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BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

APPLICATION FOR LICENSE FOR MAJOR PROJECT

SUSITNA HYDROELECTRIC PROJECT

VOLUME 9

DRAFT

EXHIBIT E

CHAPTER 3

SECTIONS 1 AND 2

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ON JULY 29, 1983

This system consists of placing one of the following notations beside each text heading:

(o) No change was made in this section, it remains the same as was presented in the July 29, 1983 License Application

(*) Only minor changes, largely of an editorial nature, have been made

(**) Major changes have been made in this section

(***) This is an entirely new section which did not appear in the July 29, 1983 License Application

VOLUME COMPARISON

VOLUME NUMBER COMPARISON

LICENSE APPLICATION AMENDMENT VS. JULY 29, 1983 LICENSE APPLICATION

EXHIBIT	CHAPTER	DESCRIPTION	AMENDMENT VOLUME NO.	JULY 29, 1983 APPLICATION VOLUME NO.
A	Entire	Project Description	1	1
B	Entire	Project Operation and Resource Utilization	2	2 & 2A
	App. B1	MAP Model Documentation Report	3	2B
	App. B2	RED Model Documentation Report	4	2C
	App. B3	RED Model Update	4	--
C	Entire	Proposed Construction Schedule	5	1
D	Entire	Project Costs and Financing	5	1
	App. D1	Fuels Pricing	5	1
E	1	General Description of Locale	6	5A
	2	Water Use and Quality	6	5A
	Tables Figures		7	5A 5B
	Figures		8	5B
	3	Fish, Wildlife and Botanical Resources (Sect. 1 and 2)	9	6A 6B
		Fish, Wildlife and Botanical Resources (Sect. 3)	10	6A 6B
		Fish, Wildlife and Botanical Resources (Sect. 4, 5, 6, & 7)	11	6A 6B
	4	Historic & Archaeological Resources	12	7
	5	Socioeconomic Impacts	12	7
	6	Geological and Soil Resources	12	7
	7	Recreational Resources	13	8
	8	Aesthetic Resources	13	8
	9	Land Use	13	8
	10	Alternative Locations, Designs and Energy Sources	14	9
	11	Agency Consultation	14	10A 10B
F	Entire	Project Design Plates	15	3
F	Entire	Supporting Design Report	16	--
G	Entire	Project Limits and Land Ownership Plates	17	4

SUMMARY TABLE OF CONTENTS

SUSITNA HYDROELECTRIC PROJECT
LICENSE APPLICATION

SUMMARY TABLE OF CONTENTS

EXHIBIT A
PROJECT DESCRIPTION

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT A
PROJECT DESCRIPTION

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT A
PROJECT DESCRIPTION

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT B
PROJECT OPERATION AND RESOURCE UTILIZATION

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT B - APPENDIX B1

MAN-IN-THE-ARCTIC PROGRAM (MAP)
TECHNICAL DOCUMENTATION REPORT
STAGE MODEL (VERSION A85.1)
REGIONALIZATION MODEL (VERSION A84.CD)
SCENARIO GENERATOR

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT B - APPENDIX B2
RAILBELT ELECTRICITY DEMAND (RED) MODEL
TECHNICAL DOCUMENTATION REPORT (1983 VERSION)

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT B - APPENDIX B3
RAILBELT ELECTRICITY DEMAND (RED) MODEL
CHANGES MADE JULY 1983 TO AUGUST 1985

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT C
PROPOSED CONSTRUCTION SCHEDULE

EXHIBIT D
PROJECT COSTS AND FINANCING

EXHIBIT D
PROJECT COSTS AND FINANCING

EXHIBIT D - APPENDIX D1
FUELS PRICING

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 1
GENERAL DESCRIPTION OF THE LOCALE

EXHIBIT E - CHAPTER 2
WATER USE AND QUALITY

EXHIBIT E - CHAPTER 2
WATER USE AND QUALITY

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 3
FISH, WILDLIFE, AND BOTANICAL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 3
FISH, WILDLIFE, AND BOTANICAL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 4
HISTORIC AND ARCHEOLOGICAL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 5
SOCIOECONOMIC IMPACTS

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 5
SOCIOECONOMIC IMPACTS

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 6
GEOLOGICAL AND SOIL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 7
RECREATIONAL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 7
RECREATIONAL RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 8
AESTHETIC RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 8
AESTHETIC RESOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 8
AESTHETIC RESOURCES

Title	Page No.

APPENDICES (cont'd)

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 9
LAND USE

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 10
ALTERNATIVE LOCATIONS, DESIGNS, AND ENERGY SOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 10
ALTERNATIVE LOCATIONS, DESIGNS, AND ENERGY SOURCES

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT E - CHAPTER 11
AGENCY CONSULTATION

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT F
SUPPORTING DESIGN REPORT (PRELIMINARY)

SUMMARY TABLE OF CONTENTS (cont'd)

EXHIBIT F
SUPPORTING DESIGN REPORT (PRELIMINARY)

CHAPTER 3

FISH, WILDLIFE AND BOTANICAL RESOURCES

SECTIONS 1 AND 2

1 - INTRODUCTION

SUSITNA HYDROELECTROC PROJECT
LICENSE APPLICATION

EXHIBIT E - CHAPTER 3
FISH, WILDLIFE, AND BOTANICAL RESOURCES

TABLE OF CONTENTS

LIST OF TABLES

EXHIBIT E - CHAPTER 3
FISH AND WILDLIFE MITIGATION POLICY

LIST OF FIGURES

EXHIBIT E - CHAPTER 3
FISH, WILDLIFE, AND BOTANICAL RESOURCES

1 - INTRODUCTION (o)

This report discusses the fish, vegetation, and wildlife resources of the area that will be affected by the proposed Susitna Hydroelectric Project. Each of the major subsections (2 - Fish, 3 - Botanical Resources, and 4 - Wildlife) provides a baseline description of species and populations of the project area; an assessment of potential project impacts on this biota (assuming no mitigation); and a mitigation plan that explains how preliminary engineering design and construction planning have incorporated measures to avoid, minimize, or rectify potentially adverse effects of the project on the biological environment. In appropriate cases, resource management options to reduce or compensate for adverse impacts that cannot otherwise be mitigated are discussed.

1.1 - Baseline Descriptions (o)

These sections describe the distributions and characteristics of biological populations and communities within the project area. The discussions are based on a thorough review of the scientific literature and emphasize documented studies conducted in preparation for the Susitna Hydroelectric Project by the Alaska Department of Fish and Game and professional consultants. They provide the most current available information through March 1985 on fish, vegetation, and wildlife of the project area.

Discussions of animals focus on vertebrate species: resident and anadromous fish, big game, furbearers, birds, and non-game (small) mammals. The plant descriptions deal with species aggregations that occur in recognizable patterns, such as vegetation communities and successional stages.

The baseline descriptions emphasize functional relationships among habitat components and animal communities. Factors that regulate species distribution and abundance receive particular attention, because knowledge of these regulating mechanisms can suggest where populations are most sensitive to potential disturbance. For example, water temperature and stream regimes are discussed as regulators of fish populations, and the role of plant communities in regulating wildlife populations is examined.

1.2 - Impact Assessments (*)

It is expected that the distribution and abundance of fish, plant, and wildlife species in and around the area of the Susitna Hydroelectric

Project will change as a result of project construction and operation. The impact assessments presented in this report are based, in part, on the project description presented in Exhibit A, project operations described in Exhibit B, the proposed construction schedule shown in Exhibit C, the impacts on water use and quality presented in Exhibit E Chapter 2 and an analysis of similar activities associated with large construction and hydroelectric projects in similar habitats. In addition, the Recreation Plan presented in Exhibit E, Chapter 7, has been reviewed as a proposed project action to determine its potential impacts on fish, vegetation, and wildlife. The impact assessments link predicted physical changes with habitat utilization to provide a qualitative statement of impacts likely to result from the Susitna Hydroelectric Project. Quantitative assessments are presented where justified by current knowledge and research techniques. Changes potentially resulting from the project are discussed with respect to specific project features and activities, assuming standard engineering design and construction practice without the incorporation of mitigation measures.

Although some project impacts, if not mitigated, will be adverse, other impacts will be innocuous and some will enhance fish or wildlife productivity. Therefore, potentially beneficial impacts are given balanced treatment with those to be mitigated. Each potential effect, together with the action responsible for it, is called an impact issue.

The identification and prioritization of impact issues have followed the procedures established by the Susitna Hydroelectric Project Fish and Wildlife Mitigation Policy (Appendix E1.3). This policy was prepared by the Applicant through extensive consultation with representatives of the following resource agencies:

- Alaska Department of Fish and Game (ADF&G);
- Alaska Department of Natural Resources (ADNR);
- Alaska Department of Environmental Conservation (ADEC);
- National Marine Fisheries Service (NMFS);
- U.S. Bureau of Land Management (USBLM);
- U.S. Environmental Protection Agency (USEPA); and
- U.S. Fish and Wildlife Service (USFWS).

Criteria for assessing the relative importance of biological impact issues have been provided by; (1) mitigation policies of the Alaska Department of Fish and Game (ADF&G 1982a), the U.S. Fish and Wildlife Service (USFWS 1981c), and the Applicant (Appendix E1.3); (2) letters and testimony by local, state, and federal agencies; and (3) discussions of impact issues in workshops and numerous other technical meetings involving Susitna project personnel and resource agency representatives.

All three mitigation policies from APA, USFWS, and ADF&G imply that project impacts on the habitats of certain sensitive fish and wildlife species will be of greater concern than changes in distribution and abundance of less sensitive species. Sensitivity can be related to high human use value as well as susceptibility to change because of project impacts. The policies and comments also indicate that, for the Susitna Project area, vegetation is considered more important as a component of wildlife habitat than as a botanical resource in itself. Statewide policies and management approaches of resource agàncies suggest that concern for fish and wildlife species with commercial, subsistence, and other consumptive uses is greater than for species without such value. These species are often large, sometimes 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 evaluation species the impacts to other less sensitive species that utilize similar habitats can also be avoided or reduced.

The mitigation policies all agree that resource vulnerability is an important criterion for impact prioritization. Resources judged most vulnerable to potential project impacts have therefore been given highest priority in impact assessment and mitigation planning. Similarly, impact issues have been considered with regard to probability of occurrence. Where there is a high degree of confidence that an impact will actually occur, it has been ranked above impacts that are predicted to be less likely to occur. Also, the mitigation policies and agency comments indicate that impacts on animal productivity and population size through changes in habitat availability are of high concern. Behavioral responses that have the potential for producing population-level effects are also important. Adverse impacts that are longer lasting or irreversible have priority over short-term impacts.

1.3 - Mitigation Plans (*)

Mitigation plans have been developed for identified impact issues in accordance with the sequence of steps defined by 40 CFR 1508.20, pursuant to the National Environmental Policy Act (42 USC 4321 et seq.).

The mitigation planning sequence includes, in priority order of implementation, the following steps:

- o Avoiding the impact through project design and operation, or by not taking a certain action;
- o Minimizing the impact by reducing the degree or magnitude of the action, or by changing its location;
- o Rectifying the impact by repairing, rehabilitating, or restoring the affected portion of the environment;

- Reducing or eliminating the impact over time by preservation, monitoring, and maintenance operations during the life of the action; and

- Compensating for the impact by providing replacement or substitute resources that would not otherwise be available.

This sequential strategy for mitigation option analysis and implementation is shared by all three mitigation policies applied to the project (the Applicant - see Appendix E1.3, ADF&G 1982a, USFWS 1981c). The relationships of steps within the sequence are shown in Figure E.3.1.1 and further compared in Table E.3.1.1.

The process by which mitigation will be implemented and continually refined throughout the life of the project is shown schematically in Figure E.3.1.2. The process involves the following steps:

- Impact issue evaluation:

    Identification of the nature and extent of impacts:
        Populations
        Subpopulations
        Habitat types
        Geographical areas

    Prioritization of impacts:
        Ecological value of affected resource
        Consumptive value of affected resource
        Resource vulnerability
        Confidence of impact prediction
        Long-term vs. short-term impacts

- Option analysis procedure:

    Identification of practicable mitigation options:
        Type of mitigation option
        Sequence of implementation

    Evaluation of mitigation options:
        Effectiveness of option
        Conflicts with project objectives
        Residual impacts

    Documentation of option analysis:
        Impact issues
        Mitigation options
        Conflicts (if any) with project objectives

- Negotiation of acceptable plan

- Mitigation plan implementation:

    Engineering design and construction planning:
    - Participate in design development
    - Participate in preconstruction field surveys and site evaluations
    - Review designs, schedules, permit applications

    Construction and operation monitoring:
    - Review work accomplished
    - Evaluate degree of impact
    - Evaluate effectiveness of mitigation
    - Identify modifications to the mitigation plan
    - Submit regularly scheduled reports

    Mitigation plan modifications:
    - Propose modifications
    - Submit modifications for review
    - Implement and monitor approved modifications

Data from the baseline, impact, and monitoring studies will be used throughout the life of the project to plan and continually refine the mitigation process in a flexible, adaptive fashion.

Mitigation measures proposed for operation of the Susitna Hydroelectric Project may be classified within two broad categories:

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

- Mitigation for impacts that cannot be mitigated through modifications to design or operation of the project.

The first type of mitigation measure is project-specific and emphasizes the avoidance, minimization, rectification, or reduction of adverse impacts, as prioritized by the Fish and Wildlife Mitigation Policy established by the Applicant (Appendix E1.3) and coordinating agencies (ADF&G 1982a, USFWS 1981c). As shown in Figure E.3.1.1, these measures must first be implemented to keep adverse impacts to the minimum consistent with project requirements. They involve adjusting or adding project features during design and planning so that mitigation becomes a built-in component of project actions.

Mitigation of construction impacts will be achieved primarily by incorporating environmental criteria into preconstruction planning and design, and by good construction practices. Incorporation of environmental criteria into design activities and construction of the Susitna dams and related facilities such as transmission lines and access roads will avoid, minimize or rectify impacts to fish and wildlife habitats.

The Applicant has prepared five Best Management Practices (BMP) Manuals (APA 1985a,b,c,d,e) to be used in the design, construction and maintenance of the Applicant's projects. These manuals are entitled:

1. Fuel and Hazardous Materials

2. Oil Spill Contingency Planning

3. Water Supply

4. Liquid and Solid Waste Management

5. Erosion and Sedimentation Control

A report entitled "Drainage Structure and Waterway Design Guidelines" was also prepared (Harza-Ebasco 1985b) to establish the proper procedure for the design of drainage structures and waterways.

These manuals are the result of a coordinated effort involving federal, state, and local government agencies, and special interest groups. The manuals will be provided to the design engineer, who will utilize them in the preparation of both design and construction documents. The Applicant intends that applicable guidelines contained in these manuals will be incorporated where appropriate into the contractual documents for the Project.

When impacts cannot be fully avoided or rectified, reduction or compensation measures are justified. This type of mitigation can involve management of the resource itself, rather than adjustments to the project, and will require concurrence of resource management boards or agencies with jurisdiction over lands or resources within and around the project area.

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

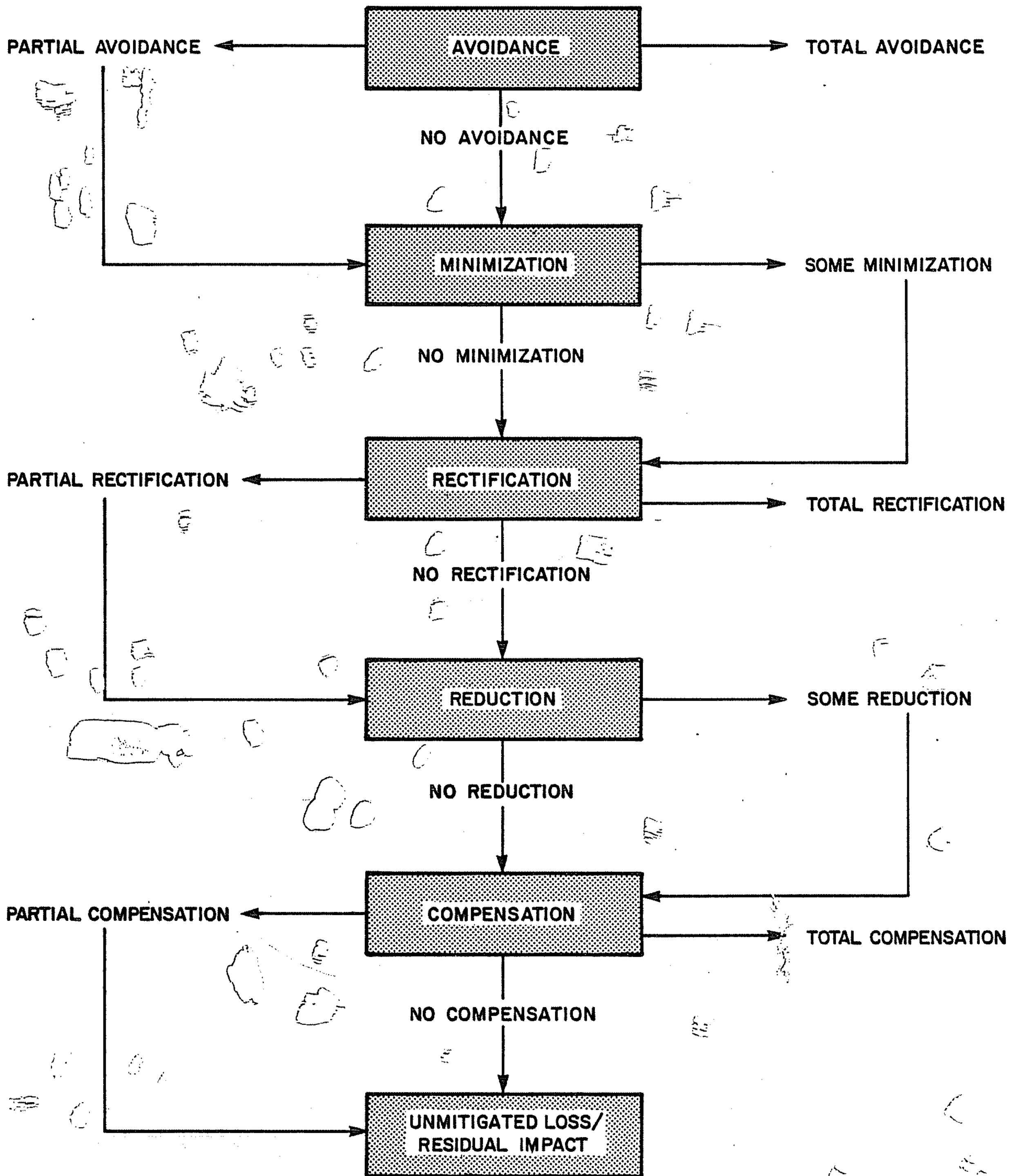
Monitoring and maintenance of mitigation features to reduce impacts over time are recognized as an integral part of the mitigation process. To assure that the mitigation plans achieve their intended goals, monitoring plans for aquatic and terrestrial resources have been develped and are described in this license application.

TABLES

TABLE E.3.1.1: MITIGATION OPTIONS ANALYSIS STRUCTURE RECOMMENDED BY SUSITNA HYDROELECTRIC PROJECT, ALASKA DEPARTMENT OF FISH AND GAME (ADF&G) AND THE U.S. FISH AND WILDLIFE SERVICE (USFWS). DESIRABILITY OF OPTIONS DECREASES FROM TOP TO BOTTOM. EXPLANATIONS OR EXAMPLES OF EACH OPTION AS DESCRIBED BY AGENCIES ARE SHOWN

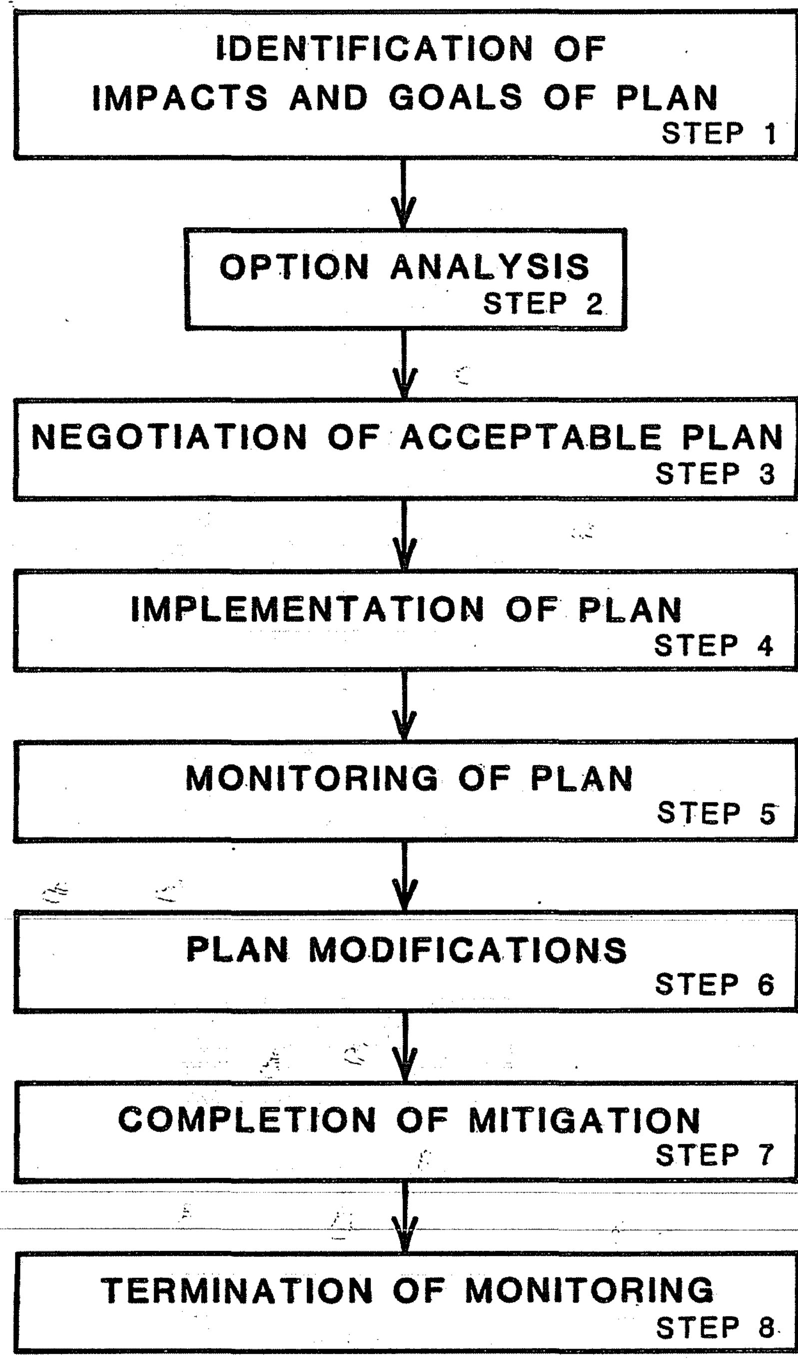
OPTION	DEFINITION: ALASKA DEPARTMENT OF FISH AND GAME	DEFINITION: U.S. FISH & WILDLIFE SERVICE
AVOIDANCE	Avoid Impact by Not Taking a Certain Action - Keep as much existing natural habitat as possible. - Maintain fish and game populations and critical habitats.	Modify Project Design to Avoid Impact - No-project alternative is one mode. - Design modifications in action type, magnitude, timing and locations are options.
MINIMIZATION	Minimize Impacts by Limiting Magnitude of Action - Maintain habitat diversity and the capacity of each system to restore itself naturally.	Modify Project Design to Minimize Impacts - Design modifications in action type, magnitude, timing and location are options.
RECTIFICATION	Rectify Impacts by Rehabilitating Environment - Repair, rehabilitate or restore abused aquatic or terrestrial systems. - Restore the same functions or structure of habitats.	Restore Damaged Environments - Reclaim disturbed sites by seeding, etc. - Restock lost fish and wildlife.
RESTRICTION	Reduce (or Eliminate) Impact Over Time by Maintenance - Operate and maintain mitigation measures to reduce impacts over time.	Maintain Mitigation Effort to Reduce Impact - Monitor and maintain mitigation measures. - Train mitigation personnel.
COMPENSATION	Compensate for Impact by Substitute Resources - Create or restore fish, wildlife and habitat values, and resource use opportunities that were unavoidably lost. - Compensation by providing substitute resources or environments is least desirable; the preferred mode is onsite mitigation.	Restore Lost Resources by Management or Replacement - Intensify production through management. - Initiate hatcheries; restocking programs. - Lease or buy new lands for enhanced management.

FIGURES



OPTION ANALYSIS

FIGURE E.3.1.1



MITIGATION PLAN DEVELOPMENT AND IMPLEMENTATION

FIGURE E.3.1.2

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

Woodward-Clyde Consultants

HARZA-EBASCO
SUSITNA JOINT VENTURE

2 - FISH RESOURCES OF THE SUSITNA RIVER DRAINAGE

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

SUSITNA HYDROELECTRIC PROJECT
LICENSE APPLICATION

EXHIBIT E - CHAPTER 3
FISH, WILDLIFE, & BOTANICAL RESOURCES

LIST OF TABLES

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF TABLES (cont'd)

LIST OF FIGURES

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

LIST OF FIGURES (cont'd)

2 - FISH RESOURCES OF THE SUSITNA RIVER DRAINAGE (**)

2.1 - Overview of the Resources (**)

2.1.1 - Description of the Study Area for Fish Resources (**)

The study area for the Susitna Hydroelectric Project fish studies includes the Susitna River mainstem, side channels, side sloughs, upland sloughs and tributaries (Figure E.3.2.1). From the terminus of Susitna Glacier in the Alaska Mountain Range to its mouth in Cook Inlet, the Susitna River flows approximately 318 miles (530 km) and drains 19,600 square miles (50,900 square kilometers). The mainstem and major tributaries of the Susitna River, including the Maclaren, Chulitna, Talkeetna and Yentna Rivers, originate in glaciers and carry a heavy load of glacial flour during the ice-free months. There are many smaller, clear water tributaries that are perennially silt-free, except during floodflows, including Tyone River, Oshetna River, Portage Creek, Indian River, Kroto Creek (Deshka River) and Alexander Creek (Figures E.3.2.2 to E.3.2.4).

Streamflow is characterized by moderate to high flows between May and September and low flows from October to April. High summer discharges result from snowmelt, rainfall and glacial melt. Winter flows are almost entirely ground water inflow (see Exhibit E, Chapter 2, Section 2.2.3). Freezeup begins in the higher regions in early October, and most of the river is ice free by late May.

Three study reaches have been defined for baseline data gathering and impact analysis based upon stream morphology, flow regime and anticipated impacts. These study reaches are: the impoundment from the Oshetna River (River Mile RM 236) to Devil Canyon (RM 152); Devil Canyon to Talkeetna (RM 98); and Talkeetna to Cook Inlet (RM 0). These are commonly referred to as the impoundment zone and the middle and lower river reaches, respectively.

The Susitna River upstream of the Watana Reservoir will not be affected by the project and, therefore, is not included in the study area. In the impoundment zones (Watana and Devil Canyon Reservoirs), the existing flowing water habitats will become lake-like habitats in the reservoirs. Although fish resources will continue to exist in the reservoirs, it is expected that the productivity will be relatively low because the reservoirs will remain quite turbid throughout the year. Downstream from the reservoirs, the flow regime, temperature regime, water quality characteristics and ice processes are expected to be altered by the project and therefore will affect fish resources. The most affected reach downstream from the dams is the middle Susitna River from the Devil Canyon Dam Site to Talkeetna at the confluence with the Chulitna River. These changes are discussed in detail in Exhibit E Chapter 2 Section 4 and the effects to fish resources are discussed in detail in Section 2.3. Measures to mitigate for the expected adverse effects are described in Section 2.4. Effects to fish resources in the lower river (between Talkeetna and Cook Inlet) are not expected to be as great as those expected in the middle river. Basically, the effects expected in the lower river are less because the changes induced by the project will be masked by the flow, temperature and water quality regimes contributed by the Chulitna and Talkeetna Rivers as well as numerous other tributaries flowing into the lower river.

2.1.2 - Data Collection and Analysis Methods (**)

(a) Anadromous Adult Investigations (**)

Methods utilized from 1981 through 1985 to enumerate adult salmon within the Susitna River drainage included side-scan sonar monitoring, fishwheel monitoring, tag and recapture estimates and ground/aerial spawning surveys.

Side scan sonars and fishwheels were used to determine the upstream migration timing of sockeye, pink, chum, and coho salmon in the Susitna River from July through early to mid-September 1981 and 1982. Sampling locations included Susitna Station (RM 26), and Yentna Station (Yentna RM 04), Sunshine Station (RM 80) located in the lower river, and Talkeetna Station (RM 103) located in the middle river (ADF&G 1985a) as shown in Figures E.3.2.2 and E.3.2.3. Fishwheels were used from 1981 through 1984 at these stations, but sonars were only used for 1983 and 1984 at the Susitna and Yentna Stations. Fishwheels were also operated at Curry Station (RM 120) in the middle river from 1981 through 1984 and at Flathorn Station (RM 20) in the lower river during the 1984 season, but without associated sonar counters. When fishwheels were used in conjunction with the sonar, the data from the nearby fishwheel was used to apportion side scan sonar counts. Fishwheels at all stations have been used to sample adult chinook salmon, but sampling for this species has been somewhat difficult because they migrate upriver either at or soon after ice breakup when the maintenance of sampling gear in the river is impractical.

The side scan sonar counts recorded at Susitna Station were not used for defining Susitna River salmon escapements because of suspected inaccuracy of counts caused by counter siting problems. Details of these problems are discussed in ADF&G (1983a). Yentna Station (RM 04) sonar counts were considered suitable for reporting 1981 and 1982 Yentna River salmon escapements (ADF&G 1985b).

A tag/recapture program was conducted from 1981 through 1984 to estimate numbers of the five salmon species passing upstream of Sunshine, Talkeetna and Curry Stations (ADF&G 1985b). In addition, fish were tagged at Flathorn Station in 1984. Salmon captured at all fishwheel sampling sites were measured, scales were removed for age determination, and then, the fish were fitted with tags, color-coded for each site, and released. Personnel surveyed all known and suspected salmon spawning tributaries (a total number of 15) and sloughs (34) in the middle river from the confluence of the Chulitna and Talkeetna rivers at RM 101.4 to the lower end of Devil Canyon at RM 148.8 of the Susitna River at weekly intervals from late July through early October. Salmon abundance within the entirety of sloughs and selected tributary index reaches was determined by the above surveys from 1981 through 1984. The tributary index reaches were within 0.5 mile (0.8 km) of the confluence with the Susitna River. In 1984, lower river tributaries were also surveyed from their confluence with the Susitna River to one-third mile upstream. All tagged and untagged salmon were counted. Species population estimates were then calculated from survey and fishwheel catch data at each station.

The entire lengths of selected tributaries were surveyed for spawning chinook salmon from helicopters. This was done from 1981 through 1984 in the Indian River (RM 128.6) and Portage Creek (RM 148.8). Cheechako Creek (RM 152.5) and an unnamed creek (RM 156.8) were also surveyed, starting in 1982. Other Susitna, Chulitna, and Talkeetna River drainage chinook salmon spawning areas were surveyed as part of an ongoing project since 1975. The purpose of these surveys was to determine chinook salmon escapement trends in the Cook Inlet drainage (ADF&G 1985b). The suitability of helicopter surveys as a census method for chinook salmon is discussed in Neilson and Geen (1981).

Sockeye, chum, pink and coho salmon spawning activity in mainstem, side-channel, and tributary confluence locations of the lower and middle Susitna River was evaluated by a variety of techniques during 1981 through 1984 including: observation, electroshocking, and drift gill netting (ADF&G 1985b). Sampling of salmon spawning nests or redds was performed by egg pumping. This was done after fish spawning activity terminated.

Adult chinook, chum, and coho salmon were fitted with internal radio transmitters at Talkeetna and Curry in 1981 and

1982. These fish were followed to evaluate directional movements, upstream migration rates, upstream migration extent, and spawning locations.

Stationary gill nets were operated near Devil Canyon at RM 150.2 at five-day intervals from late July to mid-September 1981 and 1982 to detect adult sockeye, chum, pink, and coho salmon.

The migration timing, upstream migration extent, and probable spawning areas of eulachon in the Sustina River were evaluated from mid-May through mid-June in 1982 and 1983 by a variety of techniques. Upstream migration timing was assessed by stationary gill nets placed at selected Susitna River estuary locations. The extent of upstream migration was determined by dip net and electrofishing. Eulachon spawning habitat was determined directly by searching for eggs in substrate samples and indirectly by evaluating the spawning condition of female smelt collected by dip net and electrofishing at suspected spawning sites.

During 1981 and 1982, the migration timing, upstream migration extent, and spawning habitat selection of Bering cisco in the Susitna River were investigated. Electrofishing was used to assess the upstream migration extent and spawning habitat selection by cisco, as evidenced by spawning condition of captured fish. A fishwheel, used for salmon investigation, was maintained through late September 1981 and 1982 to intercept cisco.

(b) Resident and Juvenile Anadromous Fish Investigations (**)

Fish investigations assessed the seasonal distribution and relative abundance of resident fish in the impoundment area (including tributaries and adjacent lakes) and the middle and lower river. Because few anadromous fish (less than 60 adult Chinook salmon were observed by ADF&G in 1984) are able to migrate upstream through Devil Canyon, juvenile anadromous fish were only studied in areas downstream of the impoundment zone. Methods for sampling both resident and juvenile anadromous fish included baited minnow traps, trot (i.e., set) lines, hook and line, electrofishing, stationary and drift gill nets, and beach seines. Studies commenced in November, 1980 and have continued through spring 1985. Selected tributaries and tributary confluences, sloughs, side-channel and mainstem locations from RM 10.1 to 148.8 of the Susitna River were sampled during the winter (November to April) and the open-water season (May to October). Fewer sites were sampled during the winter than during the open-water season because of sampling constraints, including the short length of daylight, and ice conditions.

During the summer field season of 1984, fisheries resources and aquatic habitat were evaluated within the proposed access corridor (Plan 18, also referred to as Denali-North) and that portion of the proposed transmission corridor from the Watana Dam site to its intersection with the Anchorage-Fairbanks Intertie (referred to as the Gold Creek-Watana transmission corridor) (ADF&G 1984a). Forty-two proposed stream crossing sites and ten lake habitats were inventoried for fish species. General water quality (dissolved oxygen, pH, conductivity, and water temperature) discharge, and substrate data were collected at stream crossing study sites.

Streams in the corridor were sampled using a backpack electroshocker. Lakes were sampled using either gill nets, minnow traps, trot- lines, or hook and line. Otolith or scale samples were taken at both stream and lake sites for age/length determinations.

Extensive studies have been performed on the relationships between habitat and fish in the middle and lower river (Trihey 1982a; ADF&G 1983k; ADF&G 1984b; ADF&G 1984c; ADF&G 1985c). These studies have focused on examining presence of spawning activity; access for adult salmon to slough and tributary spawning sites; and development of relationships between mainstem flow and fish habitat for spawning, incubation, and rearing. Methods used have included instream flow incremental methodology, habitat indices (ADF&G 1985c) and aerial photographic techniques (R&M Consultants and EWTA 1985a,b). Habitat characteristics measured included presence of groundwater upwelling, water temperature, dissolved oxygen, conductivity, turbidity, water depth, velocity, substrate and instream cover. In addition to the above studies, laboratory investigations were conducted with eggs from Susitna chum and sockeye salmon to provide a better understanding of the relationship between temperature and egg incubation (Wangaard and Burger 1983).

Electrofishing was conducted in the lower and middle river during the 1982-1984 open-water seasons to tag resident fish and evaluate their seasonal distribution, relative abundance, and movements within the Susitna River. As part of this study, individ- ually identifiable radio transmitters of three-to-six months longevity were surgically implanted in adult rainbow trout and burbot during the open water seasons of 1981 through 1984 (ADF&G

1985c) at various locations along the Susitna River downstream from Devil Canyon (RM 152). These tags were used to evaluate autumn and winter movements and overwintering locations. Conventional winter fish sampling techniques, under-ice submerged gill net sets and baited tip-ups, were used to detect non-radio-tagged burbot and rainbow trout.

Juvenile salmonids outmigrating from the middle river have been sampled at Talkeetna Station during the open water seasons from 1982 through 1984. These studies have been designed to evaluate species and age composition, distribution, timing of migration, and catch-per-unit effort. To provide additional informaiton on population numbers, outmigrant travel times, response to changing habitat conditions, and survival, a mark recapture program for post-emergent chum and sockeye fry was performed in 1983 and 1984 using half-length coded-wire tags (ADF&G 1985c). Fish were tagged in various areas upstream of Talkeetna Station and then recaptured at Talkeetna Station. To supplement this informaiton, mark-recapture by cold branding juvenile chinook and coho salmon was undertaken in the Devil Canyon to Talkeetna reach. During 1984, outmigrant traps were used to sample downstream migrants at Flathorn Station (RM 20). In addition, intermittent trapping was performed on the Deshka and Talkeetna Rivers to examine outmigrants.

Studies were conducted upstream from Devil Canyon (RM 152) to evaluate the seasonal distribution and abundance of Arctic grayling (ADF&G 1983b). Eight major clear-water tributaries, located between RM 173.9 and 226.9, were sampled monthly from June to September during 1981 and 1982. Arctic grayling exceeding 8 inches (200 mm) in fork length were tagged with individually numbered tags. Seasonal movements and population estimates were derived from fish recapture data. Segments of the lower one mile of the above streams were sampled for Arctic grayling during 1981, whereas the entire reaches of six of the eight streams that would be inundated by the Watana impoundment were sampled during 1982. Fish were sampled by baited minnow traps, trot lines and seine to detect the presence of other resident fishes. Selected physical/chemical lotic habitat data were collected along these tributaries during 1981 and 1982.

2.1.3 - Threatened and Endangered Species (**)

No threatened or endangered species of fish have been identified in Alaska. The USFWS (1982e) does not list any fish species in Alaska as being threatened or endangered. The State of Alaska

Endangered Species Act also does not list any fish species as endangered.

2.1.4 - Overview of Important Species (**)

Fishery resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide fishing opportunities for sport anglers. Anadromous species that form the base of commercial and non- commercial fisheries include five species of Pacific salmon: chinook, coho, chum, sockeye, and pink.

Important resident species found in the Susitna River drainage include Arctic grayling, rainbow trout, lake trout, burbot and Dolly Varden. Scientific and common names for all fish species identified from the Susitna drainage are listed in Table E.3.2.1.

Both eulachon (anadromous) and round whitefish (freshwater) are present in significant numbers. However, both species receive little or no interest for either commercial, subsistence, or sport fisheries.

Salmon utilize the mainstem river environments for migration, rearing, overwintering, and, to a much lesser extent, spawning. The majority of the escapement of chinook, sockeye, pink, chum, and coho salmon in the Susitna drainage spawn in tributaries of the Susitna River and do not utilize the mainstem habitats extensively.

The most important changes due to the project are expected to occur in the middle river (Talkeetna to Devil Canyon). The relative importance of middle river mainstem habitats as a travel corridor to returning salmon adults is indicated by population estimates made at the ADF&G fishwheel stations at Talkeetna and Flathorn (Figure E.3.2.5), ADF&G, 1985b). In 1984, approximately 6 percent of all coho, 12 percent of all chum, 2 percent of all sockeye, 10 percent of all chinooks, and 5 percent of all pink salmon spawning in the entire Susitna drainage basin traveled through the mainstem middle river to reach their natal grounds. The remainder of the population spawns in tributaries of the Susitna River, principally in the Yentna, Talkeetna and Chulitna River drainages. Adult migration timing varies by species, but generally the peak inmigration to the middle reach of the Susitna occurs from late June through September.

Of those salmon that do spawn in the middle river, most spawn in tributary streams. Based on escapement counts for 1984, 34 middle river sloughs, collectively, provided spawning habitat for only approximately 5.5 percent of all salmon migrating above the Talkeetna fishwheel station (ADF&G 1985b). Coho and chinook in this reach apparently spawn only in tributary streams, pink salmon primarily in tributary streams (with a small number utilizing slough habitats), chum salmon in both tributary and slough environments, and sockeye almost exclusively in sloughs (ADF&G 1985b). Despite their relative importance to the maintenance of both chum and sockeye salmon in the middle river, slough spawning habitats are not central to the maintenance of the total Susitna River stocks of either species. Only about 2 percent of all chum and less than 0.5 percent of all sockeye spawning in the Susitna River in 1984 utilized sloughs. Spawning habitat quality apparently varies greatly between sloughs as, in the last four years, the majority (>88 percent) of the chum salmon that spawn in slough were found in 10 of the 34 sloughs. Three of these 10 (8A, 11, 21) have added significance in that they also supported over 90 percent of all sockeye spawning in the middle river.

Relatively few salmon spawn in mainstem non-slough habitats. Of those which do, chum salmon predominate. Generally, spawning habitats within the mainstem proper are small in area and widely distributed. In 1984, ADF&G made a concerted effort to identify mainstem middle river spawning habitats, identifying 36 spawning sites. Numbers of fish counted at each of these sites varied from one to 131 with an average of 35 (ADF&G 1985b).

Four of the five salmon species present use middle river waters for rearing purposes (ADF&G 1984c). From May to September juvenile chinook salmon rear in tributary and side channel environments, coho mostly rear in tributary and upland sloughs, and sockeye move from natal side sloughs to upland sloughs for rearing. From May to July rearing chum salmon are distributed throughout side slough and tributary stream environments (ADF&G 1984c).

Rainbow trout and Dolly Varden were recorded at mouths of tributary streams. Rainbow trout do not occur upstream from Devil Canyon. Arctic grayling are the dominant species upstream from Devil Canyon.

2.1.5 - Contribution to Commercial and Non-Commercial Fishery (**)

(a) Commercial (**)

Figure E.3.2.6 shows the ADF&G upper Cook Inlet salmon management areas. With the exception of sockeye and chinook salmon, the majority of the upper Cook Inlet commercial catch of salmon originates in the Susitna Basin (ADF&G 1984h). The upper Cook Inlet area is that portion of

Cook Inlet north of Anchor Point and Chinitna Bay (Figure E.3.2.6). The long-term average annual catch of 3.0 million fish is worth approximately $18.0 million in 1984 dollars to the commercial fishery (ADF&G 1984p). In recent years commercial fishermen have landed record numbers of salmon in the upper Cook Inlet fishery with over 6.7 million salmon caught in 1983 and over 6.2 million fish in 1984. The quantitative contribution of the Susitna River to the commercial fishery can only be approximated because of:

- o the higher number of intra-drainage spawning and rearing areas;
- o the lack of data on other known and suspected salmon-producing systems in upper Cook Inlet;
- o the lack of stock separation programs (except for sockeye salmon); and
- o overlap in the migration timing of mixed stocks and species in the Cook Inlet harvest areas.

Therefore, the estimates of contributions of Susitna River salmon to the upper Cook Inlet fishery should be viewed as approximations.

(i) Sockeye Salmon (**)

The most important species in the upper Cook Inlet commercial fishery is sockeye salmon. In 1984, the total sockeye harvest of 2.1 million fish was valued at $13.5 million (ADF&G, 1984p). The commercial sockeye harvest has averaged 1.34 million fish annually in upper Cook Inlet for the last 30 years (Table E.3.2.2). The estimated contribution of Susitna River sockeye to the commercial fishery is between 10 to 30 percent (ADF&G 1985b). This represents an estimated annual commercial harvest of between 134,000 to 402,000 Susitna River sockeye over the last 30 years. In 1983, Susitna River sockeye contributed approximately 500,000 fish to the total catch of 5 million (Table E.3.2.3). The 1983 commercial sockeye catch was the highest in 30 years of record (Table E.3.2.2).

(ii) Chum Salmon (**)

Chum salmon and coho salmon are about equal in importance in the upper Cook Inlet commercial fishery and rank second and third in value after sockeye. The upper Cook Inlet chum salmon catch has averaged 659,000 fish annually since 1954 (Table E.3.2.2). The contribution of Susitna River chum to the upper Cook Inlet fishery is about 85 percent (ADF&G 1985b). This contribution represents an estimated annual chum harvest of 560,000 Susitna River fish in the commercial harvest over the last 30 years. In 1982, the Susitna River contributed approximately 1.21 million fish of the record harvest of 1.43 million chum salmon taken in the upper Cook Inlet fishery (Table E.3.2.2). In 1984, the total chum salmon harvest of 684,000 fish in the commercial fishery was valued at $2.0 million (ADF&G 1984p).

(iii) Coho Salmon (**)

Since 1954, the upper Cook Inlet coho salmon commercial catch has averaged 264,000 fish annually (Table E.3.2.2). Approximately 50 percent of the commercial coho harvest in upper Cook Inlet is from the Susitna River (ADF&G 1985b). This contribution represents an average annual Susitna River coho harvest of 132,000 fish in the commercial fishery over the last 30 years. In 1982, the Susitna River contributed an estimated 388,500 fish (Table E.3.2.3) to a record harvest of 777,000 coho taken by the upper Cook Inlet fishery. In 1984, the total coho salmon harvest of 443,000 fish in upper Cook Inlet had a worth of $1.8 million (ADF&G 1984p).

(iv) Pink Salmon (**)

Pink salmon is the least valued of the commercial species in upper Cook Inlet. The upper Cook Inlet average annual odd-year harvest of pink salmon since 1954 is about 120,000 fish, with a range of 12,500 to 544,000 fish. The average annual even-year harvest is approximately 1.58 million pink salmon with a range of 0.48 to 3.23 million fish (Table E.3.2.2). The estimated contribution of Susitna River pink salmon to the upper Cook Inlet pink fishery is 85 percent (ADF&G 1984h). This represents an average annual Susitna River contribution of 0.10 million odd-year and 1.34 million even-year pink salmon to the upper Cook Inlet fishery over the last 30 years. In 1984, the total pink salmon harvest of 623,000 fish in upper Cook Inlet was worth an estimated $0.5 million (ADF&G 1984p).

(v) Chinook Salmon (**)

The commercial chinook harvest has averaged 19,200 fish annually in the upper Cook Inlet fishery over the last 30 years (Table E.3.2.2). Since 1964, the opening date of the commercial fishery has been June 25. The Susitna River chinook run begins in late May and peaks in mid-June. Thus, by June 25 the majority of chinook have already passed through the area subject to commercial fishing. Catches of chinook salmon have averaged 11,600 fish annually for the 20 year period of 1964-1983. Approximately, 10 percent of the total chinook harvest in upper Cook Inlet are Susitna River fish (ADF&G 1985b). This represents an average annual contribution of 1,960 chinook to the upper Cook Inlet fishery for the last 30 years, or 1,160 fish for 1964-1983. In 1984, the 8,800 chinook caught in the upper Cook Inlet fishery were valued at $0.3 million (ADF&G 1984p).

(b) Sport Fishing (**)

Increases in population and tourism in Alaska have resulted in a growing demand for recreational fishing. Recreational fishing is now considered a significant factor in total fisheries management, particularly in Cook Inlet where commercial and non-commercial user conflicts have developed (Mills 1980). The Susitna River and its major salmon and resident fish-producing tributary streams provide a multi-species sport fishery. Estimates of the sport fish harvest are available for the Susitna River Basin as a whole and cannot be divided into specific areas which will or will not be affected by the Project. Since 1978, the drainage has accounted for an annual average of 127,100 angler days of sport fishing effort, which is approximately 9 percent of the 1977-1983 average of 14 million total angler days for Alaska and 13 percent of the 1977-1983 average of 1.0 million total angler days for Southcentral Alaska (Mills 1979, 1980, 1981, 1982, 1983, 1984).

