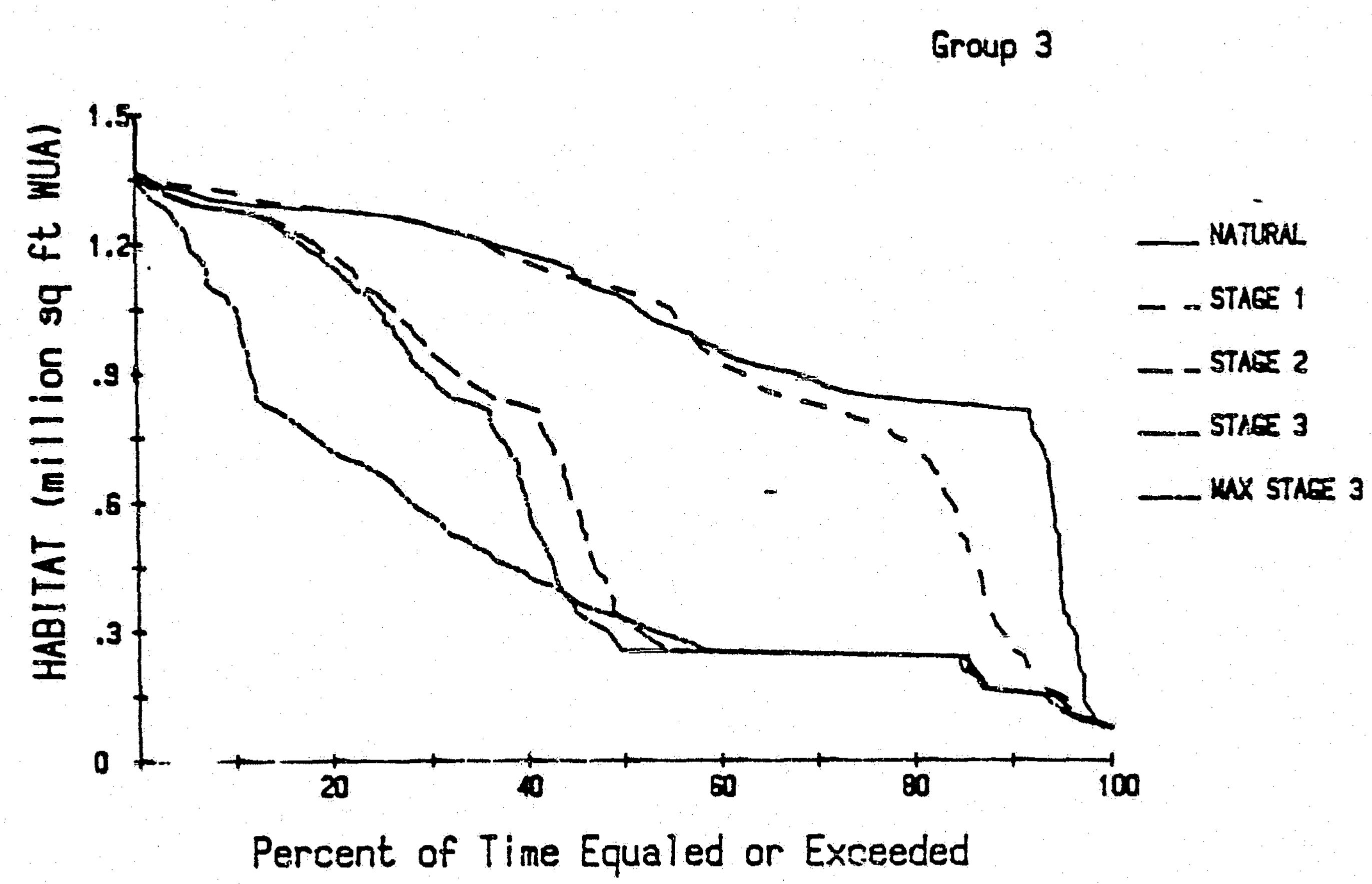

Flow duration curve and chinook rearing habitat duration curve for Group 3.

FIGURE 92

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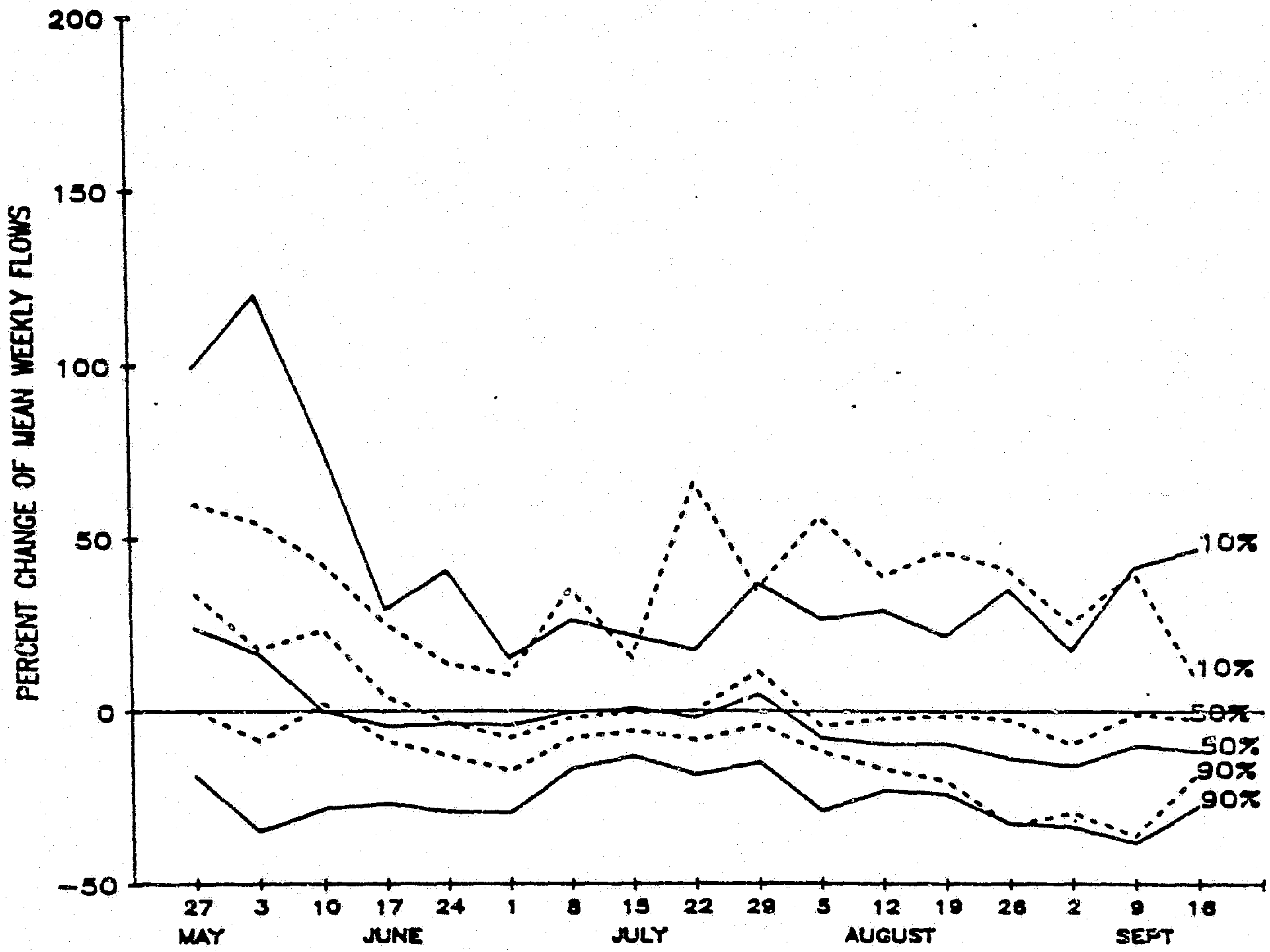

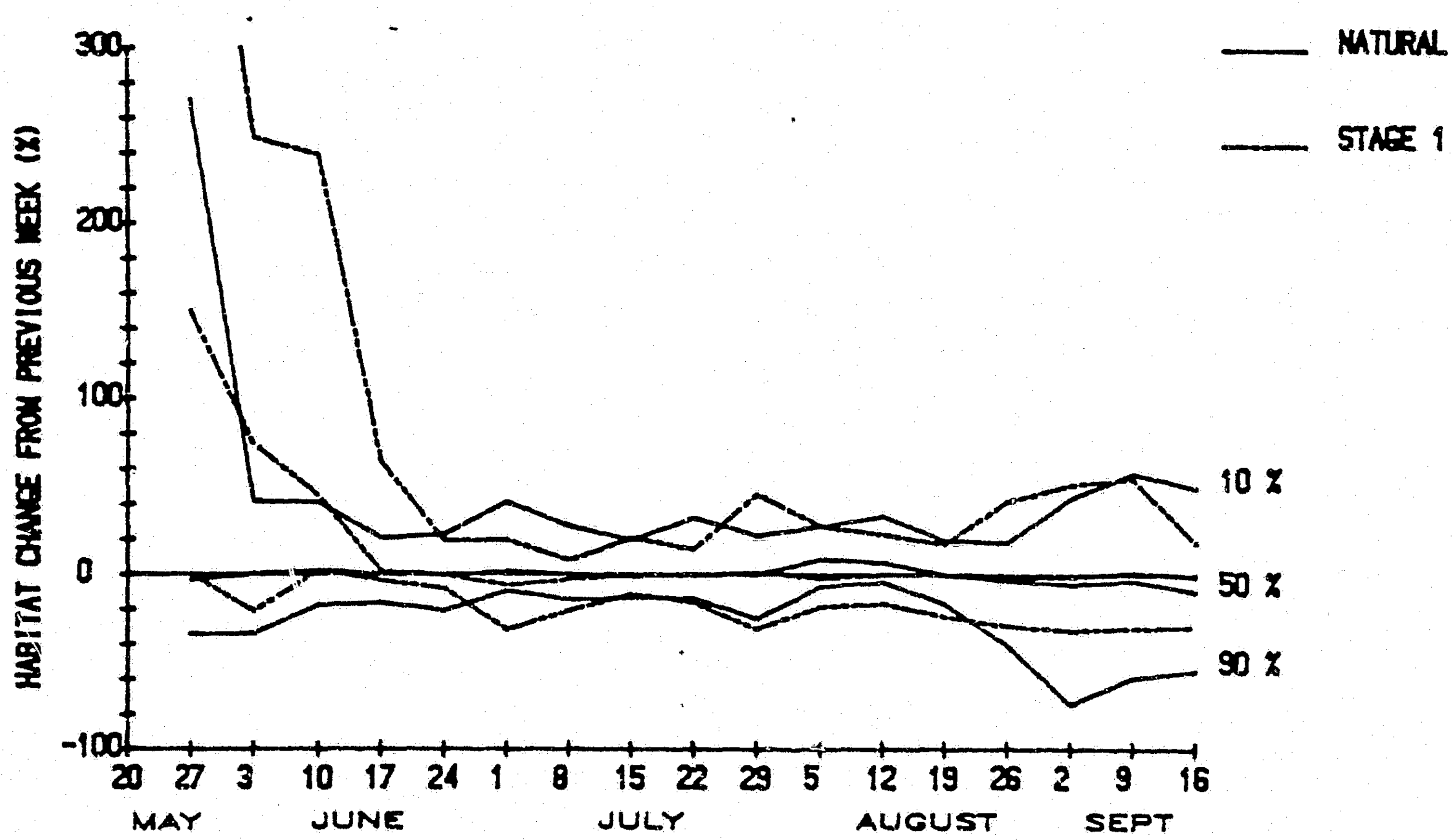

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 3 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 93

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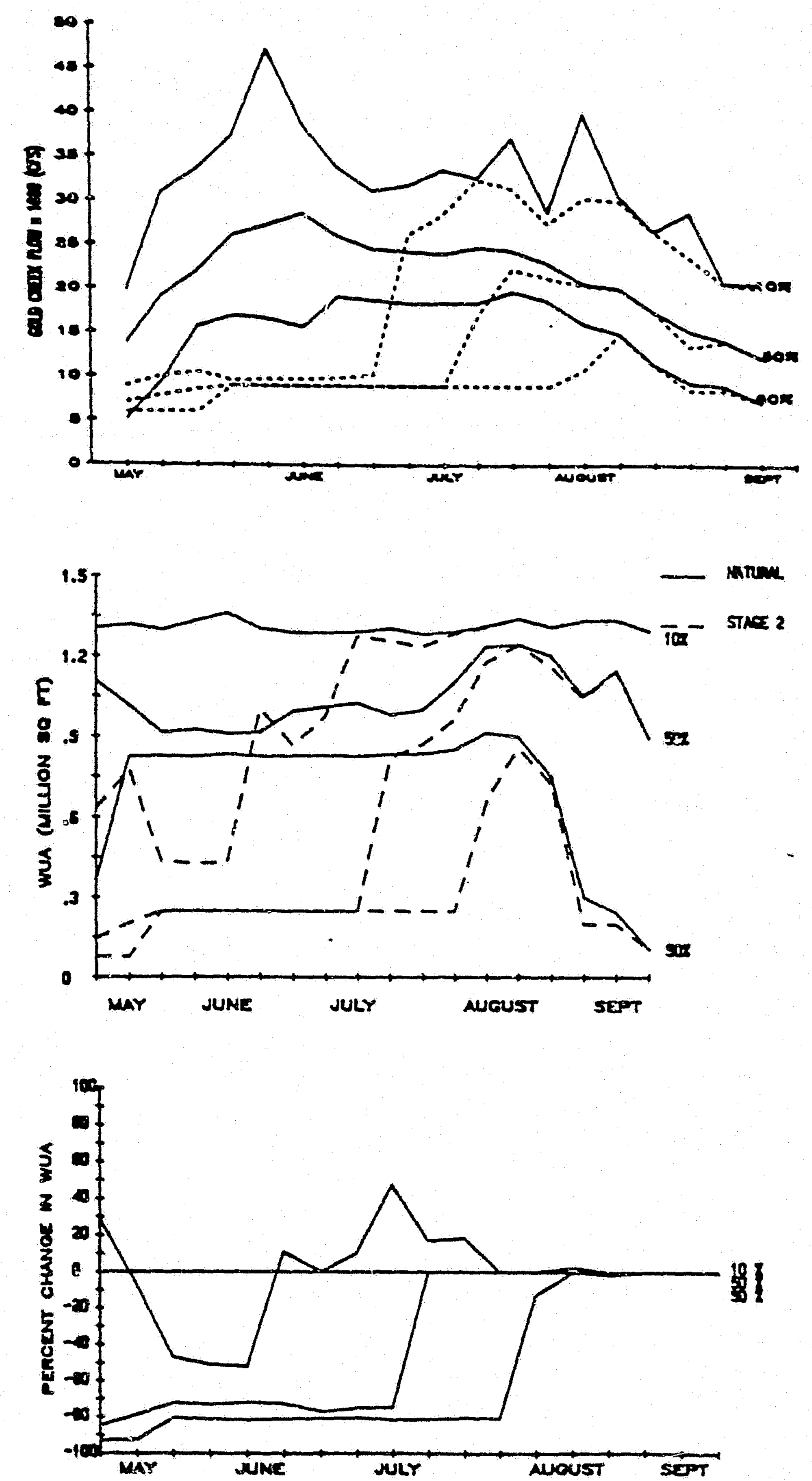

Mean weekly discharge (upper), chinook rearing WUA for Group 3 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 94

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percent or greater about half the time. In July the magnitude of the reduction would decrease and by mid-August habitat availability would be about the same as natural.

With-project habitat stability would decrease substantially primarily as in week-to-week increases in habitat during July and August that may exceed 300 percent (Figure 95).

The contribution of Group 3 to total middle Susitna River habitat would decrease under Stage II from natural levels of 15 to 25 percent to 5 to 15 percent in May and June. The percent contribution would increase during July and would be similar to natural from mid-August to mid-September (Figure 73).

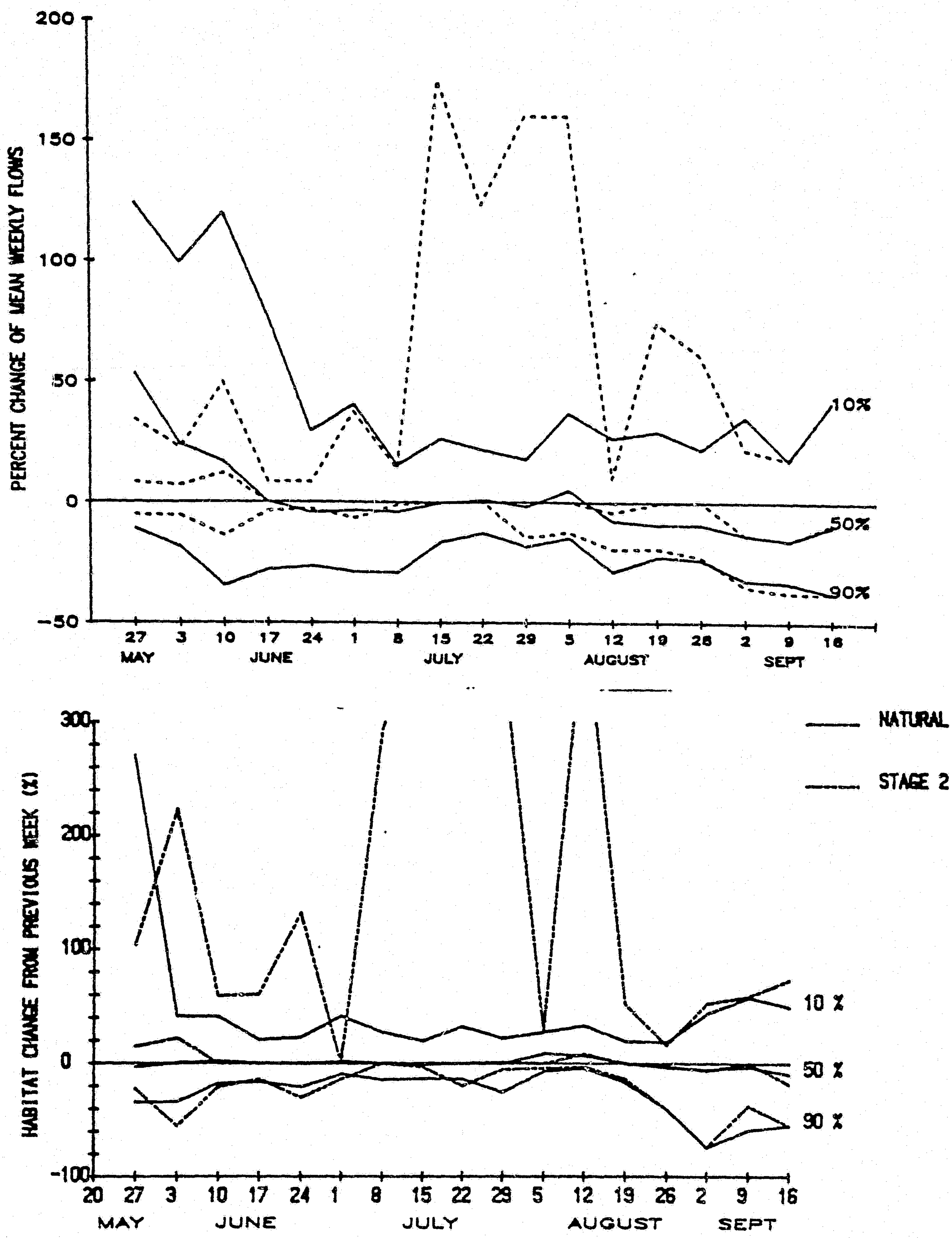
. <u>Stage III</u>

.. <u>Filling</u>

Filling of Watana during Stage III would occur over several years and consequently dicussion of habitat availability relating to this process are more appropriately addressed under operation.

.. <u>Operation</u>

Habitat availability under natural and early and late Stage III operation are compared in weekly habitat time series plots and seasonal habitat duration curves (Figure 96, 97 and 92). Early Stage III operational flows would result in substantial reductions in habitat through July at which point the frequencies of reduction would decrease to about half the time. In late Stage III reductions of 40 percent or more would be prevalent



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 3 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 95

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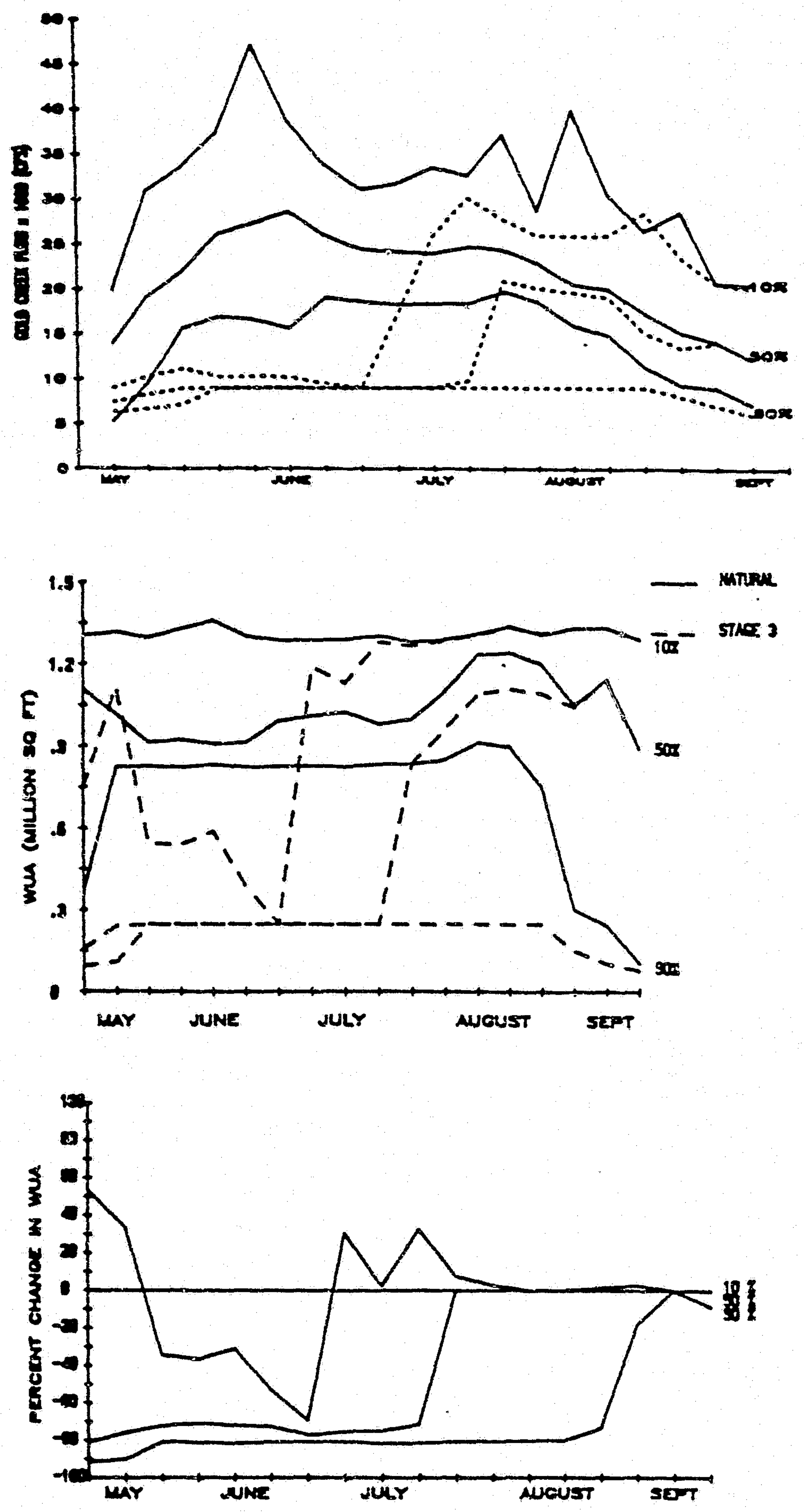

Mean weekly discharge (upper), chinook rearing WUA for Group 3 (middle) and percent change in WUA (lower)exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 96

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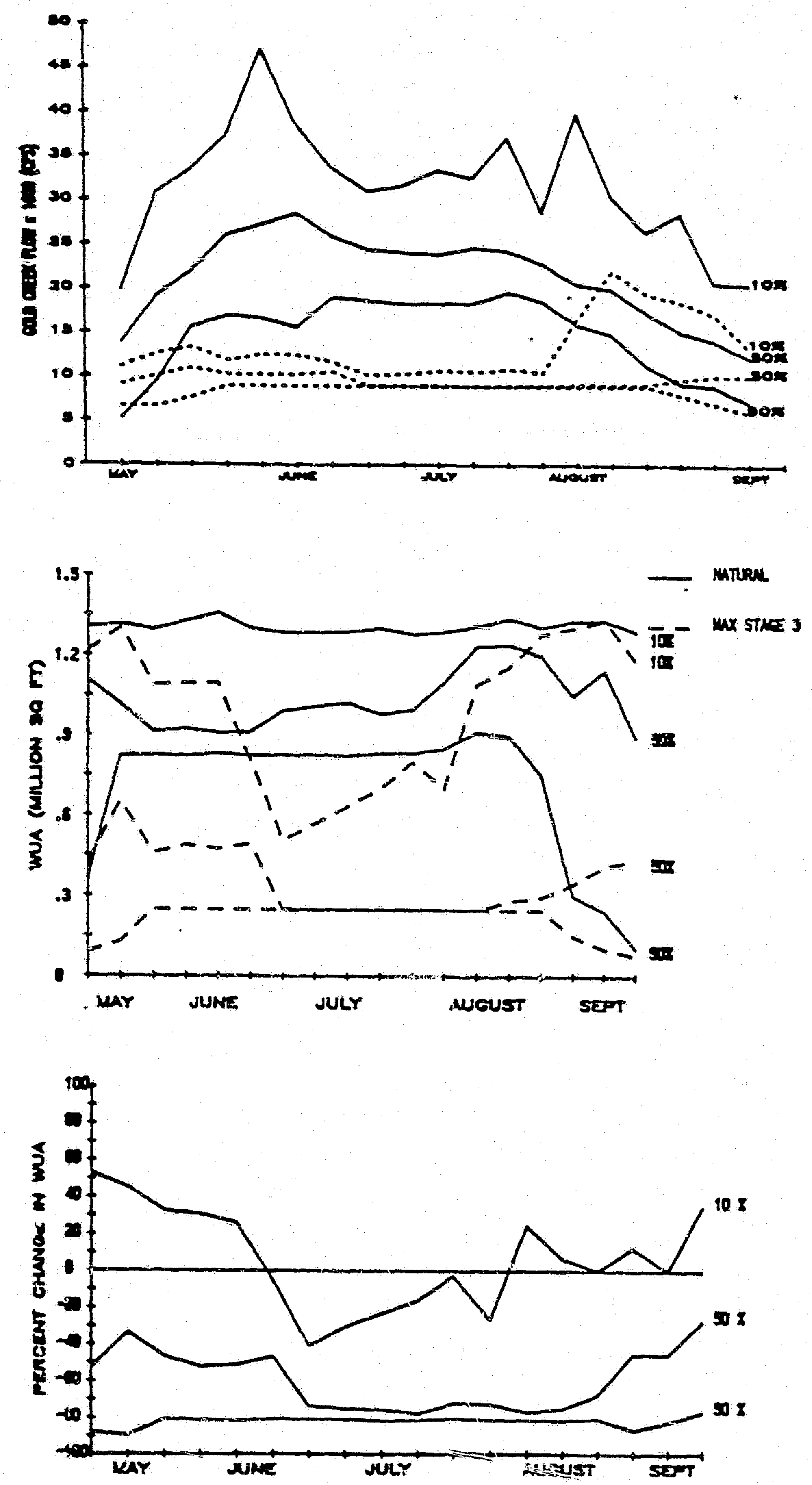

Mean weekly discharge (upper), chinook rearing WUA for Group 3 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 97

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at least 50 percent of the time for the majority of the rearing period.

Stability during early and late Stage III would be less than natural, expressed principally as large week-to-week increase in habitat during early June, July and early August (Figure 98 and 99).

The contribution of Group 3 to middle Susitna River rearing habitat decrease from natural levels of 15 to 25 percent to Stage III levels of 5 to 15 percent in early summer to 5 to 25 percent in the second half (Figures 78 and 79).

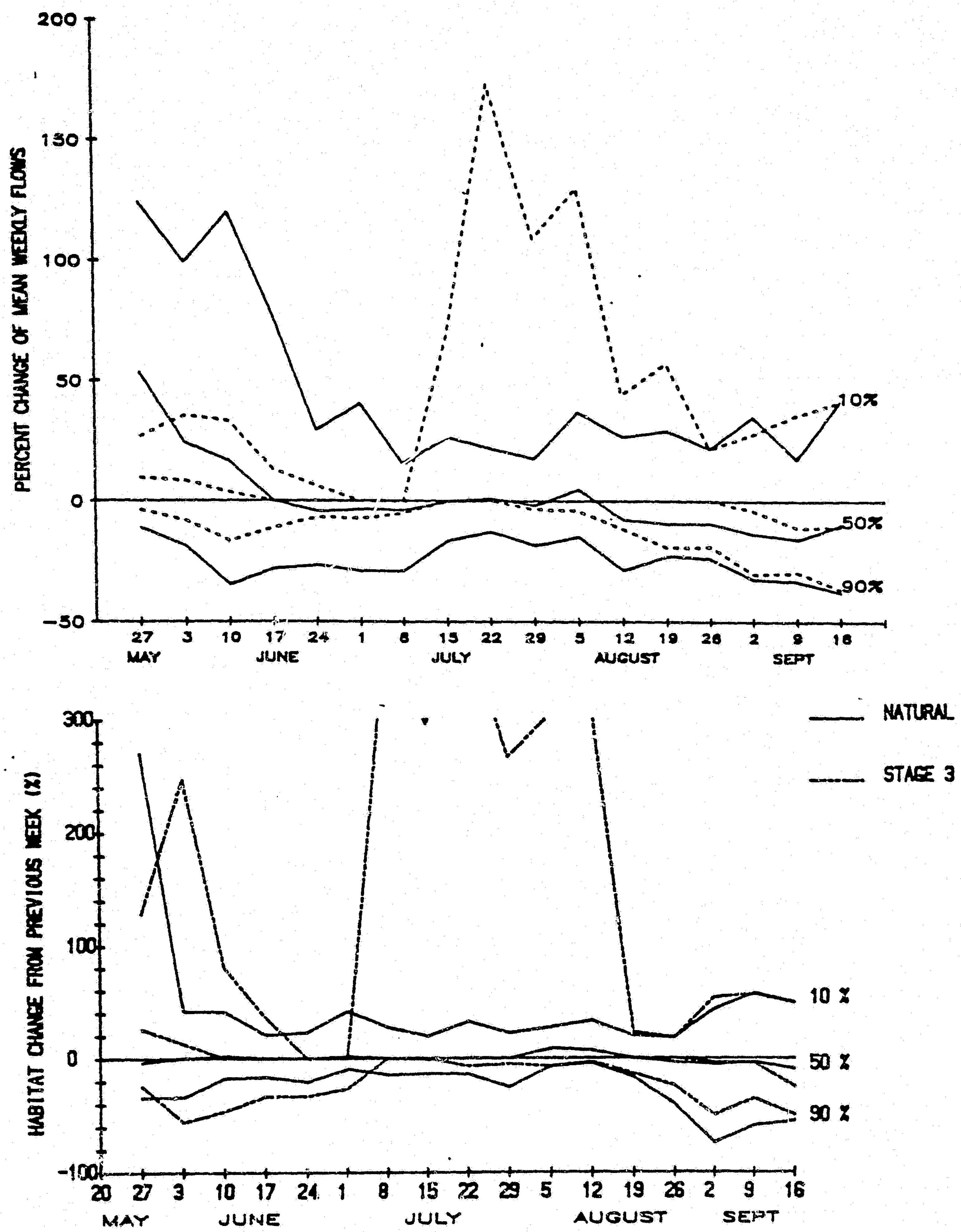
- Group 4 - Side Channels

The group is comprised of side channels with low breaching discharges, intermediate to high mean reach velocities, and substrates consisting primarily of cobbles and boulders. This group provides a substantial amount of the rearing habitat within the middle Susitna River as evidenced by the high utilization of these sites by juvenile chinook salmon during the summer months. The habitat response and percent contributions of this group to middle Susitna River rearing habitat are depicted for a range of mainstem discharges (Figure 100).