The sport fish harvests for 1978 through 1983 from the Susitna Basin, based on mail surveys to a sample of license holders, are shown in Table E.3.2.4 (Mills 1979, 1980, 1981,1982, 1983 and 1984). These are summarized in Table E.3.2.5.

(i) Arctic Grayling (**)

The annual Arctic grayling sport harvest for the entire Susitna Basin has averaged 18,200 fish and

61,500 fish in Southcentral Alaska over the last six years (Table E.3.2.5). The largest sport harvest of Arctic grayling on record in the Susitna Basin occurred in 1980 when an estimated 22,100 fish were caught. This represents about 32 percent of the total 1980 harvest of Arctic grayling in Southcentral Alaska (Mills 1981). Due to the rugged terrain and the remoteness of the impoundment area, it is believed that few grayling are harvested from this area. Instead, most grayling are harvested from areas more accessible by vehicles, boats or airplanes (e.g. streams along the Parks or Denali Highways).

(ii) Rainbow Trout (*)

The Susitna Basin and Southcentral Alaska annual rainbow trout sport harvests have averaged 16,000 and 132,900 fish respectively since 1978 (Table E.3.2.5). Between 1978 and 1983, an average of about 16,000 rainbow trout were harvested by anglers in the Susitna Basin, which represented approximately 12 percent of the Southcentral Alaska rainbow trout sport catch (Mills 1980).

(iii) Pink Salmon (*)

The annual even-year pink salmon harvest has averaged 42,950 fish in the Susitna Basin and 134,400 fish in Southcentral Alaska since 1978. The annual odd-year pink salmon sport catch has averaged 8,600 fish in the Susitna Basin and 58,300 fish in Southcentral Alaska since 1979 (Table E.3.2.5). The largest sport harvest of pink salmon on record in the Susitna Basin occurred in 1980 when an estimated 56,600 fish were caught (Mills 1981).

(iv) Coho Salmon (*)

Since 1978, the Susitna Basin and Southcentral Alaska annual coho salmon sport harvests have averaged 13,200 and 103,800 fish respectively (Table E.3.2.5).

In 1982, about 16,664 coho were landed by anglers in the Susitna Basin (Mills 1983), which is the largest annual catch on record. In 1983, almost one of every five coho entering the basin was caught by sport anglers (Table E.3.2.3).

(v) Chinook Salmon (*)

The annual chinook salmon sport harvest has averaged 37,300 fish in Southcentral Alaska and 7,950 fish in the Susitna Basin since 1978 (Table E.3.2.5). This represents an annual Susitna Basin contribution of 21 percent to the Southcentral chinook sport harvest over the six year period. The largest Susitna Basin sport harvest of chinook salmon on record occurred in 1983, when 12,420 fish were caught by fishermen (Mills 1984).

(vi) Chum Salmon (*)

The Susitna Basin and Southcentral Alaska annual chum salmon sport harvests have averaged 6,800 and 12,150 fish respectively since 1978 (Table E.3.2.5). The largest sport catch of chum salmon on record in the Susitna Basin occurred in 1978 when 15,700 fish were landed (Mills 1979). For the years 1981 to 1983, chum salmon sport harvests have averaged between 1.4 and 1.8 percent of the estimated Susitna Basin chum salmon escapement (Table E.3.2.5).

(vii) Sockeye Salmon (*)

The annual sockeye salmon sport harvest has averaged 112,900 fish in Southcentral Alaska and 2,100 fish in the Susitna Basin for the years 1978 through 1983 (Table E.3.2.5). In 1983 over 5,500 sockeye salmon were caught by fishermen in the Susitna Basin, which is the largest annual sport catch on record (Mills 1984). The sport catch of sockeye from 1981 through 1983 has averaged 3 percent or less of the estimated Susitna Basin sockeye escapement (Table E.3.2.3).

(c) Subsistence Fishing (*)

The only subsistence fishery on Susitna River fish stocks that is officially recognized and monitored by the Alaska Department of Fish and Game is near the village of Tyonek, approximately 30 miles (50 km) southwest of the Susitna River mouth. The Tyonek subsistence fishery was reopened in 1980 after being closed for sixteen years. From 1980 through 1983, the annual Tyonek subsistence harvest averaged 2,000 chinook, 250 sockeye and 80 coho salmon (ADF&G 1984e). Although the Tyonek fishery occurs in Cook Inlet, it is suspected that it intercepts fish bound mainly for the Susitna River.

2.2 - Species Biology and Habitat Utilization in the Susitna River Drainage (*)

2.2.1 - Species Biology (*)

(a) Salmon (*)

The biology of the five species of Pacific salmon inhabiting the Susitna River is described in terms of their freshwater life stages. Specifically, the following discussion focuses on the upstream migration of the returning adults, population estimates of the spawning adults, spawning locations and utilization of spawning habitats, incubation and emergence of the juveniles, and juvenile behavior after emergence from the natal areas.

(i) Chinook Salmon (*)

- Upstream Migration of Returning Adults (*)

Chinook salmon enter the Susitna River in late May and early June soon after the river becomes ice free. In general, 90 percent or more of the chinook escapement moves past the Susitna Station (RM 26) and the Flathorn Station (RM 8) prior to July 1 each year (ADF&G 1983a, 1984h, 1985b). Once the adults move into the river, they begin to disperse into various tributaries to spawn. Movement of chinook past the Sunshine Station (RM 80) begins in early June, peaks in mid to late June and and is essentially complete (more than 90 percent) by early July (ADF&G 1983a, 1984h, 1985b).

Movement of adult chinook into the middle reach of the Susitna River begins in early June, peaks near the end of June and continues to mid-July with 90 percent of the migration past Curry Station completed by late July (ADF&G 1983a, 1984h, 1985b, WCC 1985). The duration of adult chinook occurrence in the middle Susitna River is depicted in Figure E.3.2.7.

Adult chinook that reach Sunshine Station enter one of the three major upper subbasins of the Susitna River Drainage: The Chulitna River, the Middle Susitna River, or the Talkeetna River. Over 90 percent of the tagged adults observed in the Chulitna River were caught and tagged on the west bank at Sunshine Station. Similarly, over 90 percent of the tagged adults observed in the Talkeetna River were caught and tagged on the east bank at Sunshine Station. Tagged adults observed in the middle river (Talkeetna to Devil Canyon) were caught and tagged on both the east and west banks in approximately equal proportions (ADF&G 1985b).

Although adult chinook initially move into one of the three major subbasins initially, there is apparently some re-distribution prior to spawning. It is estimated that up to 45 percent of the adults moving past the Talkeetna Station (RM 103) and up to 10 percent moving past the Curry Station (RM 120) return downstream and spawn in either the Chulitna or Talkeetna Rivers or other tributaries downstream of RM 100 (ADF&G 1985b).

The rate of movement of adult chinook from the Sunshine Station upstream into the middle Susitna River is 1.8 to 3.3 miles per day (mpd) from Sunshine to Talkeetna Station and 2.2 to 4.3 mpd between the Talkeetna and Curry Stations (ADF&G 1983a, 1984h, 1985b).

- Population Estimates (*)

An accurate estimate of the total Susitna River chinook escapement is not available because the run in the lower river begins either before or during break-up of the ice cover and it has not been possible to sample the entire run. The only monitoring of chinook salmon in the lower river was conducted at the Sunshine Station where escapements have been quantified since 1982. Drainage-wide index counts from tributaries undertaken since 1981 established that most chinook escapement to the Susitna River occurs to tributaries entering the Susitna River downstream from the Sunshine Station.

A summary of the estimated escapements upstream of the Sunshine, Talkeetna and Curry Stations in 1982, 1983, and 1984 is presented in Table E.3.2.6. Escapement estimates at Sunshine Station have ranged from 52,900 to 121,700, at Talkeetna from 10,900 to 24,800, and at Curry from 9,700 to 18,000 between 1981 and 1984.

Assuming that approximately 10 percent of the chinook estimated to pass the Curry Station return downstream to spawn (ADF&G 1985b), the escapement of adult chinook into the middle river ranges from 8,000 to 15,000 fish annually.

- <u>Age Composition</u> (*)

In general, adult chinook salmon return to the Susitna River to spawn as age 5 and 6 fish with with considerable variation age composition between years (ADF&G 1984h, 1985b). Each year, some age 3 and 7 fish are also present in the population and occasionally may constitute a significant portion of the spawning population (ADF&G 1984h). A summary of the age composition of fish observed in 1981-1984 at each of the sampling stations is presented in Table E.3.2.7.

Based on scale analyses of these fish, it is estimated that more than 95 percent of the adult chinook salmon outmigrated from the Susitna River as Age 1+ juveniles (ADF&G 1985b).

- <u>Spawning Locations and Utilization of Spawning Habitats</u> (**)

Chinook salmon spawn exclusively in clearwater tributaries of the Susitna River (ADF&G 1983a, 1984h, 1985b, WCC 1985). Index counts of chinook in tributaries throughout the Susitna basin have been collected since 1976. A summary of these counts is presented in Table E.3.2.8 and provides a general description of the distribution of spawning areas and their relative importance for chinook spawning activity.

Indian River (located at RM 138.5) and Portage Creek (at RM 140) provide spawning habitat for nearly all of the chinook salmon migrating into the middle Susitna Rivers. A summary of peak index counts for all tributaries of the middle Susitna River since 1981 is provided in Table E.3.2.9 and is depicted graphically in Figures E.3.2.8 through E.3.2.13. These tributary habitats will not be affected by the changed flow regime attributable to the proposed project.

A few chinook, approximately 20 to 45 individuals, were observed in small tributaries located upstream of the rapids in Devil Canyon (ADF&G 1983a, 1984h, 1985b). Prior to these observations, velocity barriers in the rapids were thought to prevent salmon migration into the upper reaches of the Susitna. No other species is known to migrate upstream, through Devil Canyon.

- Incubation and Emergence (**)

Approximately 4,000 to 8,000 pairs of chinook salmon spawn in tributaries of the middle river. Spawning occurs in July and early August. Average fecundity of female chinook has not been estimated for Susitna River stocks, but Morrow (1980) reports average fecundities range from 4,200 to 13,600 eggs per female in Alaska. Incubation begins with egg deposition in July and ends with emergence of the fry from the spawning gravels in March or April (ADF&G 1983m). The incubation period for chinook salmon is depicted on Figure E.3.2.7.

- Juvenile Behavior (**)

Chinook emerge from the spawning gravels in late-March to mid-April. The fry remain near their natal areas in tributaries for one to two months before initiating a downstream movement into rearing and overwintering areas (ADF&G 1983m, 1984c). The initial downstream movement may result from territorial behavior by the juveniles. Some age 0+ juveniles move into the mainstem of the Susitna and have been collected throughout the drainage basin during the summer. The remainder of the age 0+ juveniles apparently remain in the natal tributaries for initial rearing and overwintering (ADF&G 1983m, 1984c). In general approximately 40 percent of the juvenile chinook (all ages) in the middle river are found in mainstem-associated habitats from May through November. Approximately 60 percent are found in tributary habitats during the same period.

The age 0+ juveniles that move into the mainstem of the middle river generally become associated with areas with moderate water velocity (<1.5 ft/sec), shallow depths (<2 ft) and high structural diversity for cover (ADF&G 1983m, 1984c). Where structural diversity is lacking, the juveniles apparently use turbid water for cover (ADF&G 1984c, 1985c, EWT&A and WCC, 1985). In the lower Susitna

River (i.e. downstream of Talkeetna), highest densities of Age 0+ juveniles were collected in tributary mouth areas characterized by deep, low velocity, clear water (ADF&G 1985c).

During the initial rearing period, juvenile chinook feed extensively on chironomid larvae (Insecta: Diptera) (ADF&G 1983m, 1985j). Terrestrial adult insects obtained from the water surface also provided a significant portion of the juvenile chinook diet (ADF&G 1983m, 1985j). Growth of age 0+ juveniles during the summer months was estimated from length measurements in 1982 and 1984 (ADF&G 1983m, 1985c). In May, age 0+ fish average between 40 and 45 mm in length. By October, average lengths of age 0+ fish range from 60 to 80 mm (ADF&G 1983m, 1985c). Growth rates of juveniles in tributaries tend to be greater than those in the mainstem (Table E.3.2.10).

Estimates of the total number of juvenile chinook have not been obtained for the middle Susitna River. However, it was estimated that in 1983, approximately 10,635,000 eggs were deposited by adult females in Indian River which provided a total production of approximately 3,211,000 chinook fry in 1984. Hence, survival from egg to fry was approximately 30 percent (ADF&G 1985c). Survival from the fry stage to outmigration as Age 0+ or 1+ fish has not been estimated for chinook.

From September through November, age 0+ fish move into clear water areas such as tributaries, tributary mouths and side sloughs (WCC 1985, ADF&G 1983m, 1984c) where they overwinter. The juveniles apparently grow during the winter and spring since Age 1+ juveniles average between 85 to 95 mm in length in late May (ADF&G 1983m). Average lengths of outmigrating Age 1+ fish are between 100 and 120 mm at the end of July and early August.

Outmigration patterns of juvenile salmon from the middle Susitna differ between Age 0+ and 1+ fish. Age 0+ juvenile outmigration, as determined from outmigrant trapping rates at Talkeetna, occur at a relatively constant rate throughout the summer with two peak outmigration periods recorded in 1982 in late June and early July and mid-August (ADF&G 1984c). In 1983, several peak outmigration events were observed (ADF&G 1985c). A similar, relatively constant rate of outmigration was observed at the Flathorn Station in the lower river. Age 1+ juveniles begin to outmigrate from the middle river in early May. Outmigration of Age 1+ fish from the middle Susitna River is essentially complete by mid-July (ADF&G 1984b, 1985c). Outmigration from the lower river peaks in mid-June and is completed by early August (ADF&G 1985c).

It is not clear as to whether the Age 0+ outmigrant juveniles survive once they enter the salt water environment. Although a large portion of the out-migrating juveniles are Age 0+ fish, scale analysis of returning adults indicates that fish outmigrating as Age 0+ juveniles comprise less than 5 percent of the total escapement (ADF&G 1985b).

The period in which juvenile chinook salmon inhabit the middle river is depicted in Figure E.3.2.7. In general, juvenile chinook inhabit the middle river throughout the year. A single age cohort moves into the river habitat from the tributaries in June or July. Some of these migrate downstream to the lower river while the remainder spend one winter in clearwater habitats associated with the mainstem. The following spring, these juveniles outmigrate to the lower river and on to Cook Inlet. Outmigration of this age group from the Devil Canyon to Talkeetna reach peaks prior to early June and terminates by the end of July throughout the drainage.

(ii) Sockeye Salmon (**)

- Upstream Migration of Returning Adults (**)

Sockeye salmon enter the Susitna River system in two distinct runs (ADF&G 1984h, 1985b). The first run enters the river in late May and early June. The run passes the Sunshine Station beginning in early June and is complete by the end of June (ADF&G 1985b). Although a few first run fish initially enter the middle Susitna River, all first run sockeye migrate into the Talkeetna River and spawn in the inlet to Papa Bear Lake which is outside the area to be affected by the project.

Second run sockeye enter the Susitna River during the last half of June. Migration of second run fish past the Sunshine Station occurs during the last half of July and the first half of August (ADF&G 1984h, 1985b). Second run sockeye enter the middle Susitna River in late July and are present through August each year. The occurrence of second run adult sockeye in the middle Susitna is depicted in Figure E.3.2.7. The escapement to the Flathorn Station in 1984 was approximately 605,800 fish. Of these only 3,500 fish were estimated to spawn in the middle river. This indicates that nearly all second-run sockeye spawn in tributaries entering the Susitna at or downstream of the Chulitna River confluence.

As was the case for chinook salmon, a significant proportion of the sockeye that initially move into the middle Susitna return downstream and spawn in stream-lake systems in the Chulitna and Talkeetna River subbasins. In 1984, approximately 35 percent of the sockeye that reached the Curry Station were fish that returned downstream to spawn in other tributary systems.

Because there are no stream-lake systems associated with the middle Susitna River, the viability of the sockeye spawners in the middle Susitna River has been questioned. Spawning sockeye in the middle river may be strays from the Talkeetna or Chulitna Rivers (ADF&G 1983a). Comparison of scales collected from fish in the respective subbasins did not provide conclusive evidence that the middle Susitna population is viable (ADF&G 1983a). However, the collection of overwintering juveniles and Age 1+ juveniles can be interpreted as evidence that the spawners in the middle river do constitute a viable population (ADF&G 1984c). In addition, the fact that the number of sockeye using the middle river for spawning is relatively constant and that they tend to use the same areas each year may also be interpreted as support for the conclusion that the population is viable. These trends are discussed in more detail below.

The rate of movement of tagged second run sockeye into the middle river is more rapid than for chinook. Adults, tagged at Sunshine Station, move between 2.4 and 5.8 mpd, from the Sunshine to the Talkeetna Stations. The average rate of travel from the Talkeetna Station to the Curry Station ranged from 2.4 to 8.5 mpd from 1981 through 1984. (ADF&G 1981a, 1983a, 1984h, and 1985b). Measurements of rates of movement were not obtained for the first run.

- Population Estimates (**)

Estimates of the number of first run sockeye escaping upstream of the Sunshine Station into the Talkeetna River were approximately 5,800 fish in 1982, 3,300 fish in 1983 and 4,800 fish in 1984.

Minimum escapements of second run sockeye into the Susitna Basin range from 175,900 in 1983 to 605,800 in 1984 with an average of 248,400 fish (ADF&G 1981a, 1983a, 1984h, 1985b, WCC 1985). In 1984, approximately 25 percent of the second run sockeye in the Susitna Basin migrate into the Yentna subbasin to spawn. Estimates of the numbers of second-run sockeye that migrate upstream of the Sunshine, Talkeetna and Curry Stations are summarized for the period 1981-1984 in Table E.3.2.6. In 1984, the second-run sockeye escapement for these stations were 130,000 (Sunshine Station), 13,050 (Talkeetna) and 3,593 (Curry).

Estimates of the total number of sockeye spawning in the middle river were obtained from periodic spawning area counts and estimates of stream life (ADF&G 1984h, 1985b). Based upon this analysis, a total of 2,200 fish spawned in the middle river in 1981, 1,500 in 1982, 1,600 in 1983 and 2,200 fish in 1984. Similar comparison with the estimated escapement past the Talkeetna Station indicates that up to 95 percent return downstream to spawn.

- Age Composition (**)

The age structure of the second run sockeye population is dominated by Age 4 and Age 5 fish. First run sockeye are predominately Age 5 fish whereas second run fish are predominately a mix of Ages 4 and 5. In 1981 and 1982, 71 and 73 percent of the second run fish at Sunshine Station were Age 5 while in 1983 and 1984, 64 and 63 percent were Age 4 (ADF&G 1985b). Some Age 3 and Age 6 adults are also present but do not represent a significant portion of the population.

Based upon scale analysis of these fish, it is estimated that over 90 percent of returning adults spent at least one winter in freshwater prior to outmigrating to salt water (ADF&G 1983a, 1984h, 1985b). A summary of the age composition of the sockeye population is presented in Table E.3.2.11.

- Spawning Locations and Utilization of Spawning Habitat (**)

Nearly all of the sockeye salmon that spawn in the middle river utilize slough habitats (WCC 1985, EWT&A & WCC 1985, HE 1984b, HE 1985a). Estimates of the number of sockeye spawning in particular sloughs were obtained for 1981-1984 (ADF&G 1984h, 1985b). Twenty-three sloughs were utilized to varying degrees. Estimates of the total number of sockeye in each slough and proportions of the total escapements into the middle Susitna for each year are summarized in Table E.3.2.12. The locations and relative abundance in terms of peak index counts are presented in Figures E.3.2.8 through E.3.2.13. Sloughs 8A and 11 provided spawning habitat for over 80 percent of the slough spawning sockeye in the middle river in 1984 (1,812 of 2,227 sockeye spawning in sloughs).

Up to 33 sockeye were observed spawning in side channels and mainstem areas. Also, as many as 13 individuals were observed in tributaries. (WCC 1985, ADF&G 1985b). Specific characteristics of the habitats utilized by the spawning sockeye are discussed in Section 2.2.2.

- Incubation and Emergence

Sockeye salmon spawn between the end of August and the end of September (ADF&G 1983a, 1984h, 1985b). Based on the estimated escapement of sockeye to the middle Susitna River, between 500 and 1,000 pairs of sockeye spawn. The average fecundity of female sockeye is approximately 3350 eggs per female (ADF&G 1984h). Therefore, between 1,500,000 and 3,500,000 eggs are deposited each year. Emergence of sockeye fry from the spawning gravels occurs in March (ADF&G 1983e, 1983m). The incubation period is depicted in Figure E.3.2.7.

- Juvenile Behavior (**)

Juvenile sockeye generally rear in lake habitats and outmigrate as Age 1+ or Age 2+ fish. However, in the middle Susitna, suitable lakes are not available for rearing sockeye. Therefore, juvenile sockeye either rear in clearwater areas of the middle river or they migrate to the lower Susitna River during their first year (ADF&G 1983a, 1984c). Based upon results obtained from outmigrant traps at the Talkeetna Station, a major portion of Age 0+ sockeye evidently move to the lower river (ADF&G 1984c, 1985c). A portion of the juveniles, however, remain in the middle reach where they rear and overwinter in side slough and upland slough areas (ADF&G 1983e, 1983m, 1984c, 1985c, WCC 1985).

Juvenile sockeye salmon feed predominately on chironomid larvae, pupae and adults (ADF&G 1983m, 1985j). The juvenile sockeye in the middle Susitna River grow from an average length of 30 mm in May to 56 mm at the end of August (ADF&G 1985c).

In the lower river, Age 0+ juveniles grow from an average of 36 mm in early June to an average of 60 mm in October (ADF&G 1985c). Age 1+ fish grow from an average length of 71 mm in May to an average length of 92 mm in July. A summary of lengths of Age 0+ and Age 1+ juveniles in provided in Table E.3.2.13.

It is possible that Age 0+ fish that move out of the middle reach move into side channel, side slough or tributary mouth areas in the lower Susitna River where they overwinter. However, results of outmigrant collections at the Flathorn Station in 1984 indicate that significant movement of Age 0+ juveniles to the estuary also occurs. (ADF&G 1985c). Based upon the results of adult scale analysis, it is likely that most of these fish do not survive (ADF&G 1985b) (See Table E.3.2.11).

Outmigration of Age 1+ juveniles begins and peaks in mid May immediately after the river becomes ice free. Outmigration rates of Age 1+ fish then decrease and the migration is essentially complete by mid to late June (ADF&G 1985c). The duration of juvenile sockeye occurrence in the middle Susitna is depicted in Figure E.3.2.7.

(iii) Coho Salmon (**)

- Upstream Migration of Returning Adults (**)

Coho salmon enter the Susitna River begining in mid-July. The movement of coho past the Susitna Station peaks in early August and is essentially complete by late August (ADF&G 1983a, 1984h, 1985b, WCC 1985). Coho migrate past the Sunshine Station begining in mid July with over 90 percent of the migration past Sunshine by mid to late August. Coho adults are abundant from the first of August to early September in the middle river (ADF&G 1983a, 1984h, 1985b). The duration of coho movement into the middle river is depicted in Figure E.3.2.7.

Although coho initially move into the middle river, a majority (75 percent of those migrating past the Talkeetna Station) return downstream to spawn in areas below the Talkeetna Station (ADF&G 1984h, 1985b). Up to 45 percent of the coho migrating past the Curry Station return downstream to spawn (ADF&G 1985b).

The rate of movement of adult coho from Sunshine Station upstream into the middle Susitna River varies from year to year. The rate of migration from Sunshine Station to Curry Station averaged 4.0 mpd in 1981, 5.3 mpd in 1982, 1.4 mpd in 1983 and 2.9 mpd in 1984. Movement rates from the Talkeetna Station to Curry Station averaged 11.3 mpd in 1981, 10.0 mpd in 1982, 5.7 mpd in 1983 and 2.8 mpd in 1984 (ADF&G 1981a, 1983a, 1984b, 1985b).

- Population Estimates (**)

The total estimated escapement of coho into the Susitna River ranged from 25,000 to 190,000 fish annually from 1981-1984 (ADF&G 1981b, 1983a, 1984h, 1985b). Estimates for 1981, 1982 and 1983 minimum escapements are derived from the sum of the fish estimated to escape into the Yentna River and to Sunshine Station (ADF&G 1984h, WCC 1985). The estimates do not include numbers of coho that spawn in tributaries entering the Susitna River between the Yentna River and Sunshine Station. A summary of the estimated escapements for 1981-1984 past the Sunshine, Talkeetna and Curry Stations is provided as Table E.3.2.6.

Assumming that approximately 75 percent of the estimated number of coho migrating past the Talkeetna Station return downstream to spawn, the total number of coho estimated to spawn in the middle reach ranges from 500 to 3,000 fish annually (ADF&G 1984h, 1985b). In 1984, the total middle river escapement accounted for approximately 0.3 percent of the total Susitna basin escapement. These fish spawn almost exclusively in tributaries which will not be affected by flow or temperature changes associated with the project.

- Age Composition (**)

The age composition of adult coho indicates two predominant life histories in the population that spawns in the Susitna River. The majority of the spawning population consists of Age 4 fish which outmigrated from the freshwater environment during the third year of life (Age 2+ juveniles). The remainder of the adults return to spawn as Age 3 fish which outmigated from the freshwater environment during their second year of life (Age 1+ fish). A few coho adults return to the river as Age 2 or Age 5 adults (ADF&G 1983a, 1984h, 1985b). A summary of the age composition of fish observed in 1981-1984 at each of the sampling locations is presented in Table E.3.2.14.

There are two distinct patterns of juvenile rearing and outmigration. It is evident that the majority of the juvenile coho rear for two complete years prior to outmigrating as Age 2+ fish. However, a significant number of the juvenile coho rear for only one year and outmigrate as Age 1+ fish.

- Spawning Locations and Utilzation of Spawning Habitat (**)

Coho salmon spawn almost exclusively in tributaries in the middle Susitina River. A few coho have been observed in mainstem and slough areas. However, these individuals were not observed to spawn (ADF&G 1983a, 1984h, 1985b). Index counts of coho in tributaries of the middle reach were made to determine the relative importance of each tributary for coho spawning. Of 25 streams surveyed for utilization by spawning coho, only 10 to 12 streams are used to any extent. Coho spawn primarily in Indian River (RM 138.5) and Whiskers Creek (RM 101). A summary of the relative importance of each tributary for coho spawning for 1981-1984 is provided in Table E.3.2.15. Peak index counts of coho are depicted graphically in Figures E.3.2.8 through E.3.2.13. These habitats will not be affected by changes in mainstem discharge or temperature regimes associated with the project. Spawning activity occurs between the first week in September and the first week of October (Figure E.3.2.7).

- <u>Incubation and Emergence</u> (**)

Incubation of coho embryos begins in mid September. Between 250 and 1,500 pairs of coho spawn annually. Average fecundity is approximately 2,800 eggs per female (ADF&G 1983a, 1984h, 1985b). Therefore, between 700,000 and 4,200,000 eggs are deposited each year.

Emergence of fry from the spawning gravels occurs between late April and early May (ADF&G 1984c). The incubation period is depicted in Figure E.3.2.7.

No estimate of juvenile population size has been made, therefore, egg-to-fry survival cannot be estimated.

- <u>Juvenile Behavior</u> (**)

After emergence from the spawning gravels, juvenile coho initiate a general downstream movement within the tributaries. Some of the Age 0+ juveniles move out of their natal tributaries into the mainstem. The remainder apparently remain in the tributaries for rearing and overwintering. At Age 1+, more coho juveniles move out of the tributaries into the mainstem. Age 1+ juveniles also remain in the tributaries, overwinter for a second year and outmigrate as Age 2+ fish. (ADF&G 1983n 1984c, 1985c, 1983n).

Juvenile coho that move into the mainstem of the middle reach generally move into clearwater areas including tributaries, tributary mouths, upland and side sloughs (ADF&G 1983m, 1984c, 1985c). Juvenile coho prefer low-velocity clearwater areas with high structural habitat diversity. During the fall, juvenile coho move into upland and side sloughs to overwinter.

The average size of Age 0+ juvenile coho in the middle river increased from approximately 40mm in length to approximately 70mm in length from May through September (ADF&G 1985c) as measured at the Talkeetna Station outmigrant trap. In the lower river, the average length of Age 0+ juveniles increased from approximately 40 mm in June to approximately 90 mm in late September and early October (ADF&G 1985c). Age 1+ juveniles (1982 Brood year) in the middle river grew from an average length of approximately 70 mm in June to over 115 mm in October. In the lower river, the average length of Age 1+ juveniles increased from approximately 90 mm in May to approximately 110 mm in October. (ADF&G 1985c).

Only a few Age 2+ juvenile coho (1981 brood year) were collected in each sampling period throughout the 1984 open water season. Consequently, no significant increase in length through the summer was evident (ADF&G 1985c). Incremental increases in average sizes of juvenile coho during the 1984 summer collecting season are summarized in Table E.3.2.16.

Stomach contents of juvenile coho were examined in 1982 and 1984 (ADF&G 1983m, 1985c). Chironomid larvae were found to numerically dominate the food items in both studies.

In 1983, outmigration of Age 0+, 1+ and 2+ juveniles from the middle reach was relatively constant through the summer. A major peak of outmigrating Age 0+ juveniles in August coincides with the redistribution of the fish to overwintering habitats in the lower river (ADF&G 1984c). In 1984, Age 0+ juveniles outmigrated in early August and Age 1+ and 2+ fish outmigrated primarily in June (ADF&G 1985c).

Outmigration of Age 0+ juveniles from the lower river peaked in late August and again in early October in 1984 (ADF&G 1985c). Peak outmigration of Age 1+ and 2+ fish occurred in early September (ADF&G 1985c).

Based upon scale analysis of returning adult coho, it is likely that the outmigrating Age 0+ juveniles do not survive once they move into salt water. Juveniles that outmigrate as Age 1+ or Age 2+ fish are the largest contributors to the adult population.

The duration of occurrence of juvenile coho in the middle Susitna River is depicted in Figure E.3.2.7

(iv) <u>Chum Salmon</u> (***)

- <u>Upstream Migration of Returning Adults</u> (**)

Adult chum salmon enter the Susitna River basin beginning in mid July. Adult chum are abundant in the lower river until the end of August with 90 percent of the escapement passing the Susitna Station or Flathorn Station during the last two weeks of August (ADF&G 1981a, 1983a, 1984h, 1985b). Over 90 percent of the chum which enter the Susitna River migrate past the Sunshine Station to spawn in one of the three major subbasins of the Susitna Drainage: the Chulitna River, the middle Susitna River or the Talkeetna River (See below).

Migration of chum salmon past the Sunshine Station generally begins in early July and is essentially complete by the end of August each year. Peak movement of chum past the Sunshine Station generally occurs in the last week of July or the first week of August (ADF&G 1981b, 1983a, 1984h, and 1985b).

Initial migration into the middle Susitna (i.e. past the Talkeetna and Curry Stations) begins during the last half of July, peaks in early August and is basically complete by the end of August (ADF&G 1981b, 1983a, 1985b).

Rates of movement of chum salmon are greater than rates estimated for chinook, sockeye and coho. The average rates of movement upstream from Sunshine to Talkeetna ranged from 3.3 mpd in 1981 to 5.8 mpd in 1984. From Talkeetna to Curry, average movement rates ranged from 4.2 mpd in 1981 and 1982 to 8.5

mpd in 1982 and 1984 (ADF&G 1981b, 1983a, 1984h, and 1985b).

- Population Estimates (***)

Minimum escapement of chum salmon into the Susitna River in 1981, 1982 and 1983 were 280,000, 460,000 and 275,000 fish, respectively (ADF&G 1981b, 1983a, 1984h). In 1984, the estimated escapement of chum salmon to the Susitna River was 813,000 fish based on results obtained from the Flathorn Station (ADF&G 1985b).

Apparently, more than 90 percent of the chum escapement migrates past the Sunshine Station. This is evidenced by the 1984 estimate of 765,000 fish moving upstream of Sunshine compared with the estimated 813,000 fish migrating past the Flathorn Station (ADF&G 1985b). A summary of the estimated escapement of chum past the Sunshine, Talkeetna and Curry Stations for 1981-1984 is presented in Table E.3.2.6. Annual averages for these stations are 431,025 (Sunshine), 54,625 (Talkeetna) and 28,225 (Curry).

Based upon estimated escapements to spawning areas in the mainstem, side sloughs and tributaries described below, 75 percent of the escapement past the Talkeetna Station and 45 percent of the escapement past the Curry Station returned downstream to spawn (ADF&G 1985b). Therefore, it is estimated that less than 2 percent of the entire Susitna River chum escapement spawn in habitats associated with the middle river.

- Age Composition (**)

The majority of the returning adults were Age 4 fish, followed by Ages 3 or 5. (ADF&G 1981b, 1983a, 1984h, and 1985b). In 1983, Age 5 fish were most abundant. A few return at Age 6. A summary of the age composition of chums observed in 1981-1984 at each of the sampling stations is presented in Table E.3.2.17.

All of the chum salmon returning to spawn in the Susitna River, outmigrated as Age 0+ juveniles (ADF&G 1981a, 1983a, 1984h, 1985b).

- <u>Spawning Locations and Spawning Habitat Utilization</u> (*)

Adult chum salmon utilize the widest range of habitats for spawning of any of the Pacific salmon using the middle reach. Based on estimated escapements past each of the sampling stations, over 95 percent of the total chum salmon escapement into the Susitna River spawn in areas upstream of the Sunshine Station at RM 80 (ADF&G 1985c).

Chum utilize tributary, side slough, side channel and mainstem areas for spawning within the middle reach.

Tributaries commonly used by spawning chum salmon include Indian River, Portage Creek and 4th of July Creek. Several other streams are used, but to a lesser extent. A summary of peak escapement estimates in tributaries of the middle Susitna River is provided in Table E.3.2.18 and the peak escapements are depicted in Figures E.3.2.8 through E.3.2.13. Based upon the peak counts, the total escapement of chum salmon to tributaries was estimated to be 3,400 fish in 1981, 3,500 fish in 1982 (ADF&G 1983a), 2,800 fish in 1983 (ADF&G 1984h), and 7,600 fish in 1984 (ADF&G 1985b). These numbers represent 16.3, 7.0, 5.5 and 7.7 percent of the estimated escapements past the Talkeetna Station in each of the respective years (not accounting for return of adults downstream). Similarly, these represent 26.7, 11.9, 13.3 and 15.4 percent of the estimated escapements past the Curry Station in each of the respective years.

Chum salmon spawned in nearly every slough within the middle Susitna during the 1981-1984 summers. Peak escapements to each slough are depicted in Figures E.3.2.8 through E.3.2.13. In 1983 and 1984 stream life surveys indicated that the average time chum salmon inhabit the spawning areas in sloughs was 6.9 days (ADF&G 1984h, 1985b). Using the average stream life and the total number of fish-days for chum in each slough, estimates of the total number of chum spawning in the sloughs were calculated (ADF&G 1984h, 1985b). Total slough escapements are summarized for each slough in Table E.3.2.19. The total numbers of chum salmon using slough habitats were 4,500 fish in 1981, 5,000 fish in 1982, 2,900 fish in 1983, and 14,600 fish in

1984 (ADF&G 1984h, 1985b). These estimates represent 21.6, 10.2, 5.7 and 14.9 percent of the escapements past the Talkeetna Station in each of the sampling years, respectively. Similarly, these represent 34.3, 17.3, 13.8 and 29.3 percent of the estimated escapement past the Curry Station each of the sampling years. Sloughs 8A, 9, 11 and 21 support more than 50 percent of middle river slough spawning chum salmon.

Chum salmon have also been observed to spawn in side channel and mainstem habitats. In the middle reach, nine chum spawning areas were identified to have spawning in 1982 (ADF&G 1983a), and no estimate of the total number spawning in those areas was obtained. In 1983, six sites were identified to support chum salmon spawning (ADF&G 1984h). Less than 1,000 fish were estimated to utilize these habitats. In 1984, 36 sites were identified as supporting adult chum spawning. An estimated total of 3,000 fish used these sites. The increases in identified use of mainstem sites for spawning in 1984 was due principally to a more intensive survey and to the increased escapement to the middle reach over previous years. In 1984, mainstem and side channel sites provided spawning areas for less than 4 percent of the escapement past Talkeetna and less than 8 percent of the escapement past Curry (ADF&G 1985b).

Based on these estimated numbers of chum salmon observed to spawn in the middle reach, approximately 75 percent of the escapement past Talkeetna and 45 percent of the escapement past Curry return downstream to spawn in areas below RM 98 where the Chulitna River merges with the Susitna River (ADF&G 1985b).

Chum salmon spawn almost exclusively in areas having groundwater upwelling (ADF&G 1983k, 1984b). Although groundwater upwelling is the principal factor associated with spawning locations, chum salmon spawning habitat is also characterized by water depths greater than 0.8 ft., water velocities between 0 and 2 ft. per second, and substrate ranging in size from large gravel to cobble (ADF&G 1984b). The sizes of substrate used by chum salmon are large in comparison with substrate sizes utilized elsewhere in Alaska (Hale 1981b, Wilson et al, 1981). This is probably due to the dependence of chums on upwelling areas and overestimation of the predominant substrate sizes by the investigators (ADF&G 1984b).

Spawning by adult chum occurs between the middle of August and the end of September in all areas (ADF&G 1983a, 1984h, 1985b). This period is depicted in Figure E.3.2.7.

- Incubation and Emergence (**)

Incubation of the chum embryos begin with deposition of the eggs in mid August to late September (Figure E.3.2.7).

Emergence of the fry from the spawning substrate occurs in February and March (ADF&G 1983m, 1984c, 1985c).

Based upon the estimated number of spawning chum salmon in the middle reach, between 3,000 and 13,000 pairs of chum salmon spawn in areas associated within the middle reach. The fecundity of chum salmon is approximately 3,200 eggs per female. Therefore, between 9,600,000 and 41,600,000 eggs are deposited each year. Egg to fry survival is estimated to be 12 to 14 percent (ADF&G 1984c,).

- Juvenile Behavior (**)

After emerging from the spawning gravels, juvenile chum salmon remain near the natal areas until early to mid-May. They then begin a general downstream movement out of the middle Susitna River. All juvenile chum outmigrate from the middle river by the end of July (ADF&G 1983m, 1984c, 1985c). In the intervening period, the juveniles increase in average size from a length of 40 mm in May to 48 mm in July (ADF&G 1985c).

Outmigration from the lower Susitna River into Cook Inlet similarly occurs between late May and mid-July (ADF&G 1985c). Peak outmigration of juvenile chum occurs in mid-June for both the middle and lower reaches (ADF&G 1985c).

No additional growth increment was observed for chum salmon between the Talkeetna Station outmigrant trap and the Flathorn outmigrant trap in 1984 (ADF&G 1985c).

The outmigration period for chum salmon is depicted in Figure E.3.2.7.

(v) Pink (**)

- Upstream Migration of Returning Adults (**)

Pink salmon enter the Susitna River in late June to early July. Movement of the adults upstream is rapid with the movement of fish past the Sunshine Station beginning in early July and ending in mid August (ADF&G 1983a, 1984h, 1985b). Movement of pink salmon into the middle reach begins in mid-July and is complete by mid-August, as determined from the movement past the Talkeetna Station. Essentially all of these fish spawn in tributaries upstream from the influence of mainstem discharges and will not be affected by the proposed project.

As with the other salmon species, the movement of pink salmon into the middle river does not indicate where they will spawn. Up to 85 percent of the pink that migrate past the Talkeetna Station and up to 80 percent migrating past the Curry Station return downstream to spawn elsewhere in the river system (ADF&G 1985b).

The rates of upstream movement of pink salmon ranged from 2.6 to 7.7 mpd from the Sunshine Station to the Talkeetna Station and from 5.7 to 17.0 mpd from Talkeetna to Curry (ADF&G 1985b). The migation period is depicted in Figure E.3.2.7.

- Age Composition (**)

Two distinct stocks of pink salmon use the Susitna River to spawn. All pink salmon follow a two year life history and return to spawn as Age 2 fish. The two stocks are distinguished as even-year fish (those which spawn in even-numbered years) and odd-year fish. As discussed below, the even-year stock is numerically dominant in the Susitna River.

- Population Estimates (**)

The numerical dominance of the even-year pink stock is evidenced by the estimated escapement to the Susitna River. Minimum escapement of adult pink salmon in 1982, based on the sum of the Sunshine Station and Yentna escapements was 890,500 fish (ADF&G 1983a). In 1984, the escapement past the Flathorn Station was estimated to be 3,629,900 fish (ADF&G 1985b). Estimates of the minimum escapements in 1981 and 1983 were 85,600 and 101,200 fish, respectively (sum of Sunshine and Yentna Station escapements) (ADF&G 1981a, 1984h).

Estimated escapement of pink salmon upstream of the Talkeetna Station was 73,000 and 177,900 in 1982 and 1984, respectively. In 1981 and 1983, the estimated escapements past Talkeetna Station were 2,300 and 9,500 fish, respectively. Escapement estimates for all sampling stations are summarized in Table E.3.2.6. Based on 1984 results, less than one percent of the total Susitna Basin pink salmon escapement spawned in habitats associated with the middle river.

- Spawning Locations and Utilization of Spawning Habitats (**)

More than 90 percent of the pink salmon in the middle reach spawn in tributaries that are not affected by mainstem discharges and, therefore, will not be affected by the project. A summary of peak index counts of pink salmon in the tributaries is presented as Table E.3.2.20 for the four year sampling period. The distribution of spawning locations is depicted on Figures E.3.2.8 through E.3.2.13.

A small portion of the pink salmon spawn in slough habitats. Even-year pink salmon tend to spawn in sloughs more than odd-year pink salmon. Whether this difference is due to stock differences or density differences is not known. Peak counts in slough areas are depicted in Figures E.3.2.8 through E.3.2.13.

Spawning activity occurs during August and occasionally during the first week of September (See Figure E.3.2.7).

- Incubation and Emergence (**)

Incubation of pink salmon embryos begins with deposition of the eggs in August. Emergence of the fry probably occurs in March and April.

In odd years, 100 to 600 pairs of pink salmon spawn in the middle reach based upon the estimated escapement and the estimated return downstream (ADF&G 1985b). In even years between 5,000 and 12,000 pair of pink salmon spawn in the middle reach. The estimated fecundity of pink salmon is 1,500 eggs per female (ADF&G 1984h). Therefore, in odd years between 150,000 and 900,000 eggs are deposited. In even years, between 7,500,000 and 18,000,000 eggs are deposited. No estimate of egg to fry survival of pink salmon in the Susitna River is available.

- Juvenile Behavior (**)

After emergence from the spawning gravels, juvenile pink salmon move out of the tributaries and the middle reach almost immediately with no increase in size. Peak outmigration of pink juveniles occurs by mid June (ADF&G 1985c), and is complete by mid July.

(b) Other Anadromous Species (o)

(i) Bering Cisco (o)

The Bering cisco is a coregonid (whitefish) that occurs from the Beaufort Sea to Cook Inlet. Although Bering cisco have been collected from upper Cook Inlet and the Knik Arm, the species was not known to inhabit the Susitna River drainage prior to 1980-1981 ADF&G studies. Interior and western Alaskan populations appear to contain both anadromous and freshwater resident forms. Susitna River Bering cisco appear to be anadromous (ADF&G 1981a).

Bering cisco were collected in the lower Susitna River between RM 70 and RM 98.5 in 1981 and 1982 (ADF&G 1983a). In 1981, the migration began in August at Susitna Station (RM 26) and on September 8 at Sunshine Station (RM 80). The 1981 fishwheel catches peaked on September 21 at Sunshine. In 1982, the migration began on August 7 at Susitna Station and on September 4 at Sunshine Station. The 1982 fishwheel catches peaked on September 27.

During 1981, spawning concentrations were identified at RM 78-79, 76-77.5 and 75. In 1982, spawning was confirmed at RM 76.8-77.6 and 81.2 (ADF&G 1983a). It is suspected that spawning may occur throughout the reach between RM 30 and RM 100 (ADF&G 1981e). Spawning substrates were composed primarily of 1- to 3-inch (2.5- to 7.5-cm) gravel. Peak spawning occurred during the second week of October in both 1981 and 1982 (ADF&G 1983). Susitna River Bering cisco appear to occupy their spawning grounds 15 to 20 days. After spawning, these fish migrate downstream to sea (ADF&G 1981a). No spawning areas for the Bering Cisco are known to exist in the middle river.

(ii) Eulachon (o)

The eulachon is an anadromous member of the smelt family that spends most of its life in the marine environment. Adults are believed to live at moderate ocean depths in the vicinity of the echo-scattering layer and in close proximity to shore. In the northern portion of its range, eulachon spawn in May and June.

During 1982, the spawning migration appeared to be composed of two segments: an early run that started prior to May 16 and ended about May 31, and a late run that started about June 1 and ended about June 10 (ADF&G 1983a). The second run was approximately 4.5 times larger in numbers than the first run. Eulachon are known to utilize the Susitna River system at least as far upstream as RM 58 in 1981 and RM 48 in 1982 (ADF&G 1983a).

In 1982, eulachon spawned in riffle areas and offshore of cut banks on unconsolidated sands and gravels. Spawning occurred at water temperatures between 37.4 to 49.1°F (3.0 to 9.5°C) (ADF&G 1983a).

(c) Resident Species (***)

(i) Dolly Varden Char (***)

Dolly Varden are found in lakes, streams, and rivers throughout Alaska. Three forms of Dolly

Varden have been identified: an anadromous form that generally inhabits coastal streams, a resident variety that inhabits rivers and lakes, and a dwarf resident form that occupies stream and lake habitats generally north of the Alaska Mountain Range (Morrow 1980).

Within the Susitna River drainge, Dolly Varden are known to inhabit various areas from the Oshetna River (RM 233.4) to Cook Inlet (ADF&G 1981f, 1981e, 1983m, 1983b, 1984c, 1985c). Throughout the drainage, populations are relatively low with insufficient numbers of fish caught to determine population size estimates. In the lower river (downstream from the Chulitna River confluence at RM 98.6) Dolly Varden were most commonly caught at the mouth of the Kashwitna River (ADF&G 1983m, 1985c). Within the middle Susitna River, Dolly Varden were captured most frequently at the mouths of Indian River (RM 138.6), Lane Creek (RM 113.6) and Portage Creek (RM 148.8).

Based on the data available for Dolly Varden populations in the middle and lower Susitna River (downstream from RM 150) it is presumed that Dolly Varden move into the tributaries during the summer months to rear and feed. In the fall, the Dolly Varden move into the mainstem in November and December to overwinter (ADF&G 1983m). Apparently, juvenile Dolly Varden move into the tributaries in the spring for rearing. Sexual maturity is attained at approximately Age 4. (ADF&G 1983m, 1984c).

Between the Oshetna River and Devil Canyon (i.e., in the impoundment zone) Dolly Varden populations are apparently small but are widely distributed (ADF&G 1983b). Populations have been found in Cheechako, Devil, Watana, Jay and upper Deadman Creeks (ADF&G 1983b). Total lengths of the fish collected in the upper Susitna River ranged from 120 to 205 mm. Thus, these stocks appear to be representative of the stunted or dwarf variety noted by Morrow (1980). This occurrence appears to be inconsistent with the distribution of the dwarf variety described by Morrow (1980). However, Morrow's description is based on the limited information available prior to the present studies and these could represent a more refined definition of the range of the dwarf variety and is therefore, not unexpected.

Seasonal movements of the population in the impoundment zones appear similar to those described for the middle and lower reaches of the Susitna River.

Populations of Dolly Varden were identified in numerous streams and lakes within the access and transmission line corridors (ADF&G 1984a). Summaries of the occurrence of Dolly Varden in the streams and lakes are presented in Tables E.3.2.21 and E.3.2.22, respectively. The locations of the streams and lakes are depicted in Figures E.3.2.8 through E.3.2.13 and Figures E.3.2.14 through E.3.2.17.

(ii) <u>Rainbow Trout</u> (***)

Rainbow trout inhabiting the Susitna River constitute one of the northernmost populations of this species (Morrow 1980). Within the Susitna River, rainbow trout populations are found up to and including Portage Creek at RM 148.8 (ADF&G 1983m). No populations have been identified upstream of Devil Canyon in the impoundment zone.

During the spring and summer months, rainbow trout are distributed in clear water areas associated with tributaries and tributary mouths (ADF&G 1984c). Highest concentrations of rainbow trout have been observed associated with the Deshka River in the lower Susitna River (ADF&G 1985c) and Whiskers Creek, Chase Creek, and Fourth of July Creek in the middle Susitna River (ADF&G 1984c). Rainbow trout often follow salmon to their spawning areas in tributaries and side sloughs where they presumably feed on eggs dislodged from the salmon redds. During the summer period, highest densities of rainbow trout are observed upstream in the tributaries. By mid-September, rainbow trout move to tributary mouth areas and presumbly move into the mainstem to overwinter.

Spawning activity probably occurs in late May to early June in upper reaches of tributaries. This is based upon the inability to capture juvenile rainbow trout at locations associated with the mainstem in early to mid summer. Juveniles are collected more frequently in the lower portions of tributaries as winter approaches (ADF&G 1984c, 1985c). Fourth of July Creek appears to support a significant spawning population. The ADF&G (1985c) believes that rainbow trout are produced in lakes in the Fourth of July Creek drainage. These move out into the river and rear. Growth of juvenile rainbow trout is similar to other northern populations (ADF&G 1983n, 1981e, 1983m).

Juvenile and adult populations in the middle Susitna River are relatively small. Estimates of the population range from 2,500 to 5,000 fish (ADF&G 1984c). The major contributor to the low population levels is attributed to the lack of suitable spawning areas (ADF&G 1984c). In addition, survival rates are relatively low. High mortality rates are attributed to poor spawning habitat, and low survival of juveniles and adults during winter months. In addition, fishing pressure during the fall, when this species is particularly vulnerable to capture at tributary mouth locations, contributes to the low population levels. Winter mortality is due principally to dessication and freezing (ADF&G 1984c, 1983e, 1985a). Several instances of dead radio-tagged fish have been recorded under the ice (ADF&G 1983e, 1985a).

Habitats suitable for rainbow trout include clear water areas with velocities less than 0.5 ft per second and depths greater than 2 ft. Rainbow trout are also associated with areas containing cover in the form of undercut banks, debris and substrate greater than 3 inches diameter (preferrably boulders)(ADF&G 1984c).

Movement of rainbow trout during summer and winter months has been documented through tracking of radio-tagged fish. Based on the results of the tracking, rainbow trout apparently move freely from tributary to tributary during the summer and throughout the mainstem areas during the winter (ADF&G 1981e, 1983m, 1983e, 1984c, 1985a). In the summer, the mainstem areas apparently serve principally as a migratory pathway; whereas, in the winter, the mainstem serves as holding areas (ADF&G 1985c, 1983m).

A population of rainbow trout was also identified in High Lake, near High Lake Lodge. High Lake is within the access and transmission line corridor between the Watana and Devil Canyon Dam sites. No estimate of the population size was made. (ADF&G 1984a).

(iii) Arctic Grayling (*)

The Arctic grayling is also one of the most important sport fish of Alaska and northern Canada and contributes substantially to the sport fishery of the Susitna River and its tributaries. Grayling are generally residents of clear, cold streams and lakes (Scott and Crossman 1973).

Silt-laden glacial systems, such as the Susitna River, are believed to support relatively few grayling; however, such systems may provide essential migratory channels and over-wintering habitat (ADF&G 1981f). The Arctic grayling is characterized by Reed (1964) as a migratory species. During spring breakup from April to June, adults migrate from ice-covered lakes and large rivers into clear, gravel bottomed tributaries to spawn (Morrow 1980). In Alaska, Arctic grayling reach sexual maturity at age 2 to 7 years and are capable of spawning several times during their lifetime. After spawning, the adults move from the spawning areas to spend the rest of the summer feeding on aquatic and terrestrial insects taken from the aquatic drift (Vascotto 1970). A downstream migration to overwintering areas in large rivers and deep lakes occurs in late August to mid-September (Pearse 1974).

During 1980-81, grayling were captured between Alexander Creek (RM 10.1) and the upper reaches of the impoundment area. Catches were low throughout winter, but increased sharply in May, both below and above the impoundment area. Below the impoundment area, catches increased during the period May 1-15 and then declined at all habitat locations throughout the summer until catches again increased at tributary mouths in September. Primary tributaries of the middle river which support grayling populations are Indian River and Portage Creek (ADF&G 1983m). Within the impoundment area, catches were highest in June and July and declined toward the end of summer and early fall (Table E.3.2.23).

Changes in distribution and catch of grayling are associated with migrational movements to spawning grounds and overwintering areas that may have been initiated in response to surface water temperature (ADF&G 1981f, 1983b). Below the impoundment area, high catches in May are associated with migration from the mainstem Susitna into nonglacial tributary spawning grounds immediately after ice leaves the tributaries (ADF&G 1983b). High catches in September are probably associated with migrational movements back to over wintering areas in the mainstem Susitna.

Within the impoundment area in May and June, grayling appeared to move upstream into pool-type habitat in tributaries where they spawn. The movement may be triggered by increasing water temperatures (ADF&G 1981f, 1983b). As surface water temperatures began to decrease in late summer and early fall, lower numbers of fish were observed in these upper stream reaches and tagged fish were observed migrating downstream. Small-scale distribution patterns and abundance within upper stream reaches are determined primarily by streamflow and channel morphology.

Observed preferred grayling habitat is characterized by high pool/riffle ratios, large, deep pools, and moderate velocities (ADF&G 1983m, 1983b, 1984c).

Additional distribution patterns in the impoundment reach were documented by catching, tagging and releasing 2,511 grayling during 1981 (ADF&G 1981f). Many tributary fish moved into the Susitna mainstem for overwintering. Analysis indicates that there is a wide range of intertributary migration as well as movement within individual tributaries.

Grayling population estimates were calculated for the reaches of major tributaries to be inundated by the Devil Canyon and Watana impoundments (Table E.3.2.24). The 1982 estimates were based on tag/recapture data during July and August 1982, while the 1981 estimates were based on results from the entire summer period. There were insufficient tag returns from Watana Creek in 1981 and from Tsusena and Fog creeks in 1982 to derive estimates. The 1982 population estimate was calculated for age groups (Table E.3.2.25). The total grayling population in the impoundment zone was estimated to be at least 16,000 in 1982, while the population of grayling over 8 inches (20 cm) was estimated to be 9,375, excluding Watana Creek in 1981 (ADF&G 1981f, 1983b). In 1982, summer density estimates ranged from 323 grayling per mile (1.6 km) in Watana Creek to 1,835 grayling per mile (1.6 km) in Deadman Creek for the reaches to be inundated (Table E.3.2.24).

There was no evidence of grayling spawning at any sampling locations between Devil Canyon and Cook Inlet. It is thought that adult grayling from the mainstem Susitna below Devil Canyon migrate into nonglacial tributaries to spawn in late April or May. In the impoundment reach, grayling fry were captured at the Watana Creek study area in 1981 indicating spawning in the immediate vicinity.

Spawning apparently occurs from late April through early May under ice or during mid-May spring floods in the lower reaches of all eight tributaries sampled within the impoundment zone (ADF&G 1983b). Suitable spawning habitat, i.e., proper spawning gravel in pool regions, was observed in all streams studied (ADF&G 1983b). Assuming favorable spawning conditions exist, it is not likely that spawning habitat significantly limits grayling in the impoundment area (ADF&G 1983b).

In addition to the tributary population, Arctic grayling populations were identified in Sally Lake, Deadman Lake and an unnamed lake on the south bank of the Susitna River near the mouth of Watana Creek. The population identified in Deadman Creek is associated with upper Deadman Creek. The lake apparently provides overwintering habitat for the population in the creek (ADF&G 1984a). The population found in Sally Lake appears to be stunted with adult grayling remaining much smaller than the adults associated with tributaries of the Susitna River (ADF&G 1983b).

Arctic grayling populations were also identified in seven streams that will be crossed by either the access road or the transmission line between the dam sites and Gold Creek (ADF&G 1984a). A summary of the streams containing Arctic grayling populations is presented as Table E.3.2.21. Maps depicting the access road and transmission line corridors and enumerating the streams to be crossed are presented as Figure E.3.2.8 through E.3.2.13. Two lakes within the access road and transmission line corridor contain Arctic grayling populations. These are Deadman Lake (described above) and Beaver Lake. The locations of all lakes within the corridors are depicted in Figures E.3.2.14 through E.3.2.17. The occurrence of grayling in these lakes is summarized in Table E.3.2.22.

(iv) Lake Trout (***)

Near the Watana impoundment area, lake trout were collected in Sally Lake in the impoundment zone and Deadman Lake. Both lakes support a limited sport fishery. The population inhabiting Sally Lake is small, estimated at approximately 1,000 fish (ADF&G 1983b). The population of lake trout in Deadman Lake is somewhat larger. Numerous lake trout were observed in Deadman Lake in relatively shallow water near the inlet stream (ADF&G 1984a).

In both Sally Lake and Deadman Lake, lake trout were located in relatively shallow water in June. Later in the summer, the fish were in deeper water, up to 75 ft deep, just below the thermocline (ADF&G 1984a). In October and November, the lake trout again moved to shallow water along the shorelines, apparently to spawn.

Ages of four lake trout in Deadman Lake ranged from 15 to 26 years (ADF&G 1984a).

(v) Burbot (**)

In Alaska, burbot are distributed in the Susitna and Copper Rivers, Bristol Bay drainages, throughout the interior, and in the Arctic (McLean and Delaney 1978). Burbot mature between ages 3 and 6 in Alaska and may live a total of 15 to 20 years.

Burbot are widely distributed throughout the mainstem Susitna River. Adults are found at tributary and slough mouths and in turbid mainstem areas. Burbot are typically sedentary but may move considerable distances during the fall prior to spawning in the winter (ADF&G 1983b).

Burbot appear to be more abundant in the lower river from the Chulitna River confluence to Cook Inlet (ADF&G 1985c). In the middle river, population densites were estimated to be 15 fish per mile (ADF&G 1984c).

In the Susitna River, spawning occurs from November to February (ADF&G 1981e, 1983m). Although no spawning activity was observed, the increase in density of adult fish at the mouth of the Deshka River and the migration of radio-tagged adult fish to the mouth of the Deshka River indicated a high probability that spawning occurs in the area (ADF&G 1985b).

Adult burbot apparently prefer areas with low light conditions (Morrow 1980), thus, the turbid mainstem areas provide the most suitable habitat. Burbot have been as characterized is being omnivorous carnivores (Morrow 1980) and are believed to be a major fish predator on other Susitna River fish species (ADF&G 1984c).

In addition to the burbot populations identified in the mainstem of the Susitna River; Beaver Lake, located along the access corridor, contains a population of burbot (ADF&G 1984a) (Figure E.3.2.15).

(vi) Round Whitefish (**)

Round whitefish are distributed across all of Arctic and interior Alaska. They are normally abundant in clearwater streams with gravel-cobble substrate but are also in large glacial rivers and lakes. Round whitefish mature between ages 4 to 7, and spawning occurs in late September through October over gravel substrate in the shallows of rivers and inshore areas of lakes (Morrow 1980). Upstream migrations are often associated with spawning.

The densities of round whitefish tend to be greatest in the middle river between Devil Canyon and Talkeetna (ADF&G 1983m). Adult round whitefish move into clearwater tributaries in June to rear. In September, round whitefish move into the mainstem where they spawn and overwinter. Spawning adults have been collected from the mouths of Lane Creek, Indian River, and Portage Creek in October (ADF&G 1985c).

Round whitefish appear to be the most abundant resident fish species downstream from Devil Canyon; in the impoundment zone, round whitefish are relatively uncommon (ADF&G 1983b).

Round whitefish are also reported to inhabit Deadman Lake where they apparently serve as a forage fish for Arctic grayling (ADF&G 1984a). During the summer months, the fish occurred in small schools of 10 to 25 fish. In the fall, schools of 50 to 100 fish were observed to spawn in 1-5 ft of water over sand and gravel substrate (ADF&G 1984a).

(vii) Humpback Whitefish (**)

In Alaska, there is a complex of three closely related species of whitefish: humpback whitefish, Alaska whitefish, and lake whitefish. Because of similar appearance and overlapping distributions, the data collected on the three species have been reported under the general heading of humpback whitefish.

Alaska whitefish are largely stream inhabitants and undertake lengthy up- and downstream migrations to and from spawning grounds. Spawning occurs in September and October. Lake whitefish reside primarily in lakes but spawn in rivers or creeks between October and December. Humpback whitefish is apparently the only species of whitefish that is considered anadromous, although migration habits vary widely in different systems. Spawning migrations begin in June with spawning in October and November (Morrow 1980).

Humpback whitefish are most abundant in the Talkeetna to Cook Inlet reach. Fish collected ranged from ages 2 to 7; Age 4 was the predominant age group (ADF&G 1981f, 1983m).

No evidence of humpback whitefish spawning was collected at any sampling location between Devil Canyon and Cook Inlet in 1981 or in 1983 (ADF&G 1981e, 1984c).

In 1983, humpback whitefish were collected from Deadman Lake (ADF&G 1984a). No estimate of the population was obtained. The youngest fish analyzed was 8 years old and all fish longer than 345 mm were 10 years old or more (ADF&G 1984a).

(viii) Longnose Sucker (**)

The longnose sucker, the only representative of the sucker family found in Alaska, is ubiquitous and occurs in most of the mainland drainages. Spawning usually occurs in spring after ice out. Spawning runs (i.e., movement from lakes into inlet streams or from deep pools into shallower, gravel-bottomed stream areas) are initiated when water temperatures exceed 5°C (41° F). Longnose sucker feed almost exclusively on benthic invertebrates but will occasionally ingest live or dead fish eggs (Scott and Crossman 1973).

Longnose suckers were collected throughout the study area from Cook Inlet to the upper reaches of the impoundment areas. Adult suckers were captured in the impoundment zone from May to September, generally near the confluence of mainstem river and the tributary streams (ADF&G 1981f, 1983b).

Downstream of Devil Canyon, longnose suckers are considerably more abundant than upstream from Devil Canyon (ADF&G 1983m). Spawning occurs in late May and early June. During this period, adults congregate in spawning areas. During the remainder of the year, adults are more dispersed throughout the mainstem (ADF&G 1983b, 1985c). Juveniles appear to utilize clearwater sloughs and tributary mouth habitats to a greater extent than adults (ADF&G 1983b).

(ix) Threespine Stickleback (**)

Threespine stickleback have been observed and captured at several locations throughout the Devil Canyon to Cook Inlet reach of the Susitna River. They are found most often in shallow, slack-water areas with soft sand-to-mud substrate and emergent or submerged, rooted vegetation (ADF&G 1984c, 1985c). These areas are essentially limited to side-slough, upland slough, tributary mouth and tributary habitats.

Two forms of the threespine stickleback, distinguished by behavioral and morphological characteristics, are known to occur in the Susitna basin. One form, trachurus, is anadromous. Trachurus usually enters coastal rivers in the early summer where it reproduces and then dies. The juveniles rear for a short time in freshwater habitats and then return to the marine environment in late summer (Morrow 1980, ADF&G 1983m). The second form, leiurus, spends its entire life in freshwater. A third form, semiarmatus is presumed to be present although none have been identified from project sampling. Semiarmatus is a hybrid of trachurus and leiurus (Wootton 1976).

The distribution of trachurus within the Susitna drainage is limited to habitats with open access to the marine environment. They have been observed in mainstem, side sloughs, side channel and tributary habitats. They have also been collected from lakes with open access to the mainstem Susitna. Leiurus are also found in these habitats as well as small lakes and ponds with isolated drainages. No populations of threespine sticklebacks have been found in the Susitna drainage upstream of Devil Canyon.

Inter-population variation for several morphological traits has been identified in the Pacific Northwest (eg., Hagen and Gilbertson 1972; Hagen and McPhail 1970; Moodie and Reimchen 1973). This extensive variation indicates that the species is capable of pronounced adaptation to local environmental conditions. In studies conducted in Southcentral Alaska within the Susitna River, Bell et al. (1985) identified several populations in small, isolated lakes that contained a high proportion of individuals with reduced or missing pelvic spines and associated anatomical structures. The importance of these findings is uncertain at this time and all populations are located outside the area which could be affected by the project. It is highly unlikely that populations with such morphological variation occur in habitats closely associated with the Susitna River (that would be potentially exposed to effects of project operation) since a high degree of isolation seems to be necessary for the evolution and maintenance of these adaptations (Bell et al. 1985).

(x) <u>Cottids</u> (**)

All sculpin species captured in the Susitna River have been grouped under the general heading of cottids. The slimy sculpin is the most common cottid found in the Susitna, although there is a possibility that three other species may be present below the impoundment area.

Slimy sculpin are present in nearly all clearwater habitats in the Susitna Basin. Adults and juveniles occupy these areas and exhibit little movement between habitats. Low densities of the sculpin are also present in mainstem habitats (ADF&G 1983m, 1983b).

Presumably, slimy sculpins represent a major predator on salmon embryos and newly emergent salmon fry.

(xi) Lamprey (o)

The Arctic lamprey, one of four lamprey species that occurs in Alaska, was observed in the Susitna River during 1981 (ADF&G 1981e). The Pacific lamprey, an anadromous species that has been reported to range into the lower Susitna River (Morrow 1980), was not observed during 1981 investigations.

Some populations of Arctic lamprey are composed of both anadromous and freshwater forms. It was speculated that a portion (30 percent) of the Susitna poulation is anadromous, based on analysis of length frequencies (ADF&G 1981e). The anadromous form is parasitic; hosts include adult salmon, trout, whitefish, ciscoes, sucker, burbot, and threespine stickleback (Heard 1966). The freshwater forms have been reported to be both parasitic and nonparasitic.

Arctic lamprey spawn during spring in streams with low-to-moderate flow. Embryos develop into a larval stage, which spend one to four years burrowed into soft substrate. After an indefinite period, adults migrate upstream to spawn.

Arctic lamprey were captured at 14 sampling sites, between RM 10 and RM 101, that were surveyed from November 1980 through September 1981. During the winter surveys, the only habitat site to produce Arctic lamprey was Rustic Wilderness where one lamprey was captured. This area is in the lower river at RM 57. All other lamprey were collected during the summer. Lamprey were not collected in the impoundment area (ADF&G 1981e).

The highest catch frequency was recorded during the September 1 to 15 sampling period. All lamprey taken during this period were collected at tributary sites downstream from RM 50.5. The lowest incidence of capture for this species during the summer was observed in the July 16-31, 1981 sampling period (ADF&G 1981e).

2.2.2 - Habitat Utilization (***)

Every river system provides a complex array of hydraulic and physical conditions within which fish and other aquatic organisms must exist. Through the process of natural selection, each species has evolved to utilize specific sets of habitat conditions from the array of conditions available in the system. The suitability, availability and subsequent utilization by the fish of specific areas within a river system are determined by the physical conditions within and adjacent to the areas or habitats.

On an instantaneous basis (i.e. at a given discharge in the river at a specific time), the suitability, availability and utilization of a particular area can be described by a relatively few principle hydraulic and morphologic parameters. The suitability of a particular area is dependent upon water depth, water velocity, substrate composition and structural attributes contributing to cover for the fish. This assumes that chemical characteristics and temperature are within the tolerance limits of the fish. It also assumes that there is sufficient food available to support the fish. The availability of suitable conditions is determined first by the presence of the particular set of conditions suitable for a particular species and secondly by the continuity of the specific area with the rest of the water body such that the fish may gain access to the area.

On a continuous basis, the suitability and availability of a particular area is dependent upon discharge in the river and season of the year. Also, the utilization of specific areas within the river system is dependent upon the season of the year, behavior and the habitat requirements of the species and life stages present.

Within the Susitna River basin, specific areas have been categorized into one of seven basic habitat types based upon their instantaneous hydraulic and morphologic characteristics. These seven habitat types are:

- Mainstem
- Side Channel
- Tributary Mouth
- Side Slough
- Upland Slough
- Tributary

o Lakes and Ponds

Characteristics of these habitat types are described in Exhibit E, Chapter 2 Section 2.1.

Each of these habitat types responds, to some degree, to changes in mainstem discharge. Changes in mainstem discharge may change water surface area and water quality, depth and velocity within a specific habitat type. Aside from the basic changes in habitat conditions associated with changes in flow, a particular site may be categorized differently at different mainstem discharge levels (EWT&A 1985b). For example, at a given discharge in the mainstem, an overflow channel may convey mainstem water and would be considered a side channel. At a lesser mainstem discharge, the channel may no longer convey mainstem water but will convey local surface runoff, tributary flow, groundwater, or a combination of these and would be considered a side slough.

In addition to the response of habitat conditions to seasonal changes in mainstem discharge, seasonal changes in water temperature and suspended sediment concentrations influence the suitability of a particular habitats site for habitation by fish. As discussed in Exhibit E, Chapter 2, dramatic seasonal changes in discharge levels occur within the river. Summer discharge is often 10 to 20 times the winter discharge. Also, the Susitna River carries a considerable suspended sediment load during the summer, whereas, during the winter, the suspended sediment load is low (Exhibit E, Chapter 2, ADF&G 1983k, 1983e).

The seven habitat types identified above can be ranked according to the sensitivity of habitat conditions within the sites to changes in mainstem discharge (HE 1984b, 1985a). This sensitivity to mainstem discharge is described below with respect to the proportion of time or the frequency with which mainstem discharge directly affects habitat conditions and is summarized in Table E.3.2.26.

Mainstem areas are by definition most sensitive to changes in mainstem discharge since habitat conditions in terms of surface area, depth and velocity vary continuously with discharge.

Side channels are less sensitive but are directly affected by mainstem discharge sufficiently great to breach the upstream ends of the channels. In general, side channels convey mainstem water more than 50 percent of the time during the summer, open water season (See Exhibit E, Chapter 2 for discussion of discharge regimes during summer vs winter months).

Tributary mouth habitats occur at the confluence of the tributaries with the mainstem. The aerial extent of this habitat type is dependent not only upon mainstem discharge but also on tributary discharge. To some extent both mainstem and tributary discharge will affect the specific location of this habitat type.

Side sloughs are less responsive to mainstem discharge changes in that mainstem discharges sufficiently great to breach the upstream ends occur less than 50 percent of the time during the open water season. However, at lower discharge levels, the mainstem discharge may affect slough habitat conditions, particularly at the mouths, through backwater effects (ADF&G 1983k, 1984r, 1985l). Mainstem discharge less than that sufficient to breach the upstream end may also affect habitat conditions through the influence on groundwater upwelling (See Exhibit E, Chapter 2 Section 2.4; R&M 1985b, APA 1984g).

Upland sloughs are relatively insensitive to mainstem discharge. The major effects on upland sloughs by changes in mainstem discharge are changes in surface area, velocity and depth due to backwater effects. Changes in mainstem discharge generally will not affect discharge or water quality parameters in the upland slough.

Tributaries, although continuous with the mainstem, are not affected by changes in mainstem discharge. Habitat conditions in tributaries are dependent only upon tributary discharge. Similarly, habitat conditions in lakes and streams within the basin are unaffected by changes in mainstem discharge. In some cases, the lakes or ponds are completely independent of the mainstem with no interconnecting body of water. In other cases, outlet streams from the lakes or ponds do provide a surface water connection with the mainstem.

In describing existing conditions, and ultimately in evaluating the effects of the Susitna Hydroelectric Project, it is necessary to identify the utilization of the habitat types by the fish species. The utilization of each habitat type is described below in terms of the species present in the habitats; when they occur in the habitats; the relative abundance of each species in the habitats; and the significance of the habitat type to the appropriate life stage of the species. As a matter of convenience, the discussion is divided into three major reaches of the Susitna River: 1) The Oshetna River to Devil Canyon (RM 233 to RM 152) representing the impoundment zone, 2) Devil Canyon to Talkeetna (RM 152 - RM 100) referred to as the middle river, and 3) Talkeetna to Cook Inlet (RM 100 - RM 0) referred to as the lower river.

(a) Oshetna River to Devil Canyon (**)

The impoundment zone reach of the Susitna River flows through a steeply cut channel that is in the process of degrading the existing riverbed. From Oshetna River (RM 233) to Devil Creek, the river is wide and often splits into two or more channels with an average gradient of approximately 13 ft/mile (2.4 m/km). From Devil Creek (RM 162) to the downstream end of Devil Canyon (RM 150), the river forms one channel that lies in a deep valley with an average gradient of 31 ft/mile (5.9 m/km). Substrates throughout the impoundment reach and mouths of tributaries consist of rubble, cobble, and boulders, often embedded in sand; gravels are present in some locations (ADF&G 1981f).

Utilization of the mainstem, tributaries and lakes within this reach are described below. Only a few isolated side sloughs, side channels and upland sloughs exist in this reach and, therefore, are not considered an important habitat component of the impoundment zone. Tributary mouth habitats are discussed in conjunction with the descriptions of the tributary habitats. Detailed data collected in this reach are presented in ADF&G reports (ADF&G 1981f, 1983b).

(i) Mainstem Habitat Near the Confluence of Major Tributaries (***)

- Species Occurrence and Relative Abundance (***)

Of the five species of Pacific Salmon, only chinook salmon have been observed upstream of the Devil Canyon Dam site at RM 150 (ADF&G 1983a, 1984h, 1985b). The lack of other salmon upstream of RM 152 is due principally to the hydraulic velocity present in the rapids within Devil Canyon. Adult chinook were observed in the mouths of Cheechako Creek, Chinook Creek, Devil Creek and Fog Creek (ADF&G 1985b). Peak index counts at these locations ranging from 1 to 35 fish, indicate that the relative abundance of chinook at these creeks is quite low.

Seven resident species (Arctic grayling, longnose sucker, humpback whitefish, round whitefish, Dolly Varden, burbot and slimy sculpin (Cottid) also occur in the mainstem and tributary mouth habitats. None of these species is present in high numbers at the tributary mouths or in the mainstem. Arctic grayling and Dolly Varden are more abundant in the mainstem during the winter (ADF&G 1983b). Burbot are present in the mainstem throughout the year (ADF&G 1983b).

- Significance of Habitat (***)

The mainstem Susitna River provides overwintering habitats for all species of resident fish occurring in the impoundment zone (ADF&G 1981f, 1983b). In addition, mainstem and tributary mouth habitats provide habitat for burbot, juvenile Dolly Varden, round whitefish and humpback whitefish during the summer.

(ii) Tributaries (***)

Eleven named and numerous unnamed tributaries flow into the Susitna River within the impoundment zone. The locations of the confluences of the tributaries with the mainstem are given in Table E.3.2.27.

- Species Occurrence and Relative Abundance (***)

Arctic grayling, Dolly Varden, longnose suckers. and cottids occur in tributary reaches within the impoundment zone (ADF&G 1983b). Utilization of tributaries is seasonal, with the major occurrence during the summer. In tributaries upstream of the Watana Dam Site, Arctic grayling are the predominant species. The total population of Arctic grayling greater than 200 mm within the impoundment zone is estimated to be about 19,000 fish (ADF&G 1983b).

Between the Devil Canyon and Watana Dam sites, Dolly Varden tend to be the more abundant species present in the tributaries. (ADF&G 1983b). Chinook salmon spawning adults, embryos and fry also may occur in the lower reaches of Chinook and Cheechako Creeks within the Devil Canyon impoundment zone since spawning activity has been observed in these streams (ADF&G 1983a, 1984h, 1985b).

- Significance of Habitat (***)

Tributary habitats in the impoundment zone provide summer spawning and rearing habitat for Arctic grayling. Because Arctic grayling require clear water for spawning and rearing, the tributaries provide significant habitat for the species.

The utilization of tributary habitat within the impoundment zone by chinook salmon is insignificant relative to the tributaries of the Middle River. This is due principally to the low numbers of chinook using these habitats (see Table E.3.2.8).

(iii) Lakes and Ponds (***)

Thirty-one lakes and ponds occur within the impoundment zone. Nearly all of the lakes and ponds are small and shallow, ranging in size from one to 55 acres. Only four of the lakes are sufficiently deep to contain free water under the ice in winter. The largest lake within the impoundment zone is Sally Lake located near the confluence of Watana Creek with the Susitna River.

- Species Occurrence and Relative Abundance (**)

Lake trout and Arctic grayling occur in Sally Lake. The only other lake known to be inhabited by Arctic grayling is on the south side of the Susitna River near the Watana Creek confluence.

The lake trout population in Sally Lake is estimated to be less than 1,000 fish (ADF&G 1983b). Arctic grayling in Sally Lake are more abundant (approximately 5,000 fish). These fish are apparently stunted since all fish collected from the lake are relatively small (mean length of 42 fish = 263 mm; range = 220-325mm; (ADF&G 1983d). No estimate of the abundance of grayling in the unnamed lake is available.

- Significance of Habitat (***)

The only occurrence of lake trout within the impoundment zone is in Sally Lake. This population is not considered important in the context of the broad distribution of lake trout in the Susitna Basin, e.g. in Deadman Lake.

The small number and size of Arctic grayling in Sally Lake compared to other lakes in the basin (e.g., Deadman Lake) indicates that this lake is not a significant habitat for grayling.

(b) Devil Canyon to Talkeetna (**)

In the reach of the Susitna River from Devil Canyon to Talkeetna, the river channel is relatively stable and straight with some meandering and minimal braiding. Numerous islands, gravel bars, and sloughs are present. Flow alternates between a single and split channels configuration throughout the reach. Between Curry (RM 120) and Talkeetna, the approximate gradient is 8.1 ft/mile (1.5 m/km). Typical substrate between Curry and Talkeetna is gravel, rubble, and cobble with small amounts of sand and silt. Above Curry the substrate varies from silt to bedrock. The majority of mainstem shoreline substrate is rubble and cobble whereas silt and gravel are the most common substrate in sloughs and slow water areas. Below Curry, streambank vegetation is dense spruce/hardwood forest. In addition to numerous smaller streams draining the surrounding hillsides, the principal tributaries to the Susitna River in the Devil Canyon to Talkeetna reach include Portage Creek, Indian River, Gold Creek, Fourth of July Creek, Lane Creek, and Whiskers Creek.

All of the seven habitat types identified above are represented within this reach and are subject of effects of altered discharge, temperature, ice processes and water chemistry attributable to impoundment of the river by the Susitna Hydroelectric Project.

Within this reach, habitats are utilized by the five Pacific salmon species and all of the known resident species of fish inhabiting the Susitna River basin with the exception of lake trout.

The morphology, discharge regime, temperature and ice regimes, water quality conditions and substrate composition under existing conditions are described in detail in Exhibit E, Chapter 2. The occurrences and relative abundances of the fish species inhabiting the habitat types in the middle river are described below. Also, the importance of each habitat type for the respective life stages of each species is also discussed.

(i) Mainstem Habitat (**)

The Susitna River from Devil Canyon to Talkeetna has both single and split channel configurations

(Figures E.3.2.18 through E.3.2.35). Single channel reaches are generally stable with banks of bedrock or a layer of gravel and cobbles. The channel is either straight or meandering. In straight channel reaches, the thalweg often meanders across the channel. Occasional fragmentary deposits can be found in the floodplain. 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.

- Species Occurrence and Relative Abundance (**)

  - Salmon (**)

    Five species of Pacific salmon utilize mainstem areas primarily as a migration corridor. Life stages of the salmon that occur in the middle river are in migrating adults, spawning adults, incubating embryos, rearing juveniles and outmigrating juveniles.

    Adult chinook salmon utilize the mainstem primarilty as a migrational corridor to the spawning areas in tributaries (ADF&G 1981a, 1983a, 1984h, 1985b). Estimates of the number of chinook adults using the mainstem habitats in the middle reach for 1981-1984 are summarized in Table E.3.2.6 and depicted in Figure E.3.2.5. The timing of the occurrences of chinook adults in the middle reach is depicted in Figure E.3.2.7. Since chinook salmon do not use mainstem areas for spawning, incubating embryos are not present. As described in Section 2.2.1, juvenile chinook move into the mainstem as part of their downstream migration to rearing habitats in the middle river, to the lower river, or to Cook Inlet. Hence, mainstem habitats serve as a migrational corridor for juvenile chinook salmon as well as for adult chinook.

    Adult sockeye similarly utilize the mainstem as a migrational corridor. Estimates of the number of sockeye migrating through the mainstem are summarized in Table E.3.2.6 and depicted in Figure E.3.2.5. The timing of adult sockeye in the middle river is depicted in Figure E.3.2.7. Nearly all sockeye adults spawn in side slough habitat. However, a few adults have been observed to spawn in mainstem areas (ADF&G 1985b). The use of mainstem habitat for spawning of adult sockeye is uncommon and, therefore, few incubating embryos are in the mainstem. Juvenile sockeye use the mainstem primarily as a migrational corridor to other habitats for rearing, overwintering and outmigration (ADF&G 1981d, 1983m, 1984c, 1985c).

The utilization of mainstem habitats by the various life stages of coho salmon is essentially the same as for sockeye salmon. The estimates of the number of coho adults present in the mainstem for 1981-1984 are summarized in Table E.3.2.6 and depicted in Figure E.3.2.5. The timing of adult coho in the mainstem of the middle river is depicted in Figure E.3.2.7. A few coho salmon have been observed to spawn in mainstem areas (ADF&G 1983a). Juvenile coho, like sockeye and chinook, use the mainstem as a migrational corridor to rearing and overwintering habitats and for outmigration to the lower river (ADF&G 1983m, 1984c, 1985c).

Adult chum salmon utilize the mainstem primarily as a migrational corridor to spawning areas. Estimates of the number of chum present in the mainstem in 1981-1984 are summarized on Table E.3.2.6 and are depicted in Figure E.3.2.5. The timing of adult chum in the mainstem of the middle reach is depicted in Figure E.3.2.7. In the period 1981-1984, up to 4 percent of the escapement of chum into the middle river (i.e., past the Talkeetna Station) and approximately 8 percent of the escapement past the Curry Station spawned in mainstem areas (ADF&G 1985b). Hence, incubating embryos do occur in mainstem habitats, probably in areas of groundwater upwelling (ADF&G 1985a, 1983k, EWT&A and WCC 1985; WCC 1985). Juvenile chum salmon use the mainstem as a migration corridor during their outmigration from the middle river (ADF&G 1981d, 1983m, 1984c, 1985c).

Pink salmon use the mainstem only for in-migration to spawning areas in tributaries and for outmigration to Cook Inlet. The timing of the adult and juvenile pink salmon in the mainstem is depicted in Figure E.3.2.7. Estimates of the number of pink salmon occurring in the middle river in 1981-1984 are summarized in Table E.3.2.6 and depicted in Figure E.3.2.5.

A summary of the utilization of the mainstem by the various life stages of the salmon species is presented in Table E.3.2.28.

- Resident Species (**)

The mainstem habitat is used by all species of resident fish known to occur in the middle river (Table E.3.2.28). However, only burbot and longnose sucker inhabit mainstem areas throughout the year. The other species are present in the mainstem only in the late fall, winter and early spring.

- Significance of the Habitat Type (**)

The principle use of mainstem habitats by salmon and resident species is as a migration corridor and as an overwintering area. To a lesser degree, the mainstem provides spawning habitat for chum salmon, burbot, longnose suckers, and a few sockeye salmon. The mainstem is utilized throughout the year by burbot and longnose sucker.

(ii) Side Channel Habitat (**)

Side channel habitats 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 channel habitats 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, 1985b). Side channel habitats normally breach, i.e., convey mainstem water, at mainstem discharges less than 20,000 cfs (EWT&A and AEIDC, 1985).

Side channel habitats 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 distribution of side channels is depicted in Figure E.3.2.18 through E.3.2.35). The utilization of side channel habitats by the various life stages of salmon and resident species is summarized in Table E.3.2.28.

- Species Occurrence and Relative Abundance (**)

  . Salmon (**)

The only life stages of salmon species observed to use side channel habitats extensively are juvenile chinook salmon, spawning chum salmon, and incubating chum embryos (ADF&G 1983a, 1983m, 1983k, 1984h, 1984c, 1984b, 1985b). A few sockeye salmon adults have been observed spawning in side channel habitats (ADF&G 1985b).

Side channels provide rearing habitat for the largest proportion of juvenile chinook salmon outside of the tributaries. Approximately 23 percent of the catch per unit effort for juvenile chinook is from side channel habitats (Figure E.3.2.31 (ADF&G 1984c). The mean catch per sampling cell for junvenile chinook increased from the end of May and remained relatively high through the summer until mid October as depicted in Figure E.3.2.37 (ADF&G 1984c). The high densities of juvenile chinook in side channels are probably due to the low velocity, shallow depth and relatively high turbidity present in side channels. Turbidity is apparently used by juvenile chinook as a form of cover (ADF&G 1983a, 1984c, 1985c). The density of juvenile chinook in side channels is considerably reduced in late October and through the winter months. Therefore, it appears that they do not use side channels to overwinter (ADF&G 1983e, 1985a). Juvenile sockeye, coho and chum salmon utilize side channel habitats to a limited extent. The occurrence of these species in the side channels is probably transitory and corresponds to the out-migration of the juveniles from the Middle River. The relative abundances of these juveniles in side channels in terms of the proportion of the catch per unit effort, are presented in Figures E.3.2.38, E.3.2.39, and E.3.2.40, respectively. The seasonal occurrences of the species is presented in Figures E.3.2.41, E.3.2.42 and E.3.2.43, respectively, as the mean catch per unit effort in each sampling period.

Some adult chum salmon use side channel habitats for spawning (ADF&G 1983a, 1984h, 1985b). Selection of side channels by chum salmon for spawning is highly dependent upon the presence of upwelling (see Section 2.2.3).

- Resident Species (**)

  The only resident species known to utilize side channel habitats is burbot. Adult and juvenile burbot have been collected occasionally in side channels when mainstem discharge is well above that required to breach the upstream ends (ADF&G 1984c).

\- Significance of Habitat (**)

Side channels provide rearing habitat for juvenile chinook salmon. Although a larger portion of the catch per unit effort is observed for tributary habitats, the sensitivity of the side channels to mainstem discharge and the relatively high proportion of chinook juveniles in side channels elevates the importance of this habitat type in evaluating the effects of changes in discharge and water quality attributable to the Susitna Hydroelectric Project.

(iii) Tributary Mouth Habitat (**)

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. Tributary mouth habitat is more obviously defined in summer than in winter because tributary water can be distinguished from mainstem water by the extreme differences in their respective turbidities. 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. This is obvious during the summer when the mainstem water is turbid and the tributary water is clear. At times the tributary mouth habitat can extend downstream as much as one mile (ADF&G 1983k, 1984s, EWT&A 1985b). The utilization of tributary mouth habitat by various life stages of salmon and resident species is summarized in Table E.3.2.28.

- Species Occurrence and Relative Abundance (**)

  - Salmon (**)

    The utilization of tributary mouth habitat by salmon is limited. Adult salmon that use tributary habitat for spawning (chinook, coho, chum and pink) have been observed to hold at tributary mouths prior to entering the tributaries to spawn (ADF&G 1983a, 1984h, 1984s, 1985b). A few chum have been observed to spawn in tributary mouth habitats, particularly at the mouths of 4th of July Creek and Indian River (ADF&G 1983a, 1984h, 1984s). For the most part, however, adult salmon use tributary mouth habitat as a migration corridor between the mainstem and tributary spawning areas.

    Incubation of chum salmon embryos deposited in tributary mouth habitats is likely to be limited and relatively unsuccessful because of the movement of the tributary mouth habitat away from the deposition sites as mainstem and tributary discharges decreases in the fall. Chum redds become dewatered and are subject to freezing (ADF&G 1984s).

    Juvenile salmon utilize tributary mouth habitat primarily as a migration corridor from the natal tributaries into the mainstem. Chinook and coho juveniles will remain in the habitat in the summer and can be collected from the mouths in August and September (ADF&G 1983m, 1984c). Presumably, the juveniles inhabit these areas to feed on drifting aquatic invertebrates from the tributaries (ADF&G 1983m, 1985j) or salmon eggs dislodged from the spawning areas (ADF&G 1983m). No overwintering juvenile salmon have been observed at tributary mouth habitats.

  - Resident Species (**)

    All of the resident species present in the middle river become associated to a greater or lesser degree with tributary mouth habitats at some time during the year. Rainbow trout move through tributary mouth habitats into tributaries for spawning and rearing (ADF&G 1983m). In early fall, adult and juvenile rainbow congregate at tributary mouth habitats to feed on dislodged salmon eggs and to overwinter. Arctic grayling, Dolly Varden, and other resident species use tributary mouths in a similar fashion. Burbot are not generally present in tributary mouths (ADF&G 1983m, 1983b, 1984c). The longnose sucker is the only species that appears to be associated with tributary mouth habitats throughout the year (ADF&G 1983m 1984c).

- Significance of Habitat (**)

The major use of tributary mouth habitat by salmon is as a migrational corridor. Use of tributary mouth habitat for spawning, incubation and rearing is limited. Resident species use tributary mouth habitat for migration into and from tributaries and, to a seasonally limited extent, for rearing.

(iv) Side Slough Habitat (**)

Side slough habitats are morphologically similar to side channel habitats and distinctions between side slough and side channels are somewhat arbitrary (EWT&A 1985b). Side sloughs are distinguished from side channels in that mainstem discharges greater than approximately 20,000 cfs are required to breach the upstream ends. Hence, side sloughs convey mainstem water less than approximately 50 percent of the time during the summer high flow months.

At mainstem discharges less than that required to breach the upstream ends, the side sloughs convey clear water. The clear water is derived from local surface runoff, small tributary outflow and upwelling groundwater (R&M, WCC & HE 1985; R&M 1985b; APA 1984g; ADF&G 1983k; 1984v; 1984r; 1985l; WCC 1984a,b). The total clearwater discharge in the side sloughs is dependent upon storm events and rates of groundwater upwelling (R&M 1985b; APA 1984g).

Habitat conditions within the mouth of side sloughs at mainstem discharges less than breaching are also affected by backwater effects of mainstem stage. The stage in the mainstem controls the water surface elevation of the lower portion of the sloughs by forming a backwater that extends some distance upstream into the slough (ADF&G 1983k, 1983n, 1984r, 1985l). This backwater is divided into two parts - clear water and turbid water. The mainstem water creates a turbid plug at the mouth that backs up clear water in the slough. As the stage in the mainstem drops, the size and character of the backwater changes. When mainstem discharge is between approximately 8,000 to 10,000 cfs at Gold Creek (RM 136.8), the backwaters are minimal at most side sloughs (ADF&G 1983k). A consequence of low mainstem discharge is that the depth of water at the entrance to the sloughs is reduced (ADF&G 1984r, 1985l). A more detailed description of the hydrologic and water quality characteristics of side sloughs is presented in Exhibit E, Chapter 2. The utilization of side slough habitats by salmon and resident species is summarized in Table E.3.2.28.

- Species Occurrence and Relative Abundance (**)

  ◦ Salmon (**)

    Various life stages of all five salmon species utilize side slough habitat during the year.

    Although chinook salmon do not spawn in side sloughs, juvenile chinook move into these habitats in September to overwinter (ADF&G 1983e, 1983m, 1983n). The increased number of juvenile chinook in side sloughs is depicted in Figure E.3.2.37. Side sloughs also provide rearing habitat for juvenile chinook throughout the summer, but the proportion of the catch per unit effort in side sloughs is less than 10 percent (Figure E.3.2.36).

    All but a few adult sockeye salmon spawn in side slough habitats (ADF&G 1983a, 1984h, 1985b). Peak escapement counts are depicted in Figures E.3.2.8 through E.3.2.13. Estimates of the total number of sockeye salmon spawning in each slough from 1981-1984 are summarized in Table E.3.2.12. Incubating sockeye embryos are present in the side sloughs throughout the winter months. Once the fry emerge from the gravels, Age 0+ juvenile sockeye remain in side sloughs for a short time before out-migrating in July and August (ADF&G 1983m, 1984c) as indicated in

Figure E.3.2.41 by the reduced mean catch per cell. In 1983, 44 percent of the catch per unit effort of sockeye juveniles was from side slough habitats as depicted in Figure E.3.2.38. Some sockeye juveniles overwinter in side sloughs but their occurrence is limited (ADF&G 1981d, 1983e, 1985a).

A few adult coho salmon have been observed in side sloughs (ADF&G 1983a, 1984h). Some juvenile coho move into side sloughs to rear but the proportion is relatively small, less than 10 percent of the total coho catch per unit effort, (ADF&G 1984c) as indicated in Figure E.3.2.39. The densities of coho juveniles appear greatest in July (Figure E.3.2.24 probably coinciding with redistribibition of the juveniles from natal areas to rearing areas (ADF&G 1984c).

Up to 30 percent or more of the chum salmon spawning in the middle river occurs in side slough habitats (ADF&G 1981a, 1983a, 1984h, 1985b). Peak escapements to each of the sloughs is depicted in Figures E.3.2.8 through E.3.2.13 and estimates of the number of chum salmon spawning in each slough each year from 1981-1984 are presented in Table E.3.2.19. Incubating chum embryos are present in the side sloughs through the winter.

Juvenile chum remain in side sloughs prior to out-migrating from the middle river. The relative proportion of juvenile chum catch per unit effort collected from side sloughs in 1983 is depicted in Figure E.3.2.40. Juvenile chum leave the side slough habitats by the end of June (Figure E.3.2.43, ADF&G 1983m, 1984c).

A few pink salmon utilize side sloughs for spawning as indicated in Figures E.3.2.8 through E.3.2.13. The total number of pink salmon found in side sloughs each year is dependent on the size of the escapement. During even years, use of side sloughs for spawning is higher than during odd years (see Section 2.2.1.a.v).

. Resident Species (**)

All resident species reported in this reach of the Susitna River have been observed in slough habitat.

Available data indicate that most resident species are present in sloughs as well as the mainstem throughout winter (ADF&G 1981e, 1983e, 1985a). During summer, most adult residents are not abundant in sloughs (ADF&G 1983m, 1984c). Those that were relatively abundant in slough mouth habitat during summer included burbot, longnose sucker, and rainbow trout. Previous studies indicated that juvenile whitefish, grayling, and rainbow trout were abundant in slough habitat during late summer (Friese 1975).

- Significance of Habitat (**)

A summary of the occurrence of the various life stages of salmon and resident species which use side sloughs is presented in Table E.3.2.28. The most important use of side sloughs is by chum and sockeye salmon for spawning and incubation of embryos, by juvenile chum, sockeye and coho for rearing and by sockeye, coho and chinook juveniles for overwintering.

(v) Upland Sloughs (**)

Upland sloughs are analogous to small tributaries (EWT&A 1984, ADF&G 1983n). 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 occur only at extremely high mainstem discharge. Upland sloughs are depicted in Figures E.3.2.18 through E.3.2.35. The principle influence of mainstem discharge on upland sloughs is through the backwater effect of mainstem stage (EWT&A 1984, ADF&G 1983k). The utilization of upland sloughs by salmon and resident species is summarized in Table E.3.2.28.

- Species Occurrence and Relative Abundance (**)

  . Salmon (**)

    The principle use of upland sloughs by salmon is as rearing habitat for juvenile coho and sockeye. The relative importance of upland sloughs to sockeye and coho is evidenced by the large proportion of catch per unit effort represented by upland sloughs depicted in Figures E.3.2.38 and E.3.2.39. Upland sloughs are also used by sockeye, coho and chinook juveniles for overwintering (ADF&G 1983e, 1985a). Generally, the juveniles become abundant in upland sloughs in mid to late June and remain at higher densities through September and October as shown on Figures E.3.2.41 and E.3.2.42, respectively (ADF&G 1983m).