. Stage I

. Filling

The rearing habitat during Stage I filling would be increased substantially since flows frequently would be near E-VI minimums, which are flow levels that provide the greater habitat availability for this group than higher natural flow. Habitat associated with monthly



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 3 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 98

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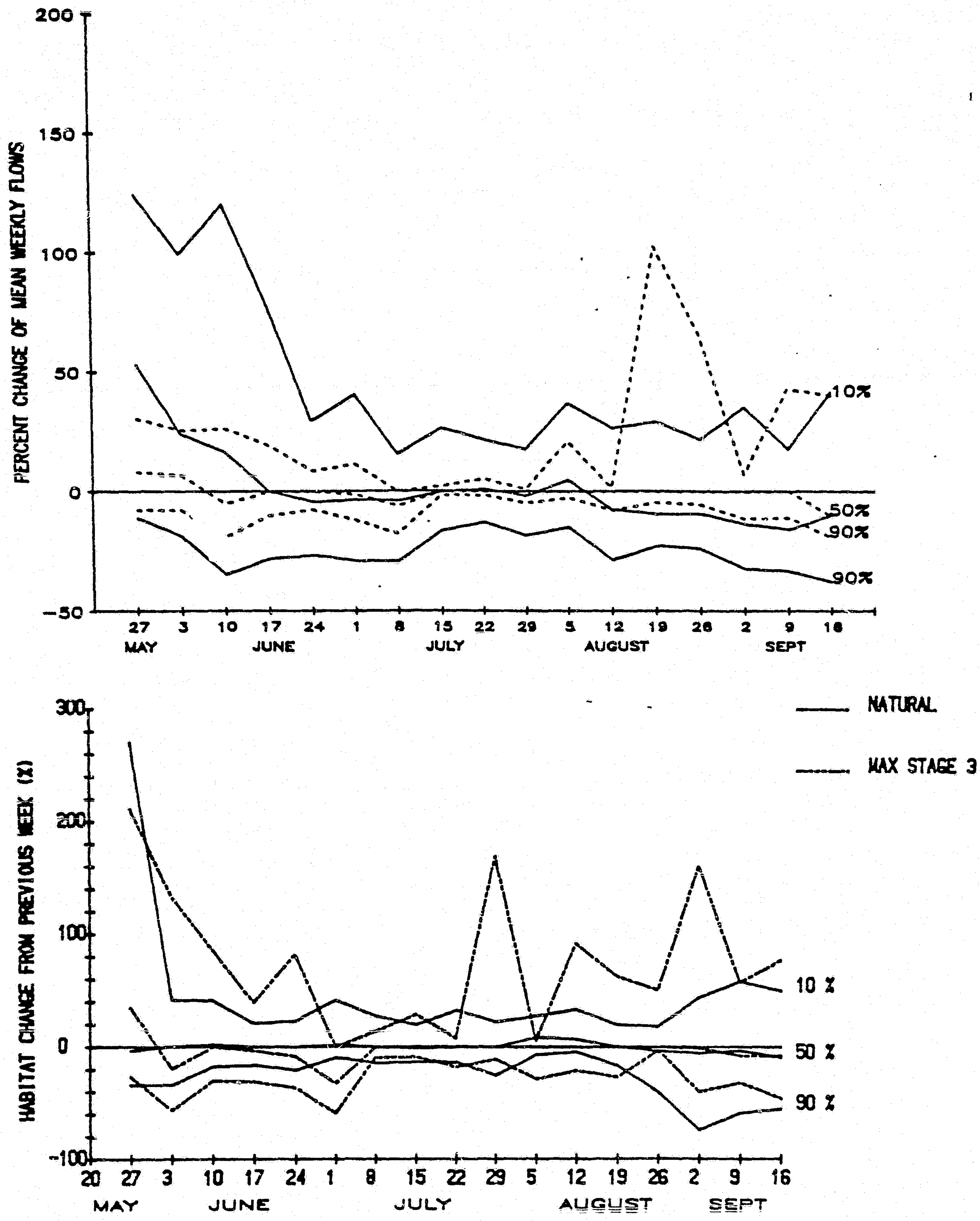

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 3 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 99

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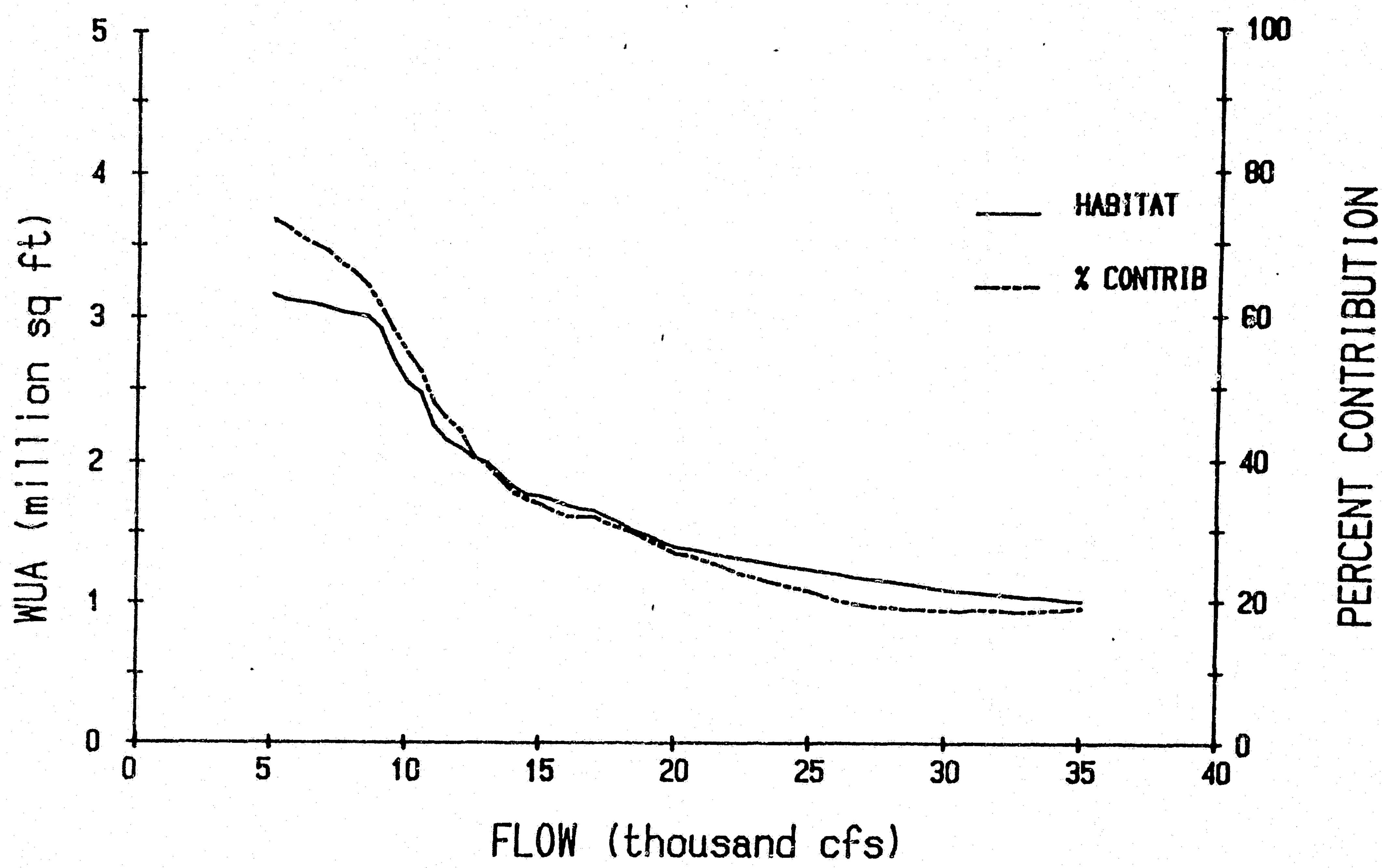

Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 4 areas in the middle Susitna River.

FIGURE 100

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filling flow estimates for June through September would be increased 28-128 percent in a dry year, 55-158 percent in an average year, and 10-107 percent in a wet year (Table 18).

.. Operation

Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figure 101 and 102). Stage I flows would result in substantial increases in habitat throughout most of the summer rearing period. From the end of August through mid-September, the magnitude of habitat increases would decrease somewhat and about half the time decreases would occur.

The stability of habitat in Group 4 sites would be greater in May and June than natural and about the same for the remainder of the season (Figure 103).

The contribution of Group 4 to the habitat provided by all groups in the middle Susitna River would be at levels much higher than natural for the rearing period through mid-August. In late August and September contribution levels would be similar to natural (Figure 70).

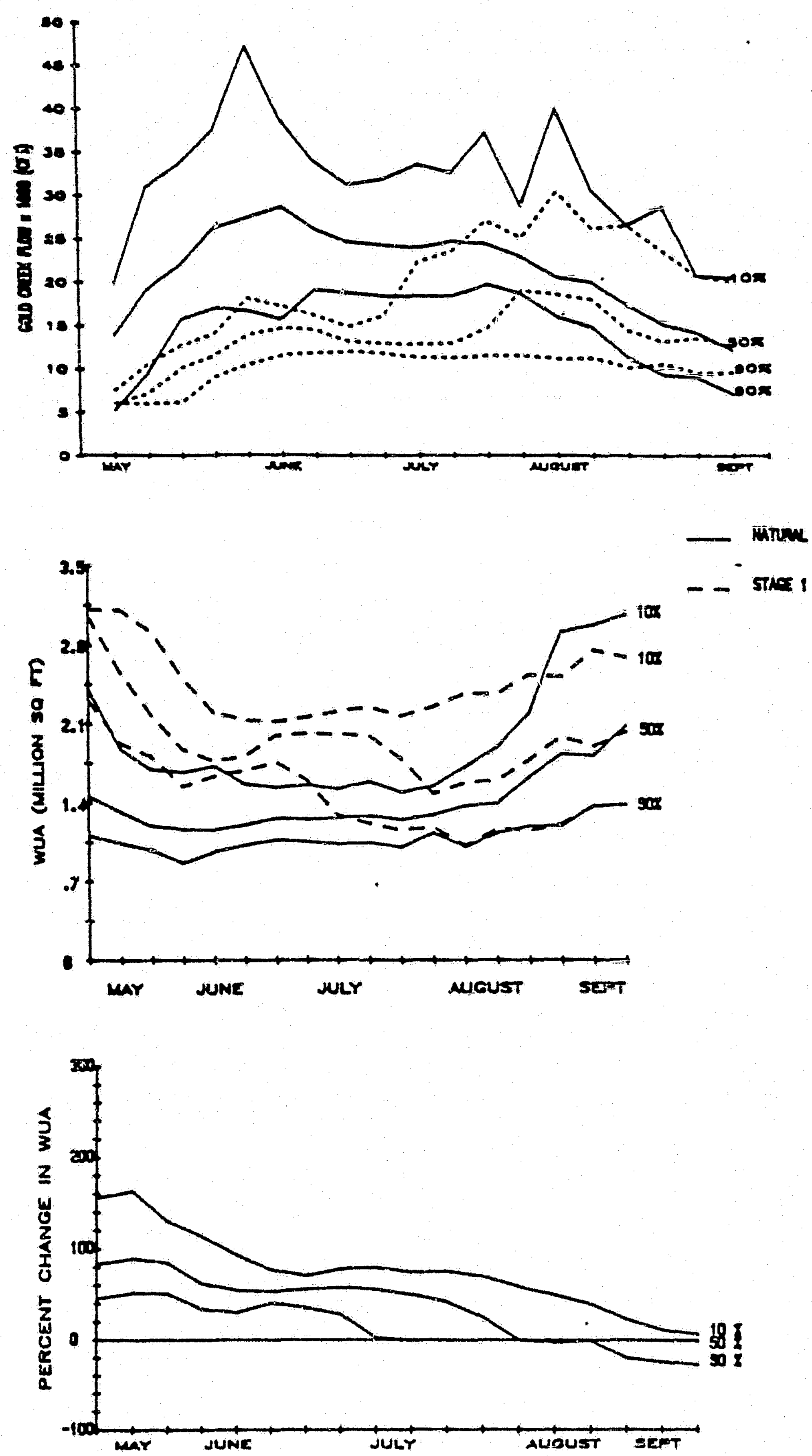
-- Stage II

. Filling

Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

Table 18. Estimated change in chinook rearing habitat in Group 4 due to filling under dry, average and wet conditions

Month	Discharge (cfs)		Rearing Habitat (sq ft WUA)		
	Natural	Filling	Natural	Filling	Change
Dry Year					
June	21,763	7,800	1,326,195	3,028,000	128.32
July	19,126	8,000	1,461,067	3,020,000	106.70
August	17,392	8,000	1,611,530	3,020,000	87.40
September	10,422	5,800	2,484,311	3,112,718	25.30
Average Year					
June	27,815	8,800	1,145,028	2,954,752	158.05
July	24,445	12,740	1,242,762	2,009,926	61.73
August	22,228	12,415	1,312,223	2,037,382	55.26
September	13,221	6,800	1,957,028	3,079,226	57.34
Wet Year					
June	31,580	10,752	1,326,195	1,461,067	10.17
July	27,753	20,547	1,461,067	3,020,000	106.70
August	25,236	15,505	1,611,530	3,020,000	87.40
September	15,124	6,800	2,484,311	3,112,718	25.30



Mean weekly discharge (upper), chinook rearing WUA for Group 4 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 101

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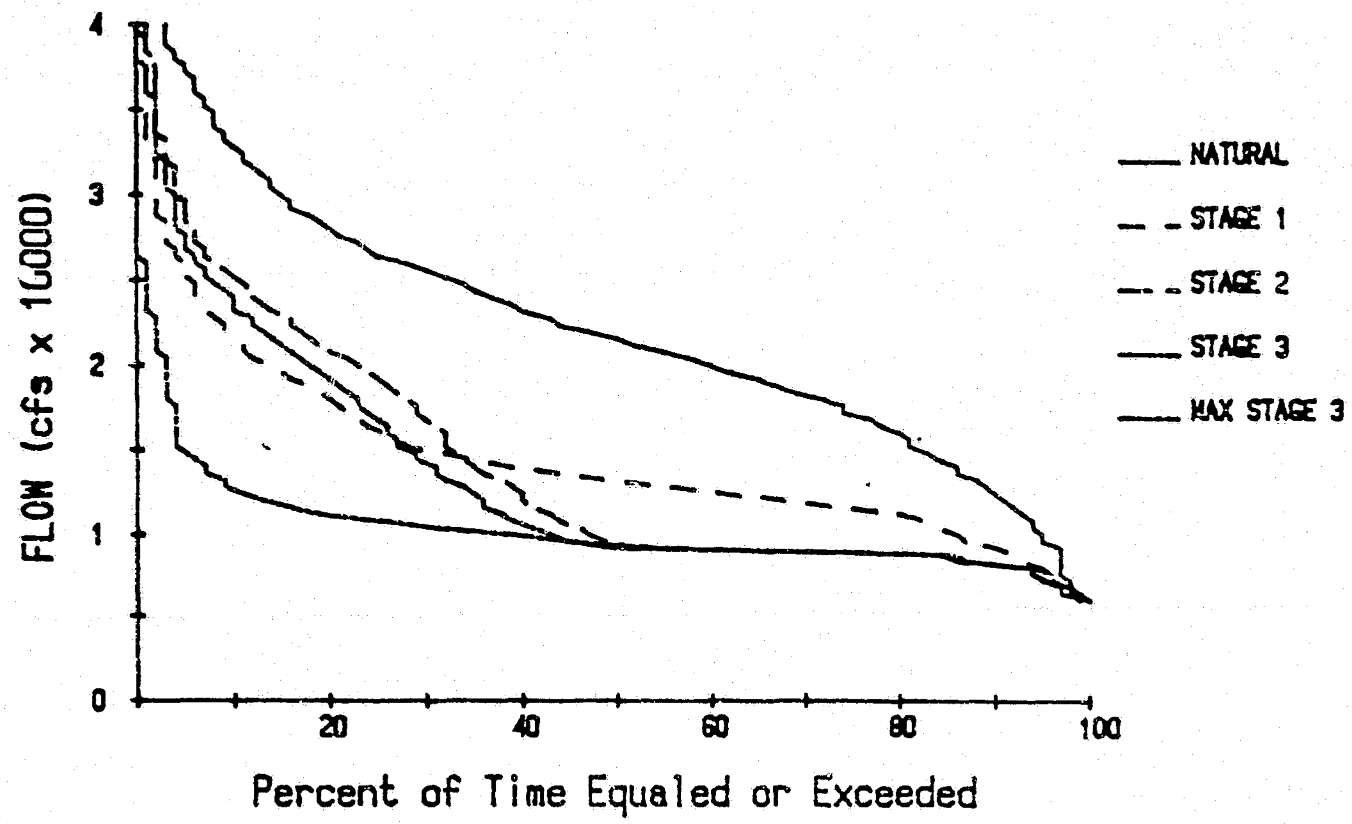
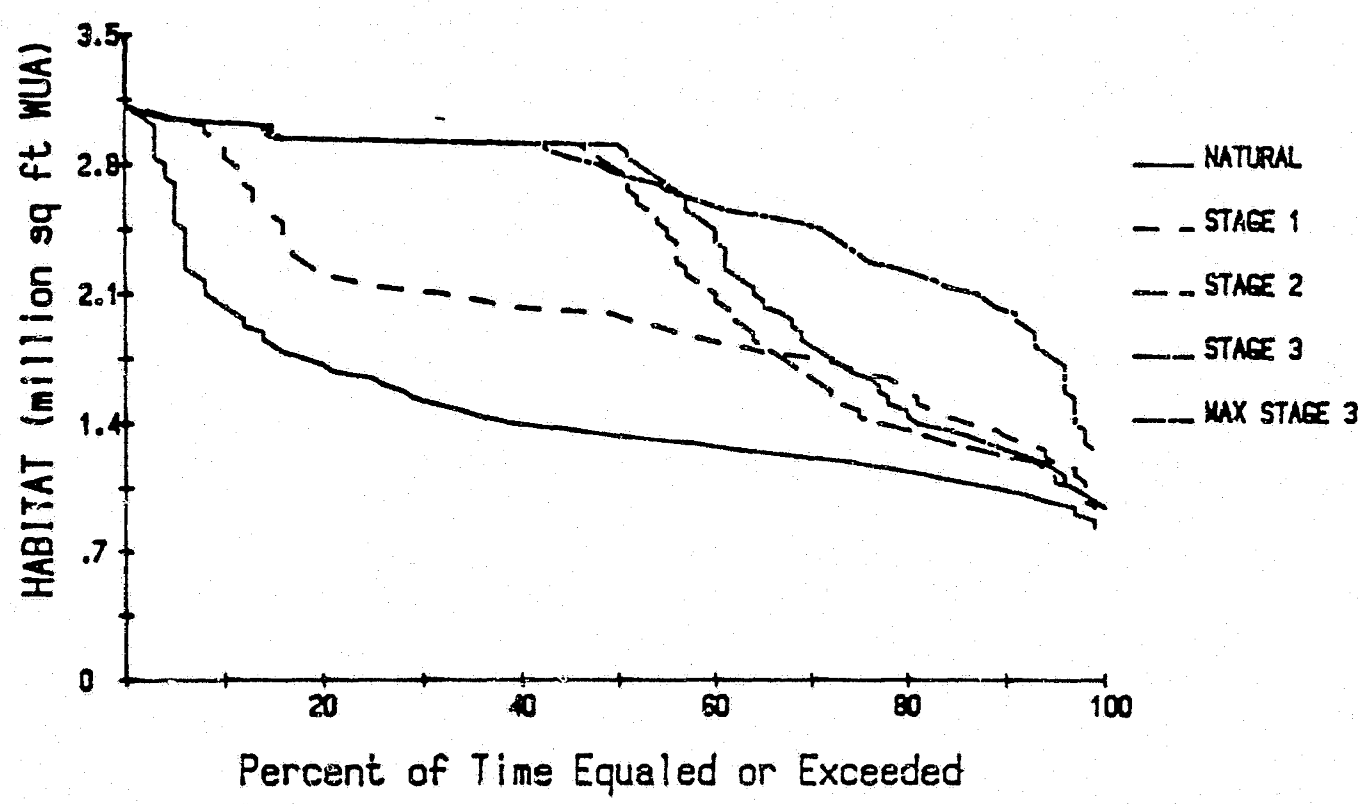


Group 4



Flow duration curve and chinook rearing habitat duration curve for Group 4.

FIGURE 102

ALASKA POWER AUTHORITY SUSITNA HYDROELECTRIC PROJECT	
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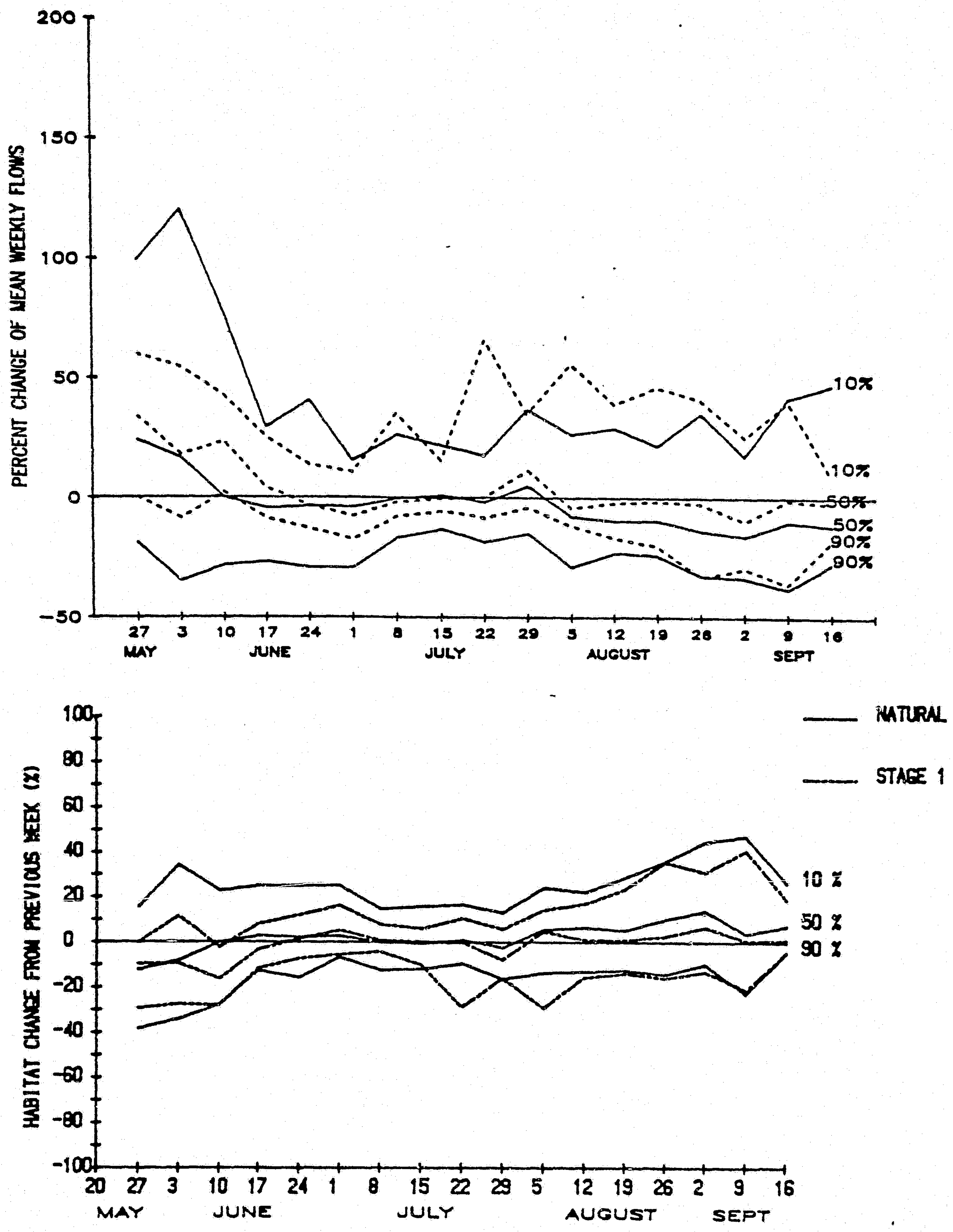

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 4 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 103

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. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figures 104 and 100). Stage II operational flows would result in habitat increases from 0 to greater than 100 percent for much of the rearing season. In late August and September habitat availability would be about the same as natural.

With-project habitat stability would increase during May and June, decrease in July and in August and September would be about the same as natural (Figure 105).

The contribution of Group 4 to total middle Susitna River habitat would increase under Stage II from natural levels of 20 to 30 percent to 55 to 70 percent in May and June. The magnitude of the percent percent contribution increase would decrease during July and would be similar to natural from mid-August to mid-September (Figure 73).

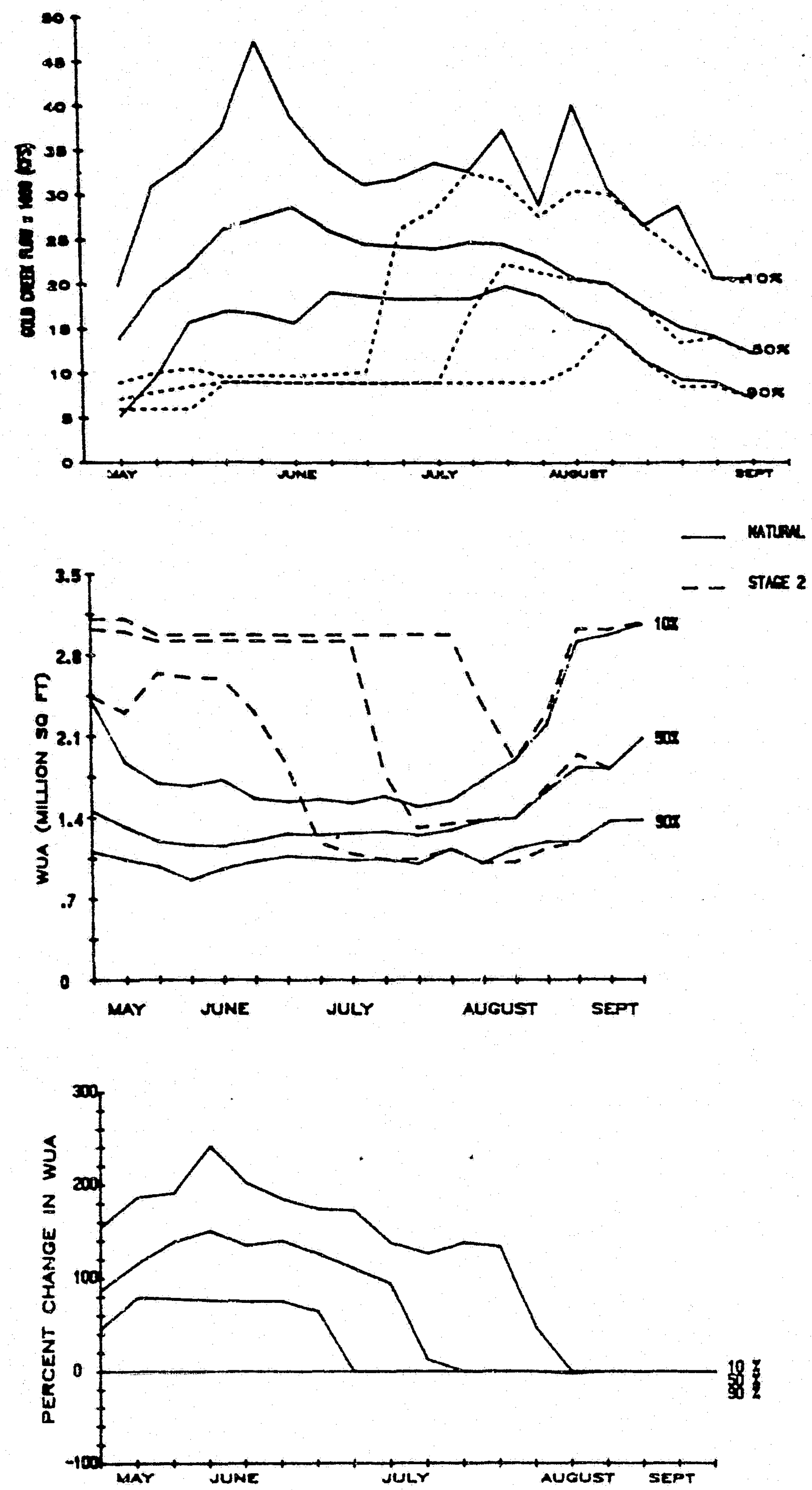
-- Stage III

. Filling

Filling of Watana during Stage III would occur over several years and consequently habitat availability is more appropriately addressed under operation.