  . Resident Species (**)

    The only resident species to be collected from upland sloughs in any abundance is rainbow trout, although individuals of all species have been collected in upland sloughs (ADF&G 1981e, 1983m, 1984c).

- Significance of Habitat (**)

  The primary use of this habitat type is for rearing and overwintering by juvenile sockeye and coho salmon as shown in Table E.3.2.28.

(vi) Tributary Habitats (**)

Tributaries that flow into the middle Susitna River all convey clear water into the river. The two major tributaries of the Middle River are Indian River and Portage Creek, each of which have an annual average discharge of approximately 500 cfs. Numerous other tributaries that flow into the middle river are identified in Figures E.3.2.8 through E.3.2.13. The utilization of tributary habitat by salmon and resident species is summarized in Table E.3.2.28.

- Species Occurrence and Relative Abundance (**)

  - Salmon (**)

    All life stages of chinook, coho, chum and pink salmon occurring in the middle reach utilize tributary habitat as depicted on Table E.3.2.28. The relative abundances of these species in tributaries are discussed partially in Section 2.2.1.a and are summarized below.

    The relative abundance, as evidenced by peak escapement counts of adult chinook salmon in middle reach tributaries, is summarized in Table E.3.2.9. Indian River and Portage Creek provide spawning habitat for the majority of the chinook using the middle river. Juvenile chinook remain into the tributaries at relatively high densities for approximately two months before some begin to move downstream into the mainstem. Approximately 61 percent of the catch per unit effort of chinook was from tributaries as depicted in Figure E.3.2.36. Chinook juveniles tend to remain in the tributaries throughout the summer(Figure E.3.2.37) and some juvenile chinook remain in the tributaries throughout the winter and out-migrate to the mainstem in June and July the following year (ADF&G 1983m, 1984c).

    The relative abundance of coho salmon using tributaries of the middle reach as indicated by peak index counts are summarized in Table E.3.2.15 and are depicted in Figures E.3.2.8 through E.3.2.13. Whiskers Creek, Indian River and Gash Creek provide spawning habitat for the majority of coho in most years. As with chinook salmon, incubating embryos occur in the tributaries in direct proportion to the number of adults spawning in the tributaries. Following emergence of the juveniles, many remain in the tributaries with over 50 percent to the catch per unit effort obtained from tributary habitat (Figure E.3.2.39) (ADF&G 1984c). Juvenile coho tend to remain in tributary habitats at high densities throughout the summer as indicated by the high catch per unit effort through the summer months (Figure E.3.2.42). Some reduction in the densities occurs as juveniles move out of the tributaries into side sloughs and upland sloughs

(ADF&G 1983m, 1984c). Tributaries also provide overwintering habitat for coho juveniles.

Approximately 50 percent or more of the chum salmon spawning in the middle river spawn in tributary habitats. Peak index counts are summarized in Table E.3.2.18 and are depicted in Figures E.3.2.8 through E.3.2.13. Chum embryos are present in direct proportion to the number of adults spawning in the tributaries. Juvenile chum remain in the tributaries until early July (Figure E.3.2.43) when they out-migrate from the system. Approximately 34 percent of the catch per unit effort of chum juveniles was from tributary habitat (Figure E.3.2.40).

Pink salmon utilize a number of tributaries for spawning, particularly some of the smaller streams, as summarized in Table E.3.2.20 and depicted in Figures E.3.2.8 through E.3.2.13. Juvenile pinks out-migrate from the tributaries upon emergence almost immediately after the river becomes ice free in the spring. Hence, no rearing of juvenile pink occurs in tributary habitat.

. Resident Species (**)

All resident species present in the middle river, with the exception of burbot and round whitefish sculpins, utilize tributary habitats for spawning and rearing during summer (ADF&G 1983m, 1984c). During winter, resident species tend to move out of tributaries to overwinter in the mainstem.

- Significance of Habitat (**)

Tributaries provide important habitat for nearly all species of salmon and resident species occurring in the middle river. Tributary habitat conditions provide the base for the majority of fish production occuring within this reach.

(c) Cook Inlet to Talkeetna (**)

The lower Susitna River is moderately to extensively braided throughout most of the reach. From Cook Inlet to Bell Island (RM 10), the river is separated into two braided channels; from Bell Island to the Yentna River (RM 27), a single meandering channel is formed. From the Yentna River to Sheep Creek (RM 70), the river is moderately to extensively braided, with forested islands and nonforested bars between the channels of the river. The river is reduced to a single channel near the Parks Highway Bridge (RM 84), and braiding is moderate from this point upstream to Talkeetna, (R&M Consultants and EWT&A 1985b). Gradients vary considerably in this reach. From Cook Inlet to RM 50, the gradient is 1 ft/mile (0.2 m/km); from RM 50 to 83, it is 5.9 ft/mile (1.1 m/km); and from RM 83 to Talkeetna, the gradient is 6.9 ft/mile (1.3 m/km). Typical substrate in the reach is silt and sand with some gravel and rubble. Major tributaries include: Alexander Creek, Yentna River, Kroto Creek (Deshka River), Chulitna River, and the Talkeetna River. Flows in these tributaries are considerable. The Chulitna and Talkeetna Rivers contribute about 57 percent of the total flow below the confluence near Talkeetna (APA 1983b).

A more complete description of the morphological character of the lower river is presented in Exhibit E, Chapter 2 and complete aerial photographic coverage is presented in R&M Consultants and EWT&A (1985b). The lower river channel is relatively unstable in that the main channel changes through time. These changes can occur relatively rapidly, primarily as a result of floods with some influence by ice processes (Exhibit E, Chapter 2, Section 2.3.2). Changes in channels over the recent past are described in R&M Consultants and EWT&A (1985b).

All seven habitat types described for the middle river are present in the lower river. However, upland sloughs and lakes comprise a relatively small proportion of the total area of the reach and, therefore, are not discussed below. Because of the extensively braided character of the lower river, distinction between side sloughs and side channels is not as easily defined as for the middle river. Also, side channels and side sloughs are intricately intermixed into complex channel configurations. Therefore, side channels and side sloughes are treated together as side channel complexes.

(i) Mainstem Habitat (**)

Braided river reaches such as the lower Susitna are characterized by two or more interconnecting channels separated by unvegetated or sparsely vegetated gravel bars. The active floodplain is wide and contains numerous high water channels and occasional vegetated islands. Active channels are typically wide and shallow and carry large quantities of sediment at high flows. Bars separating the channels are usually low, gravel-surfaced, and easily erodible. The lateral movement of channels within the active floodplain of a braided river that carries large quantities of bedload is expected to be high. The channels shift either by bank erosion or by channel diversion into what was previously a high-water channel. Gravel deposits may partially or fully block channels, thereby forcing flow to develop a new channel.

Because braided river channels are wide and shallow, they are more sensitive to flow reductions than the deeper channels of a split channel system, i.e., a drop in stage could result in a substantial reduction in the width of the river and loss of large wetted areas along the margins of the channel.

- Species Occurrence and Relative Abundance (**)

  - Salmon (**)

    Adult salmon pass through this reach of the mainstem during their spawning migration. Generally, the migration extends from late May into September (specific dates are reported in Section 2.2.1.a). The relative abundance of adult salmon in this reach is high because the entire salmon run must pass through the lower sections of the river in order to arrive at spawning grounds. Population estimates of the number of salmon that pass various escapement monitoring stations are given in Table E.3.2.6 and Figure E.3.2.5.

    Spawning of adult salmon and rearing of juvenile salmon have not been documented in mainstem areas. Juvenile chinook and sockeye salmon are abundant in some mainstem areas during winter (ADF&G 1983e). Some juvenile coho are also present in the mainstem but are more often associated with tributary mouth habitats during the winter (ADF&G 1983e). The mainstem also provides a migration corridor for out migrating juveniles.

- Other Anadromous and Resident Species (**)

Other anadromous species observed in this reach include Bering cisco and eulachon. Although spawning activity by Bering cisco may occur throughout the reach between RM 30 and RM 100, three spawning areas were identified in mainstem areas (ADF&G 1983a). Eulachon were observed in the lower 58 miles of the lower river in 1981 (ADF&G 1981a), in the lower 48 miles in 1982 (ADF&G 1983a), and in 1983, eulachon were observed below RM 50 (ADF&G 1984h). A complete description of eulachon migration and spawning is presented in ADF&G (1984h). Habitat use of eulachon for spawning is described by ADF&G (1984q).

Burbot and longnose sucker are present throughout the year and utilize the mainstem for overwintering, spawning, and juvenile rearing. Habitat utilization within the mainstem is probably similar to that previously discussed for the middle river.

Apparently, burbot spawn at the mouths of the Deshka River and Alexander River in December and January (ADF&G 1985c). Juvenile and adult burbot inhabit the lower river throughout the year. Densities of habitat in the lower river are higher than in the middle river or impoundment zone.

Arctic grayling, rainbow trout, Dolly Varden, and round whitefish are resident fish that use the mainstem as a migratory channel to tributary spawning habitat and as overwintering habitat. Movement from tributaries to the mainstem for overwintering is inferred from radio-tracking studies of rainbow trout in the lower river (ADF&G 1983m).

- Significance of Habitat (**)

The primary use of lower river mainstem habitat by salmon is as a migration corridor for both adults and juveniles. The mainstem is also used to some extent for juvenile rearing and overwintering. The mainstem is also important for spawning of Bering cisco and eulachon. Burbot and longnose sucker are year-round inhabitants of mainstem habitat. These habitats provide a migration corridor for rainbow trout, Arctic grayling, Dolly Varden, and round whitefish as well as overwintering habitat for all of these species.

(ii) Side Channel Complexes (**)

Side channel complexes consist of numerous interconnecting channels that are sensitive to changes in total discharge in the river.

- Species Occurrence and Relative Abundance

. Salmon (**)

Juvenile chinook salmon, chum, and sockeye utilize side channels for rearing. Highest catches of juvenile chinook were from moderately turbid (less than 200 NTU) areas of side channel complexes. Juvenile chum and sockeye, on the other hand, were collected in greater number in the clearwater, slough areas within the side channel complexes (ADF&G 1985c).

Some chum, sockeye and pink salmon spawn in side channel side slough complexes (ADF&G 1981a, 1985b). It is evident, however, that side channel complexes provide spawning habitat for small fractions of the total populations of these species (ADF&G 1981a, 1985b).

. Resident Fish (**)

The occurrence and relative abundance of resident species occupying side channel side slough complexes are similar to that described for middle river side channels and side sloughs. Burbot, longnose sucker and rainbow trout are the more abundant resident species occupying this habitat type (ADF&G 1981e, 1985c).

- Significance of Habitat (**)

As with the side channels and side sloughs present in the middle river, side channel complexes of the lower river provide important spawning habitat for chum salmon, and overwintering habitat for chinook and sockeye juveniles.

(iii) Tributary Mouth Habitat (**)

Tributary mouth habitat in the lower river is similar to that described for tributary mouths of the middle river. The major difference is that four of the tributaries, Yentna, Kashwitna, Talkeetna and Chulitna, are of glacial origin and, therefore, do not have clearwater plumes that extend into the mainstem.

- Species Occurrence and Relative Abundance (**)

  . Salmon (**)

  Utilization of tributary mouth habitat by salmon species is similar to that described for the middle reach. Upstream migrating adult salmon tend to congregate in clear tributary mouths to rest prior to resuming their upstream migration.

  The major difference in the use of lower river tributary mouths by salmon is that these habitats provide the major rearing and overwintering habitat for juvenile chinook, sockeye and coho (ADF&G 1981e, 1983m, 1985c). Within the tributary mouth habitats, juveniles use deep, low velocity clearwater areas with overhanging and emergent vegetation or undercut banks (ADF&G 1985c). In 1981 and 1982, 95 percent of all chinook juveniles collected in the lower reach were captured in tributary mouth habitats.

  . Resident Species (**)

  The occurrence and relative abundance of resident species in tributary mouths is similar to that described for the middle river.

- Significance of Habitat (**)

Tributary mouth habitat provides important rearing areas for juvenile chinook, sockeye and coho salmon. They also provide resting areas for upstream migrating adults of all salmon species. Tributary mouths also provide substantial rearing and overwintering areas for all resident species.

(iv) Tributary Habitat (***)

Tributaries in the lower river constitute a major portion of the total habitat available for fish and also contribute nearly 80 percent of the total discharge from the drainage basin. The Yentna River contributes approximately 40 percent of the total discharge, the Talkeetna River approximately 10 percent and the Chulitna River approximately 20 percent whereas the middle Susitna River contributes approximately 20 percent of the total discharge from the basin (USGS 1983). The remaining 10 percent of the discharge is contributed by intervening, mostly clearwater, tributaries. The Kashwitna River is of glacial origin and is turbid during the summer.

- Species Occurrence and Relative Abundance (**)

  - Salmon (**)

    Tributaries of the lower river serve as spawning habitat for more than 90 percent of all salmon utilizing the Susitna River (Table E.3.2.6). As such, the tributaries provide significant incubation and rearing habitat for salmon as well as migration corridors.

  - Resident Species (**)

    The occurrence and relative abundance of resident species in the tributaries of the lower river is similar to that described for the tributaries of the middle river.

- Significance of Habitat (**)

  Tributary habitats, both clearwater and turbid, provide the primary habitat for salmon and resident species within the Susitna Basin. Because each of the tributaries is independent of effects of mainstem Susitna River discharge, no effects, attributable to the Susitna Hydroelectric Project are expected.

2.2.3 - Habitat Response to Flow Changes (***)

A particular set of physical habitat characteristics can be readily defined under steady state or instantaneous conditions. However, habitats, particularly in riverine systems, tend to change continuously through time and, therefore, are dynamic habitats. As flow or discharge in a river changes, basic habitat characteristics such as water depth, water velocity and total habitat area at a given site will also change. In order to fully understand the relationship between the occurrence and abundance of fish populations in a particular system, it is necessary to describe how a specific habitat area responds to flow changes. An appropriate method to evaluate the habitat response to flow change is to define the physical habitat at several instantaneous discharges, simulate the conditions using a mathematical model, and interpolate the conditions for intervening flows.

The process for describing habitat response to changing discharge in the Susitna River is described below. Briefly, the first step of the analysis is to describe how the total wetted surface area of the river changes with flow. Since the total wetted surface area includes a diverse array of habitat types, the second step is to subdivide the total surface area into relatively discrete categories. The third step of the process is to select habitat/lifestage combinations most sensitive to mainstem discharge (HE 1984b, 1985a). Once the species to be analyzed have been selected, the fourth step is to determine the particular responses of suitable physical habitat conditions for those species to discharge changes.

Since the wetted surface area does not necessarily describe the habitat conditions present under the surface, it is necessary to define what proportion of the surface area in a site contains suitable physical habitat characteristics such as depth, velocity, substrate or cover. The relationship between the total surface area and proportion containing suitable habitat is then calculated through a range of site or mainstem flows. By comparing depth, velocity, and substrate or other habitat characteristics present in the area with the ranges of these characteristics which are suitable for fish, an estimate of the usable area in the habitat sites through a range of flows can be made. These estimates of the habitat areas at given flows in turn can be used to quantify the response of the habitat area to flow. A description of the response of habitats to flow through time is then possible by comparing the flows in a given increment of time with the habitat response curves.

The focus of the analysis presented below is for the middle river since the flows in this reach will be most directly affected by the Project. Downstream from Talkeetna, discharge in the Susitna River is highly influenced by discharge from the Chulitna and Talkeetna Rivers and, therefore, response of habitats to changes in flow attributable to the project are attenuated. Data are available, however, to perform the analysis as described below for the middle river. (ADF&G 1985b; HE

(a) <u>Surface Area Response to Flow Changes</u> (***)

The total wetted surface area of the middle river was measured from aerial photographs representing seven mainstem discharges measured at the USGS Gold Creek Gaging Station (EWT&A 1985b). The discharges were 5,100 cfs, 7,500 cfs, 10,600 cfs, 12,500 cfs, 16,000 cfs, 18,000 cfs and 23,000 cfs. The surface areas for each discharge area were measured with a digital planimeter from the aerial photographs printed at a scale of 1 inch to 1,000 ft, as described by EWT&A (1985b). Examples of the aerial photographs used for measuring total surface at 23,000 and 12,500 cfs areas are presented in Figures E.3.2.18 through E.3.2.35.

In the process of measuring the total surface areas, discrete habitat type areas were delineated. The same habitat type delineations were retained on each set of aerial photographs so that the surface areas of the sites at each flow could be compared. The delineation of the sites at each of the flows is exemplified in comparison of the upper (23,000 cfs) and lower (12,500 cfs) panels in each of the Figures E.3.2.18 through E.3.2.35 (EWT&A 1984).

The initial classification of the total wetted surface areas was based upon the seven habitat types described in Section 2.2.2. Two of the seven habitat types, lakes and tributaries, were not included in the analysis since the surface areas do not change with mainstem discharge changes. Hence, the total wetted surface areas were initially categorized into mainstem, side channel, side slough, upland slough and tributary mouth habitat types. In some cases, the inclusion of a particular site in the areas of side channels or side sloughs did not remain the same for all discharges. At a given flow, if the particular site was conveying turbid mainstem water, the surface area of that site was included as a side channel. If at a lower mainstem discharge, the site was conveying clear water, the surface area was classified as a side slough (EWT&A 1985b).

The surface areas of the respective habitat classes at each of the seven mainstem discharges are summarized in Table E.3.2.29 and are depicted in Figure E.3.2.44. The total surface area of the mainstem increases as mainstem discharge increases. Similarly, the total wetted surface of side channel habitats increases with increasing mainstem discharge however, the rate of increase is somewhat different than in the mainstem due in part to differences in the channel morphology. Most of this surface area increase is due simply to the fact that more water in the river results in more surface area. However, part of the increase is due to the transformation of side slough into side channel habitats (EWT&A 1984). Also at higher discharges (e.g. greater than 16,000 cfs) some side channels transform to mainstem areas and as a result, the relative increase in side channel surface area is not as great as at somewhat lower discharges.

The decrease in the surface area of side sloughs at progressively higher discharges is due primarily to the transformation of clearwater side sloughs to turbid water side channels. (Table E.3.2.29, and Figure E.3.2.44).

Upland slough areas remain relatively constant at all mainstem discharges greater than approximately 7,500 cfs. This is indicative of the relative independence of these areas from mainstem discharge. (See Table E.3.2.29 and Figure E.3.2.44).

Surface areas of tributary mouth habitat show no consistent changes with respect to mainstem discharge. As discussed previously, this is because the total area of tributary mouth habitats varies with both mainstem and tributary discharge. For purposes of the following discussion, the response of tributary mouth habitat to changes in mainstem discharge is not considered further because of this evident inconsistent relationship. A more detailed discussion of the relationship is presented in ADF&G (1984s).

(b) Development of Representative Groups of Habitat Sites (***)

Although the classification of habitat areas into one of the five habitat types outlined above gives a first level picture of how habitat areas respond to flow change; inspection of the aerial photographs and data from specific habitat study sites (ADF&G 1983k, 1984b, 1984i; EWT&A 1984, 1985b; EWT&A and AEIDC 1985) indicates that a more refined level of classification is necessary to adequately analyze habitat response to flow with respect to specific habitat/-species combinations. The classification of sites into representative groups was accomplished by first delineating 167 specific sites within the middle river. The apparent flow conditions in each of the sites was evaluated on the seven sets of aerial photographs to determine the basic response of the habitat to change in mainstem discharge. In order to identify the basic response of the site a flow chart was developed to track and characterize the response of each site to decreases in mainstem discharge. This flow chart is presented as Figure E.3.2.45. The response of a particular habitat site or specific area was based on comparison of the habitat type at that site at 23,000 cfs with the habitat type at that site at a lower discharge.. Thus, if at 23,000 cfs the site was a turbid side channel, and at 16,000 cfs the site was a clear side channel with apparent upwelling groundwater; the site was put into Response Category 2 (see Figure E.3.2.45). If at 23,000 cfs, another site was considered to be a turbid side channel, and at 16,000 cfs it has remained a turbid side channel; the site was put into Response Category 4 (see Figure E.3.2.45). A complete description of this process and the results of the analysis is presented in EWT&A and AEIDC (1985).

In addition to determining the response behavior of specific habitat areas, certain other characteristics of the sites were used to place the sites in relatively homogenous representative groups. A primary factor considered in the evaluation of the sites was the mainstem discharge required to breach the upstream ends of defined channels. For example, defined channels which only convey mainstem water at discharges greater than 20,000 cfs and are breached at discharges less than 35,000 cfs were put into one group. Those channels for which the upstream ends become breached between 5,100 and 20,000 cfs were placed in another group and those which convey mainstem discharge and are considered to be side channels at less than 5,100 cfs were placed in another group. Other considerations used for placement into a particular group included presence or absence of groundwater upwelling, length to width ratios, cross sectional shape, mean channel water velocity, substrate composition and pool-to-riffle ratios (EWT&A and AEIDC 1985).

Based on these considerations, ten groups of sites were identified, with all sites within a group having similar responses to changes in flow and channel characteristics. The ten groups are presented in Tables E.3.2.30 through E.3.2.39. Brief descriptions of the groups and the specific sites included in the groups are presented with the tables. The sites are identified by river mile and their occurrence on the left or right side of the mainstem looking upstream. A complete description of the development of the representative groups is presented in EWT&A and AEIDC (1985).

(c) Principal Habitat/Species Combinations (***)

Although all salmon species and resident species inhabit the Middle River during some period during the year, only a few species utilize areas which are sensitive to changes in mainstem flow. Discussion of both the sensitivity of the habitat areas to mainstem flow change and the occurrence and distribution of the fish species have been presented previously in Sections 2.2.1 and 2.2.2 and Tables E.3.2.26 and E.3.2.28, respectively and are summarized in Table E.3.2.40.

Several observations can be drawn from the habitat uses summarized in Table E.3.2.28. First, tributary habitat is the habitat type used most commonly by the species inhabiting the middle river. Sockeye salmon and burbot are the only species that do not use tributaries extensively for important life history phases. Secondly, the resident species make little use of side channel, side slough or upland slough habitats; whereas the anadromous salmon frequently use these habitats. The most common use of the mainstem habitat type is for migration and movement although resident species also overwinter in the mainstem (HE 1985a).

Habitat requirements associated with migration and movement are less critical and restrictive than for the other life history categories (ADF&G 1984h, 1984c, 1985b, 1985c). Suitable depths and velocities exist over a broad range of mainstem flows. Flow requirements to satisfy the more critical needs of rearing and spawning/incubation will also satisfy the habitat needs for migration. Therefore, habitat requirements for rearing and spawning/incubation were emphasized for the remainder of the analysis.

The four sensitive habitat types from Table E.3.2.28 (MS=mainstem, SC=side channel, TM=tributary mouth and SS=side slough) were selected for comparison based on their use for rearing and spawning/incubation (See Table E.3.2.40).

Mainstem habitat (MS) is used mostly for rearing, especially overwintering (ADF&G 1984c, 1985c). Use of the mainstem by chum juveniles is transient and short-term during their downstream movement to Cook Inlet (ADF&G 1984c, 1985c). The major use of mainstem habitat by Arctic grayling, rainbow trout and Dolly Varden is for overwintering, although the populations of all the resident species in the Middle River, including burbot, are characterized as low density (ADF&G 1983m, 1984c).

Arctic grayling and rainbow trout use tributary mouth habitat (TM) for rearing during the ice-free seasons. Use by rainbow is transient, occurring mostly in the late summer and fall (ADF&G 1983m, 1984c).

Side channel habitat (SC) is used by chinook salmon for rearing and by chum salmon for spawning (ADF&G 1983a, 1983m, 1984h, 1984c, 1985b). The chum salmon spawning is limited to sites with sufficient upwelling and accounts for approximately five percent of the total chum spawning in the middle river basin (ADF&G 1983b, k, n, 1984h).

Chinook juveniles rear in side channels through most of the summer and early fall (ADF&G 1984c). The use of this habitat appears to be important to chinook produciton in the Middle River. Therefore, chinook rearing in side channels was selected as one of the critical uses of a sensitive habitat for primary consideration in developing environmental flow requirements (HE-1985a). Side channels are generally represented in Representative Groups 3, 4, and 6. (EWT&A and AEIDC 1985).

Side Slough habitats (SS) are used by salmon for both rearing and spawning/incubation. The chinook salmon rearing in side sloughs during the ice-free season is a lesser component of the total population than those rearing in side channels. Flow requirements to maintain side channel habitat would also serve chinook rearing in side sloughs. Environmental flow cases designed to protect chinook rearing in side channels should also provide for overwintering in side sloughs since, for the most part, the same fish use both habitats (ADF&G 1985a).

Chum and sockeye salmon use side sloughs for both spawning and rearing. Sockeye use of this habitat is so similar to chum, in time and location, that their habitat needs can be provided by concentrating on the more abundant chum salmon. Both species use side sloughs for short term, initial rearing prior to outmigration to Cook Inlet or movement to another habitat type. Chum salmon utilize side sloughs extensively for spawning. This is the most intensive use of a sensitive habitat in the middle river for spawning. Therefore, chum salmon spawning in side sloughs was selected as another critical use of a sensitive habitat for development of environmental flow cases (HE 1985a). Side slough habitats are generally represented in Representative Group 2 (EWT&A and AEIDC 1985).

In conclusion, two principal species/habitat combinations were selected to evaluate the response of habitat to changes in flow and the subsequent effects on fish. These species/-habitat combinations are juvenile chinook salmon rearing in side channel habitats during the summer, and adult chum salmon spawning in side slough habitat during the summer and chum embryo incubation during early winter months. Juvenile chinook overwintering in side sloughs will also be discussed to a greater extent than other species habitat combinations. These two species/habitat combinations form the focus of the flow selection and mitigation planning process (see Exhibit B and Exhibit E, Chapter 2, Section 3). Effects of an altered flow regime on other species will also be discussed.

(d) Quantification of Habitat Response to Flow Changes (***)

The fourth step is describing the response of habitat to discharge delineated in the introduction to this section is to quantify the response of habitat. This is accomplished in three steps. First, the range of physical habitat conditions that are suitable for each fish species must be described. Second, the range of habitat conditions present in a defined area at various flows must be described. Third, the proportion of the total wetted surface area within a defined area containing suitable habitat conditions for each species through a range of mainstem flows must be calculated.

(i) Development of Suitability Criteria (***)

Two basic methods may be employed to describe the particular ranges of habitat conditions that are used by fish. These are determination of preference criteria or determination of suitability criteria. Preference criteria is developed by comparing the range of available habitat conditions with the ranges utilized by the particular species. Suitabilility criteria are developed principally by defining the range of habitat conditions utilized by the species of interest. For juvenile chinook and spawning chum salmon, suitability criteria for principal habitat characteristics were developed (ADF&G 1983m, 1983k, 1983n, 1984c, 1984b).

Juvenile chinook suitability criteria were developed for depth, velocity and object cover by measuring these characteristics in areas where juvenile chinook were present (ADF&G 1983m, 1984c). During the investigations it was noted that there was some distinction between the ranges of water depths, velocities and object cover used in clearwater and those used in turbid water. Hence, two sets of suitability criteria were developed for juvenile chinook rearing (ADF&G 1984c; EWTA and WCC 1985). These criteria are presented in tabular and graphical form in Figures E.3.2.45 and E.3.2.46, respectively. Cover suitability criteria are depicted graphically in Figure E.3.2.47 and in tabular form in Table E.3.2.41. Detailed descriptions of the development of these criteria are presented in ADF&G (1984c) and EWT&A and WCC (1985).

A similar set of suitability criteria were developed for chum salmon spawning habitat. The prime consideration in this development was the presence or absence of groundwater upwelling. Throughout the field program, chum salmon were observed to spawn only in areas where groundwater upwelling was present (ADF&G 1983k, 1983n, 1984b). Due to the difficulty in determining the areal extent and the rate of groundwater upwelling as it influenced the selection of spawning sites by chum, a simple binary criterion was developed (ADF&G 1983n, 1984b). The suitability index for the presence of groundwater is 1 and for the absence of groundwater is 0. In areas where groundwater upwelling is present, suitability criteria in terms of water depth, water velocity and substrate composition were developed. No difference in the ranges of those characteristics was observed between clearwater and turbid water conditions. Therefore only a single set of criteria was developed and are presented in Figures E.3.2.49, E.3.2.50 and E.3.2.51, respectively (ADF&G 1984b).

The ranges of depth, velocity and substrate composition determined to be suitable for chum salmon spawning in mainstem affected areas of the Middle River (i.e. exclusive of tributaries) are presented in graphical and tabular form. The presence of groundwater upwelling is incorporated in the substrate suitability criterion (ADF&G 1983k, 1983n, 1984b; EWT&A and WCC 1985).

(ii) Determination of the Range of Habitat Conditions Available (***)

For the middle Susitna River, two variations of the Instream Flow Group (IFG) hydraulic models, the IFG-4 hydraulic model and the IFG-2 hydraulic model (Bovee and Milhous 1978, Bovee 1982) were used to determine the ranges of conditions available within the sites for use by juvenile chinook salmon and spawning chum salmon. Fifteen sites were selected to describe the available ranges of habitat conditions within the sites using the IFG models. (ADF&G 1983n, 1984b; EWT&A 1985c). Sites for which IFG hydraulic models were developed are identified on the list of sites within the 10 representative groups (Tables E.3.2.30 through E.3.2.39).

Two additional types of models were developed for other sites within the Middle River. The habitat simulation model developed by ADF&G (1983m, 1983n, 1984c), referred to as the RJHAB Model, uses field data directly in evaluating the available habitat for juvenile salmon rearing. A direct input variation of the IFG Model (DIHAB) which also uses field hydraulic data directly was developed by EWT&A (1985c). Neither of these models simulates hydraulic habitat conditions between the discharges at which the data were collected. The habitat conditions at set intervening flows are interpolated linearly. A total of 6 sites were modelled using the RJHAB Model and a total of 12 sites were modelled using the DIHAB variation of the IFG Model. Sites for which RJHAB and DIHAB Models were developed are identified in Tables E.3.2.30 through E.3.2.39.

Each of the IFG models was calibrated using physical habitat data collected at the model sites at 3 to 5 different site flows. Outputs of the hydraulic models include water surface area of the sites, and distributions of water depths, water velocities and substrate composition throughout the modelled sites at each calibration site flow and specified intervening site flows (ADF&G 1984b; EWT&A 1985c). The physical habitat characteristics versus site flows were then translated to physical habitat characteristics versus mainstem flows from concurrent measurements of site flow and mainstem discharge at the USGS Gold Creek Gaging Station. Mainstem versus site flow relationships are presented in (ADF&G 1983k, 1984i). Specific procedures used for hydraulic model calibrations and verification are presented in ADF&G (1984b).

(iii) Habitat Response Curves (***)

The evaluation of the response of habitat for juvenile chinook rearing and chum spawning is accomplished by determining the proportions of the total water surface of the areas within the modeled sites which have suitable physical habitat characteristics. The apportionment of the total surface area which contains suitable habitat is accomplished by multiplying the wetted surface areas of individual cells within the model site by the suitabilities with respect to depth, velocity and cover as substrate. This apportionment is generally accomplished for the IFG Model site through the HABTAT Model developed by the Instream Flow Group (Boves 1982). The surface areas of the cells are miltiplied by the suitabilities of the depth velocity and cover or substrate present in the cells. The output from this model is presented in terms of Weighted Useable Area (WUA) per 1,000 ft of stream for a range of flows appropriate to the analysis. Also, output from the model includes the gross water surface area per 1,000 ft of stream.

Usually, the WUA per 1,000 ft is used directly for the evaluation of habitat response to flow. However, because the modelled sites in the Susitna River represent a variety of habitat types (i.e. 10 Representative Groups), an index or proportion of the total surface area which contains suitable conditions was estimated. This proportion is determined by dividing the WUA/1,000 ft by the total wetted surface area/1,000 ft. These ratios are multiplied by 1,000 sq. ft. to give a number that is more easily interpreted as the WUA per 1,000 sq. ft. of water surface area.

Habitat response curves for juvenile chinook rearing were developed for 14 of the IFG Model sites (ADF&G 1984c, EWT&A 1985c). Six additional sites were modelled using the RJHAB Model developed by ADF&G (1984c). The RJHAB Model is a direct input type model in which the surface areas for individual cells within the model site are multiplied by the suitability factors and the cells WUA's summed. As with the IFG Model, the RJHAB Models provide WUA's and total surface areas. However, these are presented in terms of the total length of the model site and must be standardized to 1,000 ft of length or the proportions can be calculated directly from the ouput. One of the six RJHAB Modeling sites was also modeled with the IFG Model for comparison. Habitat Response curves for juvenile chinook salmon rearing for 20 sites are presented in tabular form in Table E.3.2.42

and are depicted graphically in Figure E.3.2.52. Sites for which IFG and RJHAB Models were developed are identified in Tables E.3.2.30 through E.3.2.39.

Habitat response curves for chum salmon spawning areas were taken directly from the IFG and DIHAB model results without standardization to 1,000 ft of stream length or to WUA per 1,000 sq. ft. of surface area. Six IFG models and 12 DIHAB models were developed at sites used by chum salmon for spawning. Results of these models, in terms of the total WUA for chum spawning at the sites, are presented in Table E.3.2.43 and are depicted graphically in Figure E.3.2.53.

The sites used by chum salmon for spawning are located throughout the middle river and each can be placed in one of the Representative Groups, which are identified in the table. In addition to the use of all modelled sites for evaluating chum spawning habitat response to flow, standardization of the model results to WUA/1,000 sq. ft., as described above for juvenile chinook rearing habitat, was done for the IFG model and DIHAB sites included in Representative groups 2, 3 and 4. These standardized results are presented in Table E.3.2.44 and are depicted in Figures E.3.2.54.

(e) Habitat Response Curves for Non-Modeled Sites (***)

A general characteristic of these curves response for modeled sites is that the WUA relationship is at its maximum at discharges above those required to breach the upstream ends of the sites. At discharges less than breaching flows, WUA remains relatively constant at all mainstem flows since flow in the side is relatively constant. At extremely high mainstem discharges (in excess of approximately 30,000 cfs) both chinook rearing habitat and chum spawning habitat decreases rapidly due mostly to increases in water velocity. Another general characteristic is that the shapes of the curves are affected by the particular morphological or structural characteristics of the sites. Because of generally uniform characteristics of the curves, it is possible to adjust the habitat response curves for the modeled sites to represent the response curves expected in the non-modeled sites (EWT&A and AEIDC 1985, EWT&A 1985a).

Adjustment of the habitat response curves of modeled sites for representing non-modeled sites in the representative group is accomplished in two steps. First, the response curve of the modeled site is shifted to higher or lower mainstem discharges according to the breaching discharges for the modeled and non-modeled site. For example, if the breaching flow for a modeled site is 12,000 cfs and the breaching flow for a non-modeled site is 14,000 cfs; 2,000 cfs is added to the flow coordinates for the modeled sites to give the flow coordinates for the non-modeled site. This shifting of the curve is demonstrated in Figure E.3.2.55.

Although the general structural and morphological characteristics are similar for all sites within a representative group, differences between the sites will result in some difference between the habitat values of modeled and non-modeled sites for each mainstem discharge. The second adjustment to the habitat response curves for modeled sites to represent non-modeled sites is to multiply the habitat values of modeled sites by a ratio of an index of the the structural characteristics for the non-modeled sites to an index of the structural characteristics of the modeled sites. To accomplish this, a Structural Habitat Index (SHI) for each site was developed (EWTA and AEIDC 1985). The SHI is based on channel characteristics such as: dominant cover·type/percent cover, channel geometry, substrate size/substrate embeddedness and streamside vegetation. The development of the SHI for each site is described in EWTA and AEIDC (1985). The SHI's for all sites are presented in Tables E.3.2.30 through E.3.2.39. In some cases, more than one modeled site is included in a representative group. Within the group, the range of SHI's is such that non-modeled and modeled sites can be accumulated into sub-groups with similar SHI's. The ratio of the SHIs for the non-modeled sites to the SHI for the modeled sites are then calculated and the habitat coordinates of the habitat response curves for the modeled sites are multiplied by the ratios to produce the habitat values for the non-modeled site. This process is depicted in Figure E.3.2.55. A detailed discussion of the adjustments of modeled site habitat response curves for non-modeled sites is presented in EWTA (1985a).

Once habitat response curves (in terms of WUA/1000 sq ft vs flow) are developed for each specific area, the total WUA for each site is obtained by multiplying the WUA/1000 sq ft at each flow by the total wetted surface area at each flow. This is accomplished by first dividing the WUA/1000 sq ft by 1000 sq ft and then multiplying by the wetted surface areas. The WUA's at each flow are then added to obtain total WUA's for each group.

The chinook rearing habitat response curves for nine representative groups are presented in Table E.3.2.45 and Figure E.3.2.56. By adding these curves together a total habitat response curve for middle river chinook rearing is generated. The total habitat response curve is presented in tabular form in Table E.3.2.46 and is depicted in Figure E.3.2.57. Perusal of the habitat response curves for each of the representative groups indicates that some of the groups are more sensitive to discharge than others. The most sensitive groups appear to be Representative Groups 2, 3 and 4, Sites included in Representatives Group 2 appear relatively sensitive to discharge, with peak values of WUA at mainstem discharges greater than 20,000 cfs. This corresponds to the fact that all of these sites breach at mainstem discharges between 20,000 cfs and 35,000 cfs (see Table E.3.2.31). These sites are generally considered to be side sloughs. Juvenile chinook are generally not found in these sites when mainstem discharge is less than that required for breaching (ADF&G 1984 Rpt 2). However, juveniles are found in the sites when the upper ends are breached. Sites included in Representative Group 3 generally breach at mainstem flows between 5,000 and 20,000 cfs. These sites have been observed to be utilized by juvenile chinook for rearing more extensively than any other group of sites affected by mainstem discharge. Sites included in Representative Group 4 are generally large side channels which breach at mainstem discharges less than 5,100 cfs. Juvenile chinook have been observed in these sites to some extent. It is expected that these sites will provide significant rearing habitat under project conditions because peak habitat values are associated with discharges between 8,000 and 12,000 cfs which are approximately in the range of discharges expected during project operation (see Section E.3.3 below). Taken as a subset of the total habitat available for juvenile chinook rearing, Representative Groups 2, 3 and 4 are used in the analysis to depict the effects of replacement of habitat in one group with habitat in other groups. The sub total habitat areas in these three representative groups vs flow are presented in Table E.3.2.46 and are depicted graphically in Figure E.3.2.58.

A total habitat response curve for chum salmon spawning was developed simply by adding the WUA's obtained for each of the IFG and DIHAB models presented in Table E.3.2.43. Extrapolation to non-modeled sites was not considered necessary for chum spawning habitat because the modeled sites include the spawning area for approximately 90 percent of the chum salmon estimated to spawn in habitat areas affected by mainstem discharge under existing conditions. A principal characteristic of chum spawning area is the presence of groundwater upwelling in the site (ADF&G 1983k, 1983n, 1984b). Since the presence or areal extent of groundwater upwelling is primarily dependent upon characteristics of the alluvium, upwelling areas are not expected to change significantly with changes in discharge. Therefore, changes in mainstem discharge which are attributable to project operation will directly affect the habitat availability for chum spawning and any lost area is not expected to be replaced with suitable habitat at other locations without mitigation measures. The total habitat area response curve for chum salmon spawning is presented in tabular form in Table E.3.2.47 and is depicted graphically in Figure E.3.2.59.

However, in order to be consistent with the analysis performed for the response of juvenile chinook rearing habitat to discharge, the chum spawning habitat area response to mainstem discharge was also developed for all of the modeled and non-modeled sites included in Representative Groups 2, 3, and 4. Although the extrapolation of the modeled sites to non-modeled sites for chum spawning is not necessary as explained above, the extrapolation process was conducted for these three groups of sites since each group is characterized as having groundwater upwelling present in the site and demonstrate a relatively high degree of sensitivity to mainstem discharge.

In this analysis, it must be assumed that the groundwater upwelling within the non-modeled sites is proportionally similar to the modeled sites with respect to both the areal extent and the distribution of the upwelling. Extrapolation of the IFG amd DIHAB modeled sites to the respective non-modeled sites was performed in the manner described for the chinook rearing habitat area. The habitat area response curves for the Representative Groups are presented in Table E.3.2.48 and are depicted graphically in Figures E.3.2.60 through E.3.2.62. The total habitat area response curve, including all of the IFG modeled and non-modeled sites in the three groups, is also presented in Table E.3.2.48 and is depicted graphically in Figure E.3.2.63.

(f) Habitat Response to Natural Flow Regime ***

As indicated in the habitat area response curves presented in the previous section, the availability of chinook rearing habitat and chum spawning habitat varies with mainstem discharges. The total habitat areas tend to remain relatively high over a relatively broad range of mainstem discharges. Because the fish are able to select suitable habitats from the array of habitats in the river, it is appropriate to evaluate the total habitat availability through time using the total habitat area response curves for chinook rearing (Table E.3.2.46) and chum spawning (Table E.3.2.47 and E.3.2.49).

The availability of total habitat area through time may be evaluated by translating the average weekly discharges at Gold Creek into total average weekly habitat areas. Hence, for every average weekly discharge in the 34 years of historic discharge record, equivalent habitat areas are derived from the habitat area response curves. Based upon these translations for chinook rearing and chum spawning, time series and frequency analyses may be performed. Time series analysis consists of plotting the average weekly habitat areas sequentially through the 34 years of record. The frequency analysis consists of determining the habitat values which are equalled or exceeded 90, 50 and 10 percent of the time using the weekly habitat values derived from the average weekly flows under the natural flow regime. Results of these analyses for chinook rearing and chum spawning habitats are presented in the following sections.

(i) Chinook Salmon Juvenile Rearing Habitats (***)

The evaluation of the response of juvenile chinook rearing habitats to the natural flow regime consists of determining the total area available in the Representative Groups that have suitable depth, velocity and cover characteristics. The habitat response curves presented in Section E.3.2.2.3 for juvenile chinook rearing were developed for the open-water season. These curves are not valid for winter conditions, since the juveniles redistribute themselves into side slough-type habitats that generally have warmer water derived from groundwater upwelling sources. Instream hydraulics during winter months are greatly modified by ice processes. Therefore, hydraulic models developed for open water channels are invalidated with the formation of an ice cover. In addition, the behavior of the fish and their ability to maintain position is dependent on the temperature of the water. Thus, the suitability criteria are not valid for water temperatures less than approximately 4°C. As a consequence, the time series and frequency analyses presented below are conducted for the period June through September.

- Frequency Analysis and Discussion (*)

Using the 34 years of recorded weekly average discharge at Gold Creek and the habitat area response curve for juvenile chinook rearing, the median (50 percent exceedance value) total chinook rearing habitat area in the nine representative groups of sites ranges from approximately 5,000,000 to approximately 7,000,000 sq. ft. through the summer months. Habitat areas generally decrease near the end of the summer as discharge in the river decreases. Because discharge in the river can vary substantially through the summer period, the total habitat area also varies considerably. The median (50 percent) habitat areas for each week through the summer together with the habitat areas which are equalled or exceeded 90 percent and 10 percent of the time are presented in Table E.3.2.49 and are depicted graphically in Figure E.3.2.64. The lower habitat values, i.e. the 90 percent exceedance values, are associated with both extremely low mainstem discharge and with relatively high mainstem discharge as shown in Figure E.3.2.64. The 10 percent exceedance value is closely associated with the optimum flow providing the maximum habitat values. The 10 percent exceedance values of habitat area tend to be associated with those flows corresponding to the peak habitat values presented in Figure E.3.2.64. Hence, the 90 and 10 percent exceedance habitat values do not correspond to the 90 and 10 percent exceedance flow values. Because the natural flow regime is not regulated either at the high or low discharges, the range of habitat area available through time tends to be large. Hence, chinook rearing habitat during the summer under the natural flow regime is characterized by high variation from week to week and from year to year.

A similar relationship is observed for the subset of the total chinook rearing habitat response curves including only Representative Groups 2, 3 and 4 (Table E.3.2.46 and Figure E.3.2.58). Total habitat area for juvenile chinook in the three representative groups generally ranges from approximately 2,000,000 sq ft to approximately 5,000,000 sq ft through the summer months. The range of habitat values in these group through the summer weeks represented by the 90, 50 and 10 percent exceedance values for the 34 year of record are presented in Table E.3.2.50 and are depicted graphically in Figure E.3.2.65.

Unlike the habitat values using the response curve for all sites, the median chinook rearing habitat areas gradually increase through the summer with the most noticeable increase observed in August and September (weeks 32-39) which is associated with the gradual decrease in discharge near the end of the summer. the increase in habitat area is associated with the replacement of habitat area in Representative Groups 2 and 3 by the habitat areas in Representative Group 3 and 4. This is indicated by habitat response curves for the respective groups presented in Figure E.3.2.56. During the middle of the summer, chinook rearing habitat in Representative Groups 2, 3 and 4 remains relatively stable from year to year. Considerably more variation is apparent in June, August and September as indicated by the difference between the 90 and 10 percent exceedance values in Figure E.3.2.65.

(ii) <u>Chum Salmon Spawning and Incubation Habitats</u> (*)

The evaluation of the response of chum salmon spawning and incubation habitats to changes in discharge in the mainstem consists of three principal elements: First, flow must be sufficient for the adult salmon to gain access to the spawning areas. Second, flow in the spawning habitats must be sufficient to provide suitable conditions for spawning activities as described in Section 2.2.3.d.i, that is, the habitats must have suitable water depth, water velocity, and substrates and groundwater upwelling must be present. Third, the sites must retain suitable depth, velocity and upwelling through the winter so that salmon embryos can survive and develop to the juvenile stage.

- <u>Access Conditions vs. Flow</u> (*)

The evaluation of conditions necessary for chum salmon to gain access to spawning areas is a key step in the overall evaluation of the effects of the proposed project on existing populations and their habitats. Approximately 15-25 percent of the chum salmon (approximately 5,000 to 10,000 fish) which enter the Devil Canyon to Talkeetna reach of the Susitna River spawn in side sloughs and side channels (ADF&G 1984h, 1985b).

Side sloughs and side channels are overflow channels of the mainstem which convey turbid mainstem water when mainstem discharge and, therefore, stage is sufficiently great to breach the upstream ends of the channels. Discharges of sufficient magnitude to breach the channels generally occur during the summer, open water months. When mainstem discharge is lower, the upstream ends of the channels are not breached and the channels are similar to small tributaries which convey clear water derived from local surface runoff, small tributaries and upwelling groundwater. During periods when mainstem discharge is not sufficient to breach the channels, side slough (EWT&A 1984) discharges range from about 1-2 cfs to more than 10 cfs. The actual slough dischage at any given time is dependent upon whether or not small tributaries enter the slough, the amount of local precipitation, and the amount of groundwater upwelling. When the upstream ends of the sloughs are overtopped, slough discharges range upward of several hundred cubic feet per second (ADF&G 1983k, 1984i, R&M 1985b).

The ability of chum salmon to gain access to spawning areas within specific sites is dependent upon the depth of water in the channels. In general, the shallower the water, the more difficult the passage conditions are for movement of salmon through the reach (ADF&G 1985l).

Reaches of a slough in which the water depths are occasionally sufficiently shallow to restrict movement of fish are termed passage reaches. Generally, passage reaches are located in riffle areas within the sloughs when slough discharge is relatively low (i.e. the sloughs are not breached). For most passage reaches within sloughs, the depth of water is dependent upon the slough discharge derived from local surface runoff or groundwater upwelling.

For passage reaches located near the downstream ends of the sloughs, water depth is influenced not only by slough discharge, but also by mainstem backwater. The backwater effect on the depth of water in a given passage reach is evident when the water surface elevation of the mainstem near the slough mouth is greater than the water surface elevation in the passage reach. Hence, suitable access conditions in passage reaches are primarily dependent upon the local slough discharge. However, at certain locations, the passage reach can be influenced by mainstem discharge and associated water surface elevation. When the sloughs are breached, discharge in the channel is greatly increased and provides access.

To compare conditions at a passage reach at various mainstem discharges, ADF&G established three passage condition categories representing degrees of difficulty for salmon gaining access upstream of the passage reach. These three conditions are termed: unsuccessful, successful with difficulty and successful (ADF&G 1985l). These conditions correspond to the terms acute, restricted and unrestricted, respectively (ADF&G 1983k, 1983n) and described in the original License Application (APA 1983b). The three passage conditions are distinguished by threshold depths in the passage reach and their corresponding mainstem, local discharges or combinations of mainstem and local discharges. Early analyses of passage depths which distinguish the passage conditions resulted in the definition of threshold passage depths which are greater for longer reaches (Trihey 1982d, ADF&G 1983k, 1983n, 1984r). However, further refinement of the analysis and the incorporation of observational data indicate that chum salmon passage criteria are most sensitive to depth (ADF&G 1985l). The depth criteria which distinguishes unsuccessful passage conditions from successful-with-difficulty and successful-with-difficulty from successful are presented in Figure E.3.2.66. The threshold depth criteria derived by ADF&G are similar to those derived by Thompson (1972).

Detailed analyses of passage reaches in most sloughs in the middle reach of the Susitna River have been conducted to determine mainstem and/or local discharges needed to meet the threshold depths described in Figure E.3.2.66. Local flow required to provide successful-with-difficulty and successful access conditions through the various reaches are provided in Table E.3.2.51. Mainstem discharges required to meet the threshold depths in the passage reaches located near the mouth of the sloughs are also presented in Table E.3.2.51.

Perusal of the mainstem discharges required to provide suitable access conditions at some passage reaches presented in Table E.3.2.51 indicate that the required mainstem discharges are considerably greater than the median discharges observed in the river during the chum spawning period (August-September) (Exhibit E Chapter 2). There are two possible explanations for the apparent high mainstem discharge needs .

The first consideration is that the results for local flow and mainstem discharge needs presented in Table E.3.2.51 were derived independently of each other. That is, the local discharge which provides suitable access conditions at passage reaches were derived without considering the backwater effect of the mainstem. Similarly, the mainstem discharge which has sufficient backwater to provide suitable depths through the passage reaches were derived without considering the contribution of local flow.

Local flow is derived from both local surface runoff and from groundwater upwelling. Local surface runoff tends to be episodical in nature since it is closely associated with the precipitation patterns in the local area (R&M 1985b). Groundwater upwelling on the other hand tends to be more constant through time with some fluctuation in response to mainstem stage (Exhibit E, chapter 2 Sections 2.4.4, and 4.1.2 (f)ii). Because groundwater upwelling rates can be directly related to mainstem discharge, at least for some sloughs, it is likely that sufficient discharge is available in the sloughs to provide sufficient depth through many of the passage reaches at discharges considerably less than that necessary to breach the upstream ends or that necessary to provide sufficient depth due to backwater effects only (HE 1984d).

A second consideration which must be accounted for in the determination of mainstem discharge necessary to provide suitable access conditions into the sloughs is observations of adult chum salmon in sloughs relative to the average daily discharges in the river. Average daily discharge in the middle Susitna River in 1982 ranged between 13,000 cfs and 18,000 cfs from August 1 until September 15 (USGS 1983).

Periodic counts of adult chum salmon in the various sloughs during this period indicate that chum salmon did gain access to sloughs when mainstem discharges were considerably lower than many of the threshold values presented in Table E.3.2.51 (ADF&G 1983a). The conclusion drawn from this, then, is that the threshold discharges presented in Table E.3.2.51 error in favor of the fish resource. However, they do provide a worst case for analyses of impacts resulting from the altered flow regime on access conditions for chum salmon into slough spawning habitats.

- <u>Frequency Analysis of Chum Spawning Habitat Area</u> (*)

The second analytical step in the evaluation of chum spawning habitat is the estimation of the total amount of spawning habitat area given the range of mainstem discharges that occur during the spawning period. As stated in Section 2.2.1.a.iv, chum salmon spawn in the period August through September each year. Using the 34 years of record of average weekly discharges during this period and the chum spawning habitat area response curve presented in Table E.3.2.47 and Figure E.3.2.59, the range of habitat area during each week of the spawning period was determined.

Given the 34 years of record, the median habitat area available in the sites used extensively by chum and included in the modelled sites for each week in the spawning period ranges from approximately 74,000 sq. ft. at the beginning of August to approximately 76,000 sq. ft. in the middle of September. The decline in available habitat area at the end of September corresponds to the general decline in mainstem discharge through the period (See Exhibit E, Chapter 2, Section 2.2). The total habitat area available in each week ranges from less than 26,000 sq. ft. to more than 86,000 sq. ft. The median (50 percent) habitat area available for each week in the 34 years of discharge record as well as the habitat areas equalled or exceeded 90 and 10 percent of the time are presented in Table E.3.2.52 and are depicted graphically in Figure E.3.2.67.

As shown in the table and figure for chum spawning habitat areas, the range of habitat area can vary considerably from week to week and from year to year. A general characteristic, however, is that the total habitat area available for spawning peaks during the last week of August and the second week of September which corresponds to during the peak of the chum spawning period.

Evaluation of the chum spawning habitat area under the natural flow regime was also conducted using the spawning habitat area response curve obtained from modeled and non-modeled sites in Representative Groups 2, 3 and 4 (Table E.3.2.48 and Figure E.3.2.63). A frequency analysis using the Representative Groups total habitat area response curve was performed. Based on this analysis, the median total habitat area is relatively constant through the spawning period at approximately 840,000 sq. ft. of usable area. The results of this analysis are presented in tabular form in Table E.3.2.53 and graphically in Figure E.3.2.63. The decline in the estimated total habitat area corresponds to the gradual decline in mainstem discharge during this period under natural conditions. As discussed with respect to the estimated spawning habitat areas for the modeled sites, the total habitat areas in Representative Groups 2, 3 and 4 vary considerably from week to week and from year to year. The large difference in total habitat areas between the values presented in Table E.3.2.52 and those presented in Table E.3.2.53 is due to the fact that the Repsentative Groups include many more sites and, therefore, much more surface area, than that contained only in the modeled sites. By indicating the potential spawning areas in the non-modeled (and presently non-utilized sites), the peak habitat area availability, observed for the utilized sites during the first two weeks of September, is not evident.

- <u>Frequency Analysis of Habitat Area Available for Incubation of Chum Embryos</u> (*)

The third analytical step in the evaluation of chum salmon habitats affected by mainstem discharge is the determination of suitable conditions for incubation of the embryos. Incubation begins with the deposition of the eggs during the spawning period. In the evaluation, it can be assumed that if suitable conditions for spawning are maintained into the incubation period, embryos will be able to survive. This is not completely valid since embryo development can occur when water depths and velocities are less than those required for spawning.

However, analysis of the total area which remains suitable for spawning, in lieu of ice processes effects, provides a minimum estimate of the incubation habitat availability.

Estimates of habitat area available for incubation (in this case synonymous with spawning habitat area) were derived for the period October through November, discounting the effects of ice processes (see below). Median habitat areas available in the modeled sites under the natural flow regime for incubation for each week in the October-November period are presented in Table E.3.2.54 and are depicted graphically in Figure E.3.2.68. Also presented in the table and figure are the 90 percent probability of exceedance and the 10 percent probability of exceedance habitat areas.

As indicated in the table and figure, habitat area in the incubation areas declines as discharge decreases in the fall period prior to freeze-up the river. The loss of habitat during this period, combined with the potential for freezing of substrates (ADF&G 1983m, 1985a) leads to the conclusion that the embryo populations are subject to high mortality rates due to freezing and dessication of the spawning/incubation areas. It is estimated that under the natural flow regime, mortality of chum embryos is approximately 80 to 85 percent in the middle river (ADF&G 1984c, 1985c).

A similar trend is observed for sites included in Representative Groups 2, 3 and 4. Results of the anlysis using the habitat area response curve for all sites in the three respresentative groups (Figure E.3.2.63) are presented in Table E.3.2.55 and Figure E.3.2.70.

(g) Natural Ice Processes Effects on Fish Populations and Their Habitats (***)

The analysis of the response of chinook rearing habitat area and chum spawning/incubation habitat areas presented in the previous sections are applicable only during the summer, open-water season. In the Susitna River, habitat for the fish is influenced by winter conditions for nearly seven months of the year. During the winter months, the Susitna River becomes covered with ice which changes many of the hydraulic and hydrologic relationships present in the river during the open-water season. In order to evaluate the effects of the project throughout the entire year, it is then necessary to describe how ice processes affect the mainstem and mainstem associated habitats under natural conditions so that the effects of project operation during winter months may be identified.

Natural ice processes in the middle reach of the Susitna River consist of ice cover formation, maintenance of the ice cover through the winter months and deterioration of the ice cover in the spring. The formation of the ice cover in the middle reach generally begins between early November to mid-December and is complete between mid-December and mid-January each year (R&M 1984, 1985a). The ice cover is maintained through the winter months with open water leads developing along the margins and in peripheral areas of the river. The process of ice cover deterioration begins in mid- to late-March with increasing solar radiation and is generally completed by mid-May (APA 1984f, HE 1984a, 1985a, 1985f, 1985i; R&M 1984, 1985). A more detailed description of natural ice processes is presented in Exhibit E, Chapter 2, Section 2.3.2.

During the winter, resident fish and juvenile salmon move into areas of the river that reduce their exposure to the physical hazards of cold water and freezing. Resident fish, including rainbow trout and Arctic grayling, move from tributary habitats into the mainstem of the river and move to the mouths of tributaries, side channels and side sloughs (ADF&G 1983e, 1983m, 1984c). Burbot maintain their positions in the mainstem and do not move extensively during the winter months (ADF&G 1983e, 1983m, 1984c). Coho salmon, sockeye salmon and chinook salmon juveniles remain in freshwater for at least one winter after emerging from the spawning gravels. The juveniles move into areas protected from freezing and dessication. Coho salmon generally remain in deep pools of tributary streams or move into upland slough habitats (ADF&G 1983m). Sockeye salmon are found most often in side sloughs during the winter months (ADF&G 1983m). Chinook salmon overwinter in either tributary or side slough habitats (ADF&G 1983c). Of these three species, chinook salmon tend to be the most abundant species in mainstem-affected areas (ADF&G 1983m, 1983n, 1984c).

Salmon spawn in several habitats during the late summer. Selection of sites for deposition of eggs by adult females is based upon specific habitat conditions that, over the course of evolutionary history, have led to the highest probabilities of the embryos surviving through the winter incubation period. The majority of salmon (approximately 60,000 fish) spawning in habitats associated with the middle reach of the Susitna River utilize tributary habitats which are unaffected by the ice processes in the mainstem (ADF&G 1981b, 1983a, 1984h). Approximately 30 percent (5000 fish) of the chum salmon spawning in the Middle River utilize side channels and side sloughs (ADF&G 1983a, 1984h). All of the sockeye salmon (approximately 1500 fish) and less than 5 percent of the pink salmon (approximately 1500 fish) spawning in the Middle River utilize side channels and side sloughs (ADF&G 1983a, 1984h). Since all three species utilize similar habitat conditions for spawning (ADF&G 1983k, 1983n, 1984h), chum salmon are used as the focal point for evaluating the effects of ice processes on egg incubation because they are numerically dominant.

(i) Effects of Natural Ice Processes on Resident Fish (***)

In general, ice processes in the Susitna River adversely effect the survival of resident species through the winter months. Rainbow trout, Arctic grayling and burbot remain relatively inactive during the winter (ADF&G 1983e).

Burbot spawn during the winter (ADF&G 1983m, Morrow 1980). However, they tend to utilize areas with low water velocities, protected from ice processes (ADF&G 1983e).

(ii) Effects of Natural Ice Processes on Salmon Juveniles (***)

Juvenile chinook and sockeye salmon utilize areas that are occasionally affected by mainstem flow and ice processes. In side channels and side sloughs, areas over and downstream from groundwater upwelling have water temperatures which are greater than 0°C and may attain temperatures approaching 4°C (ADF&G 1983e). Mainstem water temperature, by contrast, is near 0°C from prior to ice cover formation until breakup (R&M 1984, ADF&G 1983e). The behavior of the fish during the winter indicates that the juveniles overwinter in or near the substrates and remain relatively inactive in areas receiving groundwater upwelling (ADF&G 1983e, 1983m, 1984c; AEIDC 1984a, 1984b, 1984c).

The survival of juvenile salmon in sloughs and side channels is affected by the formation of border and anchor ice, overtopping of the side sloughs and side channels resulting from mainstem staging and increased rates of groundwater upwelling due to mainstem staging.

When border ice and anchor ice forms where juveniles are located, they may freeze if they are trapped in areas that later freeze. The potential for this is unpredictable and highly dependent upon air temperature, depth of water in the pools and strength of upwelling that may occur in the pool.

Overtopping of the upstream end of the sloughs or side channels can cause water to be diverted through the channels displacing juvenile salmon into mainstem areas. At 0°C, metabolic processes of the fish may be sufficiently low to prevent them from maintaining positions in even low water velocity areas.

Increased rates of upwelling associated with the increased stage of the mainstem due to ice cover formation probably contributes to the survival of juvenile salmon in winter (ADF&G 1983e, 1985a; APA 1984g; AEIDC 1984c, 1984b). The groundwater upwelling provides 2-4°C water temperatures in the sloughs and side channels (ADF&G 1983e, 1985a). The upwelling also inhibits the formation of a complete ice cover (R&M 1984, ADF&G 1984c). It is assumed that increased upwelling increases juvenile survival by providing warmer water temperature and greater habitat availability.

(iii) <u>Effects of Natural Ice Processes on Incubation of Salmon Embryos</u> (***)

Mortality of salmon embryos in sloughs and side channels of the Susitna River during the winter has been estimated in both field and laboratory conditions (ADF&G 1984c, 1985c, Wangaard and Burger 1983). Survival of chum salmon embryos from egg deposition to outmigration is estimated to be 12-15 percent (ADF&G 1984c, 1985a, 1985c). This estimate is based upon the estimated survival of the entire population including those eggs deposited in tributaries. By contrast, sockeye survival is estimated to be approximately 40 percent (ADF&G 1984c, 1985c). Since sockeye salmon in the middle reach spawn almost exclusively in side sloughs and side channels, it may be inferred that survival of chum salmon embryos in these habitats is considerably higher (30 to 40 percent) than the survival of the chum embryos in tributary habitats (ADF&G 1984c).

Mortality rates of Susitna River chum and sockeye were estimated as part of a laboratory study of the effects of temperature on embryo developmental rates (Wangaard and Burger 1983). Chum and sockeye embryos were incubated in the laboratory under four different temperature regimes ranging from averages of 2°C to 4°C, similar to the regimes encountered in the field. Because of the controlled conditions, the observed mortality rates of 2-5 percent are attributable either to temperature itself or to some other biological factor not associated with the physical environment (i.e. disease, lack of fertilization, or genetic disorders). It is assumed that approximately 5 percent mortality of salmon embryos in the field could be attributable to similar causes. Because of the nature of environmental conditions, it is assumed that much of the remaining mortality of salmon embryos is attributable to physical processes in the habitat.

Two principal physical factors that could account for a significant portion of the estimated mortality are associated with mainstem flow influences on the slough habitats. These in turn are influenced by ice processes. The two factors are 1) dessication and freezing of the embryos due to the reduction of mainstem flow prior to ice cover formation and 2) reduced temperature resulting from overtopping of the upstream end of the slough (ADF&G 1985a).

Dessication of embryos occurs when the areas in which the eggs were deposited (redd sites) become dewatered. Spawning occurs during a period (August and September) when mainstem flow averages approximately 15,000 cfs (ADF&G 1984r). Subsequent to the spawning period, mainstem flow decreases to approximately 8,000 cfs in October and 2,000 cfs in December and January. With this decrease in mainstem flow, the wetted surface area in the individual sloughs and side channels decreases (ADF&G 1983k, 1983n, 1984r; EWT&A 1984). This is due to reduced flow in the side sloughs (ADF&G 1983m, 1984r, R&M 1985b) and reduced areas of backwater influence at the mouths of the sloughs and side channels (ADF&G 1983a). It is likely that, as the water surface recedes, redds located along the margins of the sloughs become dewatered causing dessication or freezing of the embryos.

As the ice front progresses upstream these areas could become watered again due to staging and increased groundwater upwelling. For sloughs and side channels in the downstream portions of the reach, the ice formation process could be early enough in the winter (mid-November to early December) to prevent dessication or freezing of the embryos. However, in the upper portions of the reach, ice front progression reaches the sloughs and side channels much later (December-January). Hence, it is likely that mortality of embryos due to dessication increases from the lower end of the Middle River to Devil's Canyon.

As the ice front progresses upstream, staging of the mainstem is sometimes sufficient to overtop the upstream ends of sloughs. A result is that 0°C mainstem water is diverted through the sloughs and may overwhelm groundwater sources by downwelling of the 0°C surface water. Depending upon the developmental stage of the embryos at the time of the overtopping event, the 0°C water may cause death of the embryos or may cause developmental abnormalities (Wangaard and Burger 1983).

Laboratory studies of salmon developmental rates vs. temperature indicate that sockeye embryos are especially sensitive to thermal (cold) stress early in the developmental process (Velson 1980, Bams 1967, Combs 1965). The potential for increased mortality and developmental abnormality rates due to over topping was corroborated in the middle river by observation of large numbers of dead chum embryos, reduced fry size and higher frequency of abnormalities in Slough 8A (site 126.0R) following an overtopping event in 1982 (ADF&G 1983e). Embryos in other sloughs that were not overtopped did not exhibit the large number of dead embryos or abnormal fry.

In contrast to the three factors discussed above, a fourth factor, the effects of staging on groundwater upwelling rates, contributes to the survival of salmon embryos. Upwelling groundwater benefits embryo development by providing higher temperatures (2°C-4.3°C), more constant dissolved oxygen concentrations, and removal of fine sediments that may have a detrimental effect on embryo survival. Upwelling rates are at least partially dependent upon mainstem water surface elevation (Exhibit E, Chapter 2

Sections 2.4.4 and 4.1.2(f)ii), and staging caused by the ice formation processes. Groundwater upwelling rates increase with greater mainstem stage and may contribute to the survival of the embryos.

In summary, several factors associated with winter flow and ice processes in the mainstem of the Susitna River affect the survival of salmon embryos during the incubation period. Factors that tend to decrease survival are:

- o Reduced mainstem flow resulting in dessication or freezing of the salmon embryos; and

- o Overtopping of the upstream ends of sloughs and side channels diverting the 0°C water in to the sloughs and side channels causing thermal (cold) stress to the embryos.

A factor which tends to increase survival of embryos is increased groundwater upwelling.

2.2.4 - Streams of Access Road Corridor (**)

(a) Stream Crossings (**)

The access road to the Watana and Devil Canyon damsites will depart from the Denali Highway and proceed south to Watana (see Plate F-32, Exhibit F). From there, the road will traverse the north side of the Susitna River to the Devil Canyon damsite. A railroad spur from Gold Creek will connect to Devil Canyon. The access road corridor, including that portion of the Denali Highway to be upgraded as part of the project, contains at least 45 streams and rivers in both the Nenana and Susitna River drainages (Tables E.3.2.21 and E.3.2.56).

The portion of the Denali Highway between Cantwell and the Watana Access Road crosses 10 streams in the Jack River and Nenana River drainages (Table E.3.2.56). Fish species present in Jack River or Nenana River include grayling, northern pike, burbot, whitefish and sculpin. Of these, the tributary streams probably contain at least grayling and sculpin.

From the Denali Highway to Watana, the road will cross Lily Creek, Seattle Creek, Brushkana Creek, and Deadman Creek as well as numerous unnamed streams. These streams are tributaries of the Nenana River or Susitna River, and contain Dolly Varden, grayling and sculpin (Table E.3.2.21).

Between the Watana and Devil Canyon damsites, the access road will cross Tsusena and Devil Creeks (Table E.3.2.21). The streams contain Dolly Varden and slimy sculpin.

The road will cross the Susitna River approximately 2 miles (3 km) below the Devil Canyon damsite. Salmon and probably grayling, whitefish, cottids and longnose sucker occur in the vicinity of the crossing. The habitat in this reach of the Susitna is considered relatively poor when compared to reaches farther downstream.

The railroad between Devil Canyon and Gold Creek will cross Gold Creek, three tributaries of Jack Long Creek and a tributary of Slough 21 that contains chinook and sculpins (Table E.3.2.21). The lower reaches of Jack Long Creek contain small numbers of pink, coho, chinook, and chum salmon. Gold Creek has been documented to contain chinook, coho, and pink salmon.

(b) Streams Adjacent to Access Corridors (**)

In addition to crossing streams, the Watana access road will parallel some streams, particularly Deadman Creek. The fisheries resources are described in Section 2.3.1(a) above. Devil Creek will also be paralleled by the access road while the railroad between Devil Canyon and Gold Creek will parallel a portion of Jack Long Creek.

2.2.5 - Streams of the Transmission Corridor (**)

Transmission lines will be built from Watana and Devil Canyon to Gold Creek and from there to Anchorage and Fairbanks. From Watana to Gold Creek, the transmission line route is within 1 mile (1.6 km) of the Devil Canyon access road except near the Watana Dam. At Gold Creek the transmission lines will use the same right-of-way as the Anchorage-Fairbanks Intertie, which extends from Willow to Healy.

Resources of the Intertie are described in Commonwealth et al. (1982). At least 27 major salmon streams, including Willow Creek, Kashwitna River, Talkeetna River, Chulitna River, and Indian River will be crossed by the Intertie and, presumably, by the additional lines to be built in the right-of-way in conjunction with the Susitna Hydroelectric Project. The streams contain grayling, rainbow trout, Dolly Varden, and sculpins in addition to salmon.

South of Willow, the transmission line will be routed between the Susitna River and the Parks Highway for much of its length. It will cross Fish Creek and the Little Susitna River as well as many unnamed streams (Table E.3.2.57). The Little Susitna River contains coho, pink, chinook, chum, and sockeye salmon, as well as rainbow trout, Dolly Varden, and grayling. Fish Creek is known to support chinook, sockeye, pink and coho salmon, and rainbow trout. The unnamed tributaries to the Susitna River may also provide salmon habitat.

An underwater cable will be used to cross the Knik Arm. The transmission line will then proceed east and south to the University power substation. Knik Arm serves as a migration corridor for five species of Pacific salmon as well as other anadromous species such as Dolly Varden, Bering cisco, eulachon, and lamprey. The transmission line will skirt Otter Lake, which is stocked with rainbow trout, and will cross Fossil and Ship Creeks. Fossil Creek is not considered a fish stream. Ship Creek supports populations of pink, chum, coho, sockeye, and chinook salmon as well as Dolly Varden and rainbow trout, but because of the heavy development along its reaches, it is not considered prime fish habitat.

North of Healy, the transmisson line will cross at least 50 creeks and rivers including the Nenana and Tanana Rivers (Table E.3.2.58). These are two of Alaska's major rivers and provide habitat for salmon, grayling, whitefish, suckers, burbot, sculpins, northern pike, and inconnu. Panguinge Creek has been documented to contain coho salmon, Dolly Varden and grayling (Tarbox et al. 1978). The streams in the Little Goldstream vicinity are not considered to be important fisheries habitat because of their steep gradients. While many of the streams go dry in the summer, some do support grayling populations near their mouths.

2.3 - Anticipated Impacts To Aquatic Habitat (**)

Construction and operation of the proposed Susitna Hydroelectric Project would result in both beneficial and detrimental impacts on the aquatic habitat and associated fishery resources in the Susitna basin. Many of the potential adverse impacts can be avoided or minimized through design and/or operation of the project, as described in Exhibit E, Chapter 2, Sections 3 and 6, and Exhibit E, Chapter 3, Section 2.4. This section examines the anticipated effects of the project as proposed in Exhibit A and addresses the impacts likely to be sustained as a result of project construction, reservoir filling, and operation of Watana and Devil Canyon dams. Since the project will be constructed in three stages, impacts to the aquatic habitat are presented by project stage, and river segment. The discussions focus on the principal evaluation species/habitat combinations. Discussion of the impacts to other evaluation species is also presented.

In this section, the term "impact" refers to a change affected on a fish population or on its capability to utilize aquatic habitats resulting from project-induced changes in the physical characteristics of the environment. Impacts refer to changes or effects that are both beneficial and detrimental to fish populations. The project may alter physical characteristics of the aquatic environment that do not affect fishery resources, and therefore, these changes are not considered to be impacts to the resources. The basic project-induced changes to the physical environment considered in this evaluation includes changes to the flow regime, temperature/ice regime, and suspended sediment. The effects of changes in other habitat factors, such as sediment aggradation, degradation, dissolved gas concentrations, heavy metals, nutrients, etc. are also discussed for each stage of project development.

The description of impacts presented below is based on all available data and analyses through spring 1985. The types of impacts that have occurred at similar projects have also been considered when describing the probable impacts this project will have on the fishery resources. The discussion presents to the extent possible, quantitative estimates of the physical processes, habitat relationships, and likely response of fishery resources.

The majority of the anticipated impacts resulting from the construction and operation of the two dam development will occur during the first stage of the development of the Watana Dam. Additional impacts, but of a significantly lesser magnitude, would be sustained as a result of the addition of the Devil Canyon Dam in Stage II of the development and the raising of Watana Dam in Stage III. The Stage I Watana Dam will alter the character of the aquatic environment downstream from RM 224, the uppermost extent of the Stage I reservoir. The magnitude of change in aquatic habitats below the damsites decreases as the distance from the damsites increases. Alteration of the character of existing aquatic environment would be most notable within the impoundment zones and the 53-mile (88.3 km) reach between the Devil Canyon damsite (RM 152) and Talkeetna (RM 99). Lesser changes are anticipated in the 99-mile (165-km) reach from Talkeetna to Cook Inlet (RM 0). Most of the potential impacts to aquatic habitat that arise from dam construction will be avoided through careful design and siting, and by employing best construction management practices.

2.3.1 - Anticipated Impacts to Aquatic Habitat Associated with Stage I Watana Dam (***)

(a) Construction of Stage I Watana Dam and Related Facilities (***)

Potential impacts to aquatic habitat associated with the construction of Stage I Watana Dam and related facilities can be divided into three categories:

- o Effects of permanent or temporary alterations to water bodies (i.e., dewatering, alteration of flow regime, or alteration of channels);
- o Effects on water quality (i.e., changes in temperature, turbidity, nutrients, and other water chemistry parameters); and
- o Effects, both direct and indirect, on fish populations.

(i) Stage I Watana Dam (***)

The period of construction considered for the proposed Stage I Watana Dam consists of those activities occurring from initial site preparation to the start of reservoir filling. The proposed dam will consist of a fill structure constructed between RM 184 and RM 185 of the Susitna River. The fill will be approximately 0.5 mile (520 m) wide, 0.6 (950 m) mile long and 700 feet (267 m) high. Over 32.1 million cubic yards ($24.5x10^6 m^3$) of material will be used to construct the dam.

Prior to construction of the Stage I structure, access will be completed; the diversion tunnels and cofferdams will be completed and the river diverted through the tunnels; and site-clearing activities begun. Heavy equipment will be brought to the site, and construction material will be stockpiled in the project area.

Two cofferdams will surround the area of the main dam construction (see Plate F 5 in Exhibit F). The upstream cofferdam will be approximately 800 feet (242 m) long and 450 feet (136 m) wide; the downstream cofferdam will be 400 feet (121 m) long and 200 feet (60 m) wide. Water blocked by the upstream cofferdam will be diverted into two 36-foot (11.0-m) diameter concrete-lined tunnels approximately 3300 and 4000 feet long. The cofferdams and cutoff walls will be constructed during a two-year period and will remain in use until reservoir filling begins.

Construction of the main dam will have a number of effects on the river and its biota. Some effects will be the direct result of construction activities, while other effects will result from alteration of the river environment during construction. Impacts will vary in duration and overall extent, some being temporary or localized while others will be permanent or more widespread.

- Alteration of Water Bodies (***)

The greatest alteration of aquatic habitat during construction of Stage I Watana Dam will occur at the damsite and at the mouth of Tsusena Creek where Borrow Area E is located. At the construction site, the Susitna River flows through a confined valley with a surface width of approximately 400 feet (121 m). The river bottom is sand, gravel and boulders. The tributaries closest to the damsite are Deadman Creek at RM 187 and Tsusena Creek at RM 182. Burbot, sculpins, round and humpback whitefish, and longnose sucker occupy the damsite all year and grayling probably overwinter there (ADF&G 1983b).

The first major phase of dam construction involves placement of the two cofferdams, thereby permanently dewatering 0.75 mile (1.3 km) of riverbed at the damsite. It is anticipated that fish normally using this stretch will move into adjacent habitats and that the effects on population size will be minimal. The dewatered area will eventually be covered by the Stage I Watana dam; thus, the effect will be a permanent but relatively minor loss of aquatic habitat and a permanent blockage of fish movements through this reach.

Gravel mining will be an important activity associated with construction of the dam and related facilities. A large portion of the material for the Stage I dam will be excavated from Borrow Site E at the confluence of Tsusena Creek between RM 180 and RM 182. In the construction zone, Tsusena Creek is considered more sensitive habitat than the mainstem of the Susitna River. Anticipated impacts from gravel removal operations include increased turbidity caused by erosion and minor instream activities, introduction of small amounts of hydrocarbons from equipment operating in streams and the possibility of accidental hydrocarbon spills. These impacts will be temporary and are not expected to last beyond site operation. A long-term impact to aquatic habitat is expected at the mouth of Tsusena Creek. The volume of material to be removed will result in a pit that will become filled with water. This pit will create lentic habitat in exchange for lost riparian and upland habitat. Guidelines and techniques detailed in the BMP annual entitled "Erosion and Sedimentation Control" (APA 1985a) will be incorporated into contractual documents prior to construction in order to minimize impacts to aquatic habitat from borrow activities.

Completion of the diversion facilities in the spring of 1994 will allow the closure of the upstream cofferdam. Flow will be diverted through both diversion tunnels during the summer, although the lower tunnel will pass the greater portion. The upper tunnel begins to pass flow at 8000 cfs. Tunnel velocities for the average summer flow (approximately 23,000 cfs) will range between 20 and 30 ft/sec. During the mean annual flood (43,500 cfs), the river stage upstream of the project will be raised for a distance of about 2 miles. Immediately upstream of the project this increase will be approximately 20 feet. Some ponding will also occur during the average summer flow.

During the winter, flow will be diverted through the lower diversion tunnel, which has sufficient capacity to pass normal winter flows without significant change to the river stage upstream of the project. Water velocities in the tunnel will range from 15 to 20 ft/sec. River ice conditions are expected to be unchanged from natural conditions upstream and downstream of the project.

Experiments with fish transport indicate that fish are adversely affected when water velocities exceed 9 ft/sec (Taft et al. 1975). Relatively few resident fish occupy the mainstem area immediately upstream of the tunnels during summer; however, grayling and other resident species utilize the mainstem to overwinter. Fish that become entrained in the tunnel flow may be injured or killed by the high velocities, by rocks or other material transported by the river through the tunnels, or by impacting the tunnel walls.

High discharge velocities at the downstream end of the tunnels will scour gravels, sands and silts from the immediate area of the tunnel outlet. The velocities will also deter fish from using the area immediately downstream from the tunnel (Bates and Vanderwalker 1964; Stone and Webster 1976b), and will act as a barrier to upstream fish passage (see Section 2.4.3).

- Changes in Water Quality (***)

The primary change in water quality that is expected as a result of Stage I Watana Dam construction is increased turbidity predominately caused by increased concentrations of very fine sized suspended particulates. Increases in turbidity will vary with the type and duration of construction activity and may be of significant local consequence, but are not expected to produce a widespread detrimental effect upon aquatic habitat in the Susitna River system. Some of the first construction activities to take place will include clearing areas, construction of access roads, stockpiling of construction materials and fuel, movement of heavy equipment, and construction of support facilities. The construction of support facilities and the access roads are discussed below.

Removal of cover vegetation may result in a number of effects. The removal of cover can increase the local run-off, causing erosion, increased turbidity, and increased dissolved solids (Likens et al. 1970; Bormann et al. 1970; Pierce et al. 1970). The removal of bank cover may also increase the exposure of fish to predators, and lead to a decrease in fish populations (Joyce et al. 1980b). Temperatures in local areas may also increase.

The movement of fill materials and the actual process of construction of the fill dam will contribute to turbidity and siltation. During the transport, storage, and placement of the fill material used in constructing the dam, a small percentage will be introduced to adjacent water bodies, including the mainstem Susitna River through spills and erosion. Although the impact on the mainstem may not be severe, the impact on local clear-water streams could be significant.

Operation of heavy equipment in streams also increases siltation and turbidity. The extent of the impact of siltation and turbidity is dependent upon the extent of machinery operation in the stream beds and the substrate of the streams affected. Finer substrates tend to be most affected (Burns 1970), but effects are also dependent upon streamflows in the local area. If velocities are sufficiently high, deposition of suspended silts stirred up by the machinery will not occur locally and the effects would be minor (Shaw and Maga 1943). Since velocities can be expected to vary seasonally, the potential for impacts will vary seasonally as well. Impacts caused by machinery-induced siltation and turbidity are expected to be temporary in nature.

Increased turbidity generally reduces visibility and decreases the ability of sight-feeding fish to obtain food (Hynes 1966). Most fish species will avoid highly turbid areas and many salmonids avoid spawning in turbid waters. Temporary increases in turbidity from activities such as clearing and gravel removal may occur.

Siltation (sedimentation) is also associated with these activities. There is a considerable amount of literature dealing with siltation effects on fish (Iwamoto et al. 1978), particularly the effect on spawning and incubation. A general conclusion reached by a review of the literature (Dehoney and Mancini 1982) is that the greatest adverse impact of siltation is on immobile eggs and relatively immobile larval fish. In general, siltation can cause significant losses of incubating eggs and fry in redds, particularly by interfering with oxygen exchange. Areas of upwelling ground water are affected to a lesser extent than other areas because silt is prevented from settling. Only resident fish in the vicinity of Watana Dam, including Dolly Varden and Arctic grayling, may be affected by siltation. Entrainment of suspended materials may also affect other water quality parameters, such as trace metals and pH, but this is not expected to have a significant effect upon aquatic habitat in the Susitna system. The measures planned to minimize impacts of construction on suspended sediment and turbidity are discussed in Exhibit E Chapter 2 Sections 4.1.1(c)iii.

The production of concrete for tunnel lining, spill way and powerhouse construction, and grouting will generate concrete batching wastewater. Peters (1979) points out that the discharge of this wastewater, if untreated, can lead to detrimental effects on fish populations and habitat. A particular problem with concrete wastewater is the need to adjust its pH (10+) prior to discharge. The measures planned to minimize contamination by waste concrete are discussed in Exhibit E Chapter 2 Section 4.1.1(c)vi.

Waterbodies can be contaminated during construction activities by petroleum products that enter from a variety of sources. Fuels can enter streams, lakes and wetlands from leaks in storage tanks and pipes and from vehicle accidents during transportation. Poor maintenance of vehicles can also allow small quantities of petroleum products to enter water bodies.

Diesel fuel will be used and will have to be stored onsite in large quantities. New and used lubricating oils will also be in use. There is a great deal of literature (USEPA 1976b; AFS 1979) describing deleterious effects caused by oil spills. Aromatics in diesel fuel and gasoline are particularly toxic until evaporated. Heavier oils can coat streambeds and aquatic vegetation and interfere with production of food organisms consumed by fish (Kolpak et al. 1973). In a river as large as the Susitna, small spills are expected to dilute quickly and not cause measurable impacts. Spills into smaller tributaries, especially while incubating embryos are present, could have a significant impact on resident populations. In the winter, it is difficult to recover petroleum spills that flow under ice in rivers. Substantial mortality could result if toxic substances reach overwintering fish and other organisms. The BMP manual entitled "Oil Spill Contingency Planning" (APA 1985b) identifies the major elements of an oil spill contingency plan and also details techniques for minimizing impacts.

Waste oils containing trace metals require handling as a hazardous waste under 40 CFR 261-265. Solvents, while probably present in much smaller quantities than petroleum products, are usually considerably more toxic to aquatic life. Other chemicals of concern would include antifreeze, hydraulic oil, grease, and paints. Factors that will affect the severity of impacts of a spill are:

- The substance spilled;
- The quantity spilled;
- Frequency of spills in that area;
- The biota present;
- The life stages present;
- The season; and
- Mitigation and cleanup plans and preparedness.

- <u>Other Effects on Fish Populations</u> (*)

Other effects that instream construction activities may have on fish populations include avoidance of the area, injury, and mortality caused by instream use of heavy equipment. Heavy equipment crossings can also damage incubating eggs and preemergent fry if the crossing location passes through a spawning area.

Water will be needed for production of concrete, processing of gravel, and dust control during construction. Impacts can result from entrainment and impingement of juvenile fish as water is withdrawn from local water bodies. The use of low volume pumps equipped with proper intake screens will minimize the number of fish affected. Removal of water from local water bodies is not expected to have a significant effect on fish habitat.

Current construction plans do not require instream blasting. Blasting is planned for areas 500 feet (150 m) or more from streams. A review of the effects of blasting on aquatic life (Joyce et al. 1980a, Appendix G) indicates that effects from such blasting would probably not be lethal (at least with charges of less than 200 kg of TNT). The transmitted shock waves from the blasting may disturb fish and perhaps temporarily displace them from areas near blasting activity. This type of behavior is well-documented for a variety of noise sources (Vanderwalker 1967 and Latvaitis et al. 1977). Secondary effects of blasting include increased turbidity and siltation caused by loosened soils and dust (see effects described above). The extent of such effects would be dependent upon the location and amount of blasting.

(ii) Construction and Operation of Stage I Watana Camp, Village and Airstrips (*)

During peak construction activity for the Stage I Watana Dam, facilities to house approximately 3,300 people are anticipated (see Exhibit A, Section 1.13). The facilities must be located adjacent to the construction site to simplify transportation to and from the camps. One campsite is proposed: the construction camp and village will be located near Deadman Creek about 3 miles from the dam. This development will occupy approximately 250 acres (101 ha). The construction camp and village are to be two communities with separate roads and facilities. The two communities will be separated by natural features, lakes, and fences. After the dam is completed, a permanent townsite will be developed either at the construction camp or village site or at a site to be determined later.

The construction camp will contain the management offices, hospital, recreation hall, warehouses, communications center, bachelor dormitories, and other facilities. It is anticipated that the camp will be dismantled at the end of the Stage I Watana dam construction. The construction village will be made up of 310 temporary housing units and an additional 240 lots with utilities furnished. These temporary housing units will be used primarily for workers who are accompanied by families and will also be removed when construction of Watana is complete. The permanent town will be built to house the families of employees who will form the operation and maintenance team for Watana. The town will contain a hospital, a school, gas station, fire station, store, recreation center, and offices, as well as residences. Construction of the town will not begin until the mid-1990s, since it will not be needed until Watana is operational.

A 2500-foot (758-m) temporary airfield will be built approximately 1 mile (1.6 km) from the construction camp/village site at approximately elevation 2500 feet (760-m). The temporary airfield will be expanded and upgraded to a 6500 foot permanent airfield.

- Alteration of Waterbodies (**)

  Alteration of waterbodies resulting from the construction of camps and related facilities will be confined to the immediate area of the development. Few adverse impacts are anticipated. Gravel or other material required for facilities construction will be mined from local sources or Borrow Sites D or F, following the guidelines found in the BMP manual entitled "Erosion and Sedimentation Control" (APA 1985a). Project facilities will be located away from waterbodies to minimize the potential of increased sediment input. Overburden will be stored in areas where it will not affect waterbodies.

  Operation of the camps and airstrips is not expected to result in appreciable alteration of waterbodies.

  Water will be withdrawn from Deadman Creek approximately 7 miles (10 km) upstream from its confluence with the Susitna River for domestic use in the camp and construction village. Approximately 0.5 cfs will be needed to meet peak demands in both the construction camp and construction village. This represents less than one percent reduction in flow during the open-water season and less than 7 percent during the winter season. Little impact is expected to result from decreases of this magnitude.

- Water Quality Changes (**)

  Changes resulting from camp construction are expected to be similar to those experienced during dam construction but impacts would be much reduced in magnitude because of the relatively great distance of the camp from waterbodies inhabited by fish. Turbidity and suspended sediment levels will increase in areas where erosion enters water bodies from activities such as installation of the water intake system, but such effects will be temporary.

The most significant impacts on water quality during camp operations will result from discharge of treated wastewater into Deadman Creek, oily and silty runoff from the camps, water used for dust control, and accidental fuel spills.

Current plans call for pumping water from Deadman Creek or a series of wells to supply the camps and town during operations. Treated sewage during dam construction will be discharged into Deadman Creek. This sewage system will serve both the construction camp and village and may be used for the permanent town after the temporary camp and village are removed. The solid waste landfill shall be situated adjacent to the village and camp. Fuel will be stored within the village and the construction camp. Details of fuel storage and handling will be in accordance with contractual documents that include the information contained in the BMP Manual entitled "Fuel and Hazardous Material" (APA 1985d).

The sewage treatment plant will provide secondary treatment (Chapter 2, Section 4.1.1.g). A lagoon system will be used to store waste during the year prior to completion of the treatment plant. The stored waste will be treated before its release to the receiving stream. Secondary treatment will avoid many of the problems associated with primary treatment, such as decreased dissolved oxygen and increased BOD, increased metals, and bacterial counts (Warren 1971), although it will introduce increased levels of phosphorus and nitrogen into Deadman Creek. Also, if the discharge is treated with chemicals such as chlorine, residual levels may have detrimental effects upon aquatic organisms. Rainbow trout in the Sheep River in Canada were reported to avoid areas where chlorinated sewage effluents were discharged, and some fish mortality resulted (Osborne et al. 1981). Grayling, the
primary species in Deadman Creek, are considered to be sensitive to alterations in water quality (McLeay et al. 1983; 1984). The effects of treated discharge into Deadman Creek and thence into the reservoir will depend upon: (1) the water chemistry of the creek and reservoir; (2) the composition of the treated sewage discharge; and (3) the dilution of the discharge within the stream.

Storm drainage and oily water runoff are expected to occur at both the camp and the village, but will be more of a concern at the camp, since this is where the vehicle maintenance areas, shops, and related facilities will be located. By providing proper drainage facilities, ponding areas, and if necessary, pump stations to pump contaminated water to the treatment facility, oily and silty water will not reach Deadman Creek. The small ponds within the town limits will be more susceptible than the creeks to intrusions of oily water, storm drainage, and fuel spills.

Adverse effects may also result from oily runoff from dust control on construction roads and airstrips and from accidents involving vehicles transporting fuels. The possible frequency and severity of such occurrences cannot be predicted at this time. Runoff from the solid waste landfill is not expected to adversely impact any aquatic habitat.

- Other Effects on Fish Populations (***)

Disruption of fish populations during camp and village construction is expected to be limited due to the distance between the camp and aquatic habitats.

Operation of the camps will result in increased access to an area previously exposed to minimal fishing pressure. The areas expected to sustain the heaviest harvest pressure would be those stretches of Deadman and Tsusena Creeks and the Susitna River that are easily accessible from the camps and the damsite. The resident fish populations are thought to be at their maximum level, (ADF&G 1981f, 1984a). Studies to date have indicated a relatively high percentage of "older" age group fish (up to 9 years). Sportfishing will inflict heaviest impacts upon larger, older fish and would likely result in a change in the age distribution of the population (ADF&G 1984a).

(b) Filling Stage I Watana Reservoir (***)

Filling of the Stage I Watana reservoir will impact aquatic habitats both upstream and downstream from the dam. During the filling process, fish populations and habitats will be affected by changes in flow, temperature, and suspended sediment regimes and changes in other physical and chemical habitat factors such as dissolved gas concentrations, nutrients, and other water chemistry parameters and constituents. The filling period for Stage I Watana Reservoir, is expected to be approximately 6 months. Beginning in May 1998, it is expected that the reservoir will be filled to between el. 1,900 and el. 1,970 the first of October depending upon the Susitna River discharge upstream of Watana damsite during the summer months.

Discharge from the Stage I Watana Reservoir during the filling process will be constrained by the Case E-VI flow requirements defined at Gold Creek (See Exhibit E Chapter 2, Section 3) from May through October. The Case E-VI flow constraints are presented here as Table E.3.2.59. Estimated average monthly flows at Gold Creek during the filling of Watana Reservoir are provided in Table E.3.2.60. The average monthly flows are presented for Susitna flow conditions corresponding to years with average, low (dry years) and high runoff (wet years). It is anticipated that the first generating unit will become operational in October of 1998. Although the project will become operational at that time, the available volume in the reservoir for generation and the available capacity for generation will be relatively small. Therefore, during the first winter of operation, flows in the Susitna River will approximate natural flows, i.e. they will approach the minimum operational constraints of Case E-VI.

During the summer filling process, downstream releases will be made through the low level outlet works located in one of the diversion tunnels. The low-level discharge structure has limited capacity to control downstream temperatures. The effects of filling on river temperatures are discussed in Exhibit E Chapter 2 Section 4.1.3(c)i.

Once the first generating unit becomes operational or the water level exceeds the minimum operating level for the outlet works (cone valves), all downstream flows will be released through the powerhouse and outlet works. Water will be withdrawn from the upper part of the intake structure. Therefore, it is anticipated that winter discharge temperatures and ice processes will be similar to natural conditions.

Impacts to the aquatic resources are described below for the impoundment zone, the Watana Dam to Talkeetna Reach (middle river) and the Talkeetna to Cook Inlet Reach (lower river).

(i) Watana Reservoir Inundation (***)

Filling the Watana reservoir will inundate approximately 20,000 acres (8,100 ha). The reservoir will flood 44 miles (71 km) of Susitna River mainstem habitat and 15 miles (24 km) of tributary habitats that would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, temperature, and nutrient levels. These habitat alterations will result in changes to all trophic levels of the aquatic community presently functioning in the area. Figure E.3.2.71 shows the area to be inundated by the Watana reservoir.

Reservoir filling will begin in May 1998 with the spring runoff flows. During May, the water surface elevation of the reservoir will rise an average of 7 feet (2.1 m) per day reaching a depth of approximately 220 feet (67 m) by the end of the month (to el. 1,670 feet, or 510 m). Increases in water surface elevation of 5 feet (1.5 m) or more per day are predicted in June, 3 ft/day (0.9m) in July, and 1 ft/day (0.3m) in August and September. It is expected that the reservoir will be filled to an operational level of between el. 1,900 and el. 1,970 by the end of October, 1998, depending upon the magnitude of the river discharge during this period. The first generating unit in the Watana Powerhouse is expected to begin generating in October, 1998. Therefore, filling of the Stage I Watana Reservoir will be completed in 6 months (See Exhibit C). This is a significant reduction in the estimated filling time for the Watana Reservoir configuration presented in the original License Application (APA 1983b)

- Mainstem Habitats (***)

  Impoundment filling will affect mainstem habitats and fish populations in the impoundment zone. Since filling of the Stage I Watana Reservoir will occur in approximately 6 months, discussion of the anticipated effects to fish population in the mainstem is more appropriately discussed under reservoir operations (Section 2.3.1.c.i)

- Tributary Habitats (***)

  Impoundment filling will affect fish populations and habitats in tributaries to the mainstem within the impoundment zone. Since filling of the Stage I Watana Reservoir will be essentially complete by the end of October 1998 after beginning in May 1998, the effects on tributary habitats during the summer will be similar to those which will occur during reservoir operation. Therefore, the effects are discussed, more appropriately and completely in Section 2.3.1.c.i.