. Operation

Habitat availability under natural and early and late Stage III operation are compared in weekly habitat time series plots and seasonal habitat duration curves (Figures 106, 107 and 100). Early and late Stage III



Mean weekly discharge (upper), chinook rearing WUA for Group 4 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 104

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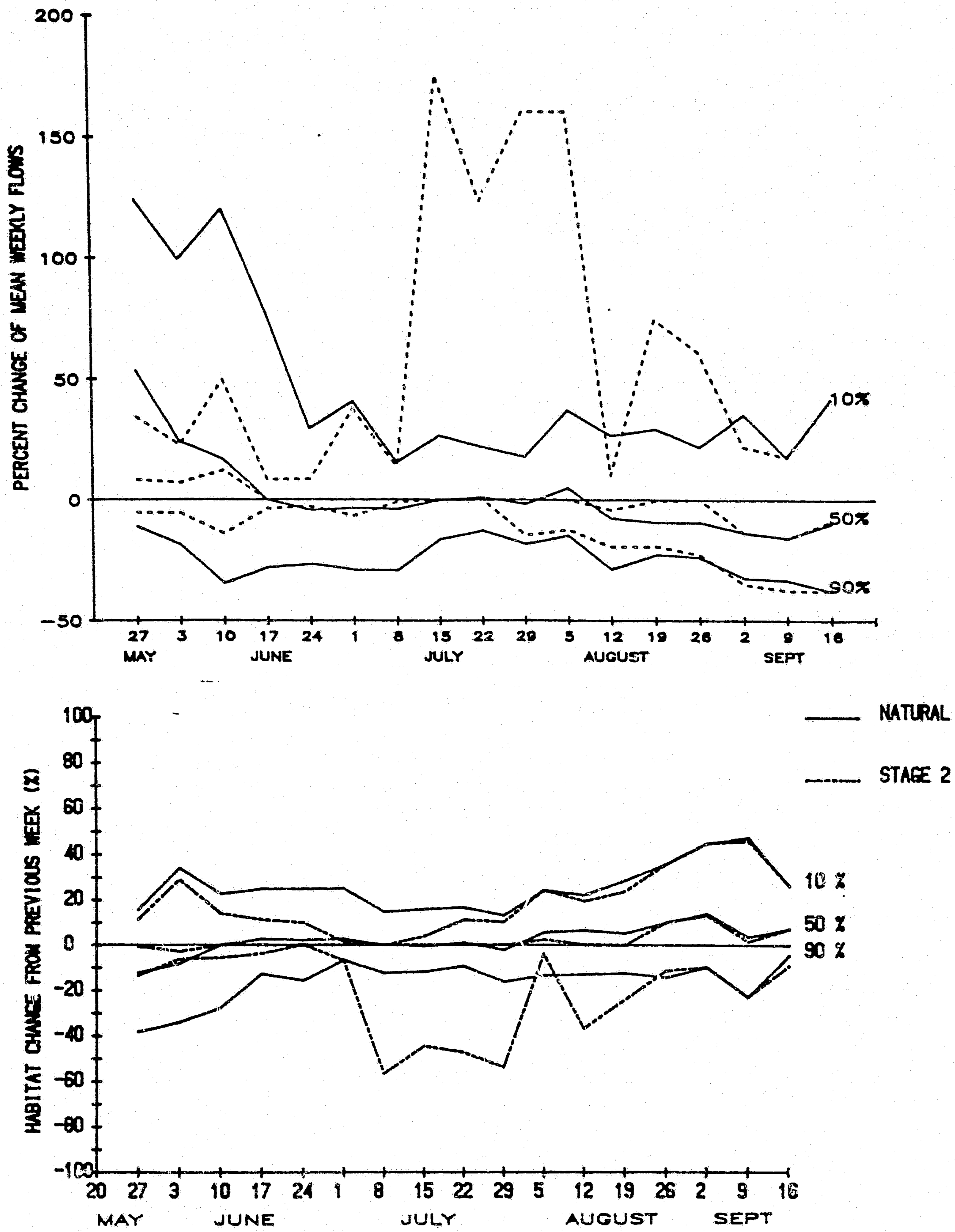

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 4 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 105

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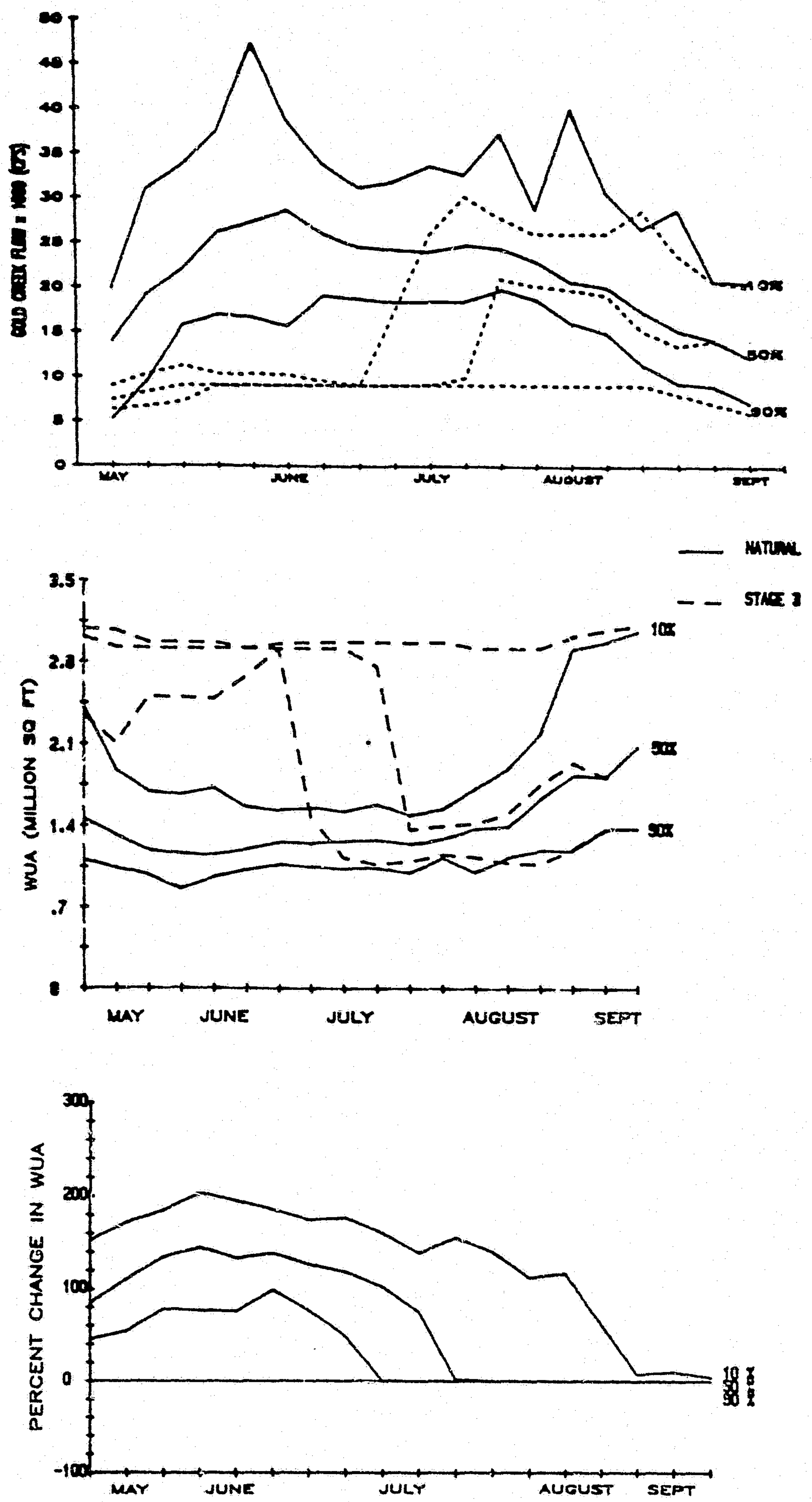
SUSITNA JOINT VENTURE



Mean weekly discharge (upper), chinook rearing WUA for Group 4 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 106

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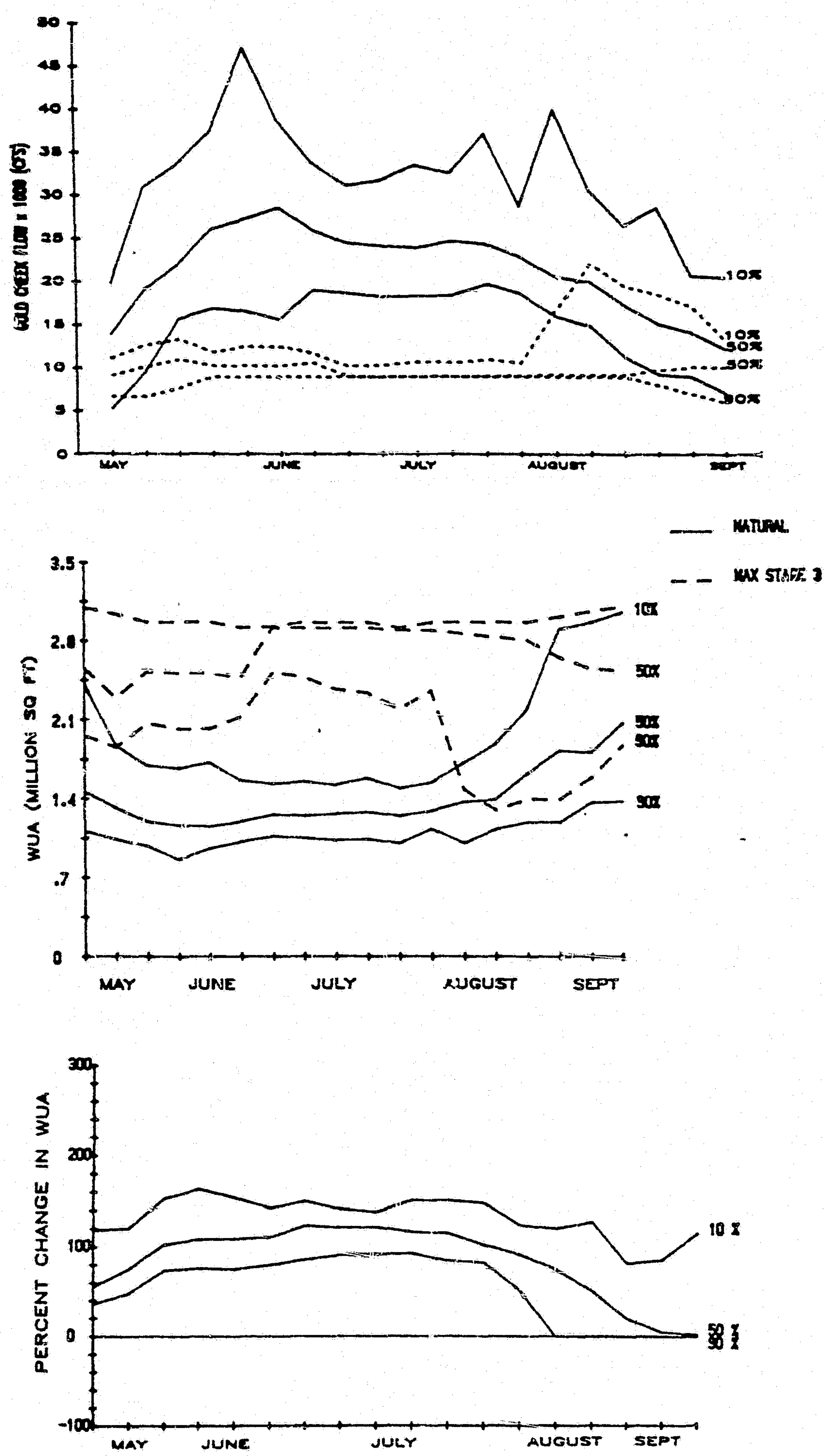

Mean weekly discharge (upper), chinook rearing WUA for Group 4 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 107

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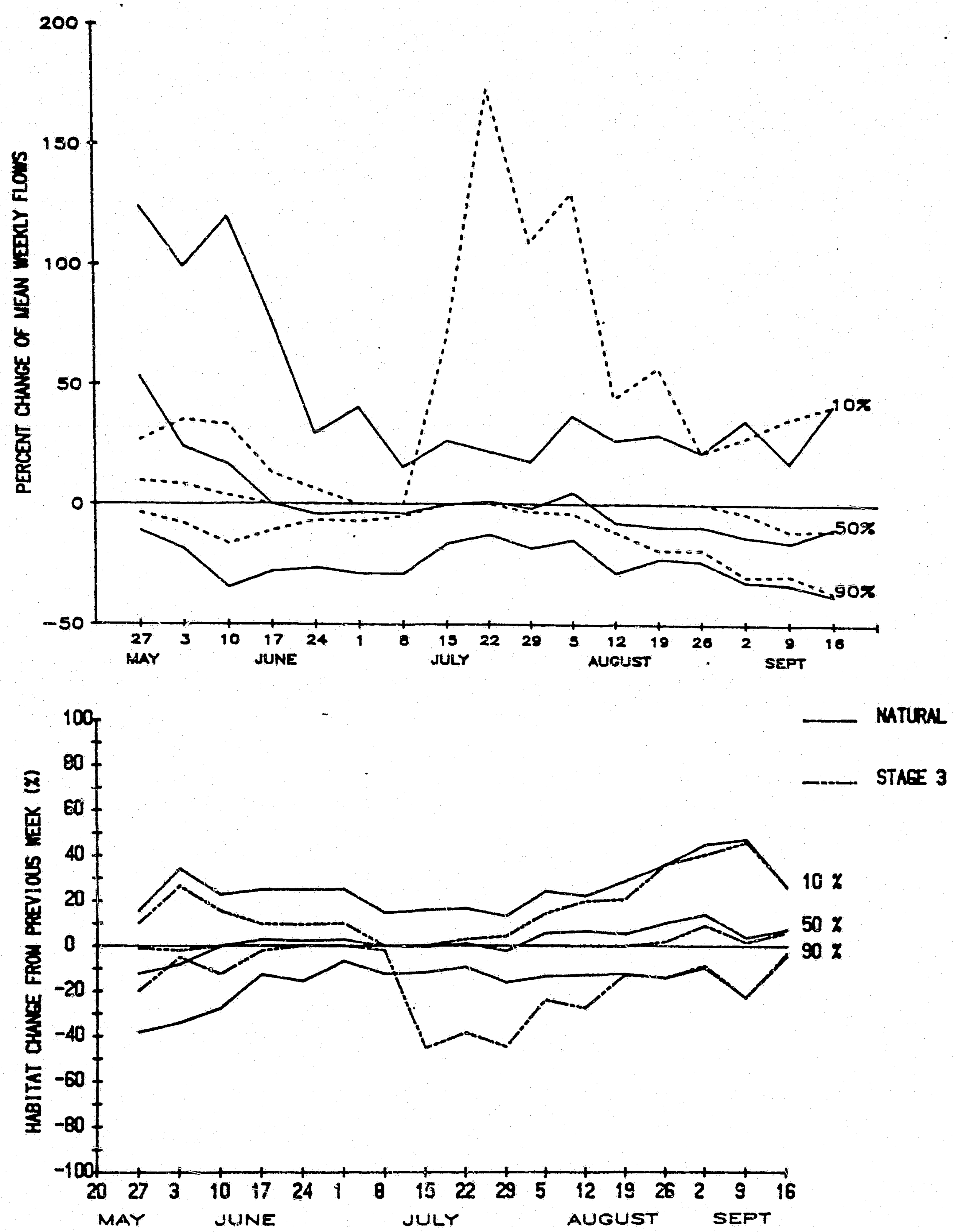
operational flows would result in substantial increases in habitat through the majority of the rearing season often exceeding 100 percent over natural.

Stability during early and late Stage III would be greater than natural, except for a few weeks during July and early August in early Stage III when week-to-week changes in habitat would exceed natural (Figure 108 and 109).

The contribution of Group 4 to middle Susitna River rearing habitat would increase from natural levels of 20 to 30 percent to Stage III levels of 40 to 70 percent through mid-summer. The magnitude of the increase in percent contribution would decrease in July during early Stage III and in August during late Stage III and by mid-September approach natural levels for both periods of Stage III (Figures 78 and 79).

- <u>Group 5 - Mainstem Shoals</u>

This group includes mainstem and side channel areas which transform into clearwater side sloughs at lower mainstem discharges. Sites within this group are characterized by fine sediment although larger substrates are possible if the shoal has stabilized and taken as gravel bar characteristics (Aaseraude et al. 1986). The Group V habitat response curve and percent contribution of the group to the total middle Susitna River rearing habitat are depicted in Figure 110. As indicated in the figure, this group contributes only a minor portion of the juvenile chinook habitat, even under optimum flow conditions.



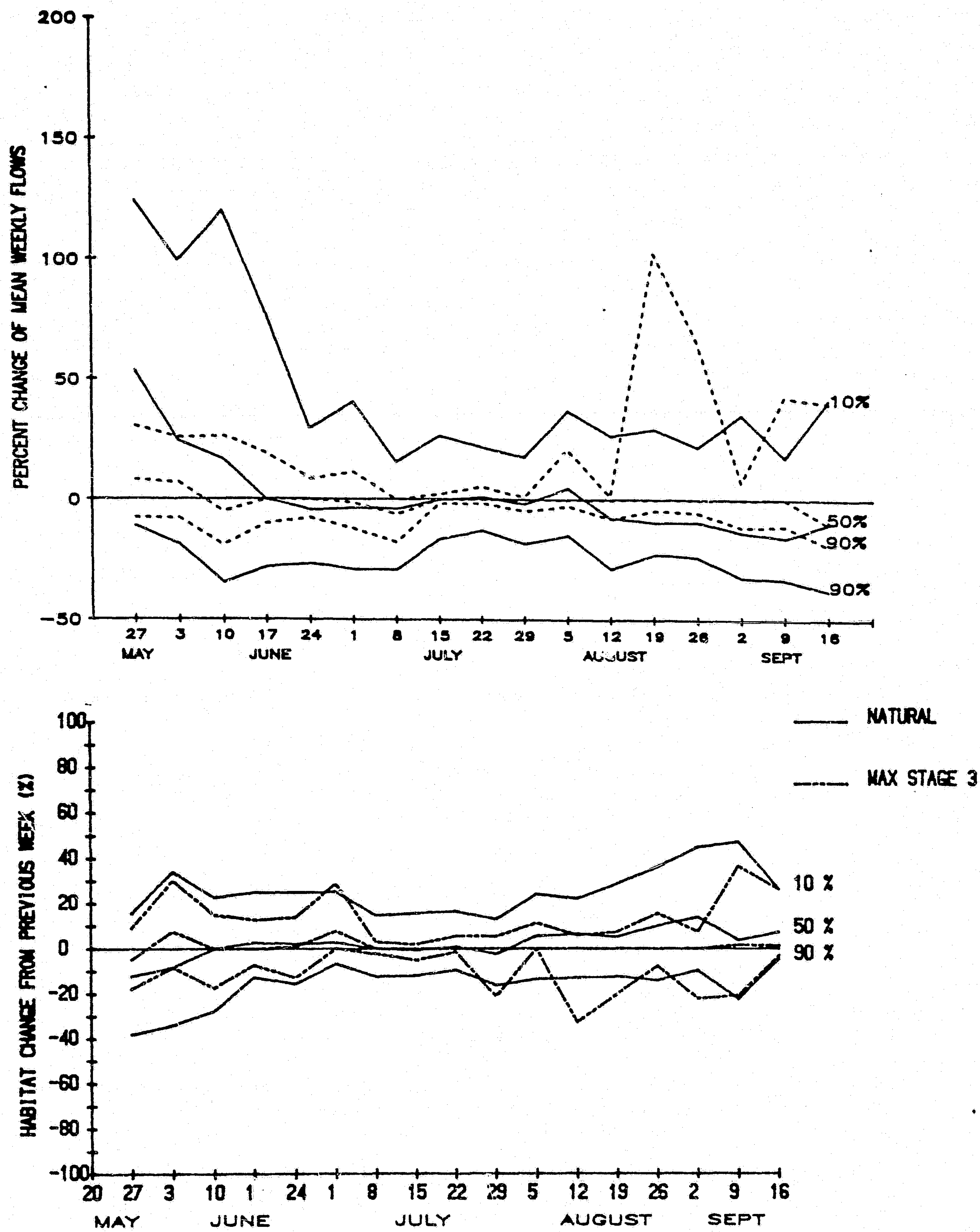
Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 4 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 108

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



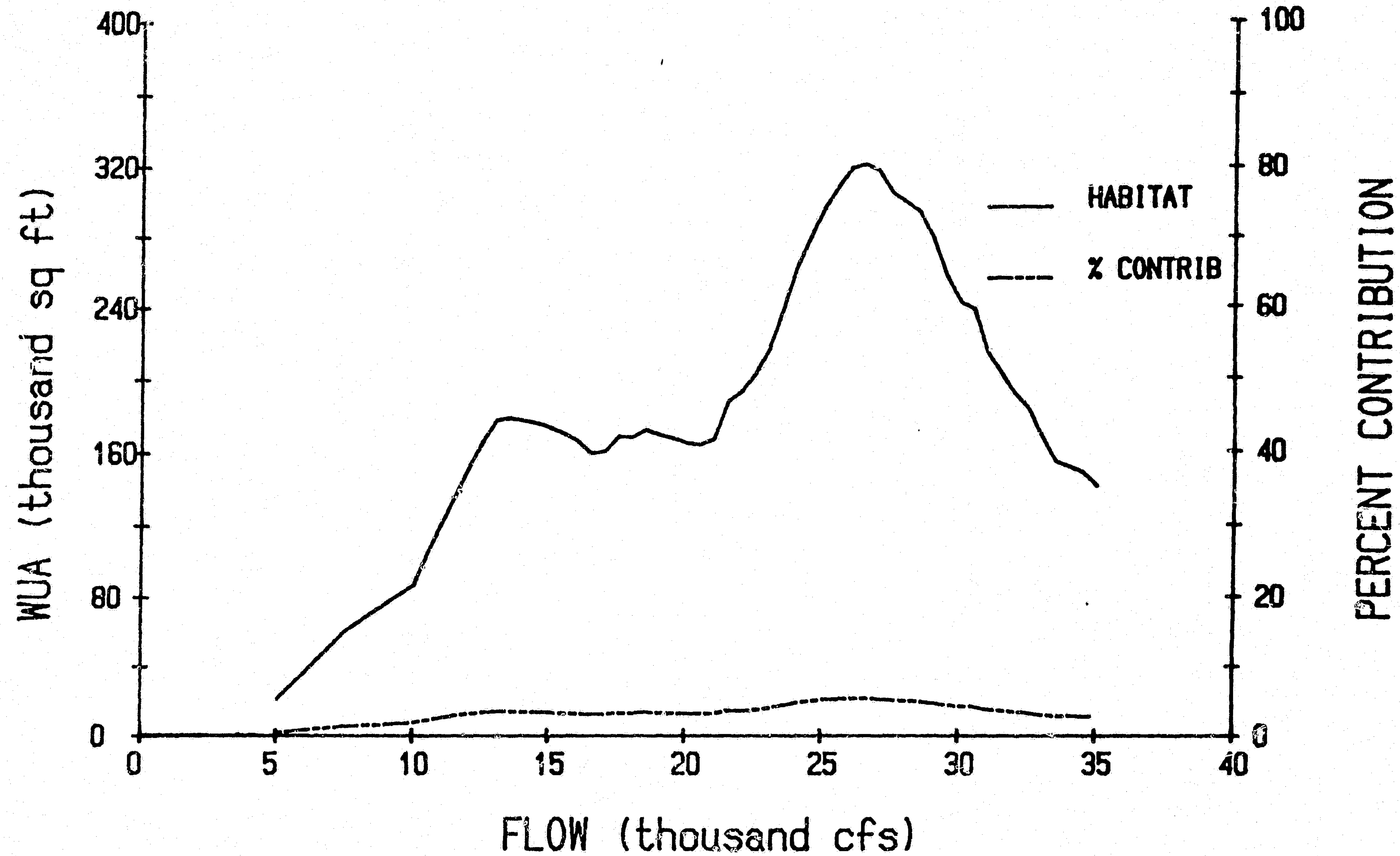
Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 4 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 109

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 5 areas in the middle Susitna River.

FIGURE 110

ALASKA POWER AUTHORITY
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HARZA-EBASCO
SUSITNA JOINT VENTURE

-- Stage I

. Filling

The rearing habitat during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below the natural flows that provide higher habitat availability for this group. Habitat associated with monthly filling flow estimates for June through September would be reduced by 39 to 67 percent in a dry year, 8 to 72 percent in an average year, and 44 to 71 percent in a wet year (Table 19).

. Operation

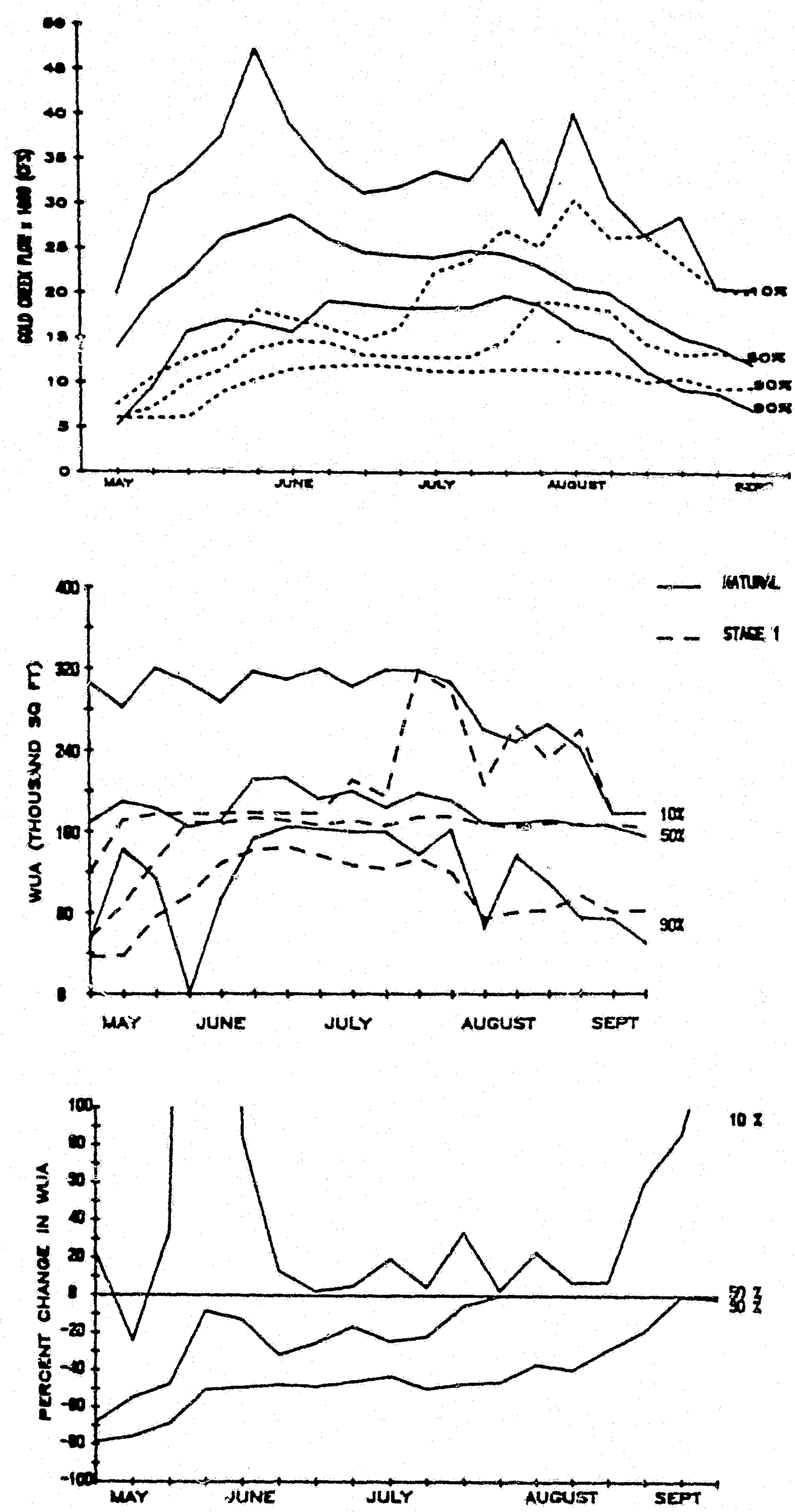
Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figure 111 and 112). Stage I flows would result in decreases in habitat from 0 to 60 percent more than half the time through July and decreases in habitat up to 40 percent about half the time for the remainder of the summer rearing period. Habitat increases would also occur throughout the season but with much lower frequencies than the decreases.

The stability of habitat in Group 5 sites would be greater through July than naturally and about the same for the remainder of the season (Figure 113).

The contribution of Group 3 to the habitat availability provided by all groups combined would be somewhat less than natural from late May through mid-July and about the same as natural for the rest of the season (Figure 70).

Table 19. Estimated change in chinook rearing habitat in Group 5 due to filling under dry, average and wet conditions.

Month	Discharge (cfs) Natural	Discharge (cfs) Filling	Rearing Habitat (sq ft WUA) Natural	Rearing Habitat (sq ft WUA) Filling	Rearing Habitat (sq ft WUA) Change
Dry Year					
June	21,763	7,800	190,477	64,128	-66.33
July	19,126	8,000	168,576	66,308	-60.67
August	17,392	8,000	166,653	101,999	-38.80
September	10,422	5,800	101,999	33,396	-67.26
Average Year					
June	27,815	8,800	301,889	278,025	-7.90
July	24,445	12,740	278,025	171,206	-38.42
August	22,228	12,415	197,333	163,160	-17.32
September	13,221	6,800	177,797	49,232	-72.31
Wet Year					
June	31,580	10,752	201,352	112,927	-43.92
July	27,753	20,547	302,585	164,178	-45.74
August	25,236	15,505	301,969	170,178	-43.64
September	15,124	6,800	172,569	49,232	-71.47



Mean weekly discharge (upper), chinook rearing WUA for Group 5 (middle) and percent change in WUA (lower)exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 111

ALASKA POWER AUTHORITY
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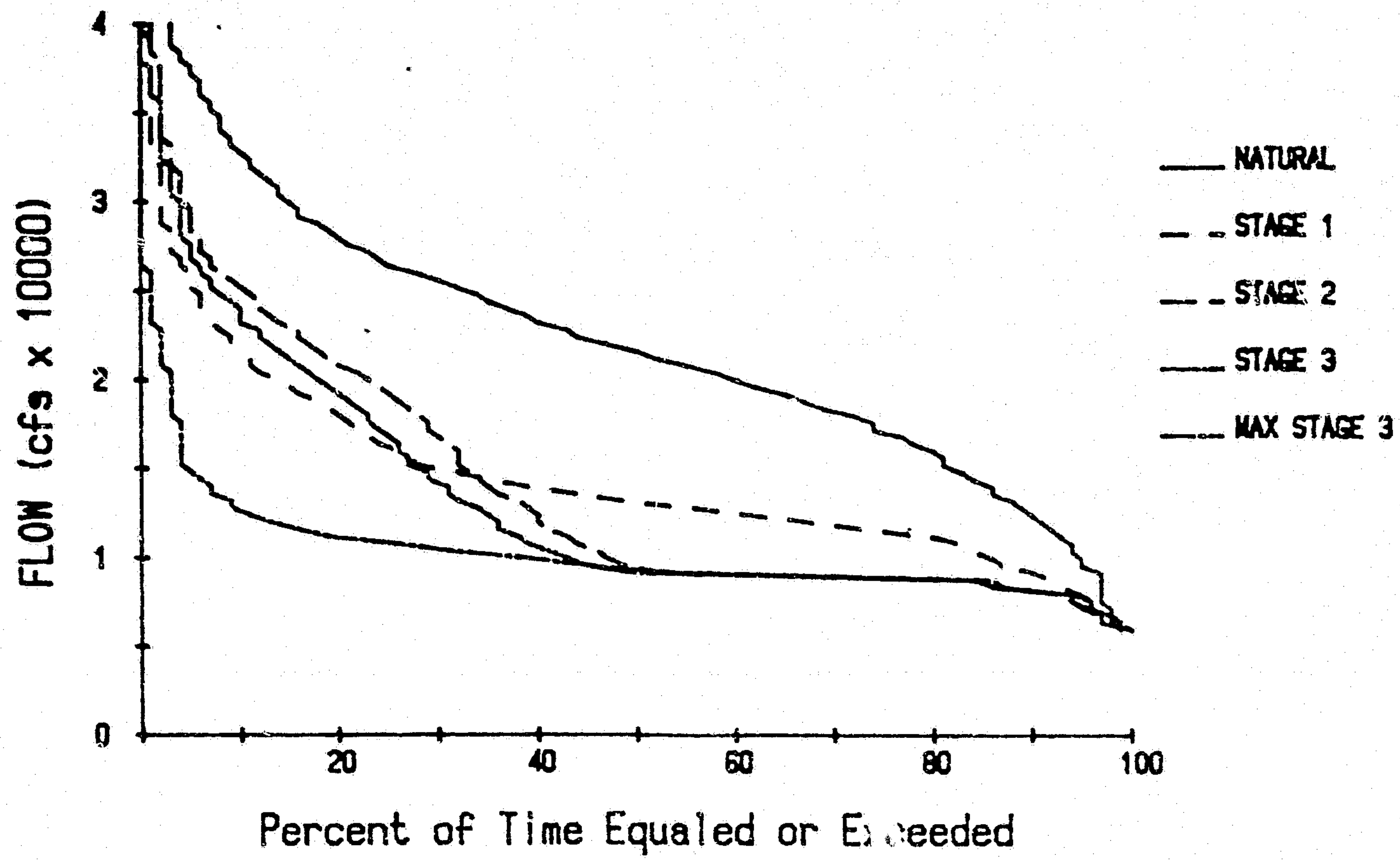
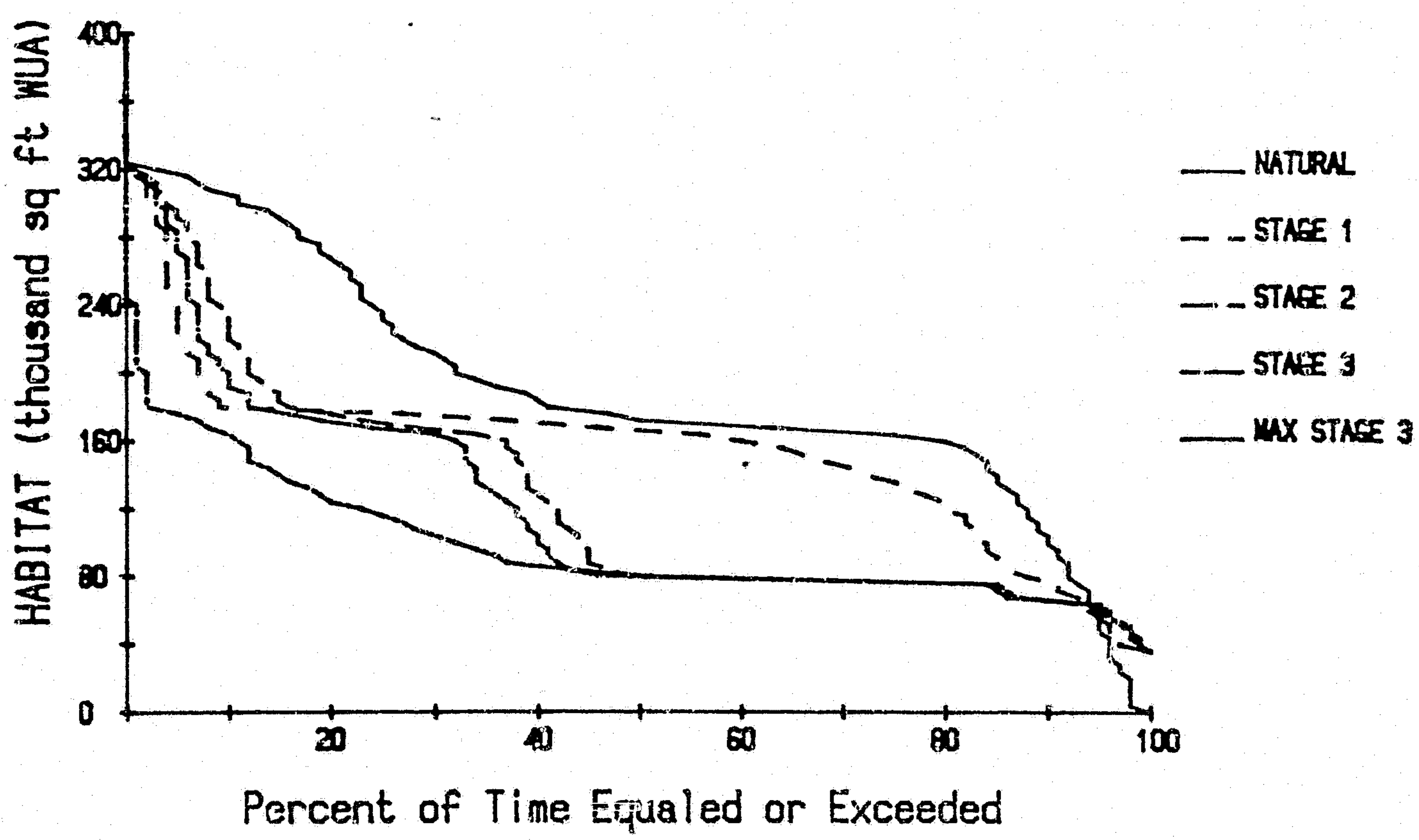
HARZA-EBASCO
SUSITNA JOINT VENTURE



Group 5



Flow duration curve
and chinook rearing habitat
duration curve for Group 5.