- Lake Habitats (**)

The filling of the Stage I Watana Reservoir will also effect 11 lakes and ponds in the impoundment zone. Because of the short duration of the filling process, the effects of the reservoir filling on these habitats is more approximately and completely discussed in Section 2.3.1.c.i.

(ii) Watana Dam to Talkeetna (*)

- Effects of Altered Flow Regime (*)

The filling of the Watana Reservoir during Stage I will reduce natural flows at Gold Creek for a period of approximately 6 months beginning in May. Estimates of the discharge at Gold Creek during the 6 month filling period are estimated for three flow conditions: dry, average and wet conditions. These were selected to represent the range of possible discharge conditions which could occur during the filling process.

The simulation of filling of Watana Stage I is discussed in Exhibit E Chapter 2 Section 4.1.2(b). As stated previously, the rate of discharge release from the Watana Dam during filling will be constrained by the Case E-VI flow requirements. Although the Case E-VI flow constraints define minimum discharge at Gold Creek on a weekly basis, average monthly minimum flow constraints were derived for evaluation of Gold Creek discharge during the filling process based on the E-VI constraints. The average monthly minimum discharge constraints, at Gold Creek; monthly average natural discharges during the dry, average and wet conditions; and estimates of the average monthly discharges during the filling period in dry, average and wet discharge conditions are presented in Table E.3.2.60. The anticipated effects of these representative discharges on fish habitats and populations are presented below.

. Effects on Principal Evaluation Species/Habitat Conditions (***)

.. Juvenile Chinook Rearing Habitats (***)

Closure of the Stage I Watana Dam and initial filling of the reservoir will result in the first major alteration of the flow regime in the middle river following start of construction. The changes to chinook rearing habitat availability during the Stage I filling period are estimated by translating the estimated monthly average discharges to estimates of the total chinook rearing habitat areas at those discharges for all Representative Groups and for the subset of the habitat areas in Representative Groups 2, 3 and 4. The translation is based upon the Habitat Area Response Curves presented in Table E.3.2.46 and Figures E.3.2.57 and E.3.2.58.

Habitat values for May discharges were not calculated since, under natural conditions, May constitutes a transition month from winter to summer. During this period, juvenile chinook generally move from overwintering areas to summer rearing areas and outmigrate from the system. Age 0+ juveniles are still in natal tributary habitats and have not begun to redistribute into mainstem affected areas (ADF&G 1983m, 1984c).

Considering the habitat area in all representative groups combined, the changes in discharge attributable to filling of the reservoir will cause a reduction in the habitat area available for chinook rearing by, at the most, 15 percent from the habitat available under natural flows during dry average and wet discharge years. The habitat areas under natural and filling discharges and the percent changes expected in each month are presented in Table E.3.2.61 for dry, average and wet years. This loss of habitat area is expected since the optimum habitat values are present at discharges greater than 20,000 cfs (Table E.3.2.46 and Figure E.3.2.57). For the most part, however, the estimated reduction in the total rearing habitat is expected to be less than 10 percent. The reduction in habitat area is not expected to adversely affect the juvenile chinook population since the reduction will be of a short duration. Also, it is emphasized that the habitat area values presented are only indicative of the equivalent habitat area which is available throughout the middle river system and does not indicate whether or not all of the area will be used by chinook juveniles. Because of these factors, the apparent reductions in habitat area will probably not affect the populations appreciably.

Considering only the habitat area present at given flows in Representative Groups 2, 3 and 4, discharge at Gold Creek during much of the summer of filling will result in an increase in chinook rearing habitat under any of the flow conditions analyzed. The total habitat areas under natural and filling discharge regimes and the percent change for each month in dry, average and wet years are presented in Table E.3.2.62. The apparent loss of habitat area in August and September is not considered to be significant since the maximum reduction is approximately 10 percent.

The evaluation of habitat loss and gain presented here are based on monthly average flows. As a result, habitat gains and losses due to daily and weekly variations of flow are not accounted for in this evaluation. Under the natural discharge regime, daily, weekly and monthly flow variation is expected to be considerably greater than during the actual filling period. Hence, during the filling period habitat areas are expected to be more constant through time than under the natural discharge regime.

The apparent increases in habitat area in Representative Groups 2, 3 and 4 during the filling period result from the replacement of lost suitable habitat area present under natural flows in some sites (Representative Groups 2 and 3) with suitable habitat area in other sites (Representative Group 4). Thus, loss of habitat in some sites is replaced by suitable habitat in other sites with a net gain in total habitat area suitable for juvenile chinook rearing.

.. Adult Chum Salmon Spawning Habitat (**)

During the filling of Stage I Watana Reservoir, discharges from the dam as estimated at Gold Creek will affect the ability of chum salmon adults to gain access to spawning habitats presently used in side channels and side sloughs.

Based upon the average monthly discharges at Gold Creek presented in Table E.3.2.59 and comparison of the threshold mainstem discharges presented in Table E.3.2.49, it is apparent that there will be some reduction in the suitability of access to specific habitat areas. A summary of the suitability of the flows for access is presented in Table E.3.2.63. Based upon the threshold discharges for the twenty four passage reaches analyzed, eleven of 24 reaches will be more difficult for adult chum to pass during filling those under natural flows in August whereas only 4 reaches will be more difficult in September in dry years. In average discharge year, twelve of 24 reaches will be more difficult during filling than under natural flows in August whereas nine will be more difficult in September. In wet years, twelve reaches will be more difficult for passage in August and eleven reaches will be more difficult in September during filling than under natural flow conditions. This analysis is based on average monthly flows and access into the habitats is attained by chum salmon during a shorter time period. Short, high-flow events could occur which would allow access to the habitat. These high-flow events are not apparent in the average monthly flows. Also, this analysis does not account for the influence of local flow on the suitability of access conditions (see Section 2.2.3.f.ii).

Although the analysis is conservative, there is an indication that access conditions for spawning chum salmon will be adversely impacted and could require mitigative action. However, since the effects of filling of Stage I Watana

Reservoir on chum access will occur only during one summer, the need for mitigative action is most dependent upon discharge conditions during operation of Stage I and subsequent development of the project.

Effects of the discharge regime during the filling period on chum spawning habitat are evaluated by translating the estimated monthly average flows for August and September in dry, average and wet years presented in Table E.3.2.60 to total habitat areas in the modeled chum salmon spawning sites. These translations are based on the modeled habitat area response curve presented in Table E.3.2.47 and Figure E.3.2.59. The average available habitat areas for dry, average and wet years in August and September during the filling period and under the natural flow regime are presented in Table E.3.2.64. Also presented in the table is the percent difference between the habitat areas for natural and filling discharges.

If a low discharge year occurs during the filling period, chum salmon spawning habitat area in habitats currently used for spawning (modeled sites) will be reduced in both August and September by 40 to 60 percent. If normal (average) discharge is maintained during the filling period, the lower discharge in August, due to filling the reservoir, is expected to increase the available chum spawning area by about 20 percent. However, the continuation of filling in September and the consequent further reduction in discharge will result in a loss of approximately 55 percent of the habitat normally available for spawning. A similar increase in available spawning habitat area in August and decrease in September is expected if discharge in the Susitna River is higher than normal. This pattern of expected gain of habitat area in August and expected loss of habitat area in September is due to the relatively narrow range of flows (11,000-17,000 cfs) corresponding to optimum habitat areas (more than 79,000 sq ft) depicted in Figure E.3.2.59. Under natural discharge regimes, discharges in the range of 11,000 to 17,000 cfs normally occur during the first two weeks of September (see Exhibit E, Chapter 2). Although the anticipated loss of spawning habitat during the filling period is significant and probably requires mitigative action, it must be recognized that the filling will occur in only one year, short-term, and is not expected to result in a long-term adverse effect.

Effects of the discharge regime during the filling period on chum spawning habitat in Representative Groups 2, 3 and 4 are also evaluated by translating the monthly average flows for August and September presented in Table E.3.2.60 to total habitat areas in the groups. These translations are based on the habitat area response curves presented in Table E.3.2.48 and Figures E.3.2.60 through E.3.2.63.

Based on these curves spawning habitat available in Representative Group 2 sites will be reduced from the habitat available under the natural discharge regime as a result of the flows expected during the filling period in dry, wet and average years. Chum spawning habitat in Group 2 sites under natural and filling flows, and the percent changes, are presented in Table E.3.2.65. The loss of habitat is expected because maximum habitat in these sites occurs at mainstem discharges between 25,000 cfs and 35,000 cfs as indicated in Table E.3.2.48 and Figure E.3.2.60.

Considerable loss of spawning habitat is also expected in Representative Group 3 sites except in August if wet conditions prevail. Comparisons of habitat areas present in Group 3 sites under natural and filling discharge regimes during August and September and the percent changes are presented in Table E.3.2.66. Habitat values for Group 3 sites reach a maximum in the range of flows between 15,000 cfs and 25,000 cfs (Table 3.2.48 and Figure 3.2.61). The slight loss in habitat area anticipated during August, given wet conditions, is not considered significant.

As indicated for chinook rearing habitat, chum spawning habitat in Representative Group 4 sites is expected to increase in August and to decrease in September during the filling period as compared with the habitat available under natural flow conditions. Spawning habitat in Group 4 sites under natural and filling discharge regimes and percent changes are presented in Table E.3.2.67. The gain in spawning habitat area in these sites is due primarily to the peak habitat values for chum spawning in the range of 8,000 cfs to 25,000 cfs (Table E.3.2.48 and Figure E.3.2.62).

Summation of the total chum spawning habitat under natural and filling flows in the three representative groups and percent changes are presented in Table E.3.2.68. Replacement habitat from Representative Group 4 sites for that lost in Representative Groups 2 and 3 is likely. The expected overall loss of chum spawning habitat is less than 5 percent in August and approximately 15 percent in September and is not considered significant. This expected reduction may be overestimated since chum salmon have been observed to gain access to and spawn in these areas at discharges similar to those expected during the filling period in average and wet years (ADF&G 1983b, 1984a).

- Effects on Other Species/Habitat Conditions (**)

During filling of Stage I Watana Reservoir, discharge in the middle river will affect other species/habitat conditions in various ways. It is not likely that upstream migration of adult salmon will be affected by the reduced discharges in the river. Access at tributary mouths for chinook, coho, chum and pink adults is not likely to be adversely effected (Trihey 1983a). Adult sockeye salmon adult access into spawning areas in side sloughs (Representative Group 2) will be affected during the filling period in a manner similar to that described for the effects on adult chum access.

Chinook, coho, chum and pink incubation habitats in tributaries will not be affected by the filling flow regime.

Effects on coho rearing habitats in upland sloughs are not expected during the filling period because of the relative independence of these sites to mainstem discharge.

No effects to outmigration of juvenile salmon are expected during the filling period since sufficient discharge will be available in the mainstem to allow downstream migration.

Rainbow trout, Dolly Varden and Arctic grayling generally move into tributary habitats during the summer months. Therefore, these species are not expected to be influenced by mainstem discharges during the filling period until late August and September.

In September all three species generally move out of tributary habitats in order to find overwintering habitats. Some rearing occurs in tributary mouth habitats and at the mouths of sloughs. Adult and juvenile rainbow trout move into these areas to feed on salmon eggs dislodged from the spawning areas. Habitats at the mouths of tributaries and sloughs are expected to be similar to that observed under natural conditions, but possibly displaced to some extent.

Burbot are not expected to be affected by the altered discharge during the filling period. Burbot are expected to occur in large quiescent mainstem areas which should be more numerous at the lower discharge expected during the filling period.

- Effects of Altered Temperature/Ice Regime (***)

Estimates of changes to the water temperature at the outlet of the Watana Reservoir during filling have been made using the DYRESM Reservoir Temperature model described in Exhibit E, Chapter 2 of this Amendment. (APA 1984g). Estimated outflow temperature is depicted for the first year of filling and is presented in Figure E.3.2.72. As described above, the Stage I Watana Reservoir will begin filling in May 1998 and will become operational in October 1998. During the filling period, water temperatures at Watana Dam will be up to 7°C cooler than normal during June, whereas, during July and August outflow temperatures will be similar to the reservoir inflow temperatures. This is analogous to the temperatures simulated for the first year of filling of Watana Reservoir described in the original License Application (APA 1983b).

Although the outflow temperatures may be less than natural in May and June, the smaller volume released from the reservoir will facilitate warming of the water through Devil Canyon Reach. Therefore, water temperatures within the middle reach (Devil Canyon to Talkeetna) are expected to be similar to natural conditions with short lags of about two weeks, being slightly cooler in May and June and slightly warmer in September. (See Exhibit E Chapter 2 Section 4.1.2(e)i).

From October 1998 until May 1999, discharge from Watana Reservoir is expected to approximate natural flows. This is due to the combination of low capacity for discharge from the dam through the powerhouse (initially only one generating unit will be operational, with the additional units becoming operational in approximately three month intervals). During the first winter of operation, temperature of the water discharged from the dam will range from 1-3°C depending upon which intake port is used to withdraw water from the reservoir and the air temperatures and will be cooler than those shown on Figure E.3.2.72 as discussed in Exhibit E, Chapter 2 Section 4.1.2(e)i).

During this period, instream water temperature is expected to decrease rapidly from 2-4° C at the Watana Dam to 0°C in Devil Canyon. The rapid decline in temperature is expected principally because of the small volume of water to be discharged. Therefore, ice formation processes in the middle river are expected to be similar to those described for natural ice processes (Exhibit E, Chapter 2 and Section 2.3.1.c.ii below). The major difference between the expected ice processes during the first winter of operation and natural ice processes is that ice formation in the middle reach will occur several weeks later than it would under natural conditions. River ice thicknesses and ice-induced staging are expected to be less than for natural conditions.

- Principal Evaluation Species/Habitat Combinations (***)

  During the initial filling of Stage I Watana effects on juvenile chinook rearing habitats and chum spawning habitats are not expected to be impacted by altered water temperatures in the river. This is due principally to the expectation that summer river temperatures will be similar to natural conditions.

Similarly, no project induced effect on juvenile chinook overwintering habitats in the side sloughs or chum incubating areas is expected during the initial winter of project operation. This is due to the expectation that water temperatures and ice processes will be similar to natural.

- Effects on Other Evaluation Species/Habitat Combinations (***)

  Because little change from natural water temperature is expected during the filling of Stage I Watana and during the first year of operation, no effects attributable to altered temperatures are expected to the other evaluation species/habitat combinations in the middle river.

- Effects of Altered Suspended Sediment Regime (**)

Due to ponding of the influent river waters and turbulence reductions in the impoundment a substantial proportion of the incoming suspended sediments will precipitate and become permanently stored within the new impoundment zone. Downstream water released for power production, environmental, or other purposes will be constrained within the E-VI flow regime, and will be released through the low level outlet works located in one of the diversion tunnels on the river's north bank. Since waters released during the Stage I filling process will be drawn from deep in the hypolimnion, near the floor of the reservoir, the quality of the released water will be less than optimum for the downstream biotic community. Although a large proportion of the larger suspended sediment particles influent to the reservoir will be trapped behind the dam, downstream releases through the diversion tunnel will still contain relatively high suspended sediment concentrations (TSS) and turbidity (NTU's). Stage I filling releases will continue from spring 1998 to about October 1998.

Mainstem channels and any peripheral habitats inundated with these turbid flows will contain less

TSS and turbidity than that which occurs during the normal open water season. Direct negative impacts to rearing juvenile salmonids in the mainstem or inundated peripheral habitats are expected to be minimal as a consequence of suspended sediment and turbidity changes resulting from Stage I filling flows.

It is expected that habitats inundated by turbid release waters during summer will experience slightly increased euphotic zones compared to what exists during much of the natural open water season. The turbid release waters, especially the particulate portion, will contain high concentrations of nutrients capable of supporting dense epilithic communities where supplied with adequate light. Stable substrates immersed in less than 1 to 2 ft. of turbid release waters, with relatively low velocities (less than 3 feet per second), will be expected to support epilithic colonization composed of periphyton (Table E.3.2.69), together with assorted bacterial, fungal and actinomycetes organisms.

The luxurient growth and large standing crops of epilithon which naturally occur over much of the mainstem streambed in September, October and November may be reduced in constantly turbid habitats because of light limitation due to high turbidity. The impacts to the biotic community's secondary and higher trophic levels because of changes in the naturally cyclic periphyton growth and standing crop of epilithic organisms are uncertain.

All of the formerly mentioned characteristics of the effects of Stage I filling flows on mainstem habitats also apply to side channels, side sloughs and other peripheral habitats inundated by turbid release waters during Stage I filling. However, since Stage I filling releases will follow the minimum flow constraints, and will be more stable than natural flows, the likelihood of breaching many peripheral habitats for prolonged durations will be less than under natural flow conditions. Therefore, continuously wetted peripheral habitats which are not inundated by turbid release waters will likely remain as productive or more productive at the lower trophic levels as they were before flow regulation. Summertime rearing of juvenile chinook and other salmonids in clear peripheral habitats is not expected to be negatively impacted, when compared to the natural situation.

Tributary habitats, for the most part, will not be affected by changes caused by Stage I filling flows. Impacts which will occur include reductions in clear hydraulically mediated, backwater zones at tributary mouths, and also include increased areas of the mainstem influenced by clearwater tributary plumes extending downstream.

Stage I filling releases, since they will contain substantially reduced TSS concentrations, will result in less particulate deposition at the mouths of inundated peripheral habitats compared to natural deposition processes. The net effects of reduced TSS concentrations, reduced replacement of perviously deposited fine sediments, and scour/removal of fine sediments by periodic high project discharges will produce a reduction in accumulated fine sediments and removal of fine sediments from many surficial mainstem areas and peripheral habitat mouth areas. The impacts to the riverine benthic communities will include: larger and more stable streambed substrate; larger volumes of and more heterogenous interstial voids among the streambed substrate; more voids for organic particulates to accumulate and be processed in; increased intragravel water circulation in surficial layers of the streambed substrate; and potentially better habitat for detrital processing microbes and some types of benthic invertebrate organisms.

Minimal and/or reduced primary productivity and perhaps productivty at all trophic levels is an expected effect of the altered sediment and turbidity regime in the reservoir and in riverine habitats downstream which are chronically inundated by turbid discharges.

- <u>Effects of Changes in Other Water Quality Habitat Factors</u> (**)

During the filling of Stage I release waters will likely contain lower dissolved oxygen concentrations than are normally found in the middle river reach, because releases through the diversion tunnel will be from water near the reservoir bottom. 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 and wind and waves and the weaker stratification during filling than during normal operation. Additionally reoxygenation of this water, however, will occur naturally as it passes downstream through the turbulent upper reaches of Devils Canyon rapids.

Stage I reservoir filling discharges will contain substantial quantities of organic detritus from the newly inundated impoundment. Some of this organic detritus may have substantial food value for macroinvertebrate communities downstream. However, such an enhancement in downstream drift of allochthonous detritus from the upstream reservoir will be temporary and rather short-lived, perhaps decreasing within 1-5 years.

Other water quality changes occurring in the open water or ice covered seasons due to Stage I Watana Reservoir filling are not expected to produce biologically important impacts to fisheries habitats downstream. It is anticipated that highly turbid conditions will substantially restrict reservoir and mainstem river euphotic zones thereby minimizing any detrimental effects due to project induced changes in nutrient concentrations. No biologically important changes in oxygen concentration are anticipated for surficial depths of the reservoir(s) or riverine habitats downstream. Detrimental biological effects are not expected to occur in the project reservoir(s) or in riverine habitats downstream due to project induced changes in dissolved nitrogen or in total dissolved gas concentrations. Basic ionic changes in water quality which will be caused by the project are not expected to be detrimental to the fisheries habitat in the reservoir or in downstream riverine habitats (see discussions of water quality in Exhibit E, Chapter 2).

(iii) Talkeetna to Cook Inlet (*)

- Effects of Altered Flow Regime (*)

Discharge in the lower river (Talkeetna to Cook Inlet) during the initial filling will be reduced by approximately 10,000 cfs to 20,000 cfs during

May, June, July and August. The largest reduction in flow will occur in June with a reduction of approximately 15,000 cfs to 20,000 cfs.

Natural mean discharges in the lower river, as measured at the USGS Sunshine gaging station during the six month filling period are as follows:

May - 28,000 cfs, June - 63,000 cfs, July - 64,000 cfs, August - 56,000 cfs, September - 33,000 cfs, and October - 14,000 cfs.

During filling the mean discharge during these months will be as follows: May - 19,000 cfs, June - 44,000 cfs, July - 52,000 cfs, August - 47,000 cfs, September - 26,000 cfs, and October - 13,000 cfs. Similar reductions in discharge at the USGS Susitna Station will also result from the filling Stage I Watana. However, the percent reductions will be less since mainstem discharge at Susitna Station is greater than at Sunshine Station (see Exhibit E, Chapter 2, Section 2).

. Effects on Principal Evaluation Species/Habitat Combinations (**)

.. Chinook Salmon Rearing Habitats (**)

As discussed for chinook rearing habitats in the middle reach, the initial filling of the Stage I Watana Reservoir will be the first major effect of the project on fish species in the lower river. Eighteen sites were evaluated for chinook rearing habitat availability using either the IFG-PHABSIM or the RJHAB models described in Section 2.2.3.d (ADF&G 1985c). These sites are located in side channel-side slough complexes or at tributary mouths.

Results of these models are presented in ADF&G (1985c). The results are reprinted here as Table E.3.2.70 and Figure E.3.2.73. The effects of the flow reductions due to filling Stage I Watana Reservoir can be estimated on a qualitative basis by comparing the habitat values for natural and filling flows at each site. A summary of the expected changes induced by the filling flows is presented in Table E.3.2.71. As shown in Table E.3.2.71, various responses of chinook rearing habitats to the altered flows in the lower river are expected during the filling process. Some habitats will improve as a result of filling flows and other habitats will deteriorate. Overall, it is expected that the beneficial and adverse effects will be approximately equal with no net loss of juvenile chinook rearing habitat through the filling period.

Tributary mouth habitats, which are heavily used by juvenile chinook in the lower river (ADF&G 1985c), will likely be more seriously affected by the reduced discharges during the filling period. The principle cause for the adverse effects will be the loss of backwater effects in the tributary mouths which provide greater depth. Apparently, juvenile chinook utilize deep, clearwater areas with undercut banks or overhanging vegetation more extensively in the lower river than in the middle river (ADF&G 1985c). Weighted Usable Area analyses for tributary mouths increases markedly between mainstem discharges of 45,000 cfs and 60,000 cfs. This effect will be partially compensated for by tributary flows which will not be affected by the project. Observations and data from tributary mouths were collected at times when both mainstem and tributary discharges were low. Data were not collected under situations of low mainstem discharge and high tributary discharge. It is probable that under such conditions the habitat availability for juvenile chinook would be greater than is indicated from the habitat vs. flow relationships depicted in Figure E.3.2.73 for tributary mouth habitats.

.. Chum Salmon Spawning Habitats (**)

A relatively few chum salmon have been observed to spawn in areas associated with the mainstem in the lower river. In 1984, a total of 12 sites were identified that were used by chum for spawning (ADF&G 1985b). The most significant of these sites is located on the west side of the river at RM 94.5 immediately upstream of the mouth of Trapper Creek. An estimated total of 3,000 to 5,000 fish were observed to spawn in mainstem or side channel habitats in the lower river in 1984. This is less than 1 percent of the total number of fish estimated to migrate past the Sunshine Station.

As discussed above for chum spawning areas in the middle river, changes to the discharge regime associated with filling the Stage I Watana Reservoir are not expected to adversely affect the spawning habitats utilized by chum salmon.

- Effects on Other Evaluation Species/Habitat Combinations (**)

All five species of salmon entering the Susitna River migrate through the lower river on their way to spawning areas. Since salmon are able to migrate under a wide range of flow conditions, changes in discharge resulting from filling of Stage I Watana Reservoir are not expected to affect migratory behavior of the salmon.

Rearing habitat for juvenile sockeye, coho and chum salmon in the lower river will be affected by the changes in discharge as described for juvenile chinook rearing habitats. The affects to the habitats, however, are not expected to significantly affect the respective populations of juveniles. The majority of juvenile sockeye rearing in the Susitna Basin occurs in lake habitats which have outlet streams which flow into tributaries of the Susitna River. Principle sockeye rearing habitats are located in the Chulitna, Talkeetna and Yentna River subbasins which will not be affected by the project. Juvenile coho generally utilize small clearwater tributaries that will not be affected by changes in mainstem discharge. Rearing of juvenile chum salmon apparently does not occur in the lower river to a large extent as evidenced by the lack of increased size between juvenile collected at the Talkeetna Station and those collected at the Susitna Station (ADF&G 1985c).

During the filling period, rainbow trout, Dolly Varden, and Arctic grayling will be utilizing tributary habitats and, therefore, will not be affected.

Burbot inhabiting the lower river are not expected to be adversely affected by the changes in discharge resulting from the filling of Stage I Watana Reservoir. The expected discharges during the filling period will be within the range of discharges occurring in the lower river under natural conditions, and sufficient deep, quiescent areas will be available for the burbot populations as described for the middle river.

- Effects of Altered Temperature/Ice Regime (***)

Because little to no change in water temperature is expected during the filling of Stage I Watana and the initial winter of operation, no effects on the evaluation species are anticipated. Migration of adult salmon to spawning areas, incubation of salmon embryos, rearing of juvenile salmon in mainstem affected areas (side channel complexes and tributary mouths), overwintering of juvenile salmon, and out-migration of juvenile salmon are expected to remain the same as for natural conditions. Similarly, rearing of rainbow trout, Dolly Varden and burbot, spawning of adult burbot and incubation of burbot embryos are expected to remain the same as for natural conditions.

- Effects of Altered Suspended Sediment Regime (***)

Below Talkeetna, water from the middle reach of the Susitna will mix with other tributary flows. Little difference from natural conditions will be demonstratable in lower river suspended sediment concentrations or turbidity during June, July and August during Stage I Filling.

Late August, September and October flows, under natural conditions, would begin to clear dramatically. Stage I Filling flows will continue to be relatively turbid compared to natural flows. High turbidity is expected to minimize primary productivity in constantly turbid aquatic habitats.

No biologically important effects due to an altered suspended sediment regime are expected to occur in the lower river, during Stage I Filling, with respect to fish because of continuing effects from other tributaries.

- Effects of Changes in Other Habitat Factors (***)

Other important water quality changes in the lower river during Stage I Filling are not anticipated because of dilution effects from other tributaries. Therefore, no effects on aquatic organisms are anticipated which could be attributable to such changes.

(iv) Estuary at Cook Inlet (***)

- Effects of Changes in Suspended Sediment Regime (***)

Demonstrable changes in suspended sediment regime are not expected at the Susitna River estuary due to Stage I filling until September and/or October. Beginning during the fall of 1996, slight to moderate suspended sediment and turbidity increases may be expected because of continuously turbid discharges from the low Watana reservoir. These increases will be minimal because of substantial dilution by major upstream tributaries. Effects on the estuary are expected to be mostly confined to mild fertilization due to the nutrients associated with particulates.

- Effects of Altered Water Quality Due to Stage I Filling (***)

Because of substantial dilution by the Chulitna, Talkeetna, Kashwitna, Deshka, Yentna and other tributaries, no biologically important water quality changes are expected in the Susitna River estuary during Watana Stage I Filling.

(c) Operation of Stage I Watana Dam (**)

Operation of the Stage I Watana Dam will substantially alter the existing habitat conditions upstream and downstream from the dam. The changes attributable to Stage I will result from operation of the reservoir and from releases from the dam to meet energy demand requirements throughout the year. The impacts associated with the operation of Watana Dam are described below by river reach: impoundment zone, middle river and lower river.

(i) Effects of Stage I Watana Reservoir Operation (**)

When Stage I Watana Reservoir is filled and becomes operational, the reservoir will have a surface area of approximately 20,000 acres (8,100 ha) at its normal maximum water surface elevation of El. 2000 ft. At the normal maximum water surface elevation, the reservoir will inundate approximately 40 miles of mainstem habitat, approximately 15 miles of tributary habitat and 11 lakes and ponds ranging in size from less than one acre to approximately 5 acres.

Seasonal variations in the surface area of the reservoir will occur as a result of project operation. The reservoir will be filled to the normal maximum operating water surface elevation of 2000 ft. MSL by the end of the summer (approximately by September 1). During the winter months (beginning approximately October 1), the reservoir will be drawn down because power release flows will be in excess of inflow to the reservoir. Drawdown will continue until approximately May 1, when the summer refill period will begin. The maximum drawdown of the reservoir by the end of April will be 150 ft. below el. 2000 or to el. 1850 ft. At el. 1850 ft., the reservoir will have a surface area of approximately 12,000 acres. During the winter months, the average rate of drawdown of the water surface elevation will be approximately 0.7 ft. per day. Refilling of the reservoir will begin at the onset of the open water period, approximately May 1. If refilling is complete by the end of August, the average rate of rise in water surface elevation will be approximately 1.3 ft. per day. A schematic of the drawdown-refill cycle for the Stage I Watana Reservoir is presented as Figure E.3.2.74.

- <u>Effects to Mainstem Habitat</u> (**)

Impoundment of the Susitna River by Watana Dam will alter the physical characteristics of mainstem habitats and consequently affect the associated fishery resources. Burbot, longnose sucker, and whitefish generally occupy mainstem habitats year-round. Arctic grayling use mainstem habitats for overwintering (ADF&G 1981f, 1983b).

Mainstem habitats would be eliminated by the impoundment and replaced by a reservoir environment. The expected physical characteristics of the reservoir are presented in Exhibit E, Chapter 2, Section 4.1.1

Water quality conditions expected in the reservoir are discussed in Exhibit E, Chapter 2, Section 4.1.3,c and are not expected to preclude fish utilization of the reservoir area.

At present, mainstem habitats are utilized by burbot during the open-water season. Longnose sucker and whitefish generally occupy mainstem habitats only in the vicinity of tributary mouths (ADF&G 1981f, 1983b). Burbot, longnose sucker, and whitefish are found in glacial lake environments in south-central and southwestern Alaska (Bechtel Civil and Minerals, Inc. 1981; Russell 1980). Since these fish are associated with habitats similar to those that will be present in the reservoir, conditions within the reservoir during filling are not expected to adversely affect these species. Thus, these species are expected to utilize the reservoir habitats year-round after the reservoir is filled.

Burbot are found throughout interior Alaska and inhabit both rivers and lakes. They generally prefer low light conditions and are often associated with turbid water environments. The Watana Reservoir should offer suitable habitat for burbot. However, burbot spawn in relatively shallow water (1-5 ft) over sand, gravel and stone substrates. Eggs settle to the bottom where they develop (Morrow 1980). Since spawning occurs in January and February, it is likely that some burbot will spawn in shallow areas of the reservoir at a time when the reservoir is being drawn down. As the reservoir is drawn down further, the eggs may become dewatered and either dessicate or freeze. This will result in a reduced recruitment rate to the population. A few burbot may move into the upper Susitna or Oshetna River to spawn (Morrow 1980); however, mark-recapture studies indicate that burbot are rather sedentary (ADF&G 1983b, Morrow 1980).

A burbot population is expected to remain in the reservoir area, and could expand over existing populations. However, the densities are expected to remain low due to reduced recruitment and reduced food supplies. Because this species is not highly sought by fishermen, any reduction in population density is not considered significant and, therefore, does not warrant mitigative action.

Burbot spawning areas may be located in mainstem habitats near tributary mouths. These areas will be inundated during the first year of filling, eliminating their present value as spawning areas. Since the habitat in the vicinity of tributary mouths would be changing rapidly, it is unlikely that stable spawning areas (similar to those presently existing) would develop during reservoir filling. The loss of spawning habitat is expected to adversely affect burbot production in the proposed impoundment.

Water depth, water quality, and food availability are critical factors associated with overwintering habitat (Bustard and Narver 1975; Tripp and McCart 1974). The reservoir is expected to provide adequate depth and water quality conditions for overwintering fish. Species which currently overwinter in mainstem habitats are Artic grayling and Dolly Varden. Suspended sediment concentrations in the impoundment are expected to be tolerable for fish, although considerably higher than existing suspended sediment concentrations in the mainstem Susitna River during the winter. Particles less than 5 to 10 microns in diameter are expected to remain in suspension (Exhibit E, Chapter 2, Section 4.1.3(c)(iii)). Overwintering fish in lake habitats with suspended glacial flour levels similar to those expected for the Watana Reservoir are reported from other areas (Russell 1980; deBrugn and McCart 1974). When filled, the reservoir will increase the amount of habitat having suitable conditions for overwintering fish. The increase in overwintering habitat may have a beneficial impact on fish resources of the upper Susitna basin above the Watana Dam, if lack of available overwintering habitat presently limits fish populations in the area.

Winter reservoir water temperatures may increase the quality of overwintering habitat in the upper Susitna basin. Reservoir temperatures in the top 100 feet (30 m) are expected to be in the range of 0°C to 3°C (33.8 to 35.6°F) (Exhibit E, Chapter 2, Section 4.1.3.c.i.). Present winter water temperatures in mainstem habitats in the proposed impoundment area are near 0°C (32°F). These warmer water temperatures may benefit fish by increasing overwinter survival. During the winters of 1981-1982, 1982-1983 and 1983-1984, fish inhabiting the middle and lower river apparently sought out water with warmer temperatures (ADF&G 1983e, 1985a). Other investigators have reported that fish prefer warmer water areas in the winter (Umeda et al. 1981).

- Effects on Tributary Habitats (**)

Stage I Watana Reservoir will inundate portions of four named tributaries: Deadman, Watana, Kosina, and Jay Creeks (Figure E.3.2.71.) At the maximum surface elevation of 2000 ft. MSL, the reservoir will extend into the tributaries various distances, depending upon the location of the tributary confluence with the river or reservoir and the gradients of the tributary streambeds. The locations, lengths and gradients of tributaries affected by the Stage I Watana Reservoir are summarized in Table E.3.2.72. Because of the annual drawdown-refill cycle, certain portions of the inundated tributary reaches will alternately exhibit tributary or reservoir characteristics. Assuming a maximum reservoir drawdown of 150 ft, the approximate lengths of tributaries within the drawdown zone are generally less than 2 miles. These are presented in Table E.3.2.72. Lengths of tributary reaches which will be permanently inundated, i.e. not within the drawdown zone, are also presented in the Table.

All of the four named tributaries are inhabited by Arctic grayling populations which will likely be adversely impacted by the Reservoir. The initial filling and annual refilling of the reservoir will begin in May each year. This coincides with grayling spawning activities in the lower portions of the clear water tributaries. Arctic grayling spawn during spring breakup, with embryo incubation lasting 11 to 21 days (Morrow 1980). Spawning areas in the lower portions of the tributaries will be inundated in May and June during the initial filling of the reservoir. During reservoir operation, artic grayling will spawn in the tributaries upstream of the reservoir surface elevation in May and June. Since the reservoir is at its minimum level during this time and will begin to rise as the summer high flows are stored, some of the spawning sites will be inundated prior to their hatching. Hence, only those spawning areas sufficiently far upstream from the reservoir that the embryos hatch before the area is inundated will provide a source of recruitment for the grayling population.

Arctic grayling depend on tributary habitats for summer rearing areas. Grayling are not expected to occupy reservoir habitats during the summer as they are not found in lake habitats with turbidity levels similar to those projected to occur in the reservoir (Russell 1980). (See Exhibit E, Chapter 2, Section 4.1.3(c)(iv) for projected impoundment turbidity levels). Under existing conditions, grayling population densities in tributaries range from 323-1835 fish per mile (Table E.3.2.24, ADF&G 1981f, 1983b). The total number of Arctic grayling estimated to occur within the Stage I impoundment area is approximately 11,000 fish. Grayling occupying tributary habitats inundated by the reservoir will likely be lost because of lost rearing habitat. A small percentage of these grayling are expected to remain in the reservoir near tributary mouths.

Approximately 2 miles (3.2 km) of Deadman Creek will be inundated by the reservoir at full pool. Presently, a waterfall located about 1 mile (1.6 km) upstream from the mouth prevents upstream fish migration. The reservoir will inundate this barrier and allow fish passage to the upper Deadman Creek and Deadman Lake. Since the available habitats in Deadman Creek are presently occupied by grayling, the inundation of this barrier is not expected to improve grayling production in upper Deadman Creek.

Dolly Varden will be only slightly affected by the inundation. Dolly Varden occupy a wide range of habitat types in south-central Alaska including glacial lakes with a wide range of water quality (Russell 1980). In the project area, Dolly Varden occupy tributary habitats during the open-water season and, after spawning, return to the mainstem to overwinter. It is anticipated that Dolly Varden will occupy reservoir habitat year-round.

Dolly Varden spawn in the fall, the embryos incubate through the winter, and the alevins emerge in the late spring. Although the reservoir will be drawn down during the spawning and incubation period, any spawning areas available in the fall would not be affected since the areas will be in tributaries upstream of the reservoir.

- Effects on Lake Habitats (***)

Eleven lakes and ponds will be inundated by the Stage I Watana Reservoir. The only pond known to be inhabited by fish is located on the floodplain along the left side of the Susitna River (looking downstream) near the mouth of Watana Creek. The pond is inhabited by a population of Dolly Varden. However, no information is available pertaining to the size of the population. The Dolly Varden present in this pond will probably respond to inundation similar to the populations inhabiting the tributaries.

(ii) Watana Dam to Talkeetna (***)

- Effects of Altered Flow Regime (***)

Operation of the Stage I Watana Dam is expected to begin in October of 1998 with the first commercial operation of the first generating unit. The project will become fully operational with the commissioning of the fourth generating unit in the summer of 1999. Once the project becomes operational, the discharge regime downstream from the project will be altered from the filling regime and the natural discharge regime. In general, operation of the project will result in lower than natural discharges in the river during the period May through September, and, higher than natural discharges from October through April.

In addition to changing the general discharge regime through the year, a further change will be the reduction of peak flood events. As described in Exhibit E, Chapter 2, flood event peaks are not expected to be as high but may be of longer duration due to the storage capacity and operation guidelines of the reservoir.

Discharge from the Watana Dam is constrained, on the one hand, by the Case E-VI flow constraints defined for discharge requirements at Gold Creek. On the other hand, discharge and, thereby, energy production from Watana Dam are constrained by the storage capacity of the reservoir. Within these constraints, discharge from the dam and at Gold Creek will be dependent upon the energy demand in the system, the capacity of the units to generate power, and the amount of water available. Although it is expected that as energy demand grows from early years of Stage I operation, discharge should also increase, particularly during the winter months, and, consequently, summer discharges should decrease commensurate with a larger drawdown of the reservoir. However, because Stage I Watana Reservoir has a limited storage capacity, the total energy production capacity of the Stage I project is limited. As discussed in Exhibit B, energy demand in the system during Stage I operation is expected to grow from approximately 4,520 gigawatt hours (GWH) to approximately 4,760 GWH from 1999 to 2004. Energy production from the project, however, will grow from approximately 2,280 GWH to approximately 2,310 GWH. Therefore, the flow regimes for Stage I operation may be represented by those associated with an average demand of approximately 4,670 GWH and an average energy production of approximately 2,300 GWH. The average weekly discharges at Gold Creek for the 34 years of record are presented in Exhibit E, Chapter 2, Section 4.1.3. The mean, minimum, and maximum average monthly flows at Gold Creek for the observed 34 years of record for the natural and Stage I flow regimes are presented in Table E.3.2.73. The average monthly and mean average monthly discharges were derived from the average weekly discharges for natural conditions and Stage I operation. Habitat analyses described below were conducted using the weekly average discharges for the 34 years of record.

To determine the effects of the altered flow regime on aquatic resources, it is necessary to translate the weekly average discharge values to corresponding weekly average habitat area values. This translation is based on the habitat area response curves presented in Section 2.2.3.e. Probability of occurrence curves (percent exceedence curves) and time series (sequential) analyses of the resulting habitat area values were prepared and compared with the percent exceedence and time series analyses results presented in Section 2.2.3.f to determine the expected effects of the altered flow regime. For the purposes of this presentation, only the probabilities of occurrence (percent exceedence) values are presented with some reference to the time series analysis.

. Effects on Principal Evaluation Species/Habitat (**)

.. Juvenile Chinook Rearing Habitats (**)

As described in Section 2.2.1.a, juvenile chinook salmon inhabit mainstem affected areas in the middle river throughout the year. Throughout the summer, open-water months, the juveniles in the mainstem affected areas occupy habitats which are commonly characterized as having turbid water. Densities of juveniles in turbid water areas are generally more than twice those in clear water habitats (ADF&G 1984c). During the ice-covered period, juvenile chinook are found in the greatest concentration in areas influenced by groundwater upwelling. Because of these differences in habitat utilization between summer and winter months, the analysis of the effects of the altered flows associated with Stage I operation is separated into the two periods. Focus for the open water season will be for the period June through September and focus for the ice-covered season will be for the period November through April. The months of May and October correspond to the transition from winter to summer conditions and from summer to winter conditions in both the natural and Stage I operation flow regimes.

The probability of occurrence and frequency analysis of the weekly average habitat areas is based on the translation of weekly average discharges in the 34 years of record to weekly average total habitat areas. Total habitat area values for each weekly average discharge are derived from the total habitat area response curve presented in Table E.3.2.46 and Figure E.3.2.57. In addition, flows were translated to habitat areas included in Representative Groups 2,3, and 4. The translations using this subset of the representative groups were made because these groups represent the types of habitats which are currently most heavily utilized by juvenile chinook (particularly Representative Groups 2 and 3) and those expected to be most similar, under project conditions, to those currently utilized. The habitat response curve for this subset of Representative Groups is presented in Table E.3.2.46 and Figure E.3.2.58.

Translations of the weekly average flows to
Translations of the weekly average flows to
habitat areas in each of the respective Representative Groups were not made. Therefore, the differences in habitat areas between natural and with-project discharges incorporate the replacement of habitat areas lost in one group of sites by habitat areas gained in another group of sites. Thus, the observed differences presented below represent the net changes in chinook rearing habitat areas attributable to Stage I operation for the open water season.

During Stage I operation, the median total habitat area for chinook rearing in the 34 year simulation during the summer months is expected to be nearly the same as the median total habitat area available under the natural flow regime. The median habitat area values (i.e. the 50 percent exceedance values) for the Stage I flow regime and the natural flow regime for each week are presented in Table E.3.2.74. Also presented in the table are the 90 percent and 10 percent exceedance values for the Stage I and the natural flow regimes. These values are dipicted graphically on Figure E.3.2.75. Habitat areas expected to be equalled or exceeded 10 percent of the time under the Stage I flow regime during the first half of the summer are somewhat less than the areas equalled or exceeded 10 percent of the time under the natural flow regime. However, by mid-summer, i.e. by Calendar Week 30, the range of values for available chinook rearing habitat area under the Stage I flows is nearly the some as under natural flows. Two points must be emphasized with respect to the apparent reduction in the available habitat areas for the first part of the summer. First, as indicated in Figure E.3.2.37, juvenile chinook generally do not become prevalent in mainstem affected areas until the first part of July. Thus, reductions in available habitat area during the earlier time period will not affect the populations. Secondly, the results of this analysis indicate only the total equivalent surface area which is suitable for chinook rearing and does not necessarily mean that juvenile chinook will use all of the suitable habitat area available.

The reduction in the habitat area equalled or exceeded 10 percent of the time, evident during the first weeks of the summer, is due primarily to the fact that Stage I discharges in the early summer weeks are not sufficiently great to achieve the peak habitat area values present in Representative Groups 2, 5 and 8 (See Figure E.3.2.56). With the exception of Representative Group 2, groups which provide optimum habitat area at discharges greater than approximately 25,000 cfs (e.g. Representative Groups 5 and 8) are not known to be heavily utilized by juvenile chinook for rearing under natural conditions. Therefore, the apparent reduction of habitat area in these groups, reflected in a total habitat reduction, is not expected to affect the juvenile chinook populations.

In contrast, by considering only the habitat areas included in Representative Groups 2, 3 and 4 (Figure E.3.2.58), it is evident that habitat currently used extensively by juvenile chinook will increase as a result of the Stage I flow regime. Habitat areas representing the 90, 50, and 10 percent exceedance values for the three representative groups are presented in Table E.3.2.75 and depicted in Figure E.3.2.76. the values for the natural flow regime are presented for comparison. The major cause for the expected increase in habitat area is that considerable habitat is present in sites included in Representative Group 4 at lower discharges, in the range of project flows, than is present at higher discharges in the range of natural flows. Although the habitat areas that are used by juvenile chinook under natural conditions (i.e. in Representative Groups 2 and 3) may be lost due to the lower discharges associated with Stage I operation, habitat areas in Representative Group 4 sites will be gained. Hence, lost habitat areas used by chinook juveniles under natural flows will be replaced by suitable habitat areas in other sites.

A further characterization of the estimated habitat areas under the Stage I flow regime is that the range of variation in habitat area from week to week and from year to year is relatively narrow as shown in the figures. Comparison of the range of habitat areas for natural conditions, also presented in Figure E.3.2.74, with those expected during Stage I operation, indicates that under the project flow regime, even though the total chinook rearing habitat areas will be less than under the natural flow regime, the habitat areas will be more constant through time. This is also true for the Representative Groups 2,3, and 4. The range of habitat areas included in all sites and included in Representative Groups 2, 3, and 4 under the natural flow regime are superimposed on the respective ranges of habitats under the Stage I flow regime in Figures E.3.2.75 and E.3.2.76 for comparison. Based on this analysis, it is evident that the primary goal of the Case E-VI flow regime to maintain the chinook rearing habitat is achieved. In fact, the chinook rearing habitat expected to be available in the three representative groups during Stage I operation will be greater than that available with the natural flow regime.

During the winter, juvenile chinook generally move into areas influenced by groundwater upwelling as described in Section 2.2.1.a.i. Because mainstem discharge during the winter months will be greater during Stage I than under natural conditions, the availability of clearwater area in the areas which are currently used by juvenile chinook is expected to be greater during Stage I. The increase in area used by chinook for overwintering is expected even though the mainstem is expected to be turbid. Turbid water from the mainstem will not affect these overwintering areas (i.e. the side sloughs). Thus, the clarity of mainstem water is not relevant. The increase in clearwater area is expected both as a result of the increased mainstem discharge causing increased backwater areas at the mouths of clearwater channels, and as a result of increased rates of groundwater upwelling (APA 1984g). Since clearwater overwintering habitats are expected to be more extensive during Stage I project operation, juvenile chinook survival is also expected to be greater.

However, a factor which could offset this expected increased survival is the effect of ice processes associated with the Stage I discharge and temperature regime. Given the Stage I discharge regime, formation of the ice cover is expected to begin somewhat later than under natural conditions. The formation of an ice cover will cause the water surface elevation to increase significantly. This process is discussed in more detail in Exhibit E, Chapter 2, Section 4.1.3.c.ii, by HE (1984a), and by R&M (1984, 1985b). Staging of the water surface would be sufficient to cause diversion of mainstem discharge into clearwater habitats used by juvenile chinook during the winter months. The diversion of 0°C mainstem water into these habitats would increase the mortality of juvenile chinook because 0°C water will reduce the ability of the juveniles to maintain their positions and the increased velocities associated with the diversion of water into the channels would tend to displace the juveniles downstream, out of the sites. In addition, it is expected that mainstem discharge will remain turbid through the winter months. Hence, diversion of turbid water into the overwintering areas could cause reduced survival of the juvenile chinook due to increased physiological stress. However, this is not expected to be significant.