FIGURE 112

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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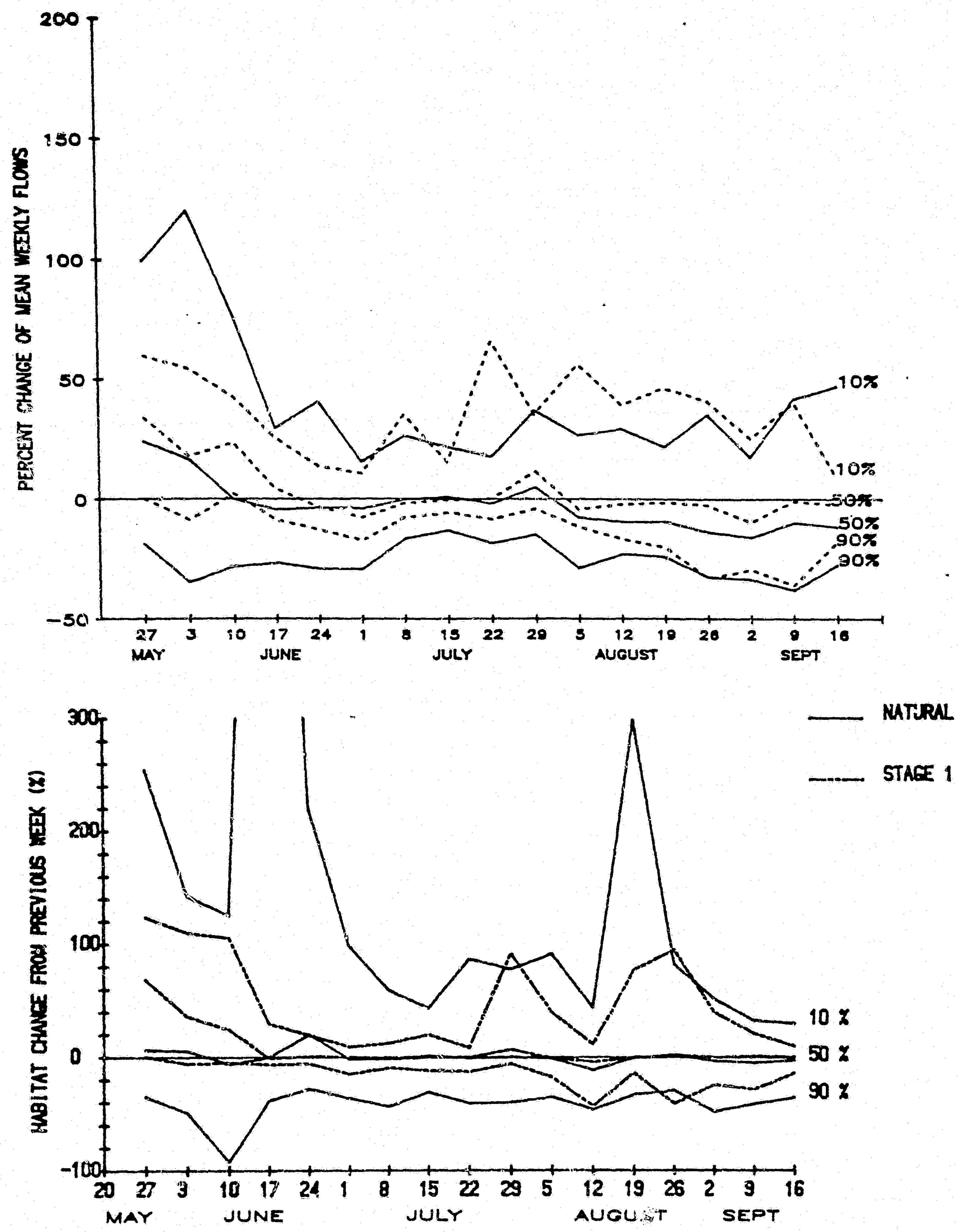
HARZA-EBASCO
SUSITNA JOINT VENTURE



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 5 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 113

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SUSITNA HYDROELECTRIC PROJECT

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HARZA-EBASCO
SUSITNA JOINT VENTURE

-- Stage II

. Filling

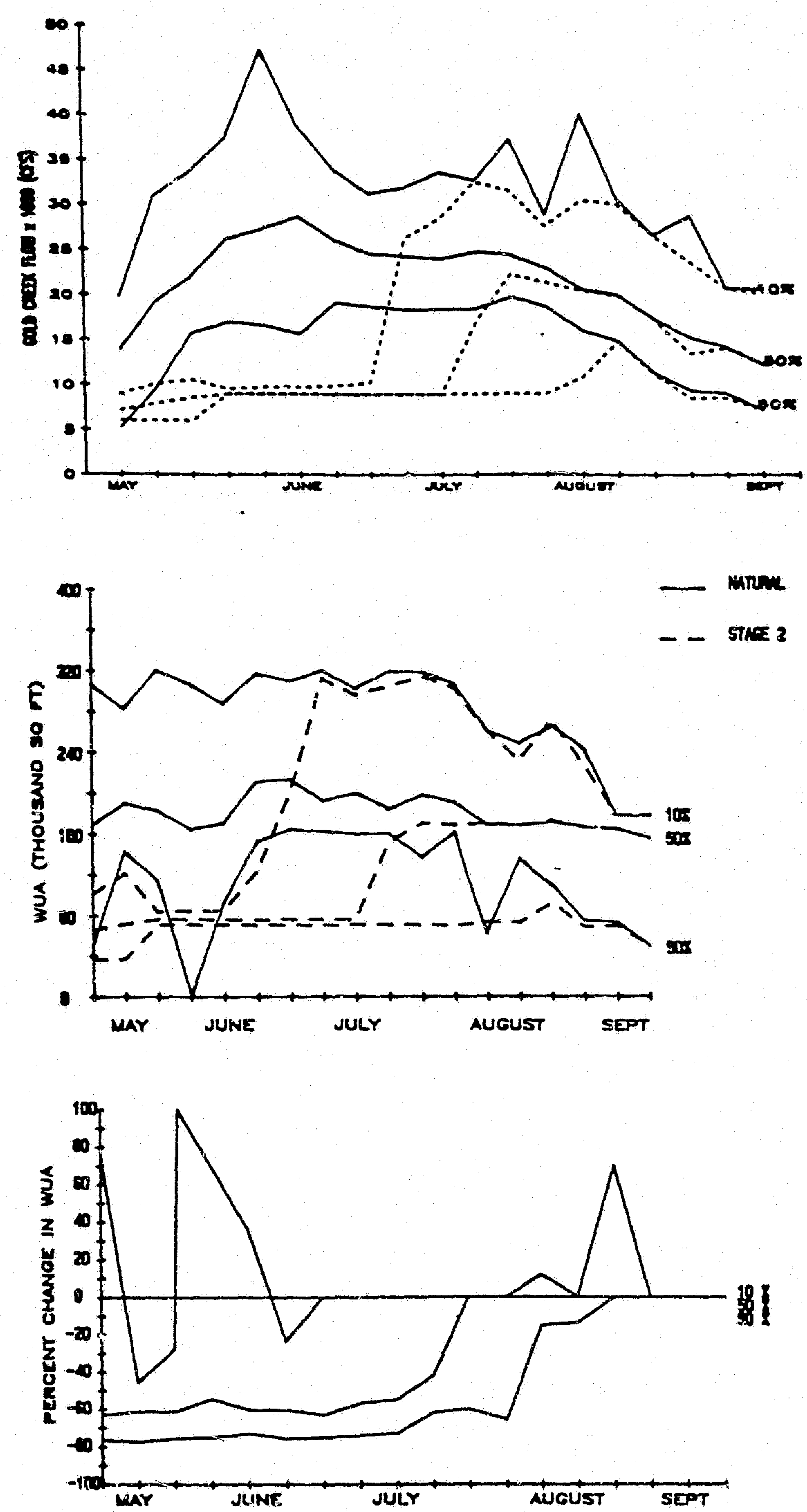
Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figures 114 and 112). Stage II operational flows would result in habitat reductions from 60 to 75 percent about half the time in May, June, and July. By the end of July the magnitude of these reductions would decrease and by end of August habitat availability would be about the same as natural.

With-project habitat stability would increase substantially in May and June, decrease in July, and be approximately the same or slightly greater in August and September (Figure 115).

The contribution of Group 5 to total middle Susitna River habitat would decrease under Stage II from natural levels of 2 to 5 percent to about 2 percent in May and June. The percent contribution would increase during July and would be similar to natural from mid-August to mid-September (Figure 73).



Mean weekly discharge (upper), chinook rearing WUA for Group 5 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 114

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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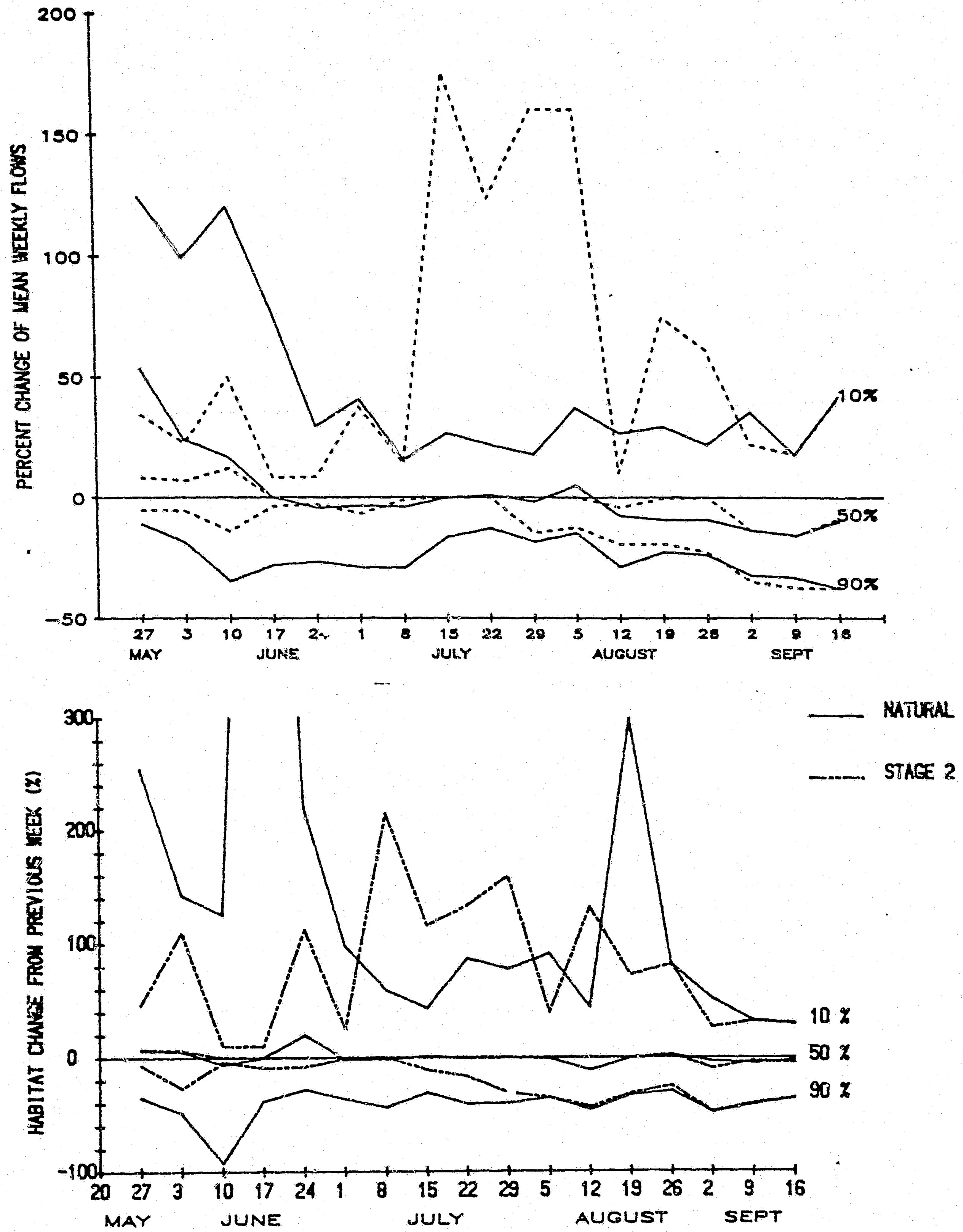
HARZA-EBASCO
SUSITNA JOINT VENTURE



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 5 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 115

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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HARZA-EBASCO
SUSITNA JOINT VENTURE

-- Stage III

. Filling

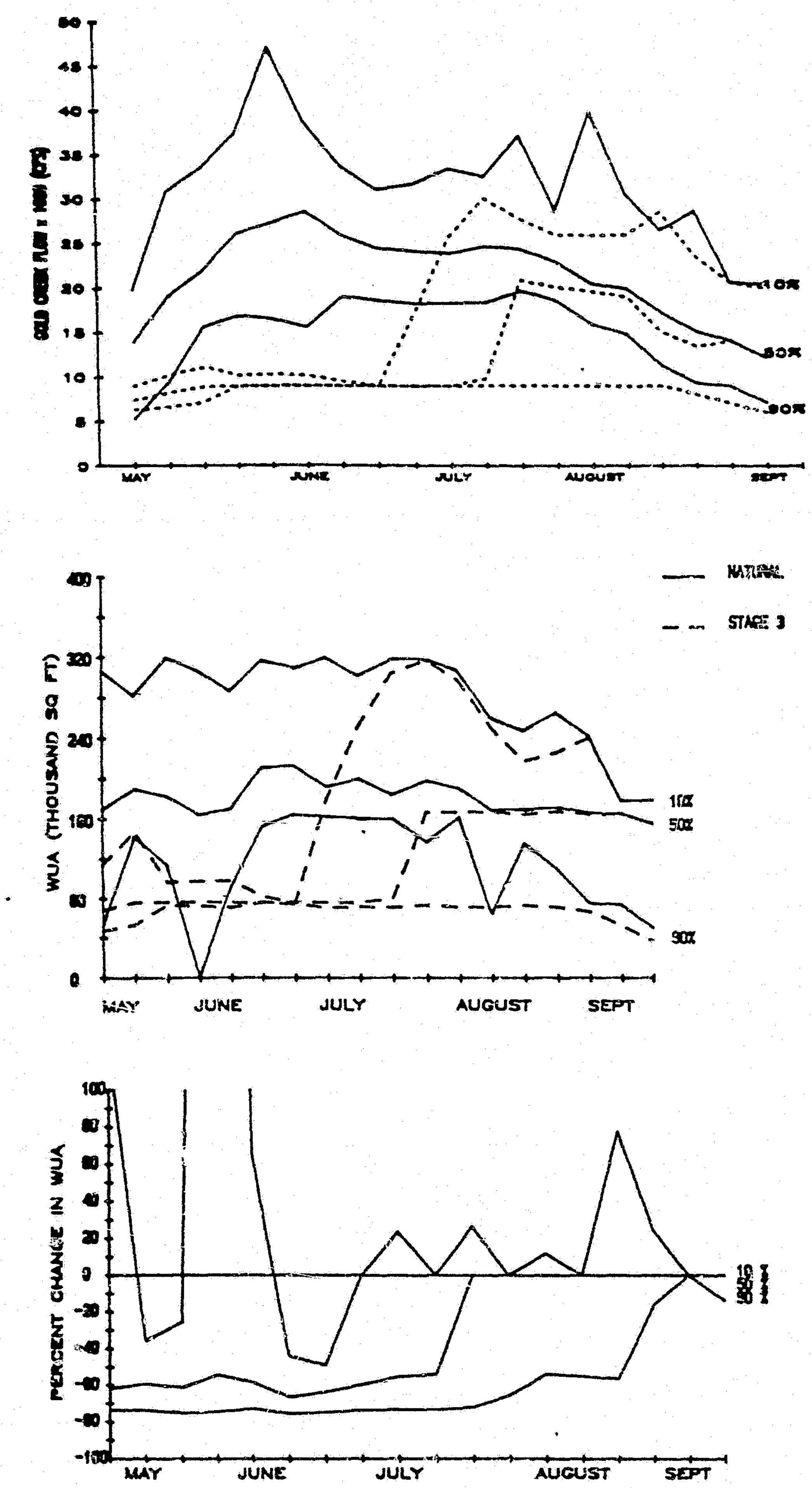
Filling of Watana during Stage III would occur over several years and consequently habitat availability is more appropriately addressed under operation.

. Operation

Habitat availability under natural and early and late Stage III operation are compared in weekly habitat time series plots and seasonal habitat duration curves (Figures 116, 117 and 112). Early Stage III operational flows would result in substantial reductions (up to 70 percent) in habitat through June. In July the frequencies of reduction would decrease and by August would occur about half the time. In late Stage III reductions of 40 percent or more would be prevalent at least 50 percent of the time through July. In August, habitat availability would range from infrequent slight increases to more frequent decreases up to 60 percent.

Stability during early and late Stage III would be greater than natural for the majority of the rearing season, with the exception of some large increases (100 percent) in week-to-week habitat availability during July and early August in early Stage III (Figures 118 and 119).

The contribution of Group 5 to middle Susitna River rearing habitat decrease from natural levels of 2 to 5 percent to Stage III levels of 2 to 3 percent in early summer to 2 to 4 percent in the second half (Figures 78 and 79).



Mean weekly discharge (upper), chinook rearing WUA for Group 5 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 116

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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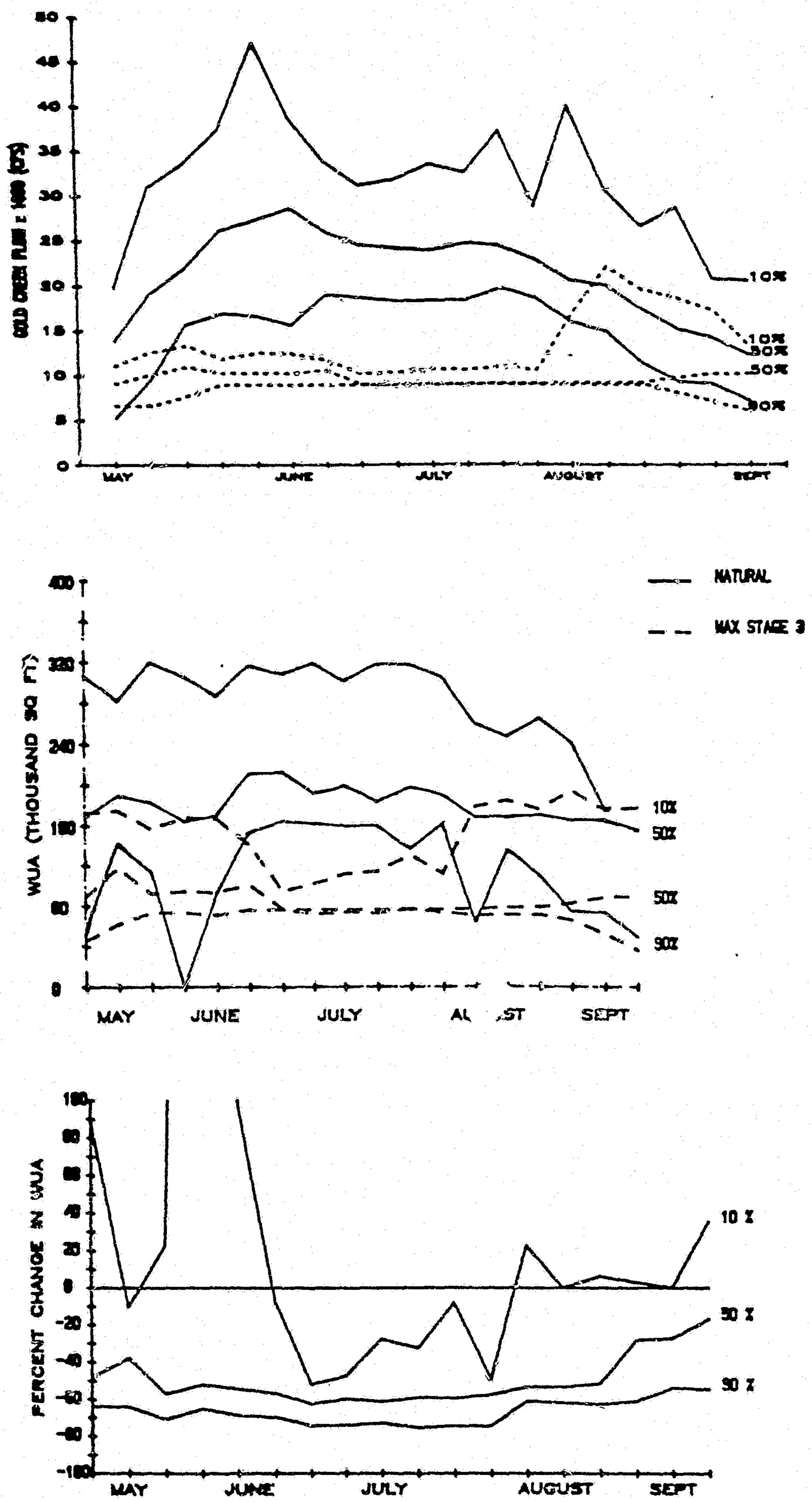
HARZ -EBASCO
SUSITNA JOINT VENTURE



Mean weekly discharge (upper), chinook rearing WUA for Group 5 (middle) and percent change in WUA (lower)exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 117

ALASKA POWER AUTHORITY
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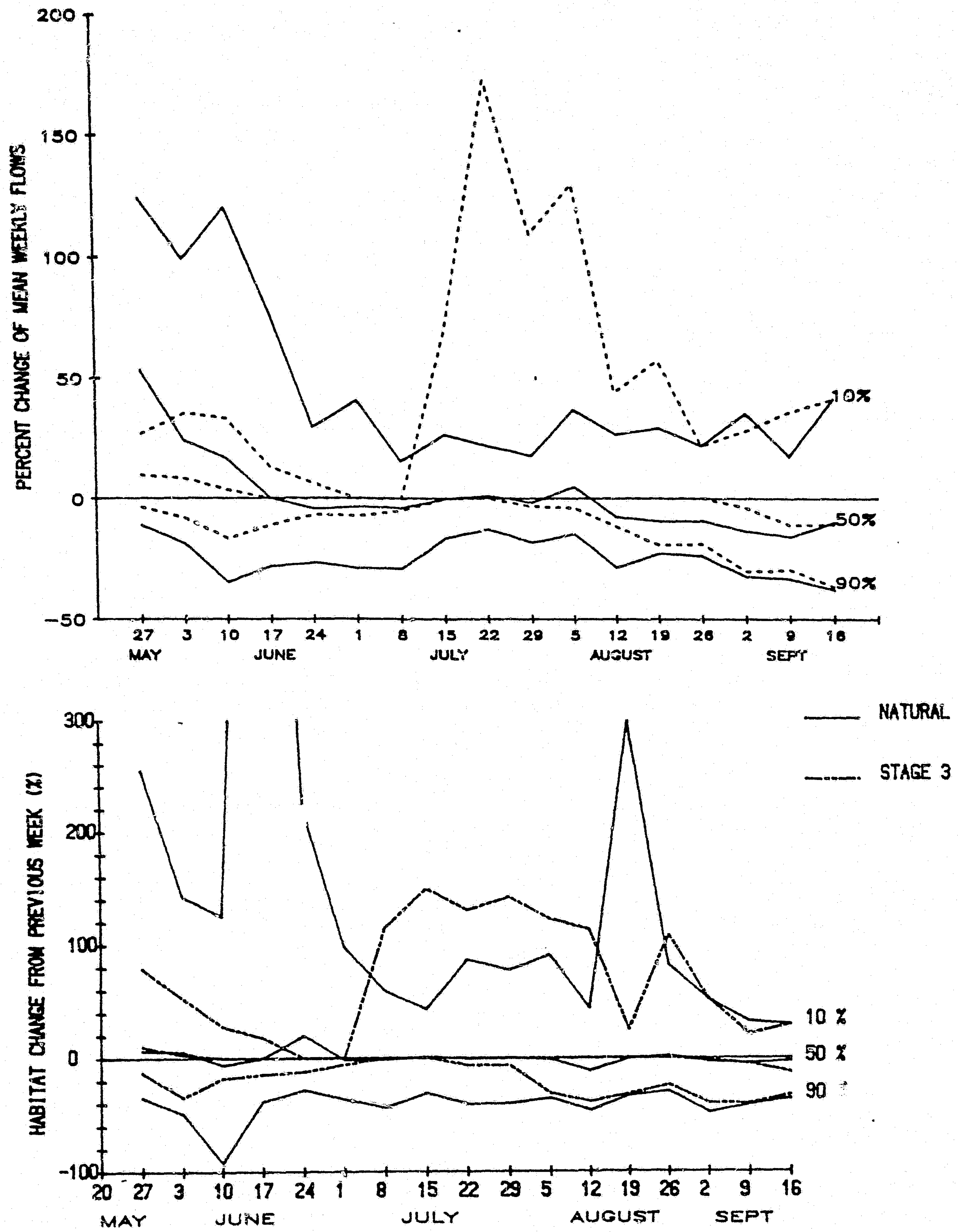
HARZA-EBASCO
SUSITNA JOINT VENTURE



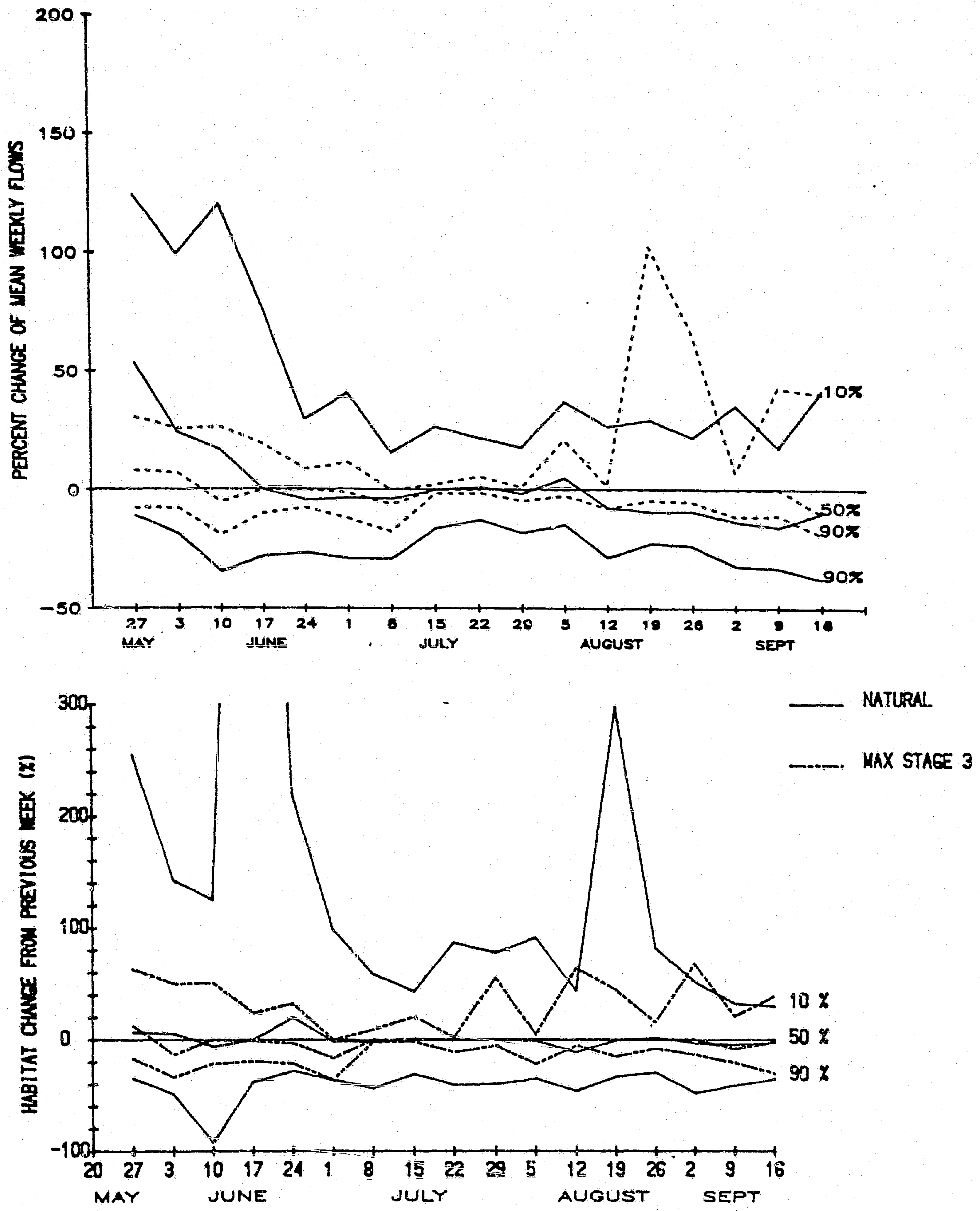
Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 5 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 118

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 5 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 119

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

- Representative Group VI

This group is comprised of overflow channels which parallel the mainstema nd represent a transition area between schools and side channels. The sites within this group breach at a wide range of mainstem discharge. The habitat response curve and percent contribution of this group to the total middle Susitna River rearing habitat are presented in Figure 120.

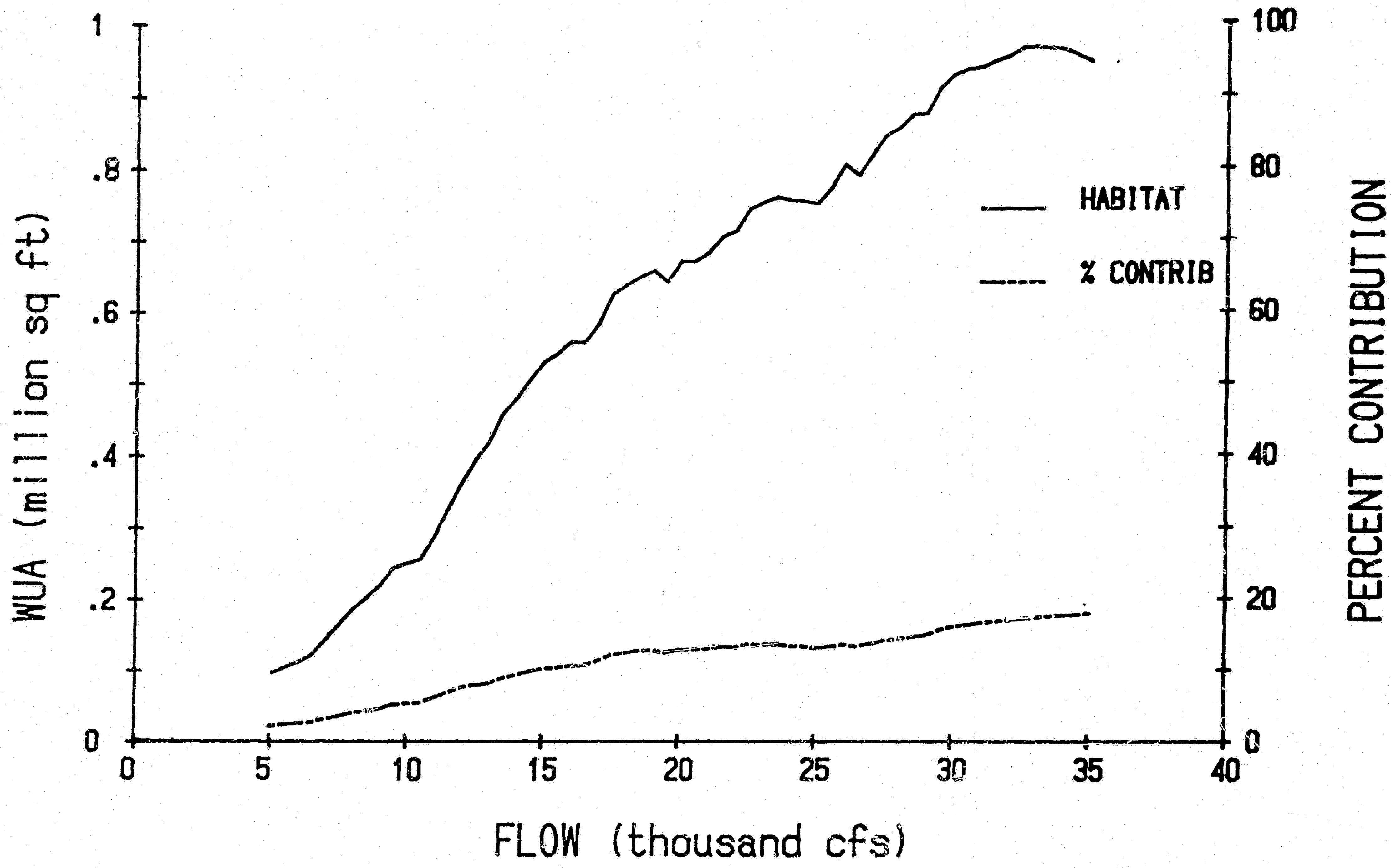
- Stage I

  . Filling

  The rearing habitat during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below the natural flows that provide the higher habitat availability for this group. Habitat associated with monthly filling flow estimates for June through September would be reduced by 58-75 percent in a dry year, 46-75 percent in an average year, and 1 to 5 percent in a wet year (Table 20).

  . Operation

  Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figure 121 and 122). Stage I flows would result in decreases in habitat ranging up to 80 percent throughout the majority of the summer rearing period. From mid-August through mid-September, the magnitude of habitat decreases would decrease and about half the time Stage I flows would provide an increase in habitat.



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 6 areas in the middle Susitna River.

FIGURE 120

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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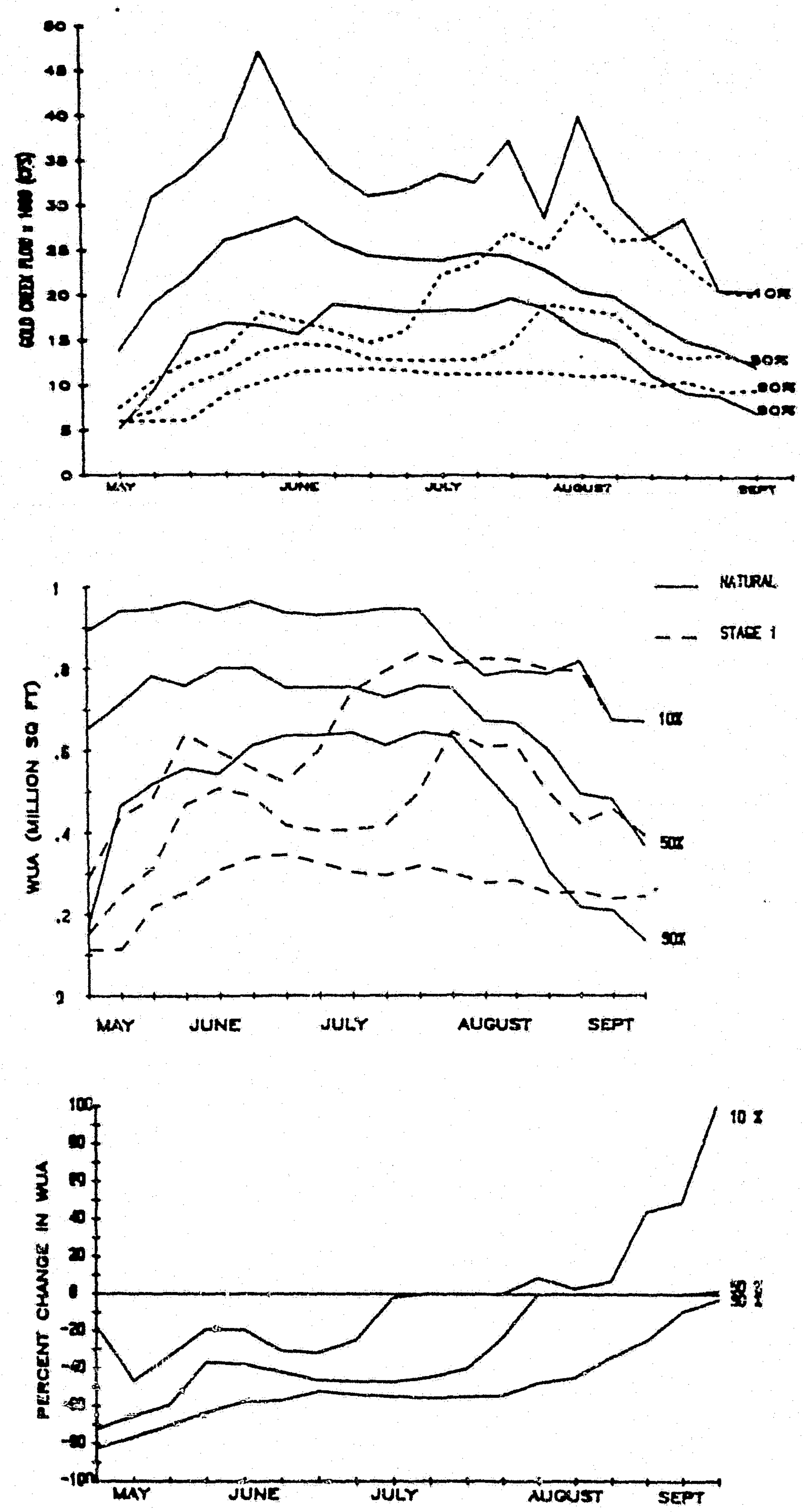
SUSITNA JOINT VENTURE

Table 20. Estimated change in chinook rearing habitat in Group 6 due to filling under dry, average and wet conditions.

Month	Discharge (cfs)		Rearing Habitat (sq ft WUA)		
	Natural	Filling	Natural	Filling	Change
Dry Year					
June	21,763	7,800	708,711	177,698	-74.93
July	19,126	8,000	653,226	186,971	-71.38
August	17,392	8,000	615,371	186,971	-69.62
September	10,422	5,800	256,040	108,309	-57.70
Average Year					
June	27,815	8,800	850,918	211,848	-75.10
July	24,445	12,740	754,517	405,138	-46.30
August	22,228	12,415	726,215	387,206	-46.68
September	13,221	6,800	435,185	134,065	-69.19
Wet Year					
June	31,580	10,752	947,797	272,748	-71.22
July	27,753	20,547	849,505	671,626	-20.94
August	25,236	15,505	761,384	541,119	-28.93
September	15,124	6,800	532,313	134,065	-74.81



Mean weekly discharge (upper), chinook rearing WUA for Group 6 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 121

ALASKA POWER AUTHORITY
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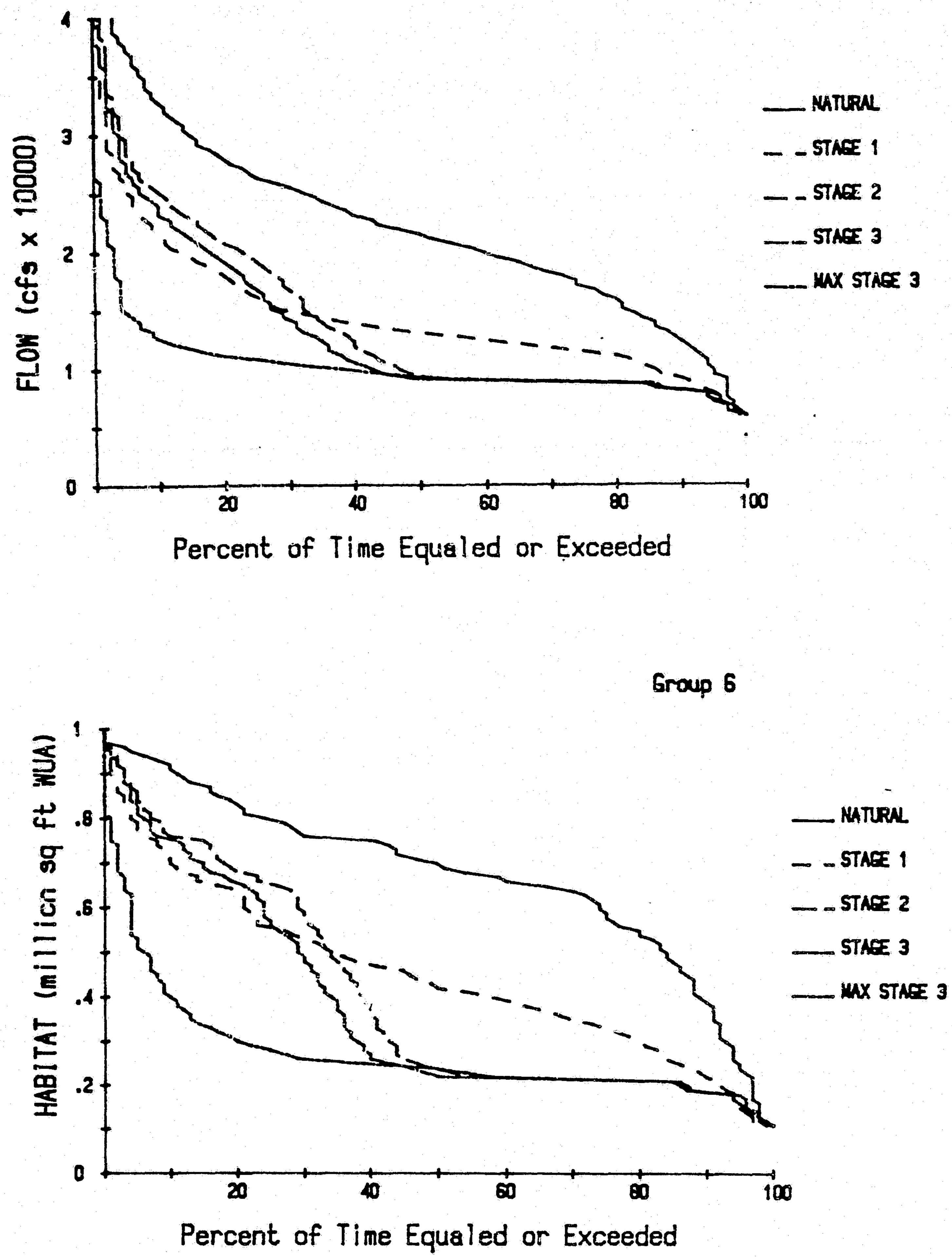
SUSITNA JOINT VENTURE



Flow duration curve and chinook rearing habitat duration curve for Group 6.

FIGURE 122

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE

The stability of habitat in Group 6 sites would be somewhat less than natural for most of the rearing season, particularly mid-July to mid-August when weekly changes in habitat can reach 70 percent (Figure 123).

The contribution of Group 6 to the habitat availability provided by all groups would decrease from natural levels of 10-15 percent to with-project levels of 5 to 12 percent through July. In August and September, percent contribution would be similar (Figure 70).

-- Stage II

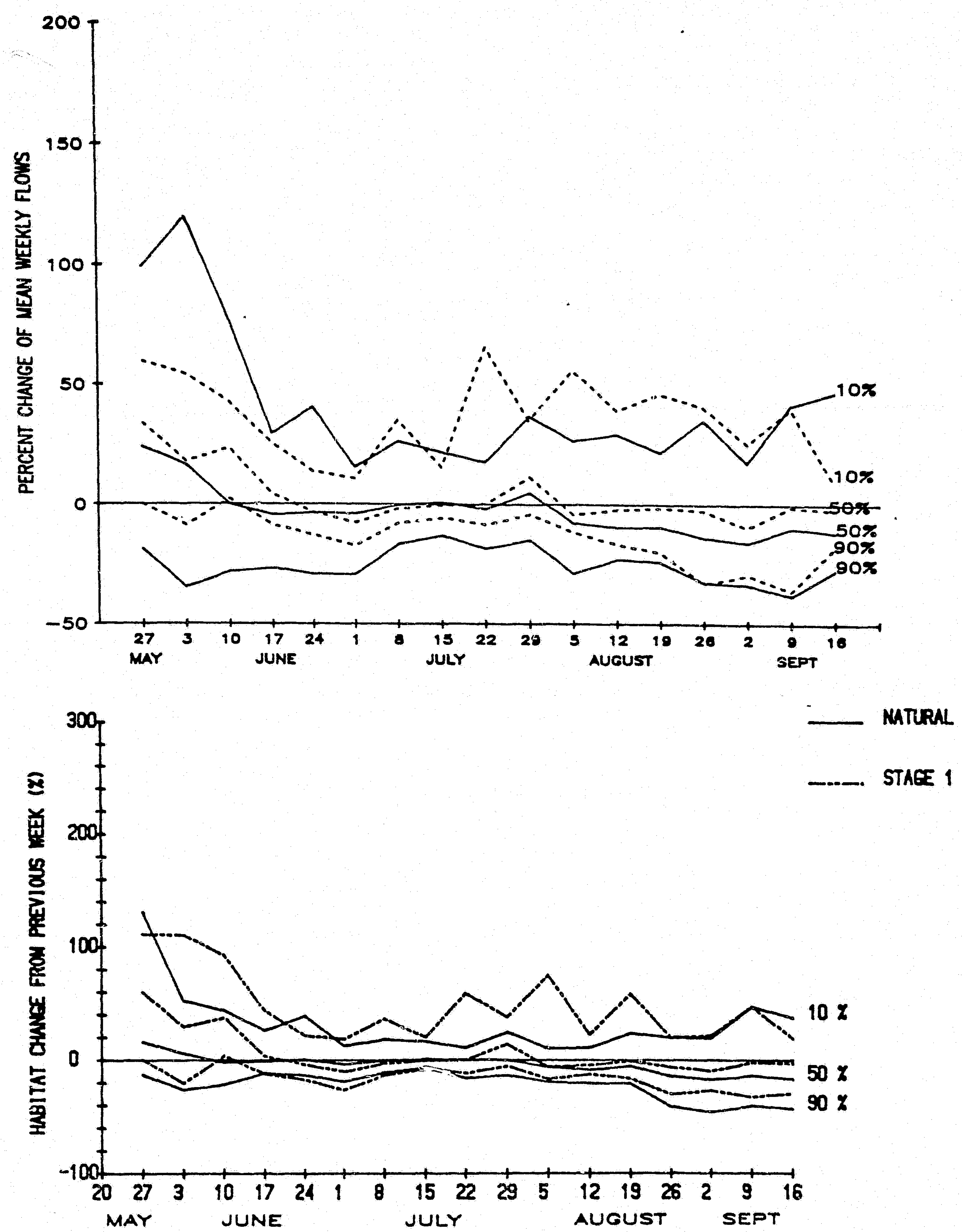
. Filling

Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curves (Figures 124 and 122). Stage II operational flows would result in habitat reductions from 60 to 80 percent in May and June. In July the magnitude of the reduction would decrease and by mid- August habitat availability would be about the same or slightly greater than natural.

With-project habitat stability would decrease substantially primarily due to week-to-week increases in habitat during July and August. In late August and September stability would be similar (Figure 125).



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 6 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 123

ALASKA POWER AUTHORITY
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ENTRIX, INC.

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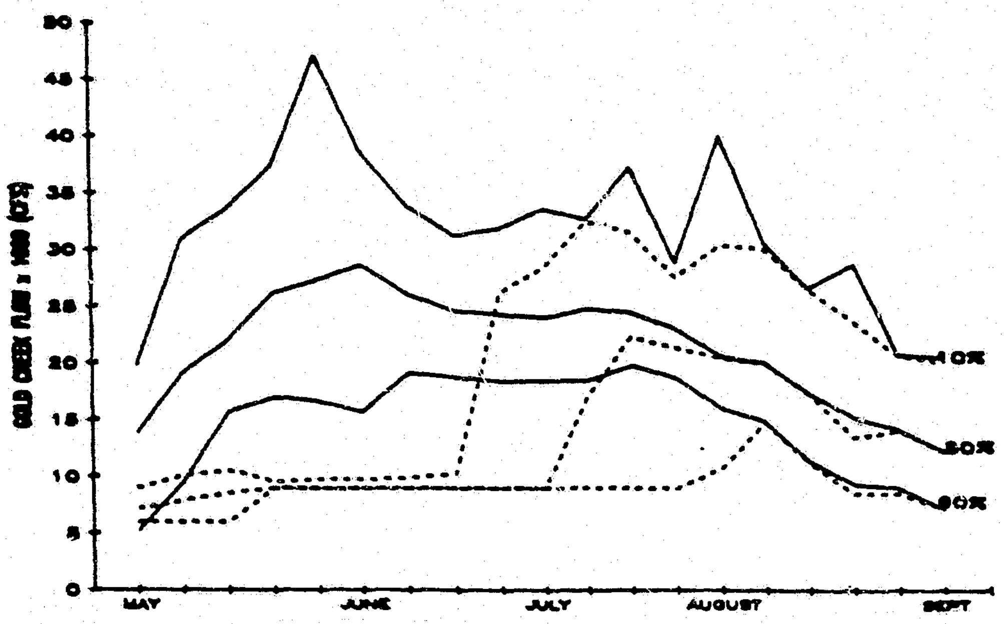
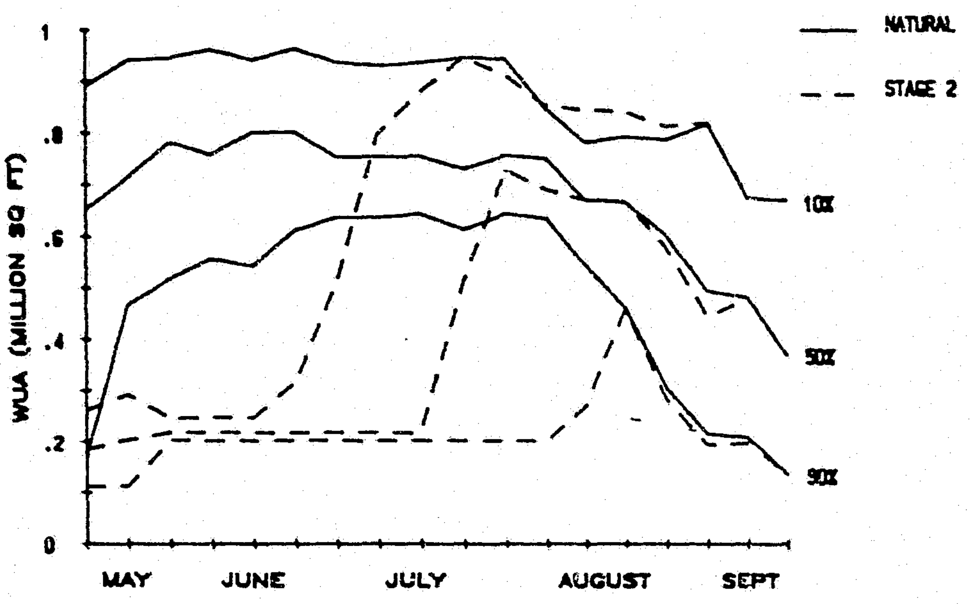
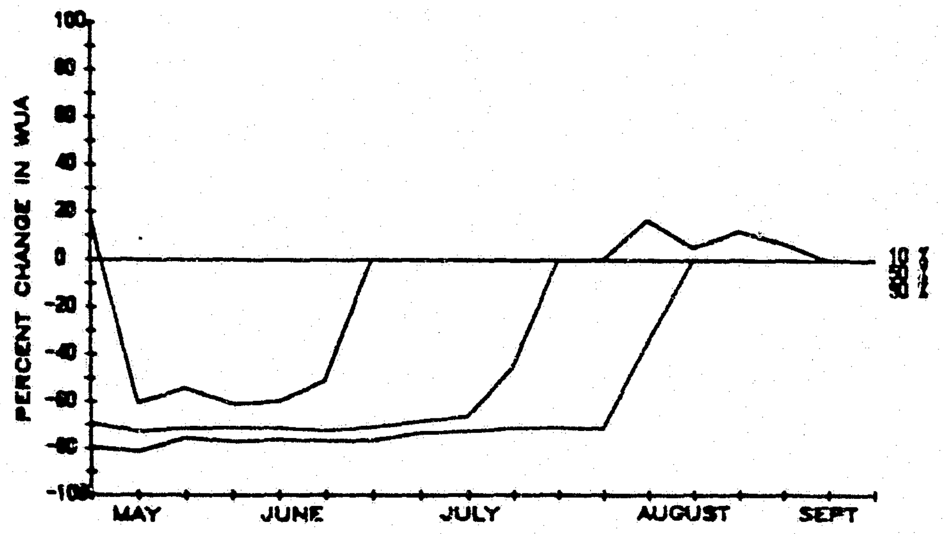
SUSITNA JOINT VENTURE







Mean weekly discharge (upper), chinook rearing WUA for Group 6 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 124

ALASKA POWER AUTHORITY
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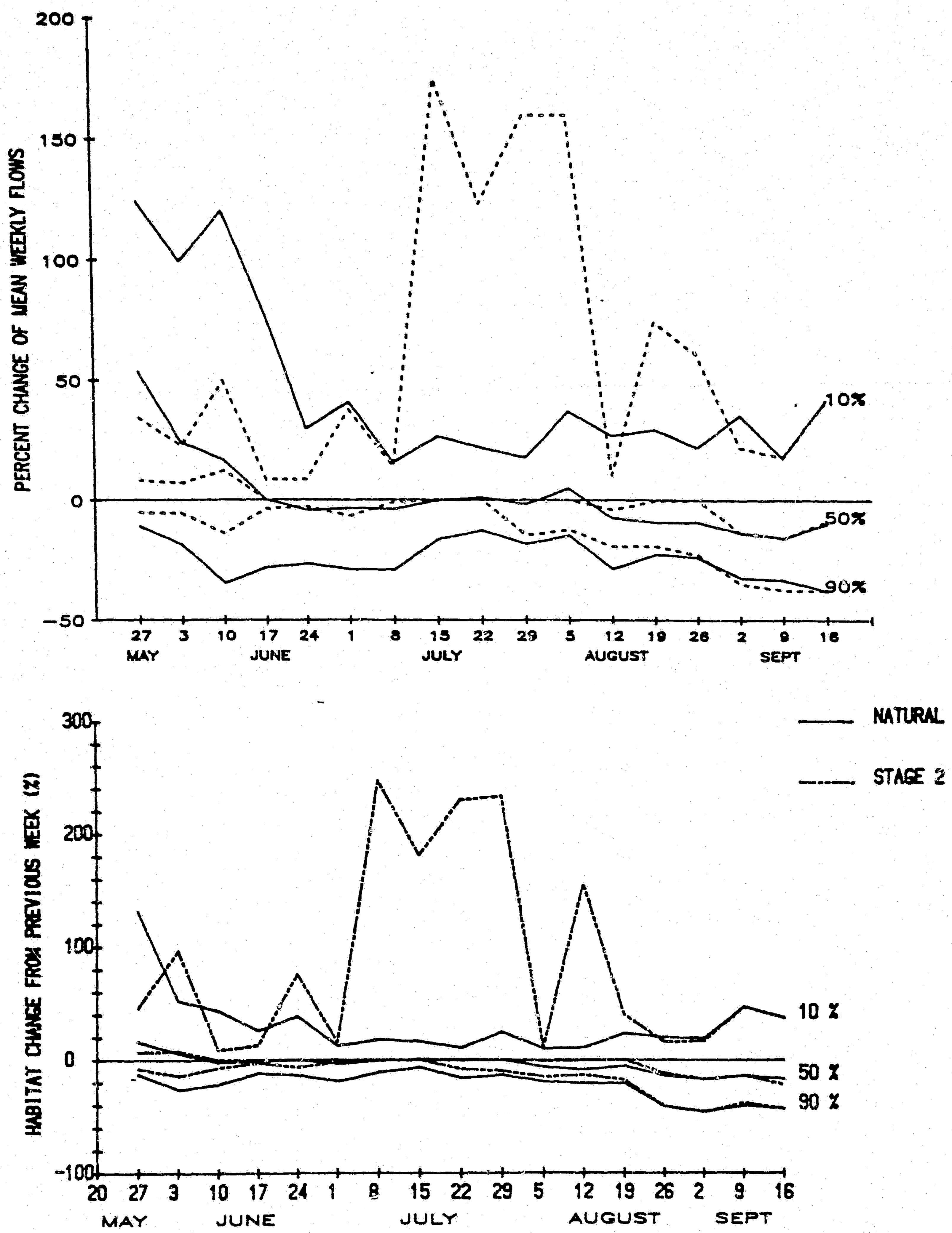
SUSITNA JOINT VENTURE



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 6 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 125

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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HARZA-EBASCO
SUSITNA JOINT VENTURE

The contribution of Group 6 to total middle Susitna River habitat would decrease under Stage II from natural levels of 10 to 18 percent to about 5 percent in May and June. The percent contribution would increase during July and would be similar to natural from mid-August to mid-September (Figure 73).

. Stage III

.. Filling

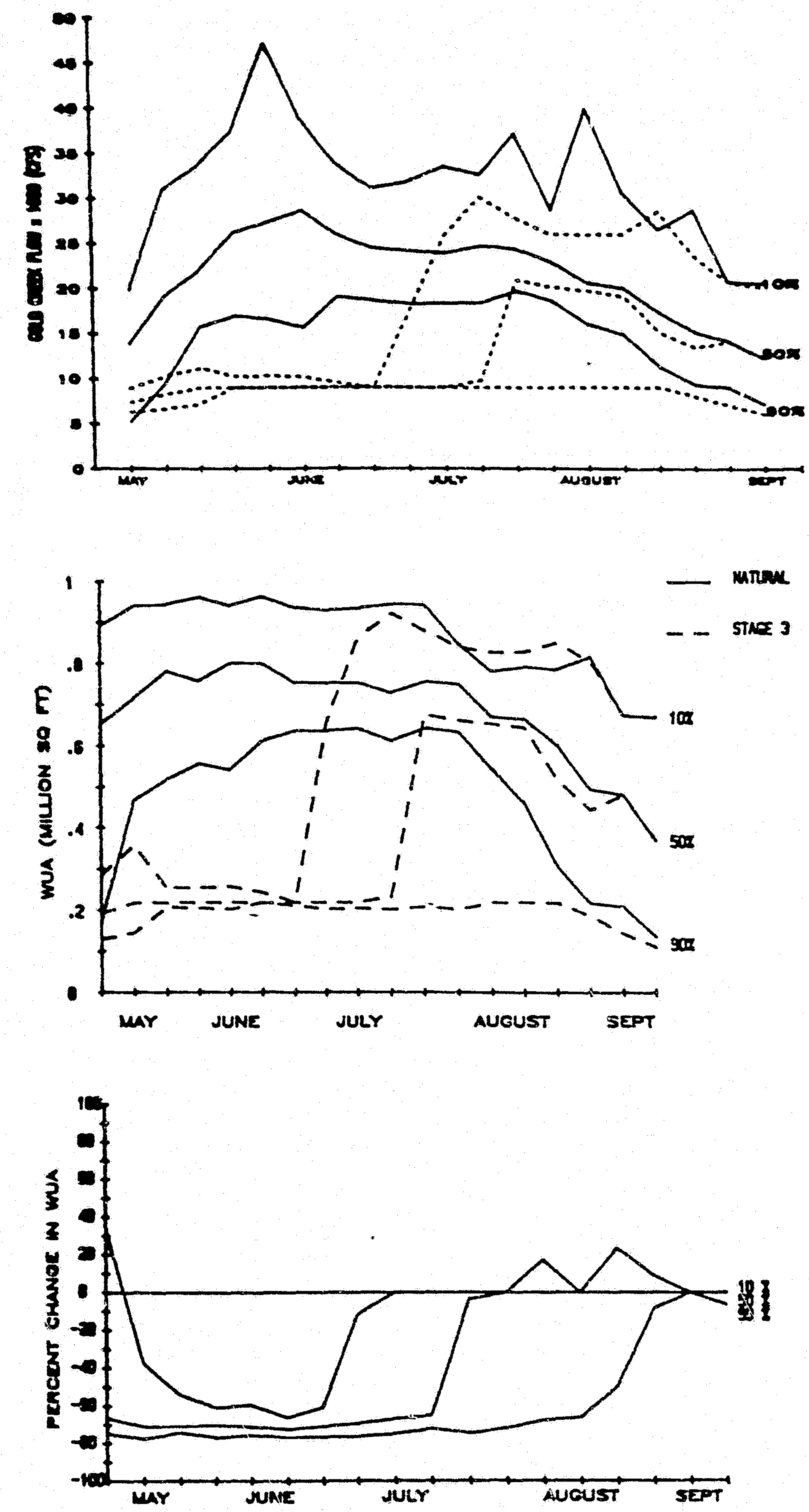
Filling of Watana during Stage III would occur over several years and consequently habitat availability are more appropriately discussed under operation.