The ice front is expected to progress only part of the way up the middle river, with some of the reach remaining ice free. Chinook juveniles in sites within the ice-free reach are expected to exhibit higher survival rates than those in sites within the ice covered reach. In the absence of mitigation efforts designed to protect peripheral habitats, overtopping of the overwintering habitat sites in those areas influenced by an ice cover could result in a generally adverse effect on juvenile chinook. However, in general, survival of overwintering juvenile chinook is expected to increase under the with-project flow regime.

.. <u>Chum Spawning Habitats</u> (**)

As described in Section 2.2.1.a, chum salmon spawn during August and September each year. During Stage I operation, discharge at Gold Creek will increase over the previous months (June and July) because the Stage I Watana Reservoir will be filled. Therefore, most of inflow to the reservoir will be discharged downstream either through the turbines or through the outlet works. As indicated in Table E.3.2.73, mean discharge at Gold Creek will be approximately 18,000 cfs in August and approximately 14,000 cfs in September as compared with mean flows of 22,000 cfs and 13,000 cfs, respectively, under the natural flow regime. Because the Stage I operational discharges in August and September will be similar to those under the natural flow regime, access to traditional spawning areas used by chum salmon in the mainstem are not expected to be adversely affected. A summary comparison of natural and Stage I operation access conditions at several chum spawning habitats is presented in Table E.3.2.76. Based on the mean average monthly discharge at Gold Creek, access conditions through six of the 24 passage reaches evaluated will be adversely affected by the Stage I flow regime in August whereas only one passage reach will be adversely affected in September. In general, major adverse effects on access to chum spawning areas, particularly through those passage reaches directly affected by mainstem backwater, are not anticipated.

Analysis of the effects to chum spawning habitats was performed using the habitat area response curve developed for the modeled sites (Table E.3.2.47 and Figure E.3.2.59). Sites included in this curve provide spawning habitat for over 70 percent of the adult chum which spawn in non-tributary, mainstem-affected areas in the middle river.

Translation of the simulated weekly average discharges for the 34 years of record to weekly average habitat areas using this curve was performed and a frequency analysis conducted. The analysis was conducted for simulated average weekly discharges during August and September. The habitat areas available in the modeled sites expected to occur at least 90 percent, 50 percent and 10 percent of the time are presented in Table E.3.2.77 for the expected flows during Stage I operation. Habitat areas in these sites under natural flows are also presented for comparison. These values are depicted graphically in Figures E.3.2.77. Comparison of the median spawning habitat values obtained for the Stage I operational flow regime with the values obtained for the natural flow regime, reveals several conclusions regarding the effects of the Stage I operating regime under the Case E-VI flow constraints. Throughout Stage I operations median habitat values will be equal to or greater than the median values present under natural flow conditions. This is most pronounced for the last part of September when natural discharge declines prior to the beginning of winter. Discharge in the last part of September with Stage I operating will be the same as the optimum flows for chum spawning habitat (approximately 14,000 cfs, Table E.3.2.47).

Spawning habitat areas equalled or exceeded 90 percent of the time will also be greater during Stage I operation due principally to the reduction of high weekly average discharge events which normally occur as a result of storms. Discharge of the storm-related high flow events through the reservoir will occur over a longer period and will not reach the peak levels observed in the unregulated river. Similarly, naturally occurring low flow events near the end of September, which are associated with low habitat area values, will be augmented by the Stage I operation in response to the minimum Case E-VI flow constraints and the need to discharge water for power generation. The overall effect of the Stage I operational flow regime, then, is that more habitat area is expected to be available for chum spawning and the week to week and year to year variation in the amount of spawning habitat area available will be reduced.

A similar analysis of chum spawning habitat was conducted during the aggregate habitat area response curve for Representative Groups 2, 3 and 4 presented in Table E.3.2.48 and Figure E.3.2.63. Using this habitat response curve, somewhat different results are obtained.

Total habitat areas during Stage I operation for chum spawning during August and September are expected to decline somewhat from those available under the natural flow regime. Chum spawning habitat areas in the three Representative Groups, expected to be available fifty percent of the time during Stage I operation, are presented in Table E.3.2.78. Habitat areas expected to be equalled or exceeded 90 and 10 percent of the time in under the Stage I flow regime are also presented in the Table. Similar values for natural flows are also presented in the table for comparison. These values are depicted graphically in Figure E.3.2.78. Comparison of these values indicates that the range of variation in the availability of suitable spawning habitat for chum during Stage I operation is less than the variability observed for the natural flow regime. This is due primarily to the reduction in flow variation from week to week and from year to year during the spawning period. Hence, although it is anticipated that the total habitat area for chum spawning in mainstem affected areas may be reduced in the three Representative Groups, spawning habitat area is expected to remain relatively constant through the spawning period and from year to year as was observed in the analysis using only the modeled spawning sites.

As described in Section 2.2.1.a, chum embryos in mainstem affected 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 Table E.3.2.73. As a result, embryos deposited in the spawning areas are not expected to be as subject to dessication and freezing (ADF&G 1985b). In fact, water depths and velocities in the spawning areas will be maintained at higher than natural levels. It can be assumed that the total spawning habitat area, as calculated using the models and habitat criteria described above and in Section 2.2.3, is also indicative of the suitability of the area for incubation: If the area is suitable for spawning, it is also suitable for incubation of the embryos. Thus, calculations of the spawning habitat areas for discharges in October and November may be used to evaluate the availability of the areas for incubating embryos. Using this assumption, estimates of incubation habitat loss or reduction will be overestimated and estimates of habitat gain will be underestimated. However, this approach is useful as an index of the effects of the altered flow regime or the incubating embryos. Also, the use of open water models to discuss incubation habitat areas under project conditions can be justified, at least in October and November, since it is expected that the formation of an ice cover in the middle river during project operation will not occur until late November or December as discussed in Exhibit E, Chapter 2 and when ice does form, it will not progress as far upstream as under natural flow conditions.

Total habitat area in the modeled sites available for incubation in October and November for the Stage I flow regime is presented in Table E.3.2.79 and is depicted graphically in Figure E.3.2.79. Values associated with the natural flows are also presented for comparison. Comparison of the Stage I values with the natural flow regime values indicates that suitable habitat areas for incubation will be much higher under project operation than under natural conditions. Hence, it is anticipated that chum embryo survival will be enhanced in mainstem affected areas as a result of project operation.

Similar results are obtained using the spawning habitat response curve developed for Representative Groups 2, 3 and 4 (Table E.3.2.48 and Figure E.3.2.63). Spawning habitat areas expected to be equalled or exceeded 90 percent, 50 percent and 10 percent of the time in the three Representative Groups during Stage I operation are presented in Table E.3.2.80 and Figure E.3.2.80. Results of the analysis of spawning habitat areas in Representative Groups 2, 3 and 4 for the natural flow regime are also presented in the table. Again, the total spawning habitat available for incubation of chum embryos in these sites will be greater with the Stage I operating flows than with the natural flows.

As discussed in Exhibit E, Chapter 2, Section 4.1.3, ice cover in the middle river is expected to form later than under comparable natural conditions. In addition, the ice cover will not extend as far upstream. Thus, upstream of the ice front, chum salmon incubation areas are not expected to be affected by overtopping of the upstream ends of the habitats as a result of staging of mainstem water surface elevations associated with the ice formation process. However, downstream of the ice cover, staging and, therefore, the probability that a site will be overtopped by mainstem water will be greater than under natural conditions (see Exhibit E, Chapter 2 Sections 2 and 4.1 for a complete description of the ice processes). The overtopping of a particular chum spawning/incubation site would adversely affect chum embryo development (ADF&G 1983m, Wangaard and Burger 1983). Hence, although there is some gain in the expected survival of chum embryos due to the maintenance of higher than natural discharge in the river during the winter months, the anticipated probability that sites located downstream of the ice front will be overtopped could eliminate the anticipated gains. Overall, in the absence of mitigation measures to protect the peripheral habitats, survival of chum embryos in mainstem affected areas would be less than under natural conditions.

- Effects on Other Evaluation Species/Habitat Combinations (**)

Baseline conditions in the reach of the Susitna River within the Devil Canyon impoundment zone will be altered as a result of the Watana facilities. The principal physical changes will be the alteration of the flow regime, reduction in the total suspended sediment loads during May through September, moderation of the temperature regime, and increase in the turbidity and suspended sediment concentrations during the winter months. In general, all of these regimes will be changed from exhibiting considerable extremes in magnitude between summer and winter conditions to remaining relatively constant throughout the year.

Adult salmon generally do not use this reach of the Susitna River for spawning; however, a few chinook salmon are able to negotiate the rapids within Devil Canyon and up to 20 spawning pairs have been observed in both Cheechako and Chinook Creeks (ADF&G 1983e, 1984h). In addition, five to 10 individuals have been observed in Devil's Creek and one spawning pair has been observed as far upstream as Fog Creek (ADF&G 1985b).

The absence of the other salmon species in the Devil Canyon impoundment zone and upstream is apparently due to velocity barriers at the rapids within Devil Canyon. This is supported by radio telemetry tracking results of chinook and chum salmon adults and gill net captures of coho, chum and pink salmon adults in the lower portion of Devil Canyon. Radio tagged chinook and chum salmon were tracked into the Devil Canyon reach (ADF&G 1983m). These individuals subsequently returned downstream to spawn. Movement of coho, chum and pink salmon into the Devil Canyon reach was demonstrated by the capture of adults of each species at RM 150.2 and 150.4 (ADF&G 1983m). Presumably, these fish would have returned downstream to spawn, since none has been observed upstream of the lower rapids area at the Devil Canyon dam site. It can be inferred from these results that farther upstream movements of adult coho, pink, and chum salmon are largely blocked by the rapids.

Because of the somewhat lower flows in this reach during Stage I operation, it is expected that the number of chinook salmon able to negotiate the rapids in Devil Canyon will increase. In addition, it is possible that individuals of the other species may be able to gain access to spawning habitats in Devil Canyon. Hence, during Stage I operation an expansion of the use of habitats upstream of the Devil Canyon Dam site is expected.

As discussed under the effects of Stage I filling flows on other evaluation species/habitat combinations, no adverse effects to the upstream migration of adult salmon are expected as a result of the altered flow regime.

Chinook, coho, chum and pink salmon adults that spawn in tributary habitats will not be affected by project discharges in the middle river.

Sockeye spawning and incubation habitats will be affected by project flows similar to the effects to chum spawning and incubation described previously.

Juvenile coho and sockeye move into upland slough sites (Representative Group 1) which are not affected to a large extent by mainstem discharge.

Outmigration of juveniles of all salmon species will not be affected by the altered flow regime since there will be sufficient discharge in the river to accommodate outmigration.

Rainbow trout, Dolly Varden and Arctic grayling generally move into tributary habitats during the summer months and, therefore, will not be affected by the altered summer flow regime. Since discharge in the river during the winter months will be greater under project conditions than under natural conditions, it is expected that more habitat with suitable conditions for overwintering will be available for these resident species. Some loss of habitat may occur in the reaches of the middle river that form an ice cover. However, since the ice cover will form later than under natural conditions and will not extend as far upstream, it is expected that rainbow trout, Dolly Varden and Arctic grayling survival will be greater under project conditions than under natural winter flows. Burbot populations in the middle river are not expected to be adversely affected by project operation since they commonly inhabit deep, low velocity areas which will be maintained and possibly increased under project flows.

- Effects of Altered Temperature Regime (***)

Effects of the altered temperature/ice regimes attributable to Stage I Watana operation may be divided into two seasons: the summer open water period and the winter ice covered period. As with the discussion of effects of the altered flow regime, each of these seasons is discussed with respect to the average flow and temperature regime expected during Stage I operation.

Water temperature during the summer months is a function of discharge from the reservoir, temperature of the water at the dam, climatic conditions and distance downstream from the dam. Estimates of water temperature at various locations downstream were made using results of the reservoir operations model for determination of discharge; results of the DYRESM model for temperature at the dam; and results of the SNTEMP instream temperature model which integrates the results of the other models with climatic conditions to predict water temperatures at various locations downstream from the reservoir (HE 1985a, AEIDC 1984a, b, and c). The sensitivity of river temperatures to extreme hydrological and meteorological conditions and various project operations is discussed in Exhibit E, Chapter 2, Section 4.1.3(c)i: The selection of cases for simulation is also discussed in that section.

Instream temperatures for the summer months were estimated using 1981 and 1982 discharge and climatic conditions. Summaries of the instream temperatures at various locations for the period May through October using 1981 and 1982 climatic and flow conditions for the Stage I energy demand are presented in Tables E.3.2.81 and E.3.2.82, respectively. Tables E.3.2.83 and E.3.2.84 present comparable instream temperatures for natural conditions. These estimates were based upon the assumption that outflow temperatures were to match inflow temperatures as nearly as possible given the constraints for operating the temperature control ports of the intake structure. The assumptions for estimating instream temperature are discussed in detail in Exhibit E, Chapter 2.

During the winter months, discharge from the Watana Reservoir will be considerably greater under Stage I of the project than under natural conditions (Table E.3.2.73). 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 which port in the intake structure is being utilized at the time and the preceding climatic conditions. 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. This pattern is depicted in Figure E.3.2.81 for the period November through April assuming the inflows and climate for the 1981-1982 winter.

Once the water is released from the reservoir, water temperature will decline to 0°C at various rates depending upon the air temperatures. As depicted in Figure E.3.2.82, the zero-degree isotherm will occur at various points within the middle river depending upon the time of year and the particular climatic conditions. The depicted location of the zero-degree isotherm assumes climatic conditions observed during the 1981-1982 winter months and discharges from the reservoir during Stage I operation. In general, during cold periods, the zero-degree isotherm is located further upstream whereas during relatively warm periods, the zero degree isotherm is located further downstream. Once the river instream temperature becomes 0°C, formation of ice occurs as described in Chapter 2 of Exhibit E. The ice cover will begin to form in the middle river in December and will progress upstream to approximately RM 139 by the end of January. The ice cover will then begin to recede through the remainder of the winter as the amount of solar radiation increases during the late winter and early spring months. It is expected that the middle river will be ice free by the end of April (as depicted in Figure E.3.2.82).

Effects on aquatic habitats will occur during this period as a result of water surface elevation staging described in Exhibit E, Chapter 2. The principle changes in the temperatures and ice regimes associated with operation of Stage I of the Susitna Hydroelectric Project are:

- Summer river temperatures at the Watana Dam will be up to 3°C cooler in May than under natural conditions, nearly the same as natural in June, July and August, and up to 7°C warmer in October.

- Summer water temperatures at Portage Creek (RM 149) will be approximately 2-3° cooler in

May, approximately the same in June, July and August and up to 4.5°C warmer in October.

- Summer water temperatures at the downstream end of the middle river, i.e. near RM 99 will follow the same basic pattern but the differences from natural conditions will be reduced (See Tables E.3.2.81 through E.3.2.84).

- During winter months, from November through April, water temperature at the Watana Dam outlet will be 1-3°C warmer than under natural conditions (Figures E.3.2.81) and will remain above 0°C for some distance downstream (Figure E.3.2.82).

- An ice cover will begin forming in the middle river in December, reach its furthest upstream extent in January and will likely recede to somewhere downstream of the middle river by mid to late April (Figure E.3.2.82).

- Because water released from Watana Dam throughout the winter will be between 1° and 3°C, water temperatures upstream of the ice front will be 0-3°C warmer than under natural conditions.

. Effects on Principal Species/Habitat Combinations (**)

.. Juvenile Chinook Rearing/Overwintering Habitats (**)

As described in Section 2.2.1.a.i, juvenile chinook begin to move into the mainstem as Age 0+ fish sometime in June and July each year. Age 1+ fish, which overwintered in tributary habitats also move into the mainstem. During June and July, it is expected that water temperatures in the mainstem will be nearly the same as under natural conditions. Therefore, rearing of juvenile chinook in side channel habitats in June and July is not likely to be affected by project induced temperature changes. However, because warmer water temperatures are expected in the mainstem from August through the end of October, it is expected that the Age 0+

juveniles will remain in side channel habitats and continue to grow for a longer period than under natural conditions. Once water temperatures begin to decline to below 4°C, juvenile chinook are expected to move into and slough habitats to overwinter. It is expected that juvenile chinook in the upper portions of the middle reach (RM 130-RM 150) will begin moving to side sloughs somewhat later in the fall than chinook juveniles in the reach between RM 99 and RM 130. The difference in the timing of the movement to overwintering habitats is due to the differences in temperature between the upper and lower portions of the middle reach shown in Tables E.3.2.81 and E.3.2.82.

As a result of the extended warm water period in the fall, it is expected that the juvenile chinook will begin the winter, ice covered period at sizes similar to those attained under natural conditions. An estimate of the incremental increase in size cannot be made given the information which is available. It is possible that the sizes of Age 0+ fish in the mainstem affected areas (i.e. side channels and side sloughs) may approximate those attained by juvenile chinook in tributary habitats (Table E.3.2.10).

During late fall, juvenile chinook move into side channel and side slough areas that are normally only indirectly affected by mainstem discharge and temperature. In side sloughs, particularly, certain areas have water temperatures which are greater than 0°C and may attain temperatures approaching 4°C (ADF&G 1983e, 1985a) due to the presence of groundwater upwelling. Mainstem areas, by contrast, have 0°C water temperature from prior to ice formation until breakup (R&M 1984, ADF&G 1983e). Circumstantial evidence pertaining to the behavior of the fish during winter months indicates that the juveniles overwinter in or near the substrates in the upwelling areas (ADF&G 1983e, 1983m, 1984c; AEIDC 1984a, b, c).

In the side sloughs, overwintering juvenile chinook may be affected by water temperature and ice in the mainstem indirectly through the groundwater or directly as a result of the staging of the mainstem water surface sufficiently to overtop the upstream end of the sloughs. Increased water elevation (less than that sufficient to overtop the upstream end of the slough) tends to increase the rate of upwelling in the sloughs and thereby provides greater amounts of warm water (Exhibit E, Chapter 2, Section 4.1.2(f)(ii)). This, in turn, increases the likelihood that juvenile chinook will survive through the winter.

On the other hand, if staging of the mainstem water surface is sufficient to overtop the upstream berm, significant amounts of 0°C, mainstem water could be diverted into the slough. At 0°C, metabolic processes of the fish may be sufficiently low to prevent the fish's ability to maintain their positions in even relatively low water velocity areas. Thus, the diversion of 0°C mainstem water could cause the juvenile chinook to be flushed out of the side sloughs and, thus decrease their probability of survival. Under natural conditions, mainstem discharge is quite low during the winter (1500-2500 cfs) and staging due to ice formation seldom attains sufficient elevations to overtop the upstream ends of the sloughs. However, with Stage I of the Project, mainstem discharge will be considerably greater during the winter (5,000-12,000 cfs between November and March). Simulation of the ice formation process under natural and Stage I conditions indicates that more side slough and side channel sites will be overtopped downstream of the ice front (Table 3.2.85) and overtopping will be of a greater magnitude than under natural conditions. However, upstream of the ice front, staging due to ice cover formation will be less under Stage I than under natural conditions because no ice cover is expected to form under Stage I flow and temperatures.

Hence, the survival of juvenile chinook in all side slough habitats in the winter months is expected to increase as a function of the increased rates of groundwater upwelling in the sloughs. However, without mitigative measures, this gain is countered by potential loss of the habitats resulting from more likely overtopping of the upstream ends of the sloughs and diversion of 0°C mainstem water into sloughs downstream of the ice front.

In summary, altered temperature and ice regimes attributable to operation of Stage I of the Susitna Hydroelectric Project are expected to have the following effects on juvenile chinook salmon:

- o Delay in the onset of the summer rearing in the mainstem due to lower than natural water temperature in May.

- o Prolongation of the summer rearing period in the fall due to the persistence of warmer water temperatures into the fall.

- o Increased overwinter survival due to the delay in the formation of an ice cover and higher mainstem discharge which maintains higher rates of warm groundwater upwelling in the side sloughs.

- o The greater likelihood of overtopping of the upstream ends of side sloughs due to ice formation and cover will cause loss of juvenile chinook salmon from the side sloughs if no mitigation efforts are taken to protect these habitats.

.. Chum Spawning/Incubation Habitats (**)

As described in Section 2.2.2.a.iv, chum spawning occurs in August and September of each year in side channels, side sloughs and to some extent mainstem habitats. During this period, mainstem temperature will be approximately the same under Stage I of the Project as under natural conditions. Thus, the principle factor governing the availability of spawning habitat is mainstem discharge as discussed in the previous section and no affects due to an altered summer temperature regime are expected during Stage I operation.

Incubation of chum embryos in the various habitats begins with deposition of the eggs and continues through emergence of the fry from the gravels in March and April each year. During this period changes in the winter temperature and ice regimes will affect the survival rates of the chum embryos.

Under natural conditions, winter mortality of chum salmon embryos have been estimated in both field and laboratory conditions (ADF&G 1984c, 1985c; Wangaard and Burger 1983). Survival of chum salmon embryos from egg deposition to outmigration of the juveniles is estimated to be 12 to 14 percent (ADF&G 1984c). This estimated mortality is based upon the total estimated number of eggs deposited in tributary, side channel, side sloughs and mainstem habitats and the estimated total number of outmigrants from the middle river.

The causes of chum embryo mortality may be partitioned to some extent to account for effects of temperature and ice processes on survival in side sloughs and side channels. Mortality rates of Susitna River chum embryos were estimated as part of a laboratory study of the effects of temperature on development (Wangaard and Burger 1983). Chum embroys were incubated under four different temperature regimes varying from averages of 2°C to 4°C, similar to regimes encountered in the field. Because of the controlled conditions, the observed mortality rates of 2-5 percent are attributable either to the temperature or to some other biological factor not associated with the physical environment (i.e. disease, lack of fertilization, genetic disorder, etc.). It is, therefore, safe to assume that an approximate 5 percent mortality of chum embryos in the field situation could be attributable to similar causes. Because of the nature of environmental conditions, it is safe to assume that much of the remaining mortality of chum embryos is attributable to physical processes in the habitat.

Two principal physical factors which could account for a significant portion of the estimated mortality are associated with mainstem flow influences on the spawning habitats which are in turn affected by ice processes in the river. The two factors are; 1) dessication and freezing of the embryos due to the reduction of mainstem discharge prior to ice cover formation (ADF&G 1985a); and, 2) reduced temperature in the spawning areas resulting from staging of the mainstem water surface and overtopping of the upstream ends of the sloughs. Mortality due to dessication and freezing was discussed previously under the effects of the altered flow regime.

When the upstream ends of side channels and side sloughs are overtopped as a result of ice formation and water surface staging, 0°C water is diverted into the channels and may cause water temperatures in the substrates to decline to near 0°C. Depending upon the developmental stage of the embryos at the time of an overtopping event, the 0°C water may cause death of the embryos or may cause developmental abnormalities to occur (Wangaard and Burger 1983). Laboratory studies of salmon developmental rates vs. temperature indicate that sockeye embryos are especially sensitive to thermal (cold) stress early in the developmental process (Velson 1980, Bams 1967, Combs 1965). Although not documented for chum embryos, it is likely that the embryos are also susceptable to low water temperatures during the early developmental period. The increased mortality and developmental abnormality rates observed by Wangaard and Burger (1983), were corroborated in the middle Susitna River by observation of large numbers of dead embryos, reduced fry size and higher frequency of abnormalities in Slough 8A following an overtopping event in 1982 (ADF&G 1983m). Embryos in other sloughs which were not overtopped did not exhibit the large number of dead embryos or abnormal fry.

In contrast to the three factors discussed above, a fourth factor, the effects of staging on groundwater upwelling rates, likely contributes to the survival of chum salmon embryos. Upwelling groundwater benefits embryo development by providing higher water temperatures (2°C-4°C) in the spawning gravels, more constant dissolved oxygen concentrations, and removal of fine sediments which may have a detrimental effect on embryo survival. Upwelling rates are at least partially dependent upon mainstem water surface elevation (Exhibit

E, Chapter 2, Secitons 2.4.4 and 4.1.2(f)(ii)) and staging of mainstem water caused by the ice formation processes results in increased groundwater upwelling rates which in turn contributes to the survival of the embryos.

In summary, several factors associated with winter flow and ice processes in the mainstem of the Susitna River under natural conditions affect the survivorship of salmon embryos during the incubation period. Factors which tend to decrease survival are:

- o Reduced mainstem flow resulting in dessication or freezing of the salmon embryos; and

- o Overtopping of the upstream ends of sloughs and side channels diverting the 0°C water in to the sloughs and side channels causing thermal (cold) stress to the embryos.

A factor which tends to increase survival of embryos is increased groundwater upwelling and maintenance of higher water temperatures in the gravels.

The changes in water temperature during winter months resulting from operation of Stage I of the project will have several effects depending upon the particular location of the spawning/incubation areas. As discussed previously under the effects of the altered flow regime, increased mainstem discharge will maintain groundwater upwelling rates in the sloughs at a higher level than under natural conditions. Therefore, the warm groundwater temperatures will be maintained in the slough spawning areas and will increase the survival of chum embryos through the winter months.

An adverse impact of the higher discharges during the winter is that in those areas in which an ice cover will form, mainstem water surface staging will likely be sufficient to overtop the upstream ends of the sloughs, thereby diverting 0°C water into the areas having incubating chum salmon embryos. As discussed with respect to juvenile chinook overwintering areas, the magnitude of overtopping will be greater than under natural conditions and may penetrate into the substrates sufficiently to retard developmental rates. Retardation of chum embryos development rates due to lower temperatures has been demonstrated both in the laboratory (Wangaard and Burger 1983) and in the field (ADF&G 1983e). The influx of 0°C water could also increase the mortality of chum embryos in the side slough substrates. However, because the progression of the ice front into the middle river will occur 2-4 weeks later than under natural conditions, it is likely that chum embryos will have developed sufficiently such that the influence of 0°C water will not affect development or mortality of chum embryos significantly. Also, some portions of the middle river will not have an ice cover or the duration of the ice cover will be considerably reduced such that overtopping events will either not occur or will be relatively short in duration (see Figure E.3.2.82 and Table E.3.2.85).

In summary, the major impacts to chum spawning incubation due to temperature and ice process changes associated with Stage I of the Project are as follows:

- o Chum spawning in side channels and side sloughs will be unaffected by mainstem water temperature.
- o Chum embryo survival and development will be benefitted by the extension of warmer water conditions into the fall.
- o Maintenance of groundwater upwelling rates through the winter will prevent freezing of the chum embryos.
- o Potential adverse effects to embryo development and survival associated with overtopping of the sloughs may be greater than under natural conditions. However, delay of ice formation in the middle reach may alleviate potential adverse effects of 0°C water on embryo development and survival.

- The dispersal of the ice cover earlier in the spring and the influence of somewhat warmer mainstem temperatures in April may enhance the survival of chum fry after they emerge from the gravels.

- Other Evaluation Species/Habitat Combinations (***)

The impact of the altered temperature and ice regimes in the middle Susitna River resulting from Stage I operation on other evaluation species/habitat combinations are summarized below.

Since chinook migration occurs during July in the middle river and the estimated temperatures under Stage I operation are nearly the same as under natural conditions, no effects are expected.

Chinook spawning/incubation occurs in tributary habitats and therefore, will not be affected by the mainstem temperature and ice regimes under Stage I conditions.

Sockeye migration occurs in late July, August and early September. The minor change in mainstem temperatures will not affect sockeye migration.

Sockeye spawning and incubation occurs almost exclusively in side slough habitats under nearly identical habitat conditions used by chum salmon (ADF&G 1983k, 1983n, 1984b, EWT&A and WCC 1985.) Therefore, the impacts of temperature and ice regime changes are the same as those described for chum spawning and incubation. Sockeye juvenile rearing and overwintering habitats include side sloughs and upland sloughs. The impacts on sockeye juveniles rearing and overwintering in side sloughs are essentially the same as those described for juvenile chinook in side sloughs. Upland sloughs are generally unaffected by water temperatures in the mainstem during the summer and winter. Therefore, the anticipated temperature and ice regime changes under Stage I conditions are not expected to affect juvenile sockeye in upland sloughs. Outmigration of juvenile sockeye from the middle river generally occurs in June and July (ADF&G 1983m, 1984c). Since water temperature at this time would be similar to natural conditions, no effect to outmigration is expected.

Upstream migration of adult coho salmon generally occurs during August and September in the middle river. Since water temperatures are expected to be nearly the same as natural at this time, no adverse effects are expected. Coho spawning and incubation occurs in tributary habitats and, therefore, will not be affected by altered temperature and ice processes in the mainstem. Most juvenile coho rearing occurs in tributary habitats (ADF&G 1984c). Therefore, no effects due to mainstem temperature changes are expected. A few juvenile coho move out of the tributaries and in to upland sloughs for rearing and overwintering. Again, these habitats are not influenced by mainstem temperature and ice processes and, therefore, no project-induced temperature impacts on coho juveniles are anticipated.

Outmigration of coho juveniles from the middle river occurs in June and July when water temperatures under Stage I operation of the Project will be nearly the same as natural conditions. Therefore, no impacts are anticipated.

Upstream migration of adult chum and downstream outmigration of juvenile chum occurs in July and August; and June and July, respectively, when mainstem temperatures are expected to be nearly the same as natural conditions. Therefore no impacts are expected as a result of Stage I project-induced changes in water temperature.

Upstream migration of pink salmon occurs in July and August at a time when project induced changes in water temperatures are similar to natural temperatures. Most pink salmon spawn in tributary habitats where incubation of the embryos are not affected by mainstem temperatures during the winter months. For the few pink salmon which do spawn in side sloughs habitats, the impacts on incubating embryos will be the same as those described for chum embryos.

Outmigration of pink juveniles normally occurs in May and early June. Under Stage I operating conditions, mainstem temperatures will be up to 2-3°C less than under natural conditions. This could result in a delay in the outmigration of juvenile pink from the middle river. However, since the outmigration of pinks appears to be closely associated with breakup of the ice cover under natural conditions, the cooler temperatures may not affect the outmigration of the juveniles.

Utilization of mainstem and mainstem affected habitats by rainbow trout, Dolly Varden and Arctic grayling generally occurs from late summer through the winter months into early spring. During these periods, mainstem water temperatures are expected to be greater than natural conditions except the reaches of the river downstream from the 0°C isotherm in mid winter. In this reach, water temperatures will be the same as under natural conditions. The predominance of somewhat warmer water temperatures in the mainstem through the winter months should enhance winter survival of these populations and could result in increased winter growth assuming an adequate food supply. However, the enhancement may be offset by higher than natural turbidity levels as discussed in the following section.

No major effects to burbot populations are expected as a result of the anticipated changes in temperature and ice regimes associated with Stage I operating conditions.

- Effects of Changes in Suspended Sediment Regime (***)

Water released through the turbines at Watana Stage I will be drawn from five, vertically spaced intakes placed between elevations 1,800 and 1,980 ft MSL. In general, the uppermost and, therefore, generally, the least turbid and highest quality reservoir water will be used for power generation and consequent discharge to downstream habitats. Stage I operation flows will be increasingly larger as power production increases and new generation units come on line. Because of the relatively smaller Stage I reservoir storage volume, summer flows may be approximately 4,000 cfs greater, and winter flows about 2,000 cfs less than those originally proposed for the two stage project. Stage I operational flows will be maintained within the Case E-VI flow constraints.

A major consequence of the altered suspended sediment which will have potentially positive biological effects in all riverine habitats affected by mainstem flows will be flushing and removal of the finer sediments in the streambed. Removal of fine sediments (sand and silt) should almost always be expected to improve streambed habitat for aquatic organisms at all trophic levels. Because of greatly reduced suspended sediment loads in all project flows, re-deposition on and within streambed substrates will be substantially reduced in most riverine habitats downstream of the project. Estimated changes of suspended sediment concentrations and turbidity values during Stage I operations have been made (Table E.3.2.86.)

Few other biologically important effects different from the natural situation are expected to occur in relatively deep (greater than 1 to 2 ft.) mainstem habitats of the middle reach during the open water seasons of Stage I operations. In peripheral habitats, two potential beneficial effects of Stage I Operations will be less flooding and greater than natural flow stability. The former two effects may result in greater than natural biomass productivity at all trophic levels in predominantly clear water habitats and in very shallow turbid habitats during the open water seasons.

Incident illumination reaching stable streambed substrates may increase during the open water season, especially along the edges of the mainstem and in shallow riverine habitats peripheral to the mainstem. However, continuously high turbidity in relatively deep (greater than 1 to 2 ft.) mainstem habitats may eliminate or substantially minimize the spring and fall periphyton growth periods and the consequent fall and winter epilithon standing crops which have been observed under natural conditions.

In winter, incident light reaching stable mainstem streambed substrates will be reduced when compared to natural. An unquantifiable duration and rate of primary productivity and an unquantified epilithon standing crop which naturally occurs during the clear water, winter season in many middle river mainstem habitats may be absent or considerably reduced during the Stage I operational phase. In fall, winter and spring the invertebrate processing of epilithon and allochthonous organic materials will be affected in unknown ways by fine inorganic particulates released from the upstream project. Resultant changes at the detritivore and primary producer trophic levels will have unknown effects on rearing invertebrates and the fish utilizing these food sources. Some habitats may be affected positively and others negatively with respect to lower trophic level biomass production. The net cumulative effects may remain similar to the natural situation, but may require more than one annual cycle to stabilize.

Light to moderate "dusting" of stable substrates with fine glacial flour particulates may have a fertilization effect, particularly where incident sunlight will allow photosynthesis. Especially in relatively warm, low velocity habitats, sedimentation of rock flour particulates may stimulate profuse periphyton growth and epilithon standing crops. Analagous situations have been observed on another south central Alaskan river which is chronically turbid (Kasilof River).

Turbid mainstem discharges caused to overtop peripheral habitats containing incubating eggs and larval fish, if the organisms are not protected by relatively warm and clear, upwelling ground water, may cause detrimental effects to the developing organisms. Effects will depend, at least in part, on the organism, its life stage and the amount of rock flour deposition.

Ice related staging of cold, turbid winter discharges into peripheral habitats or any habitats used by juvenile or rearing/overwintering fish is not expected to cause direct, detrimental effects to the fish. Particulate concentrations of Stage I Operational discharges may be stressful, but are not expected to be lethal to juvenile salmonids.

Altered suspended sediment regimes during Stage I Operations are not expected to detrimentally alter access to, or use of tributaries. Clear water upwellings and clear water tributary plume habitats will likely become more important to rearing and overwintering fish in the middle river.

- Effects of Other Water Quality Changes (***)

Except for the changes in suspended sediments and turbidity, anticipated water quality changes are not expected to significantly alter habitats affected by Stage I flows in mainstem riverine habitats within the middle reach, with respect to the biotic community. High chronic turbidity will substantially restrict reservoir and mainstem riverine habitat euphotic zones thereby minimizing any detrimental effects due to project induced changes in nutirent concentrations. No bilogically detrimental oxygen concentrations are expected for either the surficial depths of the reservoir or for riverine habitats downstream. The project is not expected to cause biologically detrimental concentrations of dissolved nitrogen in either reservoir or riverine habitats downstream. Basic changes in water chemistry which are expected to be caused by the project are not expected to be detrimental to fisheries in either the reservoir or downstream aquatic habitats (see discussions of water quality in Exhibit E, Chapter 2).

(iii) Talkeetna to Cook Inlet (***)

- Effects of Altered Flow Regime (***)

Discharges in the lower river will be affected in a manner similar to that described for the middle river. However, the proportional reduction in discharge during the summer months will be less due to the influence of major tributary contributions to the lower river discharge from the Chulitna, Talkeetna and Yentna Rivers, as well as other smaller tributaries. Average monthly discharge during Stage I operation at Sunshine and Susitna Stations are presented in Exhibit E, Chapter 2, Section 4.1.3.a. A summary of the maximum, minimum and mean average monthly flows for natural and Stage I operation in 1996 and 2001 is presented in Table E.3.2.87 for the Sunshine Station and Table E.3.2.89 for the Susitna Station.

. Effects on Principal Evaluation Species/Habitat Combinations (***)

.. Juvenile Chinook Rearing Habitat (***)

The effects of the Stage I operating flow regime on chinook rearing habitats are evaluated based on the monthly average discharges at Sunshine in comparison with the habitat response curves for side channels complexes, and tributary mouth habitats presented in Section 2.3.1.b.iii. The curves presented in that section are aggregated into two curves representing side channel/side slough habitats (Figure E.3.2.83) and tributary mouth habitat (Figure E.3.2.84). The method for aggregating the individual curves is not the same as described for the middle river Representative Groups, since these curves represent the response of habitat quality in the sites and do not represent total habitat area. However, the curves may be used in a qualitative manner to evaluate anticipated changes in lower river chinook rearing habitat in side channel complexes and tributary mouths resulting from Stage I operation.

During the period June through September, chinook rearing habitat in side channels and side sloughs is expected to improve slightly over natural conditions. This is indicated by comparing the habitat quality values, estimated from Figures E.3.2.83 and E.3.2.84, at the mean average monthly flows in June, July, August and September for Stage I operation demand years (Table E.3.2.87) with the habitat quality values at the mean average monthly flows under natural conditions. The estimated habitat index values for the mean monthly discharges at the Sunshine Station are presented in Table E.3.2.89.

Habitat quality in tributary mouth habitats is expected to decrease to some extent during Stage I operation. Since considerable numbers of chinook juveniles inhabit tributary mouth habitats in the lower river, the expected reduction could be considered to be significant. However, a limitation of these curves is that the habitat qualities are a function of both mainstem and tributary discharges. Hence no values for the habitats are available when the tributary discharge is high and mainstem discharge is low. Hence, the apparent loss is not expected to be as great as that indicated in the available data.

Juvenile chinook are expected to be less susceptible to overwintering mortality because of the greater mainstem discharges in the river. The higher survival rates of overwintering chinook juveniles is expected for the same reasons described in Section 2.3.1.c.ii for middle river habitat effects.

.. Chum Spawning Habitats (**)

As discussed in Section 2.3.1.b.iii, few chum salmon spawning areas are known to exist in lower river, mainstem-affected areas, specifically in the side channel-side slough complexes. Therefore, changes attributable to Stage I operation are not expected to significantly affect chum spawning activity in habitats associated with the lower river.

. Effects of Other Evaluations Species/Habitat Combinations (**)

Altering of the lower river discharge regime as a result of Stage I operation is not expected to significantly affect other species/habitat combinations.

Discharge in the lower river will be sufficient to accommodate upstream migration of adult salmon since they are able to migrate under a wide range of flow conditions.

Since few salmon are known to spawn in lower river mainstem associated habitats, incubation of embryos will not be affected significantly. As discussed for the middle river, increased discharge in the lower river during the winter months is expected to increase the survival of those embryos which do incubate in lower river habitats.

Rearing of juvenile salmon in lower river habitats is not extensive (ADF&G 1985c and Section 2.2.1.a). Hence, rearing habitats in the lower river are not expected to be significantly affected by the altered flow regime.

As discussed in Section 2.3.1.b.iii, rainbow trout, Dolly Varden, Arctic grayling and burbot populations using lower river habitats are not expected to be adversely affected by the altered flow regime during Stage I operation.

- Effects of Altered Temperature/Ice Regimes (***)

As discussed in Section 2.3.1.c.ii, water temperature at Talkeetna is expected to be approximately the same under Stage I operating conditions as under natural conditions. The only difference anticipated is that progression of the ice front upstream during the winter months may be somewhat slower and reach Talkeetna 2-4 weeks later than under natural conditions. Therefore, no impacts, either beneficial or adverse, on salmon, other anadromous species or resident species using mainstem or mainstem associated habitats are anticipated as a result of project induced changes to the temperature and ice regimes in the lower river.

- Effects of Altered Suspended Sediment (***)

The effect of chronically turbid flows from Stage I Watana Reservoir operations on lower river habitats are expected to be similar to those effects occurring in the middle river reach. In the lower river reaches, however, dilution by additional tributary influents is expected to lessen most project induced effects (refer to previous discussions of water quality changes in Exhibit E, Chapter 2).

Below Talkeetna, waters from the middle river reach will mix with other tributary flows from the Chulitna, Talkeetna, Kashwitna, Yentna and other tributaries. Because of these dilution effects, project discharges will not demonstrably alter suspended sediment concentrations, turbidities, or riverine biology during the May through September period of open water flows in lower river habitats.

During the naturally clear water season, October through April, turbid waters flowing beyond the middle river reach will mix with clear, non-turbid water from major tributaries. The dilution from clear tributary influents will help maintain chronic winter suspended sediment concentrations within levels which may be stressful, but which are not expected to be lethal, to overwintering fish.

The effects of chronically high suspended sediment concentrations on lower trophic level biological activities in mainstem and peripheral habitats in the lower river will be similar to those described for the middle river reach (See Section 2.3.1(b)(ii). Tributaries to the lower river reach will not be impacted by Stage I operational flows.

- Effects of Other Water Quality Changes (**)

Other water quality changes resulting from Stage I operations are not expected to cause biologically important effects on mainstem, peripheral or tributary habitats in the Talkeetna to Cook Inlet reach (see previous discussions for Stage I construction and operation and discussions of water quality in Exhibit E, Chapter 2).

(iv) Cook Inlet Estuary (***)

Low suspended sediment concentrations and low turbidity are expected to enter the Cook Inlet estuary on a continuous basis due to Watana Stage I operation. No important biological effects other than mild fertilization are anticipated. Because of strong currents and high ion concentrations in the inlet, riverine borne particulates will be relatively rapidly dispersed, diluted and precipitated.

(d) Summary of Impacts Associated with Watana Dam (**)

(i) Construction Impacts (**)

The primary long-term aquatic impact related to construction of Stage I Watana Dam will be the increase in harvest pressure resulting from the increased access afforded by the project roads. In the absence of stricter harvest regulations, the increase in access near the impoundment could cause substantial alterations in resident fish population structure, with the present population of large, older grayling being replaced by younger individuals.

There will be an alteration of aquatic habitat at stream crossings but with proper construction practices as discussed in Section 2.4.3, this impact is not expected to noticeably affect fish populations. Construction activities and reservoir clearing activities will cause temporary increases in siltation and turbidity in some of the project area's clear-water streams. These impacts are not expected to extend beyond the construction period. Similarly, alterations in water quality and disturbance to fish populations are expected to impact fish only during the construction period. There will be a continuous possibility of fuel spills during the construction period when numerous construction vehicles are present in the project area. The possibility of acute spills will be reduced under operation, but the potential for spills will continue for the life of the project. Acute spills could cause locally significant impacts to fish populations, while chronic spills will affect habitat quality, particularly along roadways.

Borrow Site E, at the mouth of Tsusena Creek, will convert riparian and upland habitat into aquatic habitat. The newly-formed lake will have potential as a productive feeding and overwintering area for resident fish, but rehabilitation measures for this borrow site will not be undertaken until Stage III is completed.

(ii) Filling Impacts (**)

The primary long-term impact associated with the filling of the Watana reservoir is the loss of clear water tributary habitat. The tributary habitat that will be inundated by Stage I development currently supports a substantial population of grayling, estimated to be at least 9,140 (Table E.3.2.24). Aquatic habitats within the reservoir are not expected to support a significant grayling population (Section 2.3.1.b.i).

Between Watana Dam and Talkeetna, the primary impacts associated with filling will be a reduction in spring and summer flows, reduction in sediments, and an altered temperature regime. Mainstem and side-channel habitats will contain less turbid water and be subjected to less extreme fluctuation in water levels and flow during the summer. These changes are expected to provide more favorable fish habitat than now exists in these areas. During filling, effects on juvenile chinook rearing habitats and chum spawning habitats are not expected to be impacted by altered water temperatures, primarily because it is expected that summer river temperatures will be nearly the same as natural conditions. Similarly, no project induced effects on juvenile chinook overwintering habitats in the side sloughs or chum incubating areas is expected during the first winter. This is due to the expectation that water temperature and ice processes will be similar to natural conditions.

Slough habitats between Watana Dam and Talkeetna are expected to be the habitat type most significantly affected by filling flows. In the absence of mitigation features, filling flows are expected to cause access problems for returning adult chum and sockeye salmon. For salmon that do gain access, the spawning area within the sloughs may be reduced in area because of the lower mainstem flows (see Section 2.3.1.b.ii). If un-mitigated, these impacts would reduce the number of spawning chum and sockeye salmon in the sloughs above Talkeetna. However, with proposed mitigation measures (see Section 2.4), it is expected that these populations will be maintained.

Tributary habitats below Watana Dam and all habitats below Talkeetna are not expected to be significantly impacted during the filling of the Watana reservoir (Section 2.3.1.b.ii and iii).

(iii) Operation Impacts (**)

Operation impacts, as with filling, are divided into impacts due to the impoundment and downstream impacts.

The habitat within the Watana reservoir is not expected to support substantial fish populations (Section 2.3.1 c.i). The annual drawdown cycle will limit spawning habitat of grayling, lake trout, burbot, white fish and longnose sucker. Littoral rearing habitat is also not expected to be productive because of the drawdown cycle and summer turbidity levels and suspended sediment concentrations. Grayling are expected to reside at the mouths of the tributaries. Lake trout and Dolly Varden are expected to develop small resident reproducing populations within the reservoir. However, the population is not expected to increase sufficiently to form a significant sport fishery. Other species are expected to migrate into the reservoir from upstream habitats, primarily to overwinter, and may establish small resident populations.

Between Watana Dam and Talkeetna, the primary operational impacts will be similar to those discussed for filling: decreased summer flows, decreased flow variability and decreased sediment load. During winter, however, flows will increase over pre-project conditions and will be accompanied by increased temperature, turbidity, and suspended sediment concentrations.

More stable summer flows and decreased sediment loads and turbidity are expected to improve summer rearing habitat in mainstem and side-channel habitats. Eventually, mainstem and side-channel spawning habitats are expected to become available as the project flows remove accumulated sand and silt deposits and maintain the upper level of the substrate in clean condition (Section 2.3.1(c)(ii).

Case E-VI flow constraints, implemented during Watana Stage I filling, will be followed. These constraints plus the mitigation measures already implemented during Watana - Stage I construction are expected to maintain the number of chum and sockeye salmon spawning in the sloughs upstream from Talkeetna. The worst case scenario would be total loss of slough spawning habitat in this reach, with a reduction in the total run size.

The increase in winter flow is expected to increase overwintering habitat and will benefit resident and rearing anadromous species. The reduction of flow variability, peak flows, turbidity, and sediment load in the mainstem during summer combined with increased winter flow may lead to increases in the populations of some resident species such as rainbow trout and Dolly Varden; and rearing anadromous species such as chinook and coho salmon. The amount of increase, if any, will depend on the extent to which these physical factors presently limit the populations.

The increased winter temperatures may increase embryo development in mainstem and side-channel spawning habitats and lead to early emergence of alevins. These early emerging fry may experience increased mortality if they move downstream and encounter 0°C (32°F) water below Talkeetna. This impact will likely affect relatively few fish, primarily pink salmon, since only a small portion of the salmon spawning upstream from Talkeetna utilize mainstem and side-channel spawning habitats. Other salmon species using these habitats exhibit behavior patterns that reduce their vulnerability to these impacts (Section 2.3.1.c.ii). Impacts are not expected in tributary habitats upstream from Talkeetna.

Downstream from Talkeetna the main impact will be an increase in overwintering habitat in the mainstem and side channels because of the increased winter flows (Section 2.3.1.c.iii). No significant adverse impacts are expected.