.. Operation

Habitat availability under natural and early and late Stage III operation are compared in weekly habitat time series plots and seasonal habitat duration curves (Figures 126, 127 and 122). Early Stage III operational flows would result in substantial reductions (60 to 80 percent)in habitat through June. The frequencies of reduction would decrease in July and by August occur about half the time. In late Stage III reductions of 50 percent or more would be prevalent through July. For the remainder of the rearing period reductions would range from 0 to 70 percent.

Stability during early and late Stage III would be similar to natural, except during mid-summer during early Stage III when large increases in habitat would occur (Figures 128 and 129).

The contribution of Group 6 to middle Susitna River, rearing habitat decrease from natural levels of 10 to 18



Mean weekly discharge (upper), chinook rearing WUA for Group 6 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 126

ALASKA POWER AUTHORITY
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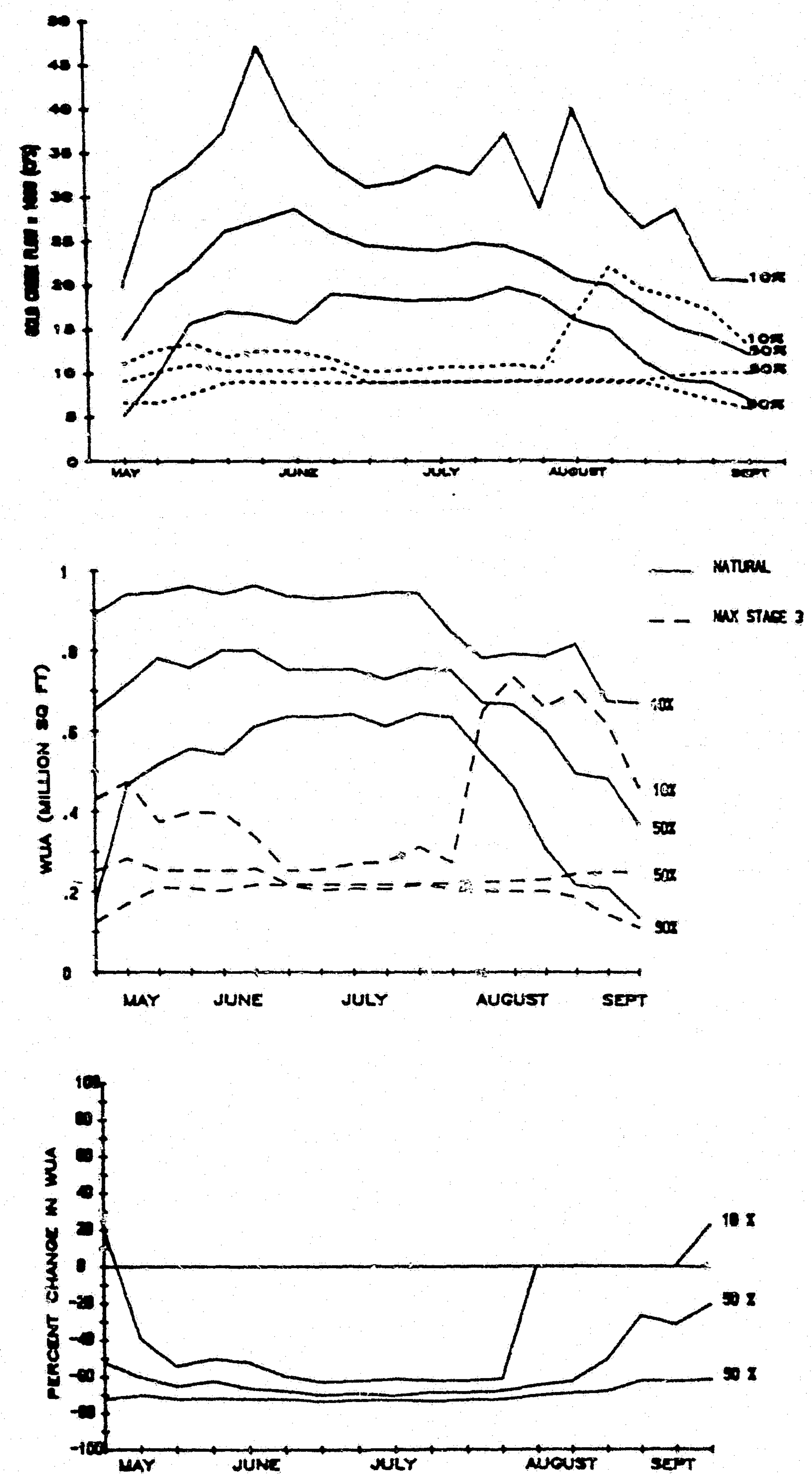
SUSITNA JOINT VENTURE



Mean weekly discharge (upper), chinook rearing WUA for Group 6 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 127

ALASKA POWER AUTHORITY
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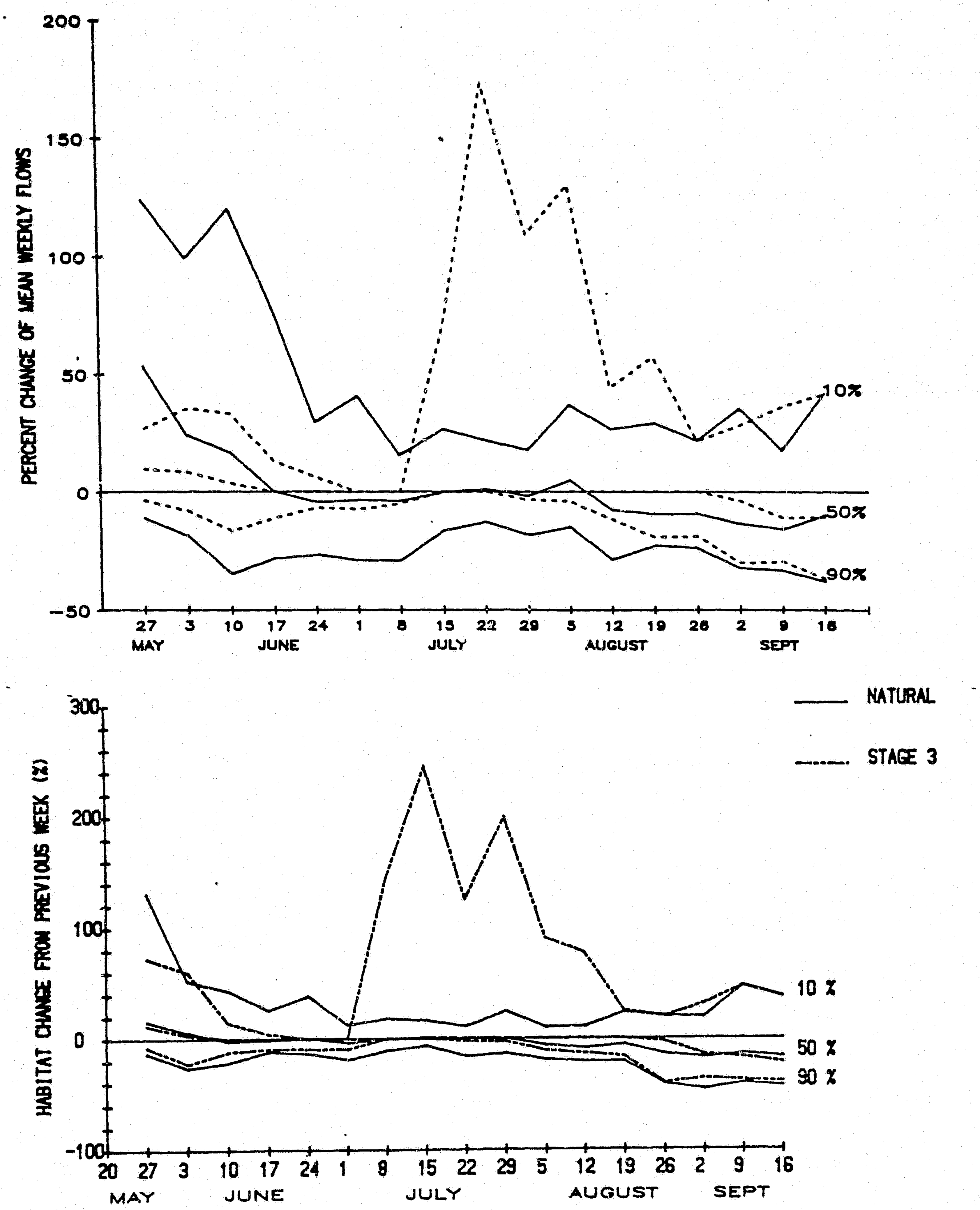
SUSITNA JOINT VENTURE



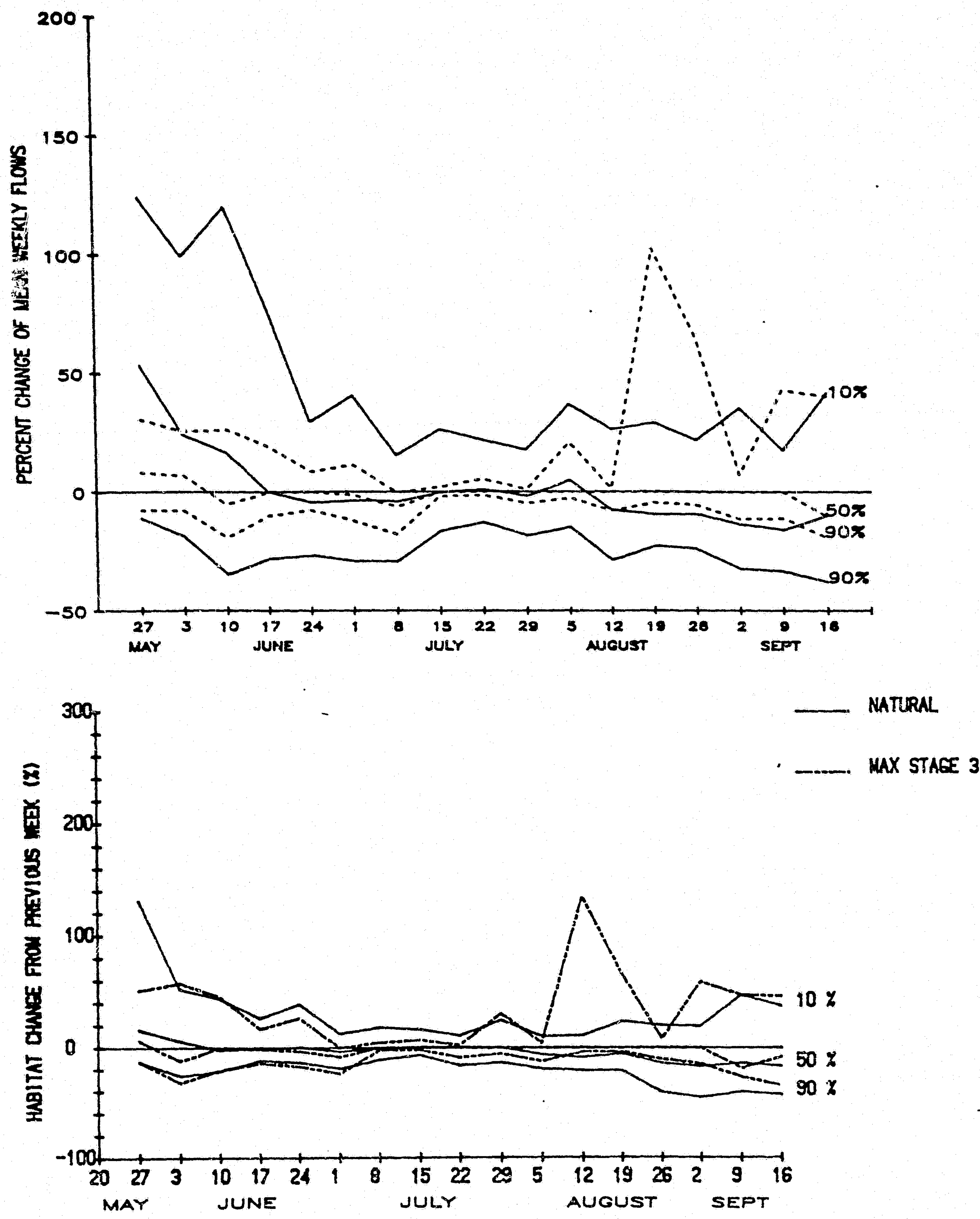
Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 6 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 128

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

ENTRIX, INC.

HARZA-EBASCO
SUSITNA JOINT VENTURE



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 6 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 129

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SUSITNA HYDROELECTRIC PROJECT

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SUSITNA JOINT VENTURE

percent to early Stage III levels of 5 percent in early summer (Figure 78 and 79).

- Representative Group VII

This group is comprised of side channels which breach at low mainstem discharges. The areas within this group are composed of a single riffle extending from the head down to a large backwater area at the mouth. The riffle generally consists of rubble and boulder size substrates in contrast to backwater areas in which sand and silts tend to predominate. The habitat response curves and percent contribution of this group to total middle Susitna River rearing habitat as a function of mainstem flow are presented in Figure 130.

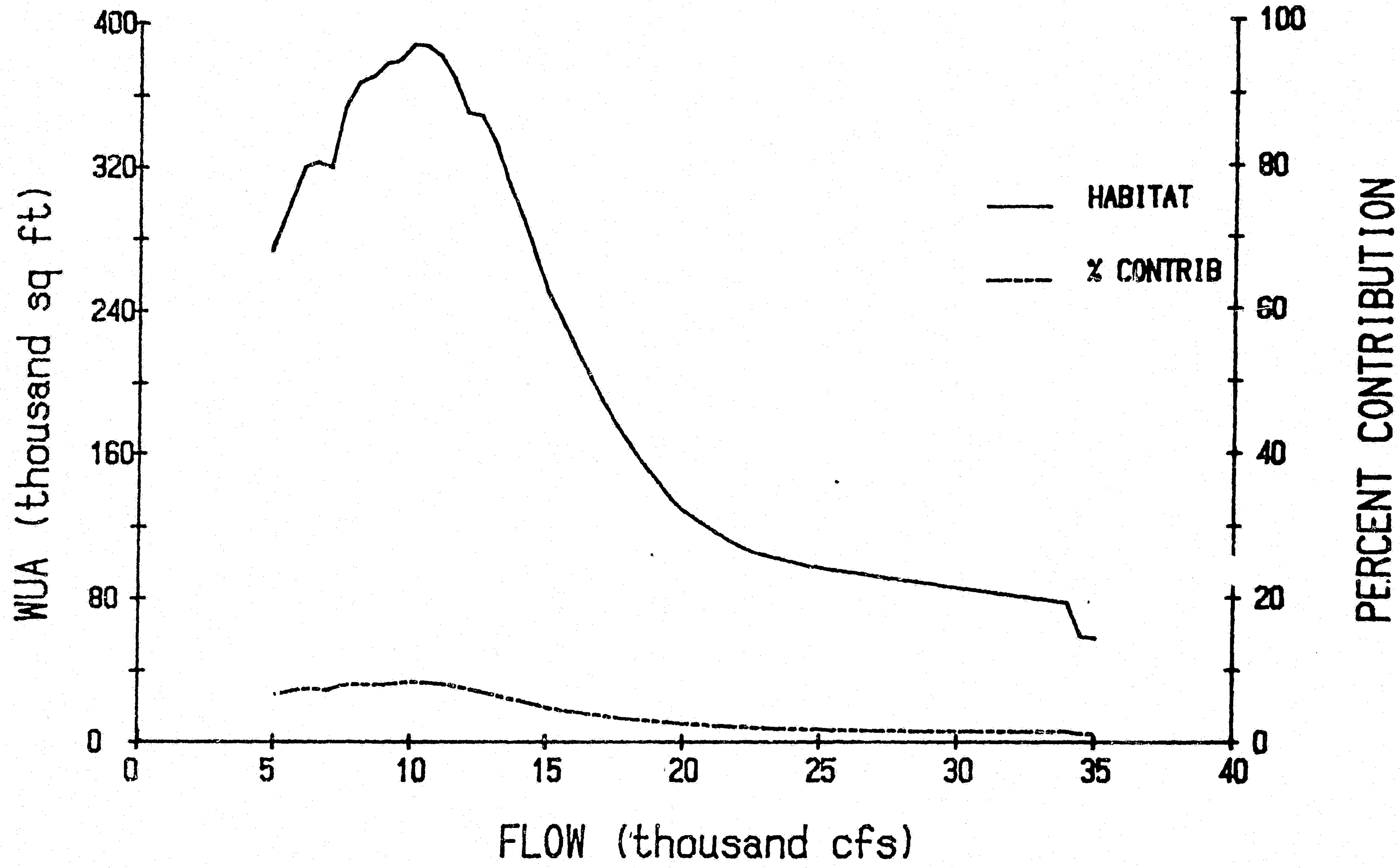
-- Stage I

. Filling

The rearing habitat during Stage I filling would generally increase substantially since flows frequently would be near E-VI minimums, near the range that provides the higher habitat availability for this group. Habitat associated with monthly filling flow estimates for June through August would increase 106-226 percent in a dry year, 224-314 percent in an average year, and 35 to 367 percent in a wet year. In September there would be a decrease of 21 percent in a dry year, a decrease of 1 percent in an average year, and a 31 percent increase in a wet year (Table 21).

. Operation

Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 7 areas in the middle Susitna River.

FIGURE 130

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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SUSITNA JOINT VENTURE

Table 21. Estimated change in chinook rearing habitat in Group 7 due to filling under dry, average and wet conditions.

Month	Discharge (cfs) Natural	Discharge (cfs) Filling	Rearing Habitat (sq ft WUA) Natural	Rearing Habitat (sq ft WUA) Filling	Rearing Habitat (sq ft WUA) Change
Dry Year					
June	21,763	7,800	111,158	361,894	225.57
July	19,126	8,000	142,057	367,372	158.61
August	17,392	8,000	178,003	367,372	106.39
September	10,422	5,800	387,335	311,783	-19.51
Average Year					
June	27,815	8,800	90,425	374,448	314.10
July	24,445	12,740	98,223	341,444	247.62
August	22,228	12,415	107,658	349,166	224.33
September	13,221	6,800	323,589	321,092	-0.77
Wet Year					
June	31,580	10,752	82,339	384,251	366.67
July	27,753	20,547	90,563	122,405	35.16
August	25,236	15,505	96,299	234,304	143.31
September	15,124	6,800	245,549	321,092	30.76

seasonal habitat duration curve (Figure 131 and 132). Stage I flows would result in substantial increases in habitat throughout the summer rearing period. Increases would range as high as several hundred percent, particularly in early summer.

The stability of habitat in Group 7 sites would be greater in May and June than naturally and about the same for the remainder of the season (Figure 133).

The contribution of Group 7 to the habitat availability provided by all groups would increase from natural levels of 4 to 8 percent in May and June to 2 to 5 percent (Figure 70).

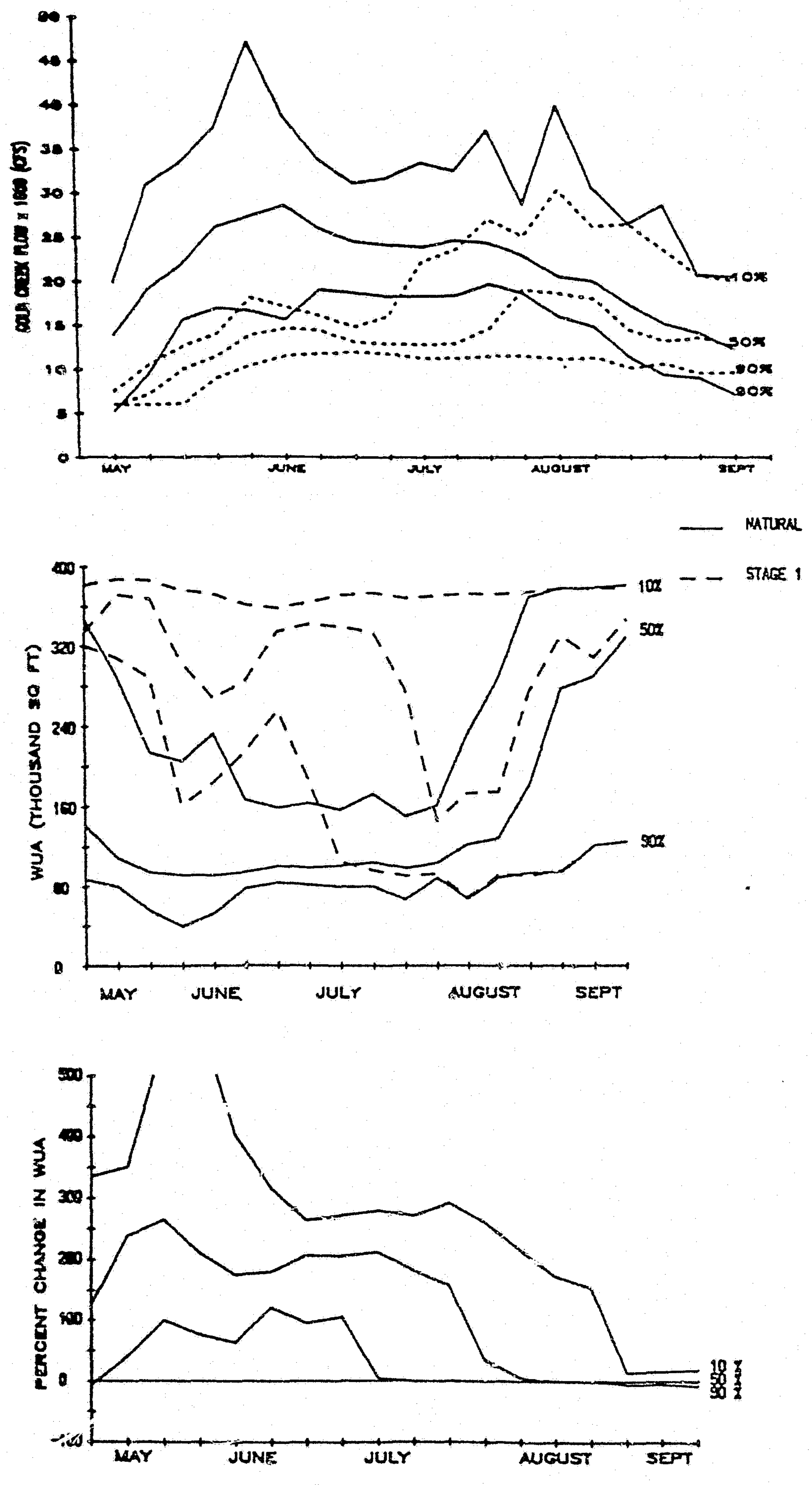
-- <u>Stage II</u>

. <u>Filling</u>

Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

. <u>Operation</u>

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figures 134 and 132). Stage II operational flows would result in substantial increases in habitat availability for this group throughout the rearing season. Increases would be greatest in May through July often exceeding 200 percent. Toward the end of August and in September habitat availability would be about the same as natural.



Mean weekly discharge (upper), chinook rearing WUA for Group 7 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 131

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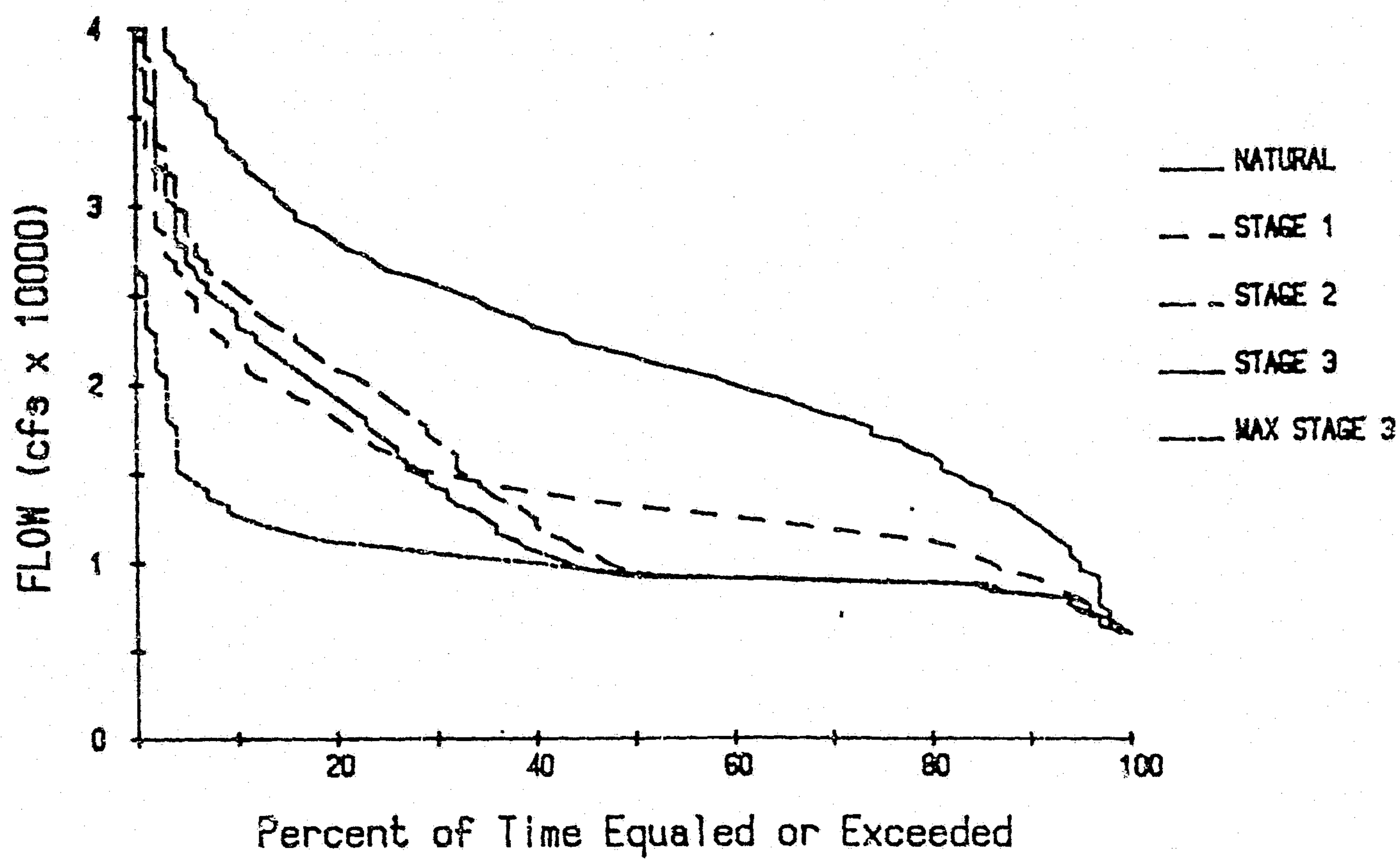

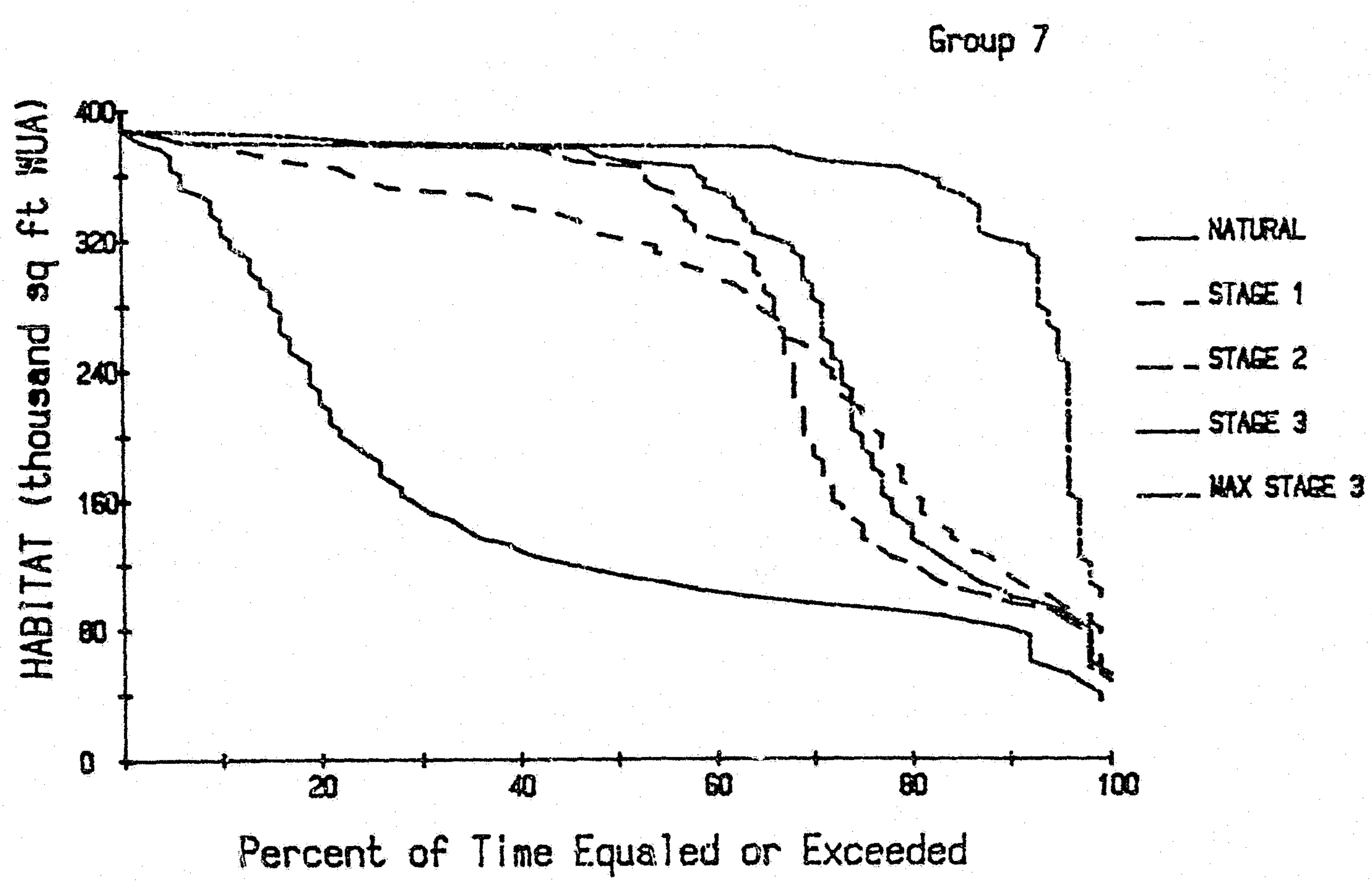

Flow duration curve and chinook rearing habitat duration curve for Group 7.

FIGURE 132

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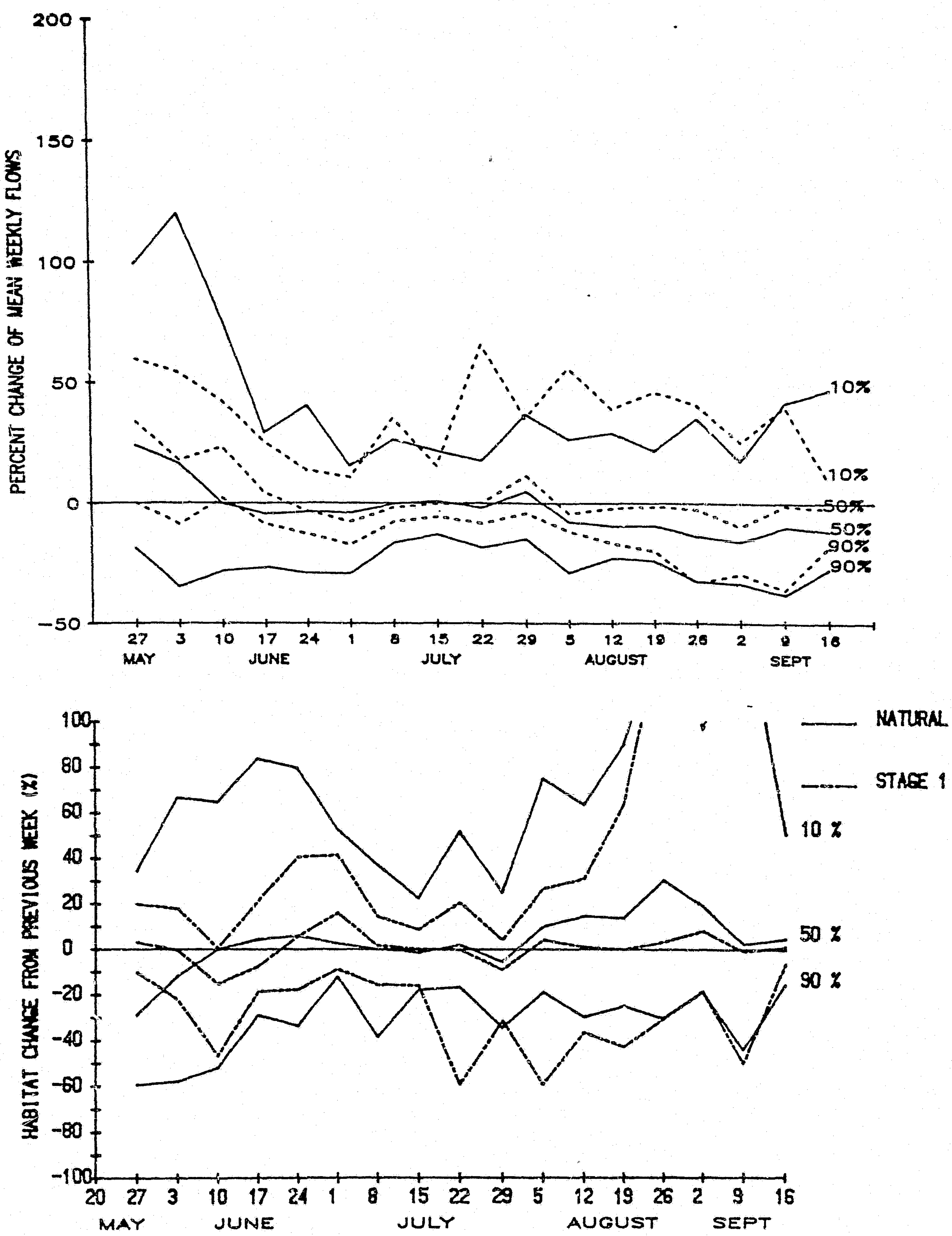

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 7 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 133

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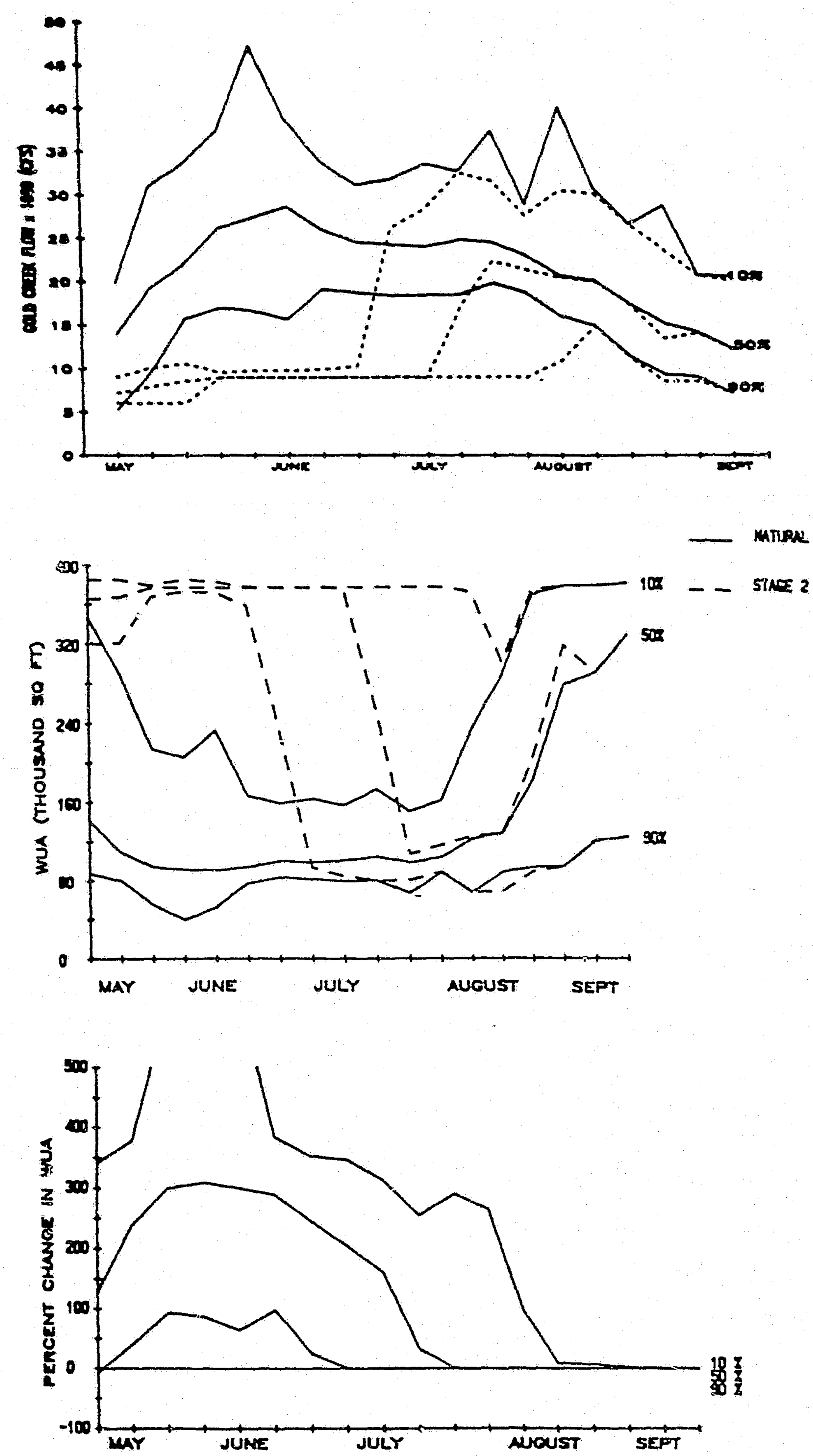

Mean weekly discharge (upper), chinook rearing WUA for Group 7 (middle) and percent change in WUA (lower)exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 134

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With-project habitat stability would increase substantially in May, June, and July. In August and September, stability would be about the same as natural (Figure 135).

The contribution of Group 7 to total middle Susitna River habitat would increase under Stage II from natural levels of 1 to 7 percent to 7 to 8 percent in May and June. The magnitude of the percent contribution increase would decrease during July and would be similar to natural from mid-August to mid-September (Figure 73).

-- Stage III

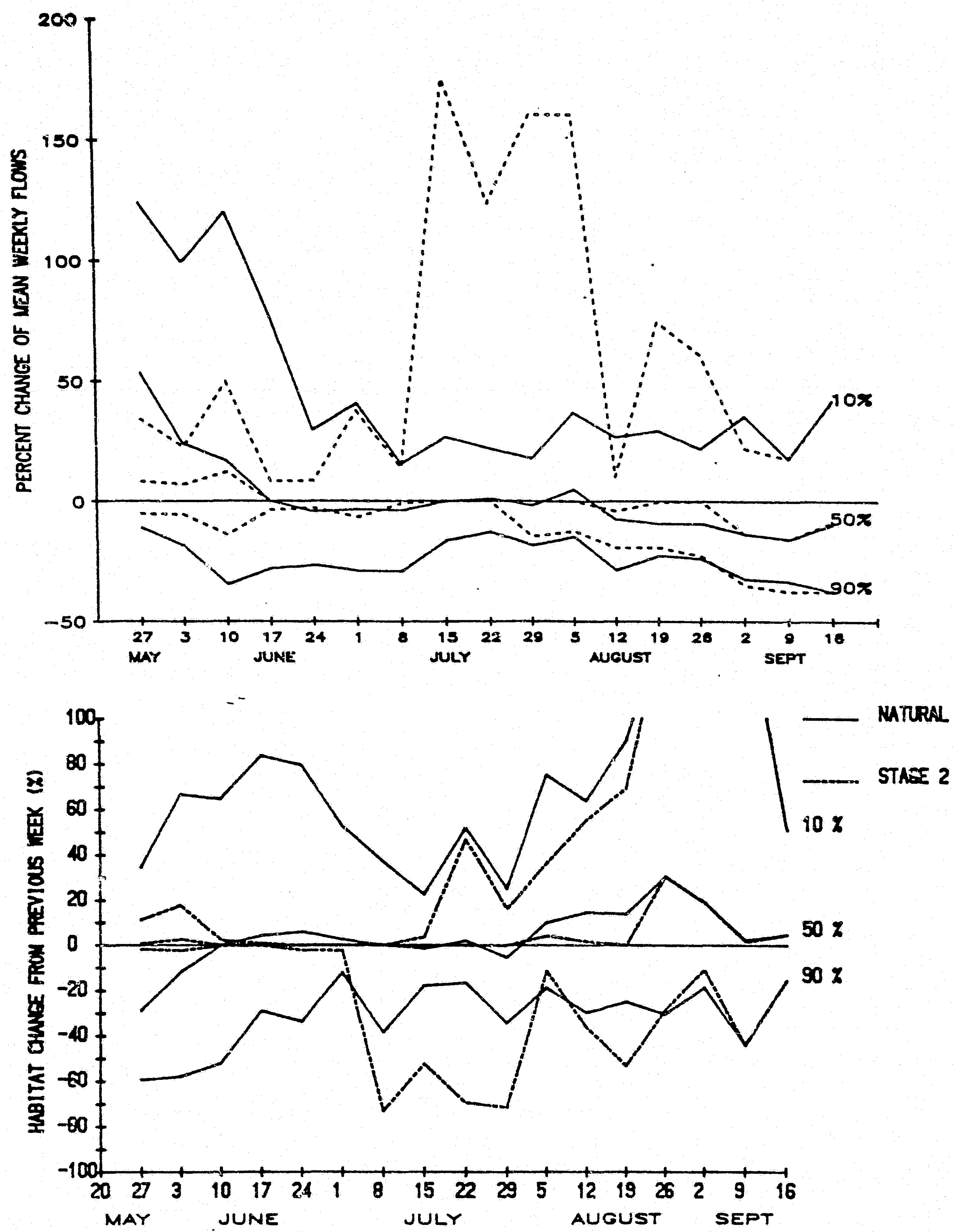
. Filling

Filling of Watana during Stage III would occur over several years and consequently habitat availability is more appropriately discussed under operation.

. Operation

Habitat availability under natural and early and late Stage III operation are compared in weekly habitat time series plots and seasonal habitat duration curves (Figure 136, 137 and 132). Early Stage III operational flows would result in substantial increases in habitat from May through August with September about the same as natural. In late Stage III these increases would be similar but also extend into September.

Stability during early and late Stage III would be greater than natural from May through mid-August (Figures 138 and 139).



Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 7 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 135

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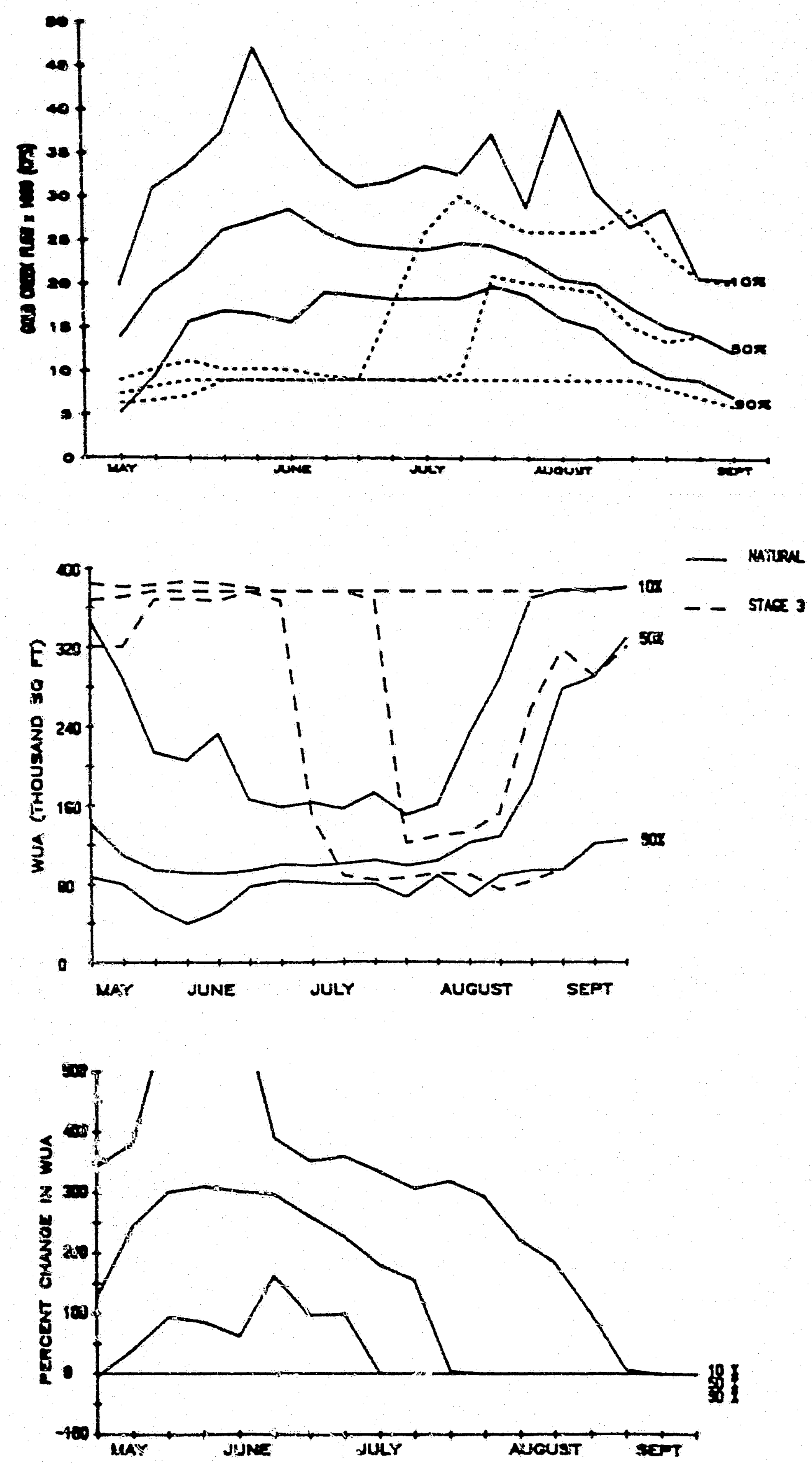

Mean weekly discharge (upper), chinook rearing WUA for Group 7 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and early Stage III flows.

FIGURE 136

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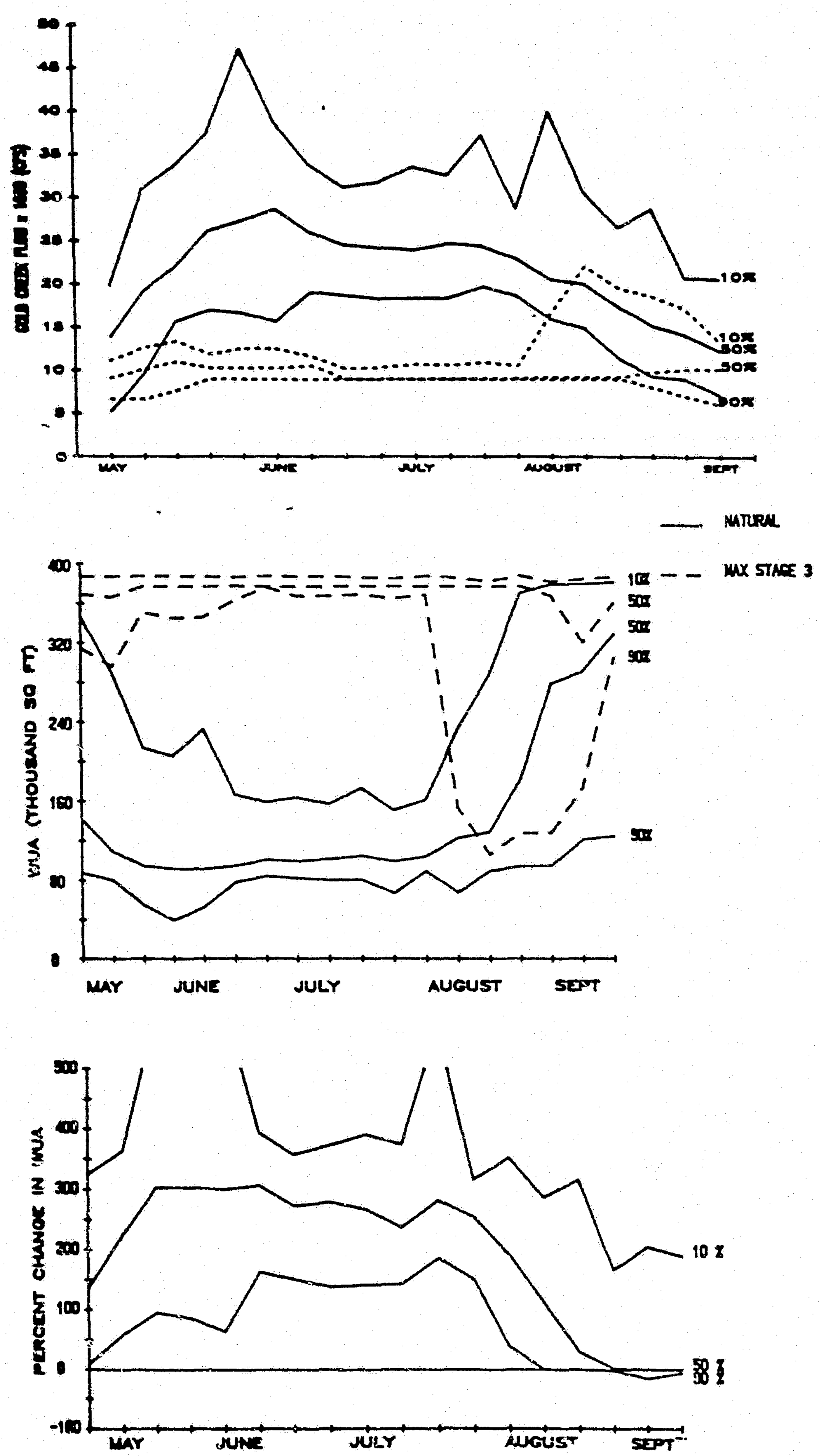

Mean weekly discharge (upper), chinook rearing WUA for Group 7 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and late Stage III flows.

FIGURE 137

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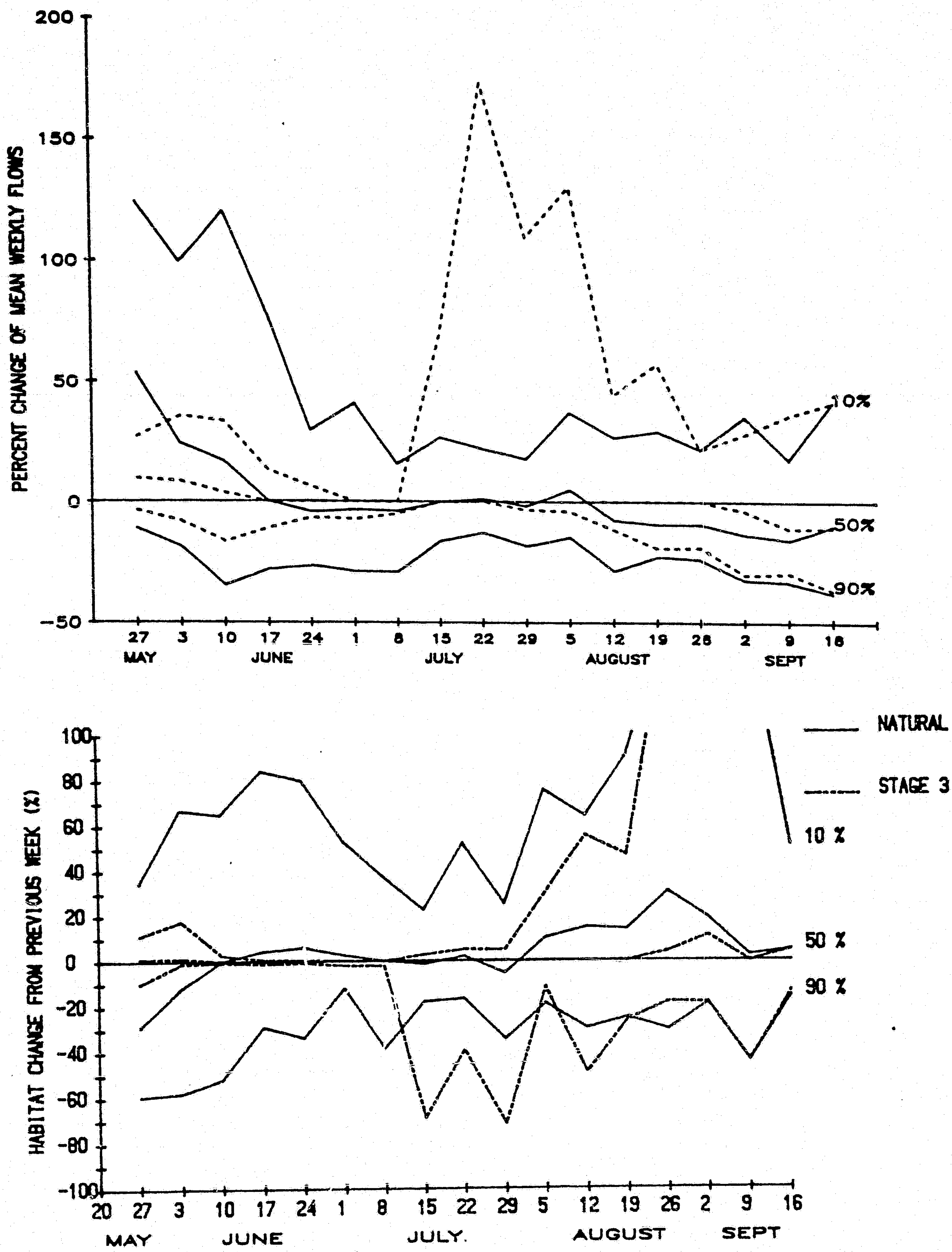

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 7 during early Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 138

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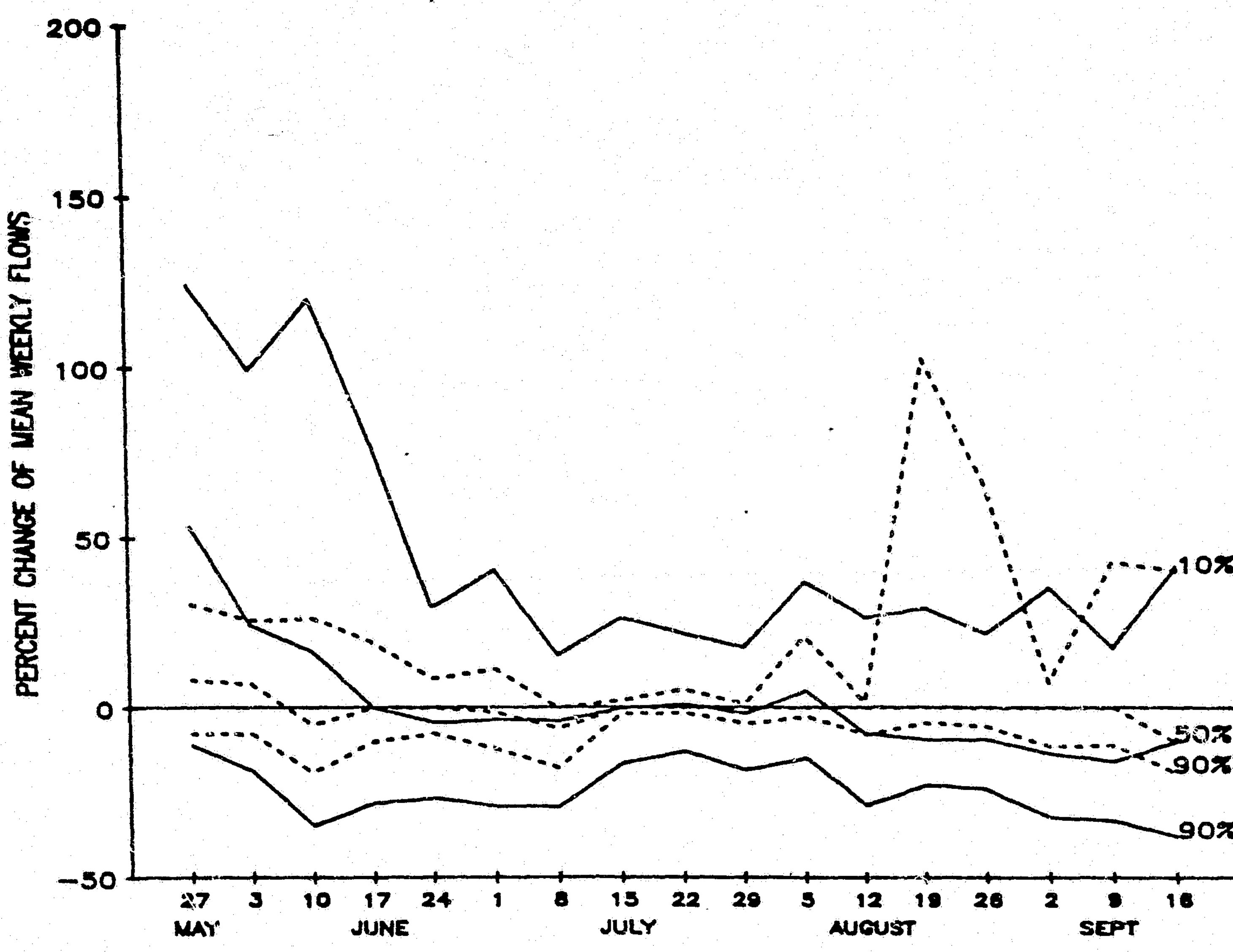

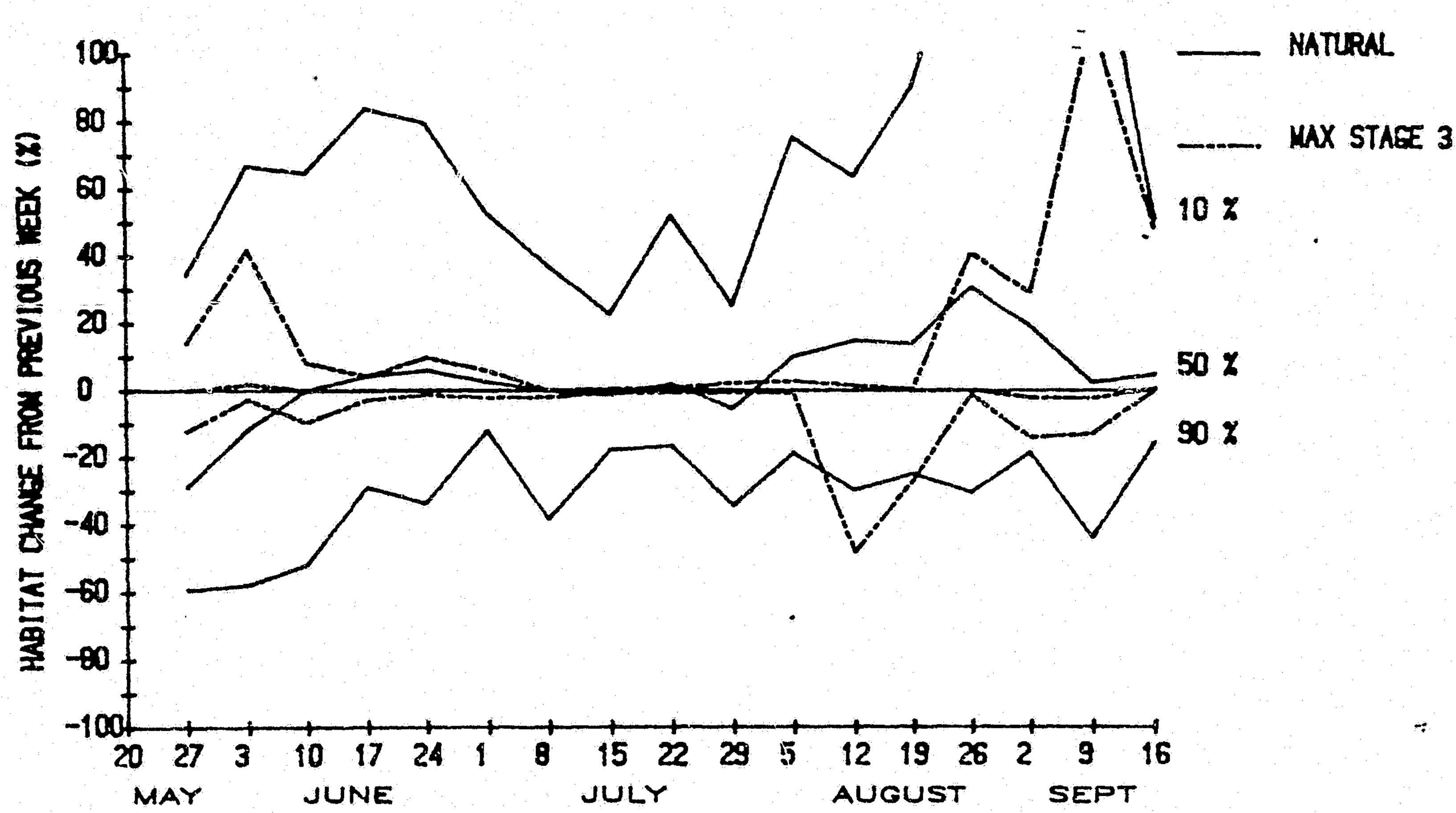

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 7 during late Stage III exceeded 10, 50 and 90 percent of the time.

FIGURE 139

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The contribution of Group 7 to middle Susitna River rearing habitat increases from natural levels of 1 to 4 percent to early Stage III levels of 7 to 8 percent in May and June. In July the percent contribution of early Stage III flows would decrease and by August would be similar to natural levels (Figure 78). In late Stage III the percent contribution would remain at highe. levels than natural for the entire rearing period (Figure 79).

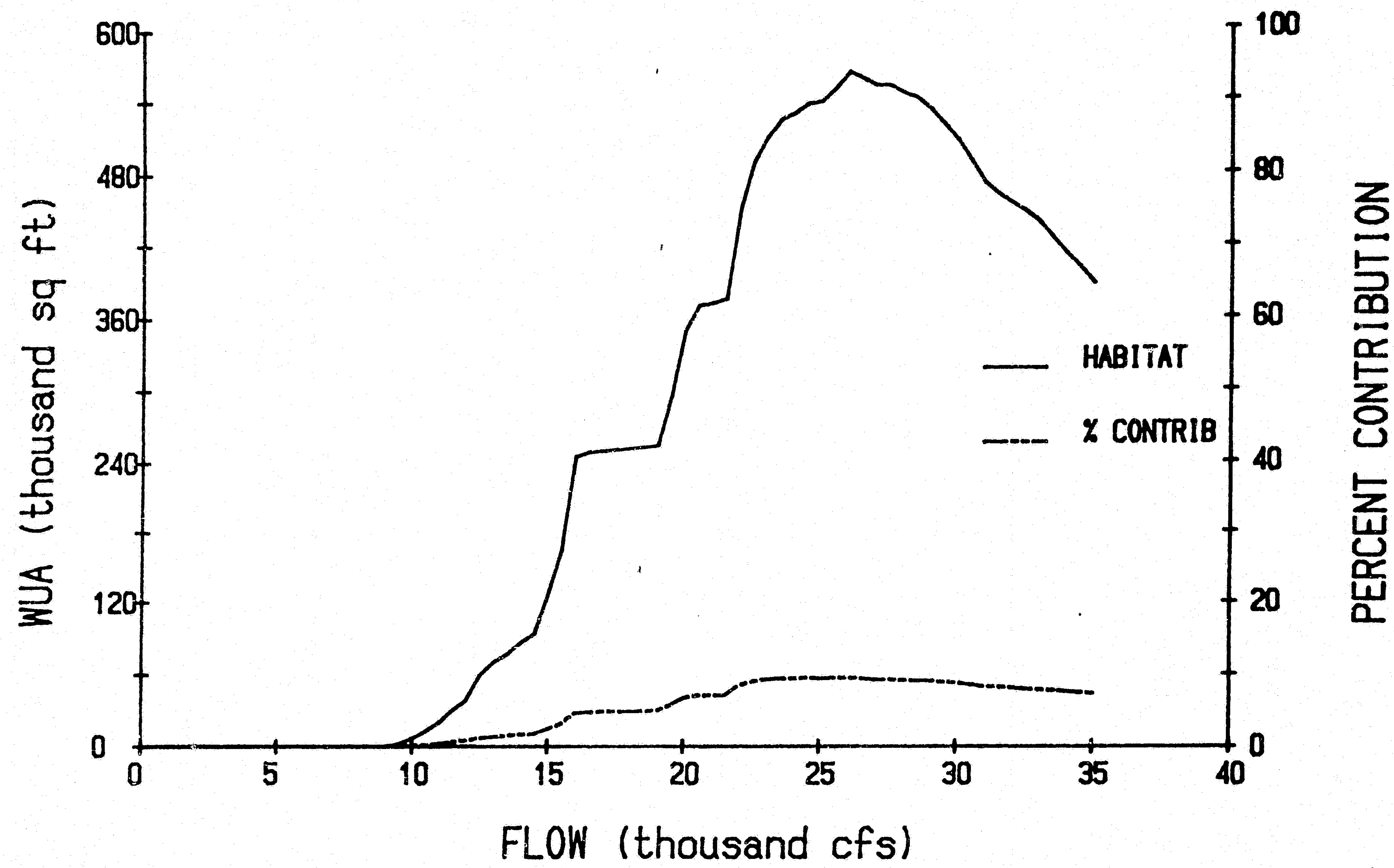
- Representative Group VIII

This group is comprised of areas which tend to dewater at intermediate to high mainstem discharges although their hydrologic, hydraulic, and morphologic properties are similar to the side sloughs and side channels in Group II and III. The habitat response curve and percent contribution of this group to total middle Susitna River rearing habitat are depicted in Figure 140. As indicated in the figure, WUA accumulates rapidly as sites become breached and peak values are attained at approximately 27,000 cfs. Due to the steep slope on the habitat response between 20,000 and 27,000 cfs, fluctuates in flow within the range either naturally or with project would result in habitat instability and wide variations in percent contribution to total habitat availability.

- Stage I

  . Filling

  The rearing habitat during Stage I filling would be reduced substantially since flows frequently would be near E-VI minimums, much below natural flows that provide the higher habitat availability for this group. Habitat associated with monthly filling flow estimates



Juvenile chinook rearing habitat response curve and percent contribution to total rearing habitat of Group 8 areas in the middle Susitna River.

FIGURE 140

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for June through September would be non-existent in a dry year, reduced percent in an average year, and 33 to 100 percent in a wet year (Table 22).

. Operation

Habitat availability under natural and Stage I flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figures 141 and 142). Stage I flows would result in substantial decreases in habitat throughout much of the summer rearing period. Beginning in mid-August, the magnitude of habitat decreases would gradually decrease and by mid-September habitat availability would be about the same or slightly greater than natural.

The stability of habitat in Group VIII during Stage I would decrease throughout most of the summer due primarily to large week to week increases in habitat which often exceed 200 percent. In September natural and project changes in habitat would be about the same (Figure 143).

The contribution of Group 8 to the habitat availability provided by all groups would be substantially less than natural in late May through mid-August during the filling process as high flows are stored in the reservoir (Figure 70).

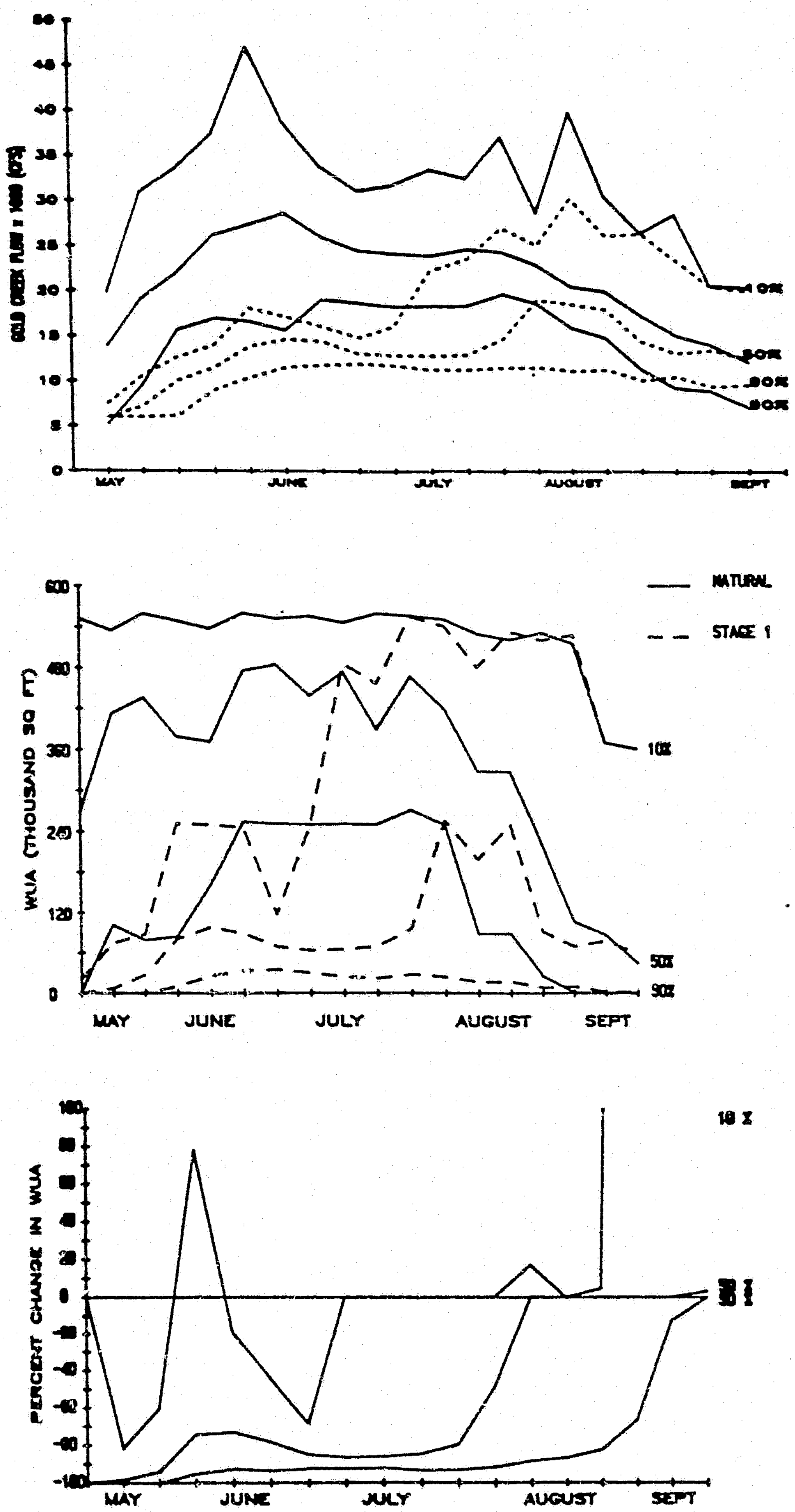
. Stage II

.. Filling

Filling flows under Stage II would be of short duration, consequently habitat availability during this period is more appropriately discussed under operation.

Table 22. Estimated change in chinook rearing habitat in Group 8 due to filling under dry, average and wet conditions.

Month	Discharge (cfs) Natural	Discharge (cfs) Filling	Rearing Habitat (sq ft WUA) Natural	Rearing Habitat (sq ft WUA) Filling	Rearing Habitat (sq ft WUA) Change
Dry Year					
June	21,763	7,800	414,540	0	-100.00
July	19,126	8,000	263,687	0	-100.00
August	17,392	8,000	250,008	0	-100.00
September	10,422	5,800	11,857	0	-100.00
Average Year					
June	27,815	8,800	547,733	0	-100.00
July	24,445	12,740	536,414	64,601	-87.96
August	22,228	12,415	467,480	55,901	-88.04
September	13,221	6,800	73,181	0	-100.00
Wet Year					
June	31,580	10,750	460,880	16,552	-96.41
July	27,753	20,547	548,561	369,992	-32.55
August	25,236	15,505	543,840	164,776	-69.70
September	15,124	6,800	135,768	0	-100.00



Mean weekly discharge (upper), chinook rearing WUA for Group 8 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage I flows.

FIGURE 141

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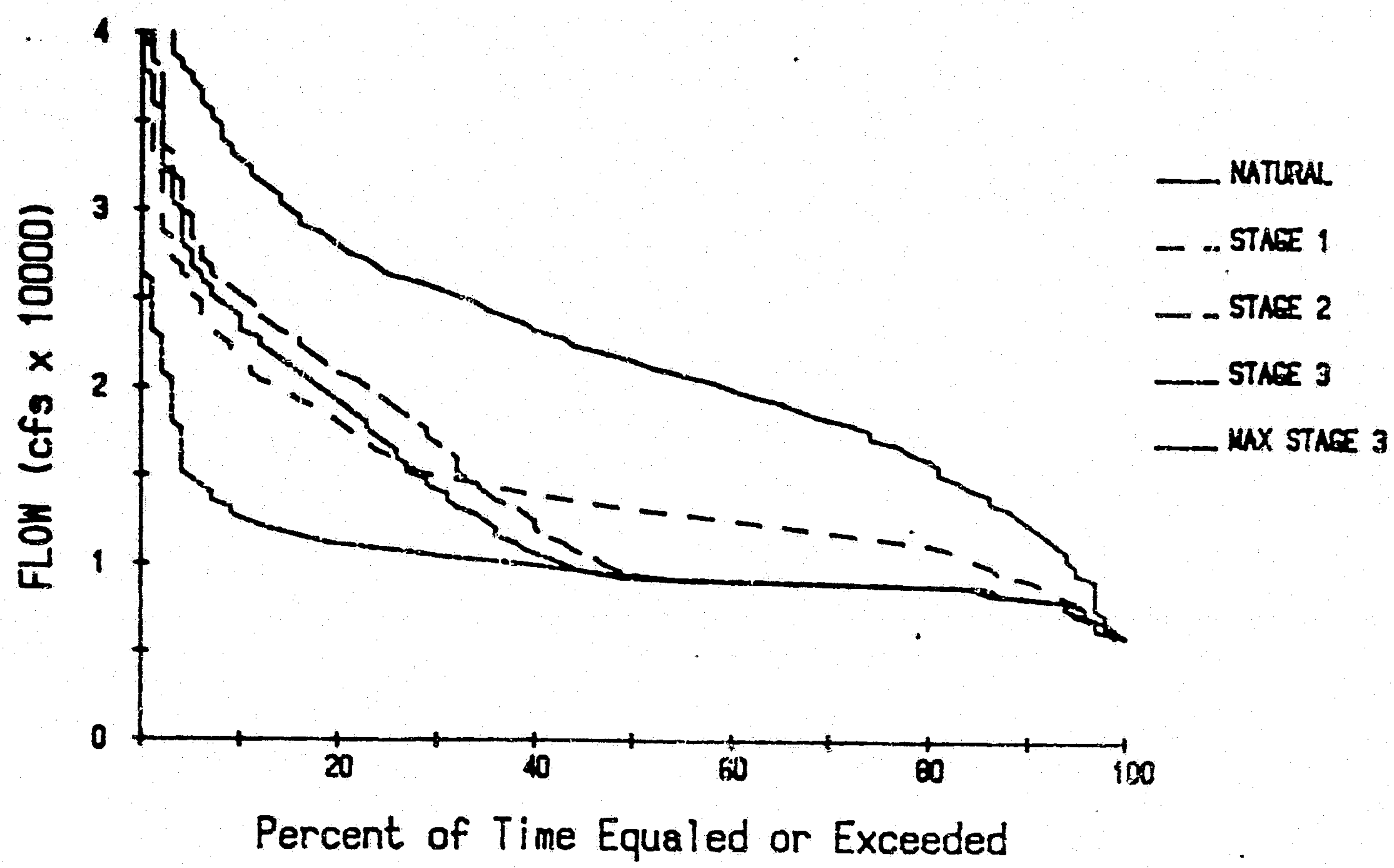
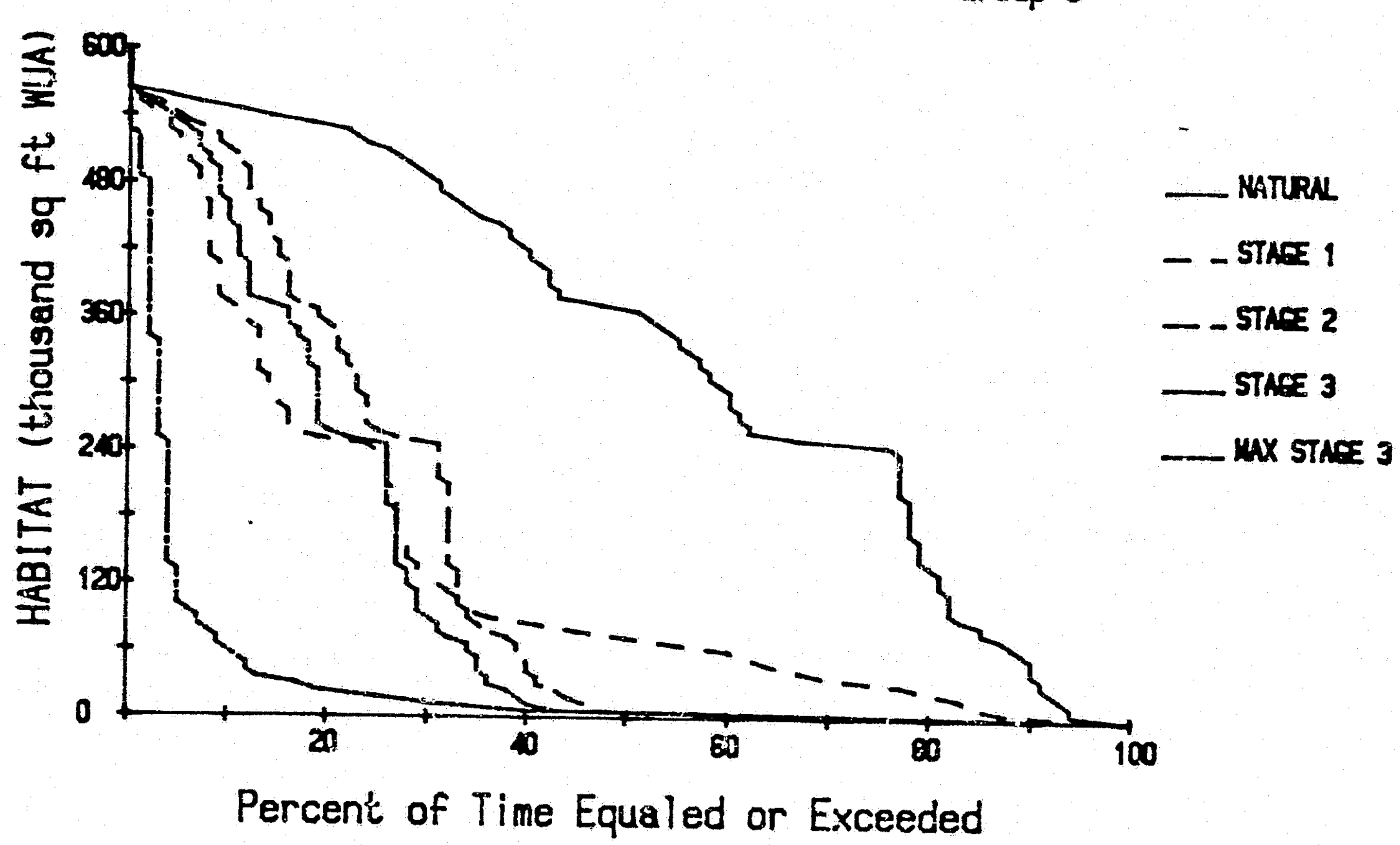


Group 8



Flow duration curve and chinook rearing habitat duration curve for Group 8.

FIGURE 142

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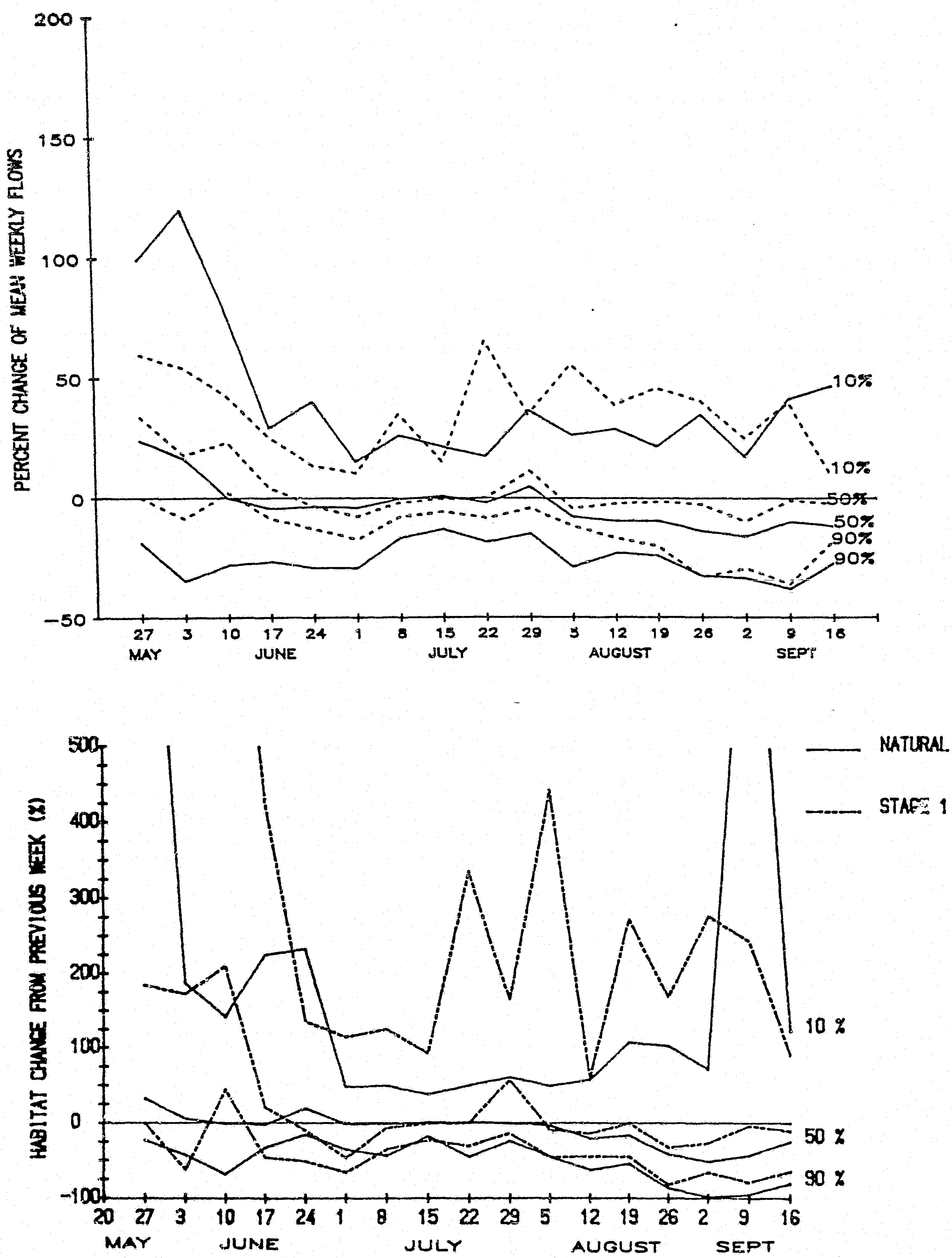

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 8 during Stage I exceeded 10, 50 and 90 percent of the time.

FIGURE 143

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.. Operation

Habitat availability under natural and Stage II flows is compared in a weekly habitat time series plot and seasonal habitat duration curve (Figures 144 and 142). Stage II operational flows would result in elimination of Group VIII habitat reductions 50 percent of the time through July and reductions to 90 percent or more in June. At the end of July the magnitude of these reductions would decrease and by mid- August habitat availability would be about the same as natural.

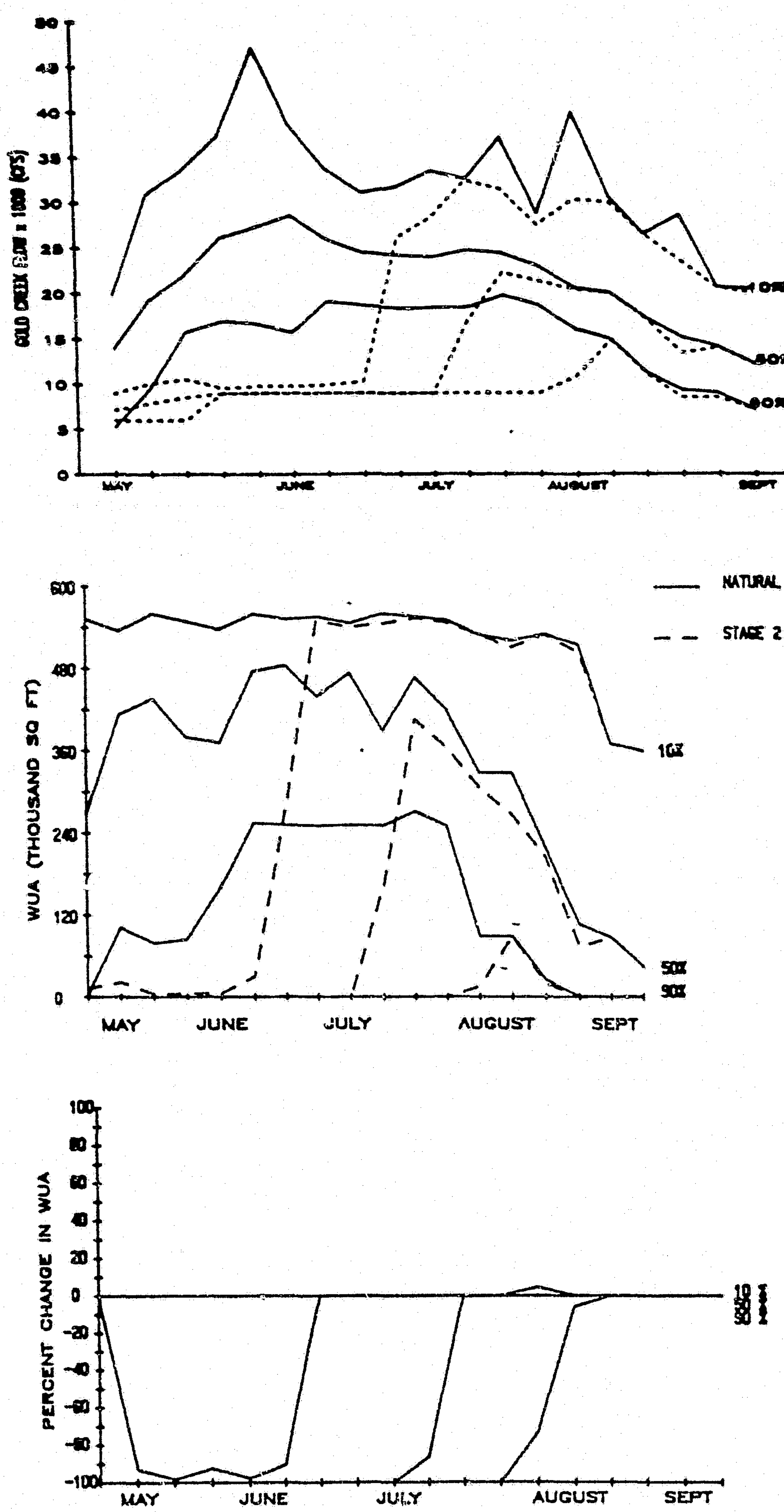
With-project habitat stability during Stage II would be less than under natural conditions for most of the summer rearing period. Week to week increases inhabitat of 200 percent or more would frequently occur. In September natural and project weekly variations in the amount of rearing habitat would be similar (Figure 145).

The contribution of Group 8 to total middle Susitna River habitat would decrease under Stage II from natural levels of 3 to 9 percent to 0 to 1 percent in May and June. The percent contribution would increase during July and would be similar to natural from mid-August to mid-September (Figure 73).

-- Stage III

. Filling

Filling of Watana during Stage III would occur over several years and consequently habitat availability is more appropriately discussed under operation.



Mean weekly discharge (upper), chinook rearing WUA for Group 8 (middle) and percent change in WUA (lower) exceeded 90, 50, and 10 percent of the time for natural and Stage II flows.

FIGURE 144

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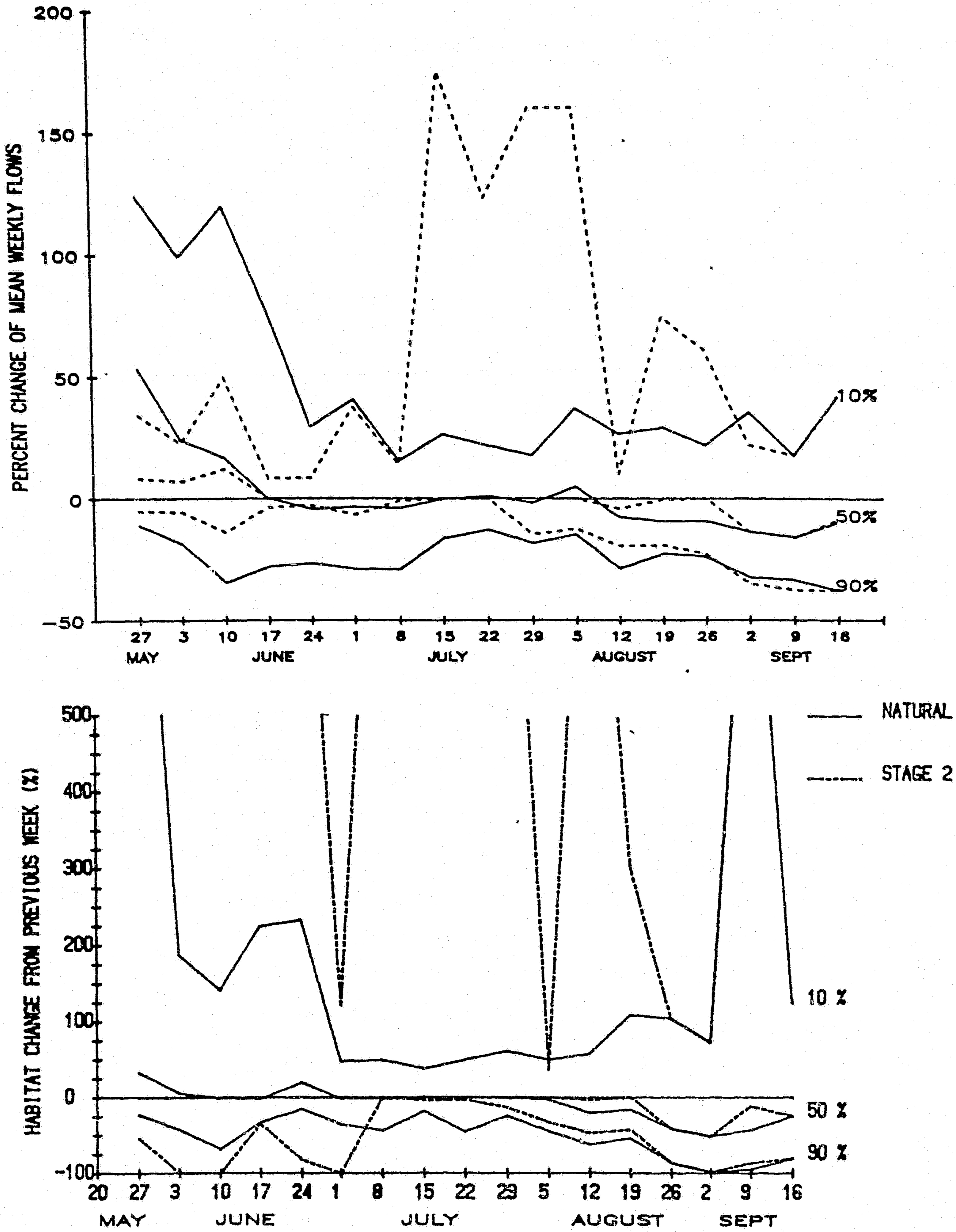

Percent change in flow (upper) and chinook rearing habitat (lower) from previous week in Group 8 during Stage II exceeded 10, 50 and 90 percent of the time.

FIGURE 145

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