2.3.2 - Anticipated Impacts to Aquatic Habitat Associated with Stage II Watana/Devil Canyon Dam (***)

Stage II of the Susitna Hydroelectric Project consists of the construction of the Devil Canyon Dam to supplement the power generation capacity of the Stage I Watana Dam. In general, the construction and operation of the Devil Canyon Dam will be as described in the original License Application (APA 1983b). The principal differences between the Stage II configuration and the original configuration will be that the Watana Reservoir will have a maximum normal operational water surface elevation of 2,000 feet MSL rather than 2,185 feet MSL, the live storage will be reduced from 3.7 to 2.4 million acre-feet, and the flow regime during construction and operation of Stage II will operate under the Case E-VI flow constraints rather than the Case C scenario described in the original License Application. This section addresses additional impacts on the aquatic resources attributable to the development of the Devil Canyon Dam, assuming the Stage I Watana Dam is operating.

(a) Construction of Devil Canyon Dam (Stage II) and Related Facilities (*)

(i) Devil Canyon Dam (Stage II) (*)

Devil Canyon Dam will be located at RM 152 of the Susitna River, approximately 32 miles (53 km) downstream from the Watana damsite. A thin arch concrete dam will be built near the downstream end of Devil Canyon and an earth/rockfill saddle dam will be constructed at the south end of the arch dam to provide closure of a low area on the south abutment. The reservoir behind Devil Canyon will cover 7,800 acres (3,120 ha) and will be about 26 miles (42 km) long (32 miles along the river before impounding) and not more than 0.5 mile (0.8 km) wide.

The concrete dam and foundation will be 646 feet (195 m) high and will have a crest length of 1,650 feet (503 m). An estimated 1.7 million cubic yards (1,300,000 m^3) of concrete will be needed to construct the arch dam. The saddle dam will be 950 feet (287 m) across and 245 feet (75 m) high and will require about 2 million cubic yards of material.

As with Watana, Devil Canyon Dam will have an underground powerhouse, intake structure, outlet works, and main spillway. A 38-foot (11.7-m) diameter tailrace tunnel will convey the turbine discharge approximately 1.3 miles (2.2 km) downstream from the arch dam.

During construction of the dam, the river will be blocked above and below the construction site by cofferdams. The flow will be diverted into a 35.5-foot (10.8 m) diameter horseshoe tunnel, 1,490 feet (451 m) long, and discharged back into the river channel. The upstream and downstream cofferdams will be about 400 feet (120 m) long and 200 to 400 feet (60 to 120 m) wide.

The adverse impacts upon aquatic habitat at the Devil Canyon damsite are expected to be similar to those at the Watana site but of lesser magnitude.

At the Devil Canyon damsite, the Susitna River is confined to a canyon approximately 600 feet (180 m) deep and 200 to 400 feet (60 to 120 m) wide at river level. The river bottom is primarily composed of cobbles, boulders, and blocks of rock; the water is extremely turbulent. Few fish live in the area of the damsite (ADF&G 1981f). Some chinook salmon migrate upstream past the Devil Canyon damsite(ADF&G 1983a, 1984h, 1985b)

- Alteration of Waterbodies (*)

  Impacts from Devil Canyon Dam construction will be primarily restricted to the vicinity of the damsite. A 1,100-foot (333-m) section of the Susitna River between the cofferdams will be dewatered for 7 years during construction. Although a small population of Dolly Varden, sculpin, and other resident species inhabit that stretch of river, it is not expected that dewatering will have more than a minor impact upon availability of suitable aquatic habitat. The dam foundation will cover about 90 feet (27 m) of river bottom. This is considered to be a minor impact.

During construction, water velocities within the diversion tunnels will be sufficintly high to prevent the upstream migration of chinook salmon. The Devil Canyon Dam will be a permanent, total migration barrier upon its completion.

The greatest impacts during construction of the dam are likely to be associated with gravel mining and processing in Borrow Site G. Gravel for filter material and for concrete aggregate will be removed from the Susitna River and from Cheechako Creek alluvial areas upstream from the damsite (Borrow Site G). The effects of gravel mining on aquatic systems have been discussed under Section 2.3.1.a. Since the material removal sites will be inundated, impacts at the sites will be transitory.

- Changes in Water Quality (o)

Potential impacts to water quality would primarily be caused by increases of turbidity due to erosion and through discharge of effluent from the concrete batching process. To minimize water quality impacts, all processing waters will be treated before being discharged to the Susitna River. Turbidity increases in the Susitna River are expected to be negligible. See Section 2.3.1.a for discussion.

- Disturbance of Fish Populations (o)

Instream activities during material extraction near Cheechako Creek could disrupt fish movements, spawning, and rearing in the creek, depending upon location, type and duration of activities. It is unlikely that the damsite itself is located in a stretch of the Susitna regularly inhabited by fish; therefore, the excavation and blasting required at the damsite would not be disruptive to fish populations.

(ii) Construction and Operation of Devil Canyon Camp and Village (*)

During construction of Devil Canyon Dam, housing will be constructed for approximately 1,900 persons (Exhibit A, Section 6.13). The construction camp and construction village will be located between 1.7 and 3.4 miles (2.8 and 5.6 km) southwest of the damsite. The camp will include bachelor dormitories, cafeteria, warehouses, offices, hospital, and recreational buildings. The village will contain housing for 160 families and will include a school, stores, and a recreation area.

The camp will be approximately 0.5 mile (0.8 km) from the village. Both developments will be more than 700 feet (210 m) above the Susitna River and more than 4000 feet (1,200 m) from the edge of the canyon. Water, sewage, and solid waste disposal facilities will be shared by both developments. Water will be withdrawn from the Susitna River and effluent from a secondary treatment system discharged into the river below the water intake. The upper reaches of Jack Long Creek border the camp and the village to the south, coming to within 200 feet (60 m) of the camp. A small unnamed creek drains a series of lakes 3,000 feet (900 m) to the east of the camp and enters the Susitna at RM 150. The creek is paralleled by the sewage outfall line for 1,000 feet (300 m) or about 20 percent of its length.

Both the camps and the village are temporary developments to be removed when Devil Canyon construction is completed. Permanent personnel responsible for operations of the Devil Canyon dam will live at the Watana permanent town. No airstrip will be built; air access will be via the permanent runway at Watana.

The unnamed creek and lakes may support grayling, Dolly Varden, or sculpin, while Jack Long Creek contains pink, chinook, chum, and coho salmon. Portage Creek contains chum, pink, chinook, and coho salmon, rainbow trout, round whitefish, and humpback whitefish. Chinook salmon, grayling, and Dolly Varden are found in the lower reaches of Cheechako Creek (ADF&G 1983a, 1983b, 1984a, 1984b, 1985a). Temporary impacts resulting from camp/village operations are expected to be limited to the area within a few miles of the damsite.

Alteration of Waterbodies (*)

No water bodies are expected to be altered as a result of Devil Canyon camp construction other than those resulting from gravel mining within the Susitna River floodplain at Borrow Site G. Since this borrow site will eventually be inundated, no permanent effects from gravel mining will occur. Camp construction is not anticipated to affect Jack Long Creek or the unnamed stream.

- Changes in Water Quality (*)

Erosion into the Susitna River from gravel mining at the mouth of Cheechako Creek is not expected to result in adverse impacts to fish. Because of its proximity to the developments, Jack Long Creek could receive uncontrolled runoff from the camp area; however, required drainage facilities and retention ponds should prevent this impact and no increase in sediment levels in Jack Long Creek are expected.

Water for camp use will be withdrawn from the Susitna River, and treated effluent will be returned to the river. The treated effluent will not affect the waste assimilative capacity of the Susitna and is expected to have no significant effect on the aquatic environment (Exhibit E, Chapter 2, Section 4.2.1(g)(i)). Storm drainage and oily water runoff from the construction camp will be collected and treated as noted above.

The fuel storage area is located on the south side of the construction camp about 200 feet (60 m) above Jack Long Creek. Accidental fuel spills are not expected to reach the creek since storage facilities will be designed to contain more than the maximum storable volume. It is not expected that runoff from the solid waste disposal site and the construction village will adversely affect any waterbodies since both will be collected and treated the same as the runoff from the camp area.

- Direct Construction Activity (*)

The camp and village at the Devil Canyon site will house approximately 1,900 workers for several years (Exhibit A, Section 6.13). As a result, streams and lakes in the vicinity may be subjected to increased fishing pressure. This area has not been heavily utilized for sport fishing in the past.

The waterbodies most likely to be affected include Cheechako Creek, unnamed creeks and lakes in the vicinity, Jack Long Creek, and to a lesser extent, the Susitna River and Portage Creek. With the exception of Portage Creek, these waterbodies are within walking distance of the camp/village and the damsite. Portage Creek enters the Susitna River from the north about 2.5 miles (4.1 km) downstream from the dam location.

(b) Filling Devil Canyon Reservoir (*)

Filling Devil Canyon reservoir would inundate approximately 32 miles (52 km) of Susitna River mainstem habitat and 6.2 miles (10 km) of tributary habitats. These habitats would be converted from lotic to lentic systems with accompanying changes in hydraulic characteristics, substrate, turbidity, suspended sediment concentrations, temperature, and nutrient levels (Exhibit E, Chapter 2, Section 4.2.2).

The filling of the Devil Canyon reservoir will be done in two stages. Upon completion of the dam to a height sufficient to allow ponding above the low level outlet facilities, the water level will be raised to an elevation above 1,050 feet (315 m) but not exceeding 1,135 feet (343 m). This filling will be accomplished in approximately 4 weeks. As soon as the power facilities and main spillway are completed (approximately two years), the reservoir will be raised to 1,455 feet (440 m), the normal operation elevation as explained in Exhibit E, Chapter 2, Section 4.2.2.(b). During filling of Devil Canyon, discharge from the project will be maintained within the Case E-VI flow constraints defined in Table E.3.2.59.

(i) Effects in Impoundment Area (*)

Closure of the Devil Canyon Dam and filling of the reservoir will result in the inundation of approximately 32 miles of the Susitna River and a total of approximately six miles of the lower reaches of the five named tributaries (Figure E.3.2.85). The lower reaches of several unnamed tributaries will also be inundated, but the lengths of these tributaries have not been determined. The only presently existing lake to be affected by the Project will be a shallow, five-acre pond at the damsite, which will be filled by the saddle dam associated with the main, concrete arch Devil Canyon Dam. The reach of the Susitna River within the Devil Canyon Reservoir presently supports small populations of Arctic grayling, burbot, longnose sucker, whitefish and Dolly Varden (ADF&G 1981f, 1983b). In addition, a small population (25-75) of chinook salmon spawn in tributaries within the impoundment zone. Impacts on mainstem, tributary and lake habitats will be similar to those described for Stage I Watana Reservoir. Due to the short period of time necessary to fill Devil Canyon Reservoir, the effects of the reservoir are more appropriately and completely described in Section 2.3.2.c.i.

(ii) Devil Canyon to Talkeenta Reach (***)

- Effects of Altered Flow Regime (***)

During the filling of Devil Canyon Reservoir, discharge from the dam to the middle Susitna River will be maintained within the Case E-VI flow constraints. The effects of the altered flow regime during filling are discussed as part of the initial Stage II operation . The effects on middle river aquatic habitats, therefore, are discussed in Section 2.3.2.c.ii. During the period the water level is being held constant at el. 1,135 the effects will be the same as for Watana Stage I operation (discussed in Section 2.3.1) since discharge will be regulated only at Watana.

- Effects of Altered Temperature/Ice Regimes (***)

As with the discussion of the effects of the altered flow regime during filling of Devil Canyon Reservoir, discussion of the effects of the anticipated altered temperature and ice regimes during filling of the Devil Canyon Reservoir are more appropriately discussed under Stage II operation effects. Changes in temperature regimes during filling will occur for 4-6 weeks in October and November of the year 2004 and, hence, any changes associated only with Devil Canyon filling will be of a short duration and will occur at a time when fish utilization of mainstem and mainstem associated habitats is not likely to be extensively affected. Also, since filling of Devil Canyon Reservoir will occur prior to the onset of winter conditions, filling of Devil Canyon will not affect ice processes in the river. Ice processes, however, will be affected by operation of Stage II as discussed in Section 2.3.2(c)(ii). During the period when the water level is being held constant at el. 1,135, the river temperature and ice conditions are expected to be similar to those discussed for Watana Stage I in Section 2.3.1, since the storage volume in Devil Canyon will be very small (see Section 4.2.2(d)).

- Effects of Altered Sediment Regime (**)

Effects of filling will be relatively short lived in relation to the projects life time and most effects are more appropriately discussed under the topic of Stage II Operations (Section 2.3.2.c.ii). In general, downstream water discharges during Devil Canyon filling will have a higher TSS and turbidity loads than that expected during Stage I operations. The altered sediment regime associated with filling Devil Canyon Reservoir will be detectable within the middle river reach, but the levels of TSS and turbidity will likely be less than or well within the ranges of values for these same parameters which have been observed under natural conditions. Effects at the aquatic biological community level are expected to be minimal. During the period when the water level is being held constant at el. 1,135, the suspended sediment and turbidity are expected to be similar to Watana Stage I operation, as discussed in Section 2.3.1.

- Effects of Other Water Quality Changes (**)

Effects of any additional water quality changes resulting from filling will be relatively short lived in relation to the project's life time, and are more appropriately discussed under the topic of Stage II Operations (Section 2.3.2.c.ii). Dissolved and particulate organic materials of allochthonous origin are expected to increase in concentration during the short filling period, but the long term effects associated with these increased organics are expected to be minimal at the level of the aquatic biological community.

(iii) Talkeetna to Cook Inlet (***)

- Effects of Altered Flow Regime (***)

As discussed in Section 2.3.2.b.ii, discharge from the Devil Canyon Dam during filling of the reservoir will be maintained within the Case E-VI flow constraints and will be similar to operation of the project given the energy demands at the time filling occurs. Therefore, the effects of the altered flow regime during filling of Devil Canyon Reservoir on habitat in the lower river are more appropriately discussed under project operation (Section 2.3.2.c.iii). During the periods the water level is being held constant at el. 1,135, the effects on streamflow would be similar to Stage I Watana operation discussed in Section 2.3.1.

- Effects of Altered Temperature/Ice Regimes (***)

As with the discussion of the impacts of the altered flow regime during filling of Devil Canyon Reservoir on aquatic habitats in the lower river, the effects of altered temperature and ice regimes are more appropriately discussed in Section 2.3.2.c.iii. During the period the water level is being held constant at el. 1,135, the effect on temperature and ice would be similar to Stage I Watana operation discussed in Section 2.3.1.

- Effects of Altered Suspended Sediment Regime (***)

Effects of filling will be short lived and are more appropriately discussed under the topic of Stage II Operations (Section 2.3.2.c.ii). During the period the water level is being held constant at el. 1,135 the effects on suspended sediment would be similar to Stage I Watana operation discussed in Section 2.3.1.

In general, open water season levels of suspended sediment and turbidity may be higher than those expected during Stage I or Stage II Operations. However, during the open water season, the influence of Stage II filling on the suspended sediment regime in the lower river is expected to be negligable due to dilution by other tributaries with high and naturally variable sediment regimes. Effects at the aquatic biological community level are expected to be negligible.

- Effects of Changes in Other Water Quality Factors (**)

Effects of any additional water quality changes resulting from Stage II filling are expected to be both short lived, with respect to the project's lifetime, and relatively negligible with regard to the aquatic biological community.

Dissolved and particulate organic materials of allochthonous origin are expected to increase substantially in concentration during the short filling period, both within and downstream of the reservoir. Long term effects to the aquatic biological community due to these increases in dissolved and particulate organic materials are expected to be negligible.

(iv) Estuary at Cook Inlet (***)

Effects of filling on the estuary are expected to be temporary and are more appropriately discussed under project operation (Section 2.3.2.c.iv).

(c) Effects of Operation of Stage II Watana/Devil Canyon Dam (**)

As stated previously, the Devil Canyon Reservoir will inundate approximately 35 miles of mainstem habitat and approximately 6 miles of the lower reaches of five named tributaries.

The Devil Canyon Reservoir water surface elevation will remain stable at near maximum operating levels most of the time. No drawdown of the Devil Canyon Reservoir is anticipated during wet years. A drawdown of approximately 20 feet may occur in median flow years during July, with refilling occurring in August (Figure E.3.2.86). A drawdown of approximately 50 ft is anticipated for dry years. During Stage II operation, Watana Reservoir will be drawn down in a manner similar to that described for Stage I operation. The expected drawdown cycle for Watana Reservoir during the operation of Stage II is depicted in Figure E.3.2.87. The lengths of tributaries to the Devil Canyon Reservoir within the drawdown zone are provided in Table E.3.2.90.

Suspended sediments transported to the Devil Canyon Reservoir generally consist of particles less than 5 to 10 microns in diameter (Exhibit E, Chapter 2, Section 4.2.3(c)(iii)). Larger particles will be trapped in the

Watana Reservoir. Sediments will also be introduced into the flow from the tributaries during floods and erosion of reservoir shorelines. Some of the particles will settle in the Devil Canyon Reservoir, but the majority will pass through, contributing to turbidity in the reservoir and in waters released downstream. Small deltas will likely form at the mouths of the tributaries. However, these are not expected to significantly alter fish habitats.

Temperature regimes in Devil Canyon Reservoir will be highly dependent upon the temperature of the water released from Watana Reservoir. The Devil Canyon Reservoir will stratify during June and July each year as warmer water from Watana enters the reservoir and remains at the surface. Maximum outflow temperatures will range between 8 and 10°C (Exhibit E, Chapter 2, Section 4.2.3(c)(i)). In July and August in most years, the outlet works in Devil Canyon Dam will be operated to release water in excess of that required for generation. This excess water will result because the Watana and Devil Canyon Reservoirs will have reached full storage capacity. Once the outlet works are operating, the cold, turbid, deeper water (4°C) will be evacuated from the reservoir and replaced by warmer Watana water (Exhibit E, Chapter 2, Section 4.2.3(c)(i)). In some years the reservoir will become uniformly mixed at about 8-10°C by mid-August and will remain relatively warm through September. The reservoir will then cool until it becomes isothermal at 4°C in October. After that time, the surface water will cool to 0°C and an ice cover will form. In general, the seasonal temperature regime in Devil Canyon Reservoir will closely follow that of Watana.

(i) <u>Effects of Operating Devil Canyon Reservoir</u> (**)

- <u>Effects on Mainstem Habitats</u> (**)

The mainstem habitats within the Devil Canyon Reservoir presently support small populations of burbot and longnose suckers throughout the year. Arctic grayling, whitefish and Dolly Varden populations use the mainstem for overwintering (ADF&G 1981f, 1983b).

The stable water level in Devil Canyon for most of the year will help create more favorable spawning conditions for most fish species. Arctic grayling, lake trout, burbot, whitefish and longnose sucker spawning is expected to be unaffected by the drawdown cycle. Dolly Varden eggs that are deposited in the draw down zone of reservoir tributaries during September and October may experience a higher mortality than those deposited above the draw down zone. The impact to Dolly Varden populations in the reservoir is expected to be minor.

Productivity in the Devil Canyon reservoir is expected to be low because of the turbidity levels--the expected turbidity in Devil Canyon is described in Exhibit E, Chapter 2, Section 4.2.3(c)(iii)--but should be greater than the productivity in the Watana reservoir because of the less extreme draw-down cycle. It is expected that the Devil Canyon reservoir will develop limited resident populations of Dolly Varden, burbot, whitefish and other species. Arctic grayling will occur in and at the mouths of clear-water tributaries.

- Effects on Tributary Habitats (**)

As with the tributaries that flow into the Watana impoundment, the lengths of the tributaries to be affected by the Devil Canyon impoundment will vary according to their gradients and location within the impoundment. The locations of the tributaries, the stream gradients and lengths of affected reaches are summarized in Table E.3.2.91.

Effects on tributaries and associated fish are also expected to be similar to those presented for the Watana Reservoir. Most of the tributaries in the Devil Canyon impoundment area are characterized by steep slopes with occasional barriers, such as waterfalls. Cheechako, Devil and Tsusena Creeks, three tributaries entering the Devil Canyon impoundment, all contain waterfalls. These falls will not be inundated by the impoundment and would still function as barriers to fish passage. Species presently using tributary habitats include Dolly Varden, Arctic grayling and whitefish.

The loss of clear-water tributary habitat in Tsusena and Fog Creeks will eliminate habitat utilized by approximately 1200 grayling longer than 8 inches (20 cm) (Table E.3.2.24). However, because the water surface elevation in Devil Canyon Reservoir will remain relatively constant during the Arctic grayling spawning and incubation period, the effects of reservoir filling and operation on

Arctic grayling are expected to be less severe than those anticipated in the Watana Reservoir.

As discussed in Section 2.3.1.c.ii, a small population (25-75) of chinook salmon presently use habitats near the mouths of four tributaries for spawning. This utilization is expected to increase to some extent during the period between initial operation of Stage I and closure of the Devil Canyon Dam. Diversion of the Susitna River for construction of the Devil Canyon Dam will eliminate salmon population use of the areas within the Devil Canyon Impoundment Zone.

(ii) Devil Canyon to Talkeetna (**)

- Effects of Altered Flow Regime (**)

Operation of Stage II will begin after completion of the Devil Canyon Dam and filling of the reservoir. The completion of the Devil Canyon Dam is scheduled for the year 2005 with initial operation beginning in late 2005. Discharge from the Devil Canyon Dam will be influenced by the discharge from Watana Dam. The annual discharge regime and changes to the discharge regime between Stage I and Stage II are, therefore, limited by the storage capacity in the Stage I - Watana Reservoir.

During the Stage II operation period, the system demand for energy is expected to grow from approximately 4,800 GWH annually to approximately 5,500 GWH annually. Growth with corresponding average annual energy production from the Stage II project is expected to be from approximately 4,200 GWH annually to 4,560 GWH annually. To represent the Stage II flow regime, discharges at Gold Creek associated with system energy demand of approximately 5,270 GWH and an average annual energy production of approximately 4,440 GWH were used for the habitat analysis. Average weekly discharges at Gold Creek for the 34 years of record to meet this energy demands and average energy production are presented in Exhibit E, Chapter 2 Section 4.2.3.a. Maximum, minimum and mean monthly average discharges at Gold Creek associated with this production are summarized in Table E.3.2.91 along with the same values for natural conditions. Comparison of the mean monthly average flows at

Gold Creek during Stage I operation (Table E.3.2.73) with those during Stage II operation (Table E.3.2.91) indicates that little difference in the discharge regime is expected between the two stages.

. Effects on Principal Evaluation Species/Habitat Combinations (**)

.. Chinook Rearing Habitats (**)

Chinook rearing habitat areas associated with Stage II operation flows were analyzed in the manner described for the Stage I flow regimes. Total chinook rearing habitat areas were derived for the average weekly flows under Stage II project operation and from the total chinook rearing habitat area response curve presented in Figure E.3.2.64 and Table E.3.2.46. Probabilities of exceedance values were calculated for the 90, 50, and 10 percent exceedance levels and are presented in Table E.3.2.93 and in Figure E.3.2.88 . Also presented are the habitat values for the natural flow regime. Comparisons of these values with the probability of exceedance values for Stage I (Figure E.3.2.75), which indicate that little change in the rearing habitat area associated with the Stage II discharge regime is expected.

Total chinook rearing habitat areas during the early summer weeks under the Stage II flow regime are expected to be slightly less than under the natural flow regime (Table E.3.2.49). By mid-summer (after Calendar Week 27), the ranges of habitat areas available in each week will be nearly the same as under the natural flow regime as depicted in Figure E.3.2.88. Under natural conditions, juvenile chinook become prevalent in mainstem affected areas after the early part of July, beginning in Calendar Week 26, (See Figure E.3.2.37). The apparent reduction in total suitable habitat area available in June under the Stage II flows occurs when few chinook juveniles are expected to be present in the mainstem affected areas and, the apparent loss of available habitat is not expected to affect the juvenile populations. As observed for the Stage I flows, variation in the amount of habitat available from week to week and year to year would be less during Stage II operation than under the natural flow regime.

The median chinook rearing habitat in Representative Groups 2, 3, and 4, however, is expected to be greater under the Stage II operational flow regime than under the natural regime. Median (50 percent), 90 and 10 percent exceedance values of habitat area in the three groups under Stage II flow conditions are presented in Table E.3.2.93, together with the habitat areas estimated for the natural flow regime. These are depicted graphically in Figure E.3.2.89. The range of available habitat areas is somewhat less during the early part of the summer, corresponding to the filling period for Watana Reservoir. Later in the summer, once the Watana Reservoir is filled, the median and range of habitat area is nearly the same as under natural conditions.

During the winter months, the probability that juvenile chinook survive through the winter is expected to increase from the Stage I flow regime. Although discharges during the winter months in Stage II will be similar to those in Stage I, the ice front is not expected to progress as far upstream (see discussion of Effects of Altered Temperature/Ice Regime presented below). Thus, some additional habitat sites which may be used by juvenile chinook for overwintering will not be subjected to overtopping due to staging of the water surface. Hence, juveniles inhabiting the sites will not be subjected to 0°C, high velocity water. Also, staging in the ice-covered reach is expected to be less than during Stage I operation with the result that sites in the ice covered reach will not be as likely to overtop or if they do overtop, the volume of water diverted through the site will be less. A more complete discussion of the ice processes during Stage II is presented in Exhibit E, Chapter 2, Section 4.2.3. The effects of ice processes on juvenile chinook are discussed in more detail in Section 2.3.1.c.ii, Effects of Altered Temperature/Ice Regime.

.. Chum Spawning Habitats (**)

Additional changes from those expected during Stage I operation in factors affecting chum spawning habitats are not expected to occur as a result of the transition from Stage I to Stage II operating flow regimes. As discussed previously, little change in the discharge regime is expected in the transition from Stage I to Stage II (Table E.3.2.91). Hence, conditions for chum access into spawning habitats will be similar to that described for Stage I. A summary of access conditions at passage reaches affected by mainstem discharge during Stage II operation is presented in Table E.3.2.94. Access conditions at natural discharges during August and September are also presented in the table for comparison.

Total chum spawning habitat areas for average weekly discharges in August and September were calculated using the 34 years of average weekly discharges anticipated under Stage II operation. Translation to total spawning habitat areas were based on the habitat area response curve for the modeled chum spawning sites presented in Table E.3.2.47 and Figure E.3.2.59. Probable habitat areas exceeded 90, 50 and 10 percent of the time were calculated for each week in August and September. These values are presented for the Stage II flow regime in Table E.3.2.95 and are depicted graphically in Figures E.3.2.90. Comparison of these habitat areas with those presented for total chum spawning habitat areas during Stage I (Figure E.3.2.77) demonstrates that the total habitat areas available during the spawning period in those sites traditionally used by chum under the natural flow regime will be somewhat less during Stage II than during Stage I operation. The available spawning habitat will be nearly the same as that observed under natural flow conditions (presented in Table E.3.2.95). In addition, the week to week and year to year variation in chum spawning habitat during Stage II will be nearly identical to that observed for the natural flow regime. This is due to the fact that the Watana Reservoir is expected to be refilled by the first part of August each year with subsequent average weekly discharges approaching natural flows.

Analysis of the chum spawning habitat availability in Representative Groups 2, 3 and 4 during Stage II operation yields similar results. Spawning habitat areas derived using the aggregate Representative Group habitat response curve presented in Table E.3.2.48 and Figure E.3.2.63 are presented in Table E.3.2.96 and are depicted in Figure E.3.2.91. The median habitat areas expected to be available in Representative Groups 2, 3 and 4 during Stage II operation are nearly the same as those expected during Stage I operation. As with the previous analysis of chum spawning habitat in modeled sites, the week to week and year to year variation in the availability of spawning habitat will be greater during Stage II than during Stage I operation and will approach that variation observed under the natural flow regime.

Survival of chum salmon embryos during the incubation period is expected to be similar to that expected under Stage I. This is indicated by the habitat area values for suitable spawning habitat in the modeled chum spawning sites during the October and November period presented in Table E.3.2.97 in comparison with the values for Stage I operation presented in Table E.3.2.79. Habitat areas in the modeled sites for the natural flow regime are also presented in Table E.3.2.97 for comparison. Habitat areas for the Stage II flow regime, presented in Table E.3.2.97, are depicted graphically in Figure E.3.2.92 . During Stage II operation, essentially no variation is evident in the chum spawning habitat area available for incubation of the embryos during October and November. This is due principally to the ability of the Stage II operation to consistently meet the energy needs of the system.

Similar results are obtained using the habitat area response curve for chum spawning habitat area in Representative Groups 2, 3 and 4 (Table E.3.2.48). The 90, 50 and 10 percent equalled or exceeded habitat areas included in the three representative groups for the Stage II flow regime are presented in Table E.3.2.98 and are depicted graphically in Figure E.3.2.93.

Some increase in the survival of chum embryos in some sites is expected as a result of changes in the ice processes associated with Stage II operation compared with Stage I operation (Exhibit E, Chapter 2 Section 4.2.3). Since the ice cover is not expected to extend as far upstream during Stage II as expected during Stage I, some spawning areas that were subject to overtopping as a result of staging, will be less likely to overtop under Stage II. Also, sites located in the reach expected to become ice covered will be less likely to overtop because staging is expected to be less than during Stage I.

. <u>Effects on Other Evaluation Species/Habitat Combinations</u> (***)

Because the discharge regime during Stage II is expected to be nearly the same as that described for Stage I, no additional effects due to altered flow regime to other evaluation species/habitat combinations are expected. Hence, the changes to habitats described for Stage I will be maintained through Stage II. The prolongation of habitat conditions associated with Stage I is expected to benefit the various species/habitat combinations by providing long term habitat stability.

\- <u>Effects of Altered Temperature/Ice Regimes</u> (***)

Differences between water temperatures under natural conditions and under project operation conditions are more pronounced during Stage II operation than under Stage I operation at all locations within the middle Susitna River. These differences are depicted in Figures E.3.2.94, E.3.2.95 and E.3.2.96 for RM 150, 130 and 100, respectively.

The regimes depicted in these figures represent the expected temperatures assuming discharges expected During Stage II operation. The estimated temperatures also assume climate and flow conditions recorded during 1981 and 1982. The expected temperatures at other locations in the middle river through the summer using the same climate, flow and demand assumptions are presented in Tables E.3.2.99 and E.3.2.100 for 1981 and 1982 respectively. Because river temperatures expected under Stage I operations are nearly the same as natural conditions, the temperature changes induced by Stage II operation represent the major project induced changes in summer temperatures which could affect the utilization of aquatic habitats by various fish species. At RM 150, near the mouth of Portage Creek, summer water temperatures are expected to be 2° to 6° cooler than under natural or Stage I operating conditions from May through July. In August, with-project temperatures are similar to natural. From September through mid-November, water temperatures will decline but at a much slower rate than under natural or Stage I conditions. Thus, temperatures are expected to be 2°-6°C warmer. During the period November through March, water temperatures are expected to be between 1° and 2°C with no ice forming in the upper end of the middle river.

At RM 130, cool water temperatures are maintained from May through July. Differences between natural and Stage II operation range from 2-4°C cooler. After October, water temperatures are 2° to 4° warmer. Through the winter, water temperatures are expected to be less than 1°C most of the time with occasional periods of -0°C water in the mainstem. During Stage II operation, an ice cover may occasionally form at RM 130 as depicted in the ice simulation presented in Figure E.3.2.97.

At RM 100, near the confluence of the Chulitna River with the Susitna River, water temperatures are expected to be 2-3°C cooler during Stage II than natural temperatures for the May-July. After mid-September, water temperature is expected to be 2-5°C warmer until mid- to late November (See Figure E.3.2.96). Ice cover is expected to form in the lower portions of the middle river in late December and will remain in the area until late March, at which time the ice cover will melt out (See Figure E.3.2.97). From the end of March until the beginning of May, water temperatures are likely to be 1-2°C warmer than under natural conditions. As with the other locations in the middle reach and as under Stage I conditions, the seasonal temperature pattern is expected to be shifted about one month later in the season than under natural conditions. This is due principally to the large time required for Watana reservoir to gain and lose heat relative to the natural stream, which is shallower and better mixed than the large reservoir.

- Effects on Principal Evaluation Species/Habitat Combinations (***)

  - Juvenile Chinook Rearing Habitats (***)

    During operation of Stage II of the Susitna Hydroelectric Project, water temperatures during May to July are expected to be 2-6°C cooler than under natural conditions. These cooler temperatures could affect juvenile chinook rearing by retarding the growth rates of those fish occupying mainstem associated habitats such as side channels. However, based upon size data collected in tributary habitats, juvenile chinook which remain in the tributaries generally grow to somewhat larger sizes than those occupying side channel and mainstem habitats (See Table E.3.2.10). Water temperatures in tributary habitats are generally 2-4°C cooler than mainstem temperatures between May and July, similar or slightly cooler than mainstem temperatures in August, and slightly warmer than mainstem tempertures in September and October (Exhibit E, Chapter 2, Section 2.3.1(c). Brett (1952) suggested that although most rapid growth of juvenile sockeye fed to satiation occurs at approximately 15°C, juvenile growth efficiency (i.e. conversion of food biomass to fish biomass) is probably greater at some lower temperature. The observed difference in growth between juveniles in tributary and juveniles in mainstem habitats could be accounted for through higher growth efficiency or more food available. Water temperatures in side channel rearing habitats are expected to be more similar to tributary water temperatures and, therefore, juvenile chinook incremental growth could approach that observed for juveniles in the tributaries. Specific growth rate for a population is highly dependant upon ration (food available), the temperature regime to which they are exposed and inherent physiological adaptations. Hence, statements regarding the effects of temperature on juvenile chinook cannot be conclusive. Based on temperature tolerance curves developed by AEIDC (1984b), water temperatures are expected to be within tolerance ranges through the summer (Figure E.3.2.98).

During winter months, juvenile chinook generally move into side slough habitats to overwinter. In the upper reaches of the middle Susitna mainstem and side channel habitats will remain at 1-3°C throughout the winter, similar to water temperatures in unbreached side sloughs under natural conditions. Therefore, the warmer water released from the Devil Canyon Dam is expected to increase the total habitat area with water temperatures in a more amenable range for survival through the winter months. Downstream from the action of the ice front, side slough habitats will be the only areas likely retaining water temperatures greater than 0°C. However, because of the staging associated with ice cover formation, many of the sloughs may be breached as depicted in Table E.3.2.101. Survival of juvenile chinook could be reduced in side sloughs which are breached and convey 0°C mainstem water.

Outmigration of juvenile chinook from tributaries into mainstem areas and ultimately out of the middle river would not be to significantly impacted by the cooler temperature. Some delay in outmigration from the middle river due to the lower mainstem temperature may occur (AEIDC 1984a). However, the delay is not expected to be sufficient to lead to excessive mortality of juvenile chinook in the lower river or in the marine environment.

.. Effects on Chum Spawning/Incubation Habitats (***)

Upstream migration of adult chum salmon into the middle river generally occurs between late July and late August. During this period, water temperatures are generally expected to be within the natural range of temperatures. During the early part of the migration season, however, somewhat cooler temperature may retard the rate of upstream migration to some extent. Because chum salmon tend to remain in mainstem areas for sometime prior to moving into spawning habitats, this retardation is not expected to adversely affect spawning activity. Once chum salmon move into side slough habitats to spawn (i.e. Representative Groups 2 and 3), water temperatures are expected to be similar to temperatures encountered prior to construction and operation of the reservoirs. It is likely that a key factor in chum salmon selection of spawning sites is the temperature difference between the surface water temperature and the temperature of the water in upwelling areas. Since groundwater upwelling temperatures average from 2°C to 4°C, temperature differences will still be detectable and, therefore, spawning activities are not expected to be adversely affected.

Incubation of chum embryos in side sloughs is not expected to be adversely affected by mainstem temperatures unless the spawning area is breached as a result of staging associated with the ice cover. Breaching of spawning areas due to ice cover formation is expected at most sites downstream from the location of the ice front. The maximum upstream location of the ice front is at approximately RM 133 in an average winter and may be a few miles downstream or upstream in a warm or cold winter, respectively.

Breaching of a site between RM 100 and RM 130, if it occurs, will occur beginning in late December and subside in mid-March at the lower reaches in an average winter. The duration of overtopping may be a few weeks more or less in a warm or cold winter, respectively. Further upstream, the breaching will occur somewhat later and will subside somewhat earlier as depicted in Figure E.3.2.96 and Table E.3.2.101. In the upper reach affected by ice cover formation, a particular site may be breached two or more times in a single winter, e.g. Slough 8A, located at RM 126.0, may be overtopped twice given the ice progression and recession depicted in Figure E.3.2.96. If the chum embryos are sufficiently developed prior to a breaching event, no significant effects on development of the embryos or mortality is anticipated due to altered temperatures as discussed in Section 2.3.1.c.ii.

If ice formation and subsequent breaching of the site occurs early in the season, some excess mortality and possible developmental abnormalities may occur. However, the mortality and abnormal development associated with such events is not expected to be greater, overall, than under natural conditions. This is due principally to the fact that sites upstream of RM 133 are not expected to be breached with zero degree mainstem water and, hence, no mortality due to zero degree water intrusion, freezing of the substrates or dessication is expected under project conditions.

- Effects On Other Evaluation Species/Habitat Combinations (***)

Upstream migration of adult chinook salmon into the middle reach occurs in late June and July. During this period, temperatures due to Stage II operation are expected to be the most different from natural water temperatures. Some delay in the rate of upstream migration is expected. However, the range of temperatures expected is within the tolerance range for adult chinook migration (Figure E.3.2.98) and, therefore, the adults are expected to reach the tributary spawning habitats within the normal time period.

Upstream migration of adult spawning sockeye salmon may be delayed slightly as a result of the altered temperature regime due to Stage II operation. However, the mainstem temperatures expected during Stage II operation are within the tolerance range for migration of Sockeye (Figure E.3.2.99).

Spawning and incubation of sockeye adults and embryos occurs exclusively in side slough and side channel habitats (Representative Groups 2 and 3). Since spawning and incubation habitats for sockeye are coincident with chum spawning and incubation habitats, the effects of the altered temperature and ice regimes on sockeye are expected to be the same as those described for chum.

Juvenile sockeye remain in side sloughs, move to upland sloughs or outmigrate to the lower river after emerging from the natal areas. For those juveniles which move out of the natal areas into upland sloughs, water temperatures in the mainstem may retard or inhibit the movement. However, once into upland sloughs, water temperatures are independent of mainstem temperatures (ADF&G 1983k, 1984u) and, therefore, no effects on rearing or overwintering are expected. Effects on juvenile sockeye which move out of the middle river are discussed in Section 2.3.2.c.iii. Mainstem temperatures throughout the summer months are expected to be within the tolerance range for juvenile sockeye (Figure E.3.2.99). However, some delay in the outmigration of Age 1+ sockeye could result from the lower temperatures (AEIDC 1984b). However, the delay is not expected to result in increased mortality of juveniles in the salt water environment.

The rate of upstream migration of coho adults may be retarded to some extent as a result of the reduced water temperatures attributable to Stage II operation. However, spawning of the adult coho in tributary habitats is expected to occur within the time frame spawning occurs under natural conditions.

Redistribution of juvenile coho from the tributaries into upland sloughs may be delayed to some extent because of the cooler mainstem water. However, because mainstem temperatures are expected to be approximately the same or slightly warmer than tributary water temperature, no adverse effects on the redistribution is expected. The range of mainstem temperatures is expected to be within the tolerance range of coho juveniles (AEIDC 1984a; Figure E.3.2.100). Since water temperature in the upland sloughs is independent of mainstem water temperature (ADF&G 1983k, 1984u) changes to mainstem water temperature due to Stage II operation are not expected to affect coho rearing and overwintering.

Outmigration of juvenile chum salmon generally occurs over a two month period in June and July. Juvenile chum generally outmigrate relatively slowly and grow to some extent prior to leaving the middle river (ADF&G 1983m, 1984c, 1985c). The lower water temperatures resulting from operation of Stage II may slow the rate of outmigration to some extent and may reduce any growth which may occur in the middle reach. Expected temperatures in the middle river are within the tolerance range for juvenile chum (AEIDC 1984b) (Figure E.3.2.101). Because juvenile chum do outmigrate relatively slowly under natural conditions, a delay in outmigration from the middle river of 1-2 weeks is not expected to have significant adverse effects. Also, since outmigrating chum salmon range in size from newly emergent fry approximately 49 mm) to approximately 65 mm total length, a reduction in the growth rates in the middle reach is not expected to adversely affect the population. If additional growth is necessary to promote survival of the juveniles in saltwater, additional growth is likely in habitats associated with the lower river (ADF&G 1985c).

As with the other salmon species, upstream migration of pink salmon is expected to be delayed somewhat as a result of the lower mainstem temperatures associated with Stage II operation. During operation of Stage II, water temperatures through the summer months are expected to be within the tolerance range for pink salmon migration (AEIDC 1984b) (Figure E.3.2.102), hence any delay in the upstream migration due to temperature effects is not expected to cause significant changes in the spawning period of pink salmon. The majority (more than 95 percent) of the pink salmon spawning and incubation occurs in tributary habitats which will not be affected by mainstem temperatures. Outmigration of pink juveniles occurs in late May and early June immediately after breakup of the ice cover under natural conditions. Since the river is expected to be ice free as early as late March, outmigration of pink juveniles is not expected to be adversely affected. Even though mainstem temperatures in May and June are expected to be 2-6°C lower than natural, it is expected that the mainstem temperatures will still be higher than the tributary temperatures. Hence, outmigration of juvenile pink is not expected to be adversely impacted during Stage II operation.

Rainbow trout, Dolly Varden and Arctic grayling generally move into tributary habitats to spawn and rear during the summer months. Therefore, the expected lower mainstem temperature will not affect these species. During the winter months, adults and juveniles of all these species move into mainstem and mainstem associated habitats. Since water temperature in much of the middle river will be higher than under natural conditions, temperature induced changes in survival rates of rainbow trout, Dolly Varden and Arctic grayling are not expected to be detrimental when compared to natural conditions. Project induced thermal changes may even enhance survival of these fishes.

Little is known of the effects of temperature on burbot growth, spawning and incubation. Lower summer temperatures could retard growth of burbot. However, since burbot are found in large lakes within the area, where they would experience lower water temperatures, the lower temperatures are not expected to adversely affect the population. Similarly, warmer temperatures in the late fall and winter, particularly upstream of approximately RM 130, are not expected to adversely impact the population.

- Effects of Altered Suspended Sediment Regime (***)

The effects of an altered suspended sediment regime during Stage II Operation conditions will be similar to that described in Stage I Operations (Section 2.3.1.c.ii). Estimated suspended sediment concentrations and turbidity values expected in the discharge from the Devil Canyon Reservoir during Stage II operation are presented in Table E.3.2.102. The major change is that Devil Canyon Reservoir will trap additional portions of the suspended sediment discharged frm the Watana Reservoir. Average annual turbidities downstream will be slightly less than during Stage I Operations (Table E.3.2.86).

Also, concentrations of suspended sediment will be slightly less during Stage II (Table E.3.2.102) than during Stage I operations (Table E.3.2.86).

The direct effects of the suspended sediment concentrations on fish in mainstem and peripheral habitats will still be stressful, but are not expected to be lethal. Vertical illumination will slightly increase due to slightly lower turbidity. The reduction in suspended sediment concentration and turbidity will allow more extensive periphyton and epilithon colonization along shallow riffles and margins of the mainstem channel and in shallow peripheral habitats chronically inundated with turbid water.

In general, detrital, primary and secondary trophic levels will be slightly enhanced in middle river habitats over the production expected during Stage I operation. Peripheral habitats not chronically affected by turbid release waters are expected to be as productive or more productive at most trophic levels during Stage II operation compared to productivity during Stage I operation. The major reason for this is the net removal of increasing amounts of fine particulates from the surficial streambed substrates.

As previously described, tributary habitats will not be affected by Stage II or any other operational flows from the project.

- Effects of Other Water Quality Changes (***)

No additional water quality changes due to Stage II operations are anticipated to cause biologically important habitat changes within the middle river reach.

Dissolved and particulate organic materials of allochthonous origin are expected to increase in concentration during the filling and the early operational years of Devil Canyon Reservoir. These concentrations of organic materials will gradually decline in waters released from Devil Canyon as their rate of erosion and leaching from the newly inundated impoundment zone decreases. Long term effects associated with these increased organics are expected to be negligible with respect to aquatic biological communities located downstream.

(iii) Talkeetna to Cook Inlet (***)

- Effects of Altered Flow Regime Stage II (***)

As discussed in Section 2.3.2.c.ii, little change in the discharge regime in the lower river is expected between Stage I and Stage II operation. The lack of difference in the discharge regime is due primarily to the limited storage capacity in Watana Reservoir. The discharge regime during Stage II operation will, however, be different from the natural discharge regime. Monthly average discharges at the Sunshine and Susitna Station gages during Stage II operation are presented in Chapter 2 Section 4.2.3.a. Maximum, minimum and mean average monthly discharges are summarized here in Table E.3.2.103 for the Sunshine Station and in Table E.3.2.104 for the Susitna Station. The same values for the natural flow regime are presented in the tables for comparative purposes.

. Effects on Principle Evaluation Species/Habitat Combinations (***)

Because the discharge regime in the lower river during Stage II operation will be nearly the same as during the Stage I operation, no additional effects, attributable to the altered flow regime are expected. Changes to chinook rearing habitats (Table E.3.2.89) and chum spawning habitats in the lower river between natural and Stage I flow regimes will be maintained through Stage II operation.

. Effects on Other Evaluation Species/Habitat Combinations (***)

As discussed above, no additional changes to the other evaluation species/habitat combinations are expected as a result of Stage II operational flow regimes. Habitat conditions influenced by mainstem discharge for other anadromous species life stages and resident species are expected to remain the same as during Stage I operation (See Section 2.3.1.c.iii).

- Effects of Altered Temperature/Ice Regime (***)

Water temperature differences between Stage II and Stage I operation downstream from the

Chulitna River confluence are expected to be considerably reduced due to the influence of the colder water in the Chulitna and Talkeetna Rivers. Differences of up to 2°C during the summer are expected and are within the natural variation occurring in the reach (see Tables E.3.2.81 and E.3.2.82 and E.3.2.99 and E.3.2.100). During the fall, warmer than natural temperatures will prevail until late October or early November. After that time, water temperatures are expected to remain at 0°C through the winter with an ice cover forming throughout the lower reach. Initial formation of the ice bridges in the lower river is expected to occur at approximately the same time as under natural conditions. Progression of the ice front upstream from the Yentna River to Talkeetna will progress somewhat slower. The ice front is expected to reach Talkeetna in late December. Because temperature differences between Stage I and Stage II operation are not expected to be significant, no impacts to salmon, other anadromous fish or resident fish resulting from temperature changes are expected. Principal habitats used by various life stages of salmon are more likely to be influenced by other factors such as tributary temperature and slough temperatures which are independent of mainstem water temperatures (ADF&G 1985d, 1985g).

- Effects of Altered Suspended Sediment Regime (***)

Conditions in the lower river during Stage II Operations are essentially like those described for Stage I Operations (Section 2.3.1.c.iii) except that the suspended sediment concentrations and turbidity values are expected to be lower.

Direct effects on fish will still be stressful, but not lethal. Lower trophic levels are expected to be more productive than natural conditions during June through August, but less productive than during natural conditions from September through May. The indirect effects of changes in the temporal regimes of the lower trophic level activities on the fisheries populations is unknown. The most detrimental effects envisioned are potential reductions in annual primary and secondary biomass production in relatively deep and chronically turbid mainstem and large side channel habitats.

- Effects of Other Water Quality Changes (***)

No additional water quality changes (other than those previously mentioned) due to Stage II Operations are anticipated which would cause biologically important habitat changes in the lower river reach.

(iv) Cook Inlet Estuary (***)

Lower suspended sediment concentrations and lower turbidities will enter the Cook Inlet estuary on a continuous basis due to Stage II Operations than for Stage I. No important biological effects are presently anticipated. Because of strong water currents and high ion concentrations in the inlet, riverine borne particulates will be relatively rapidly dispersed, diluted and precipitated.

(d) Summary of Impacts Associated with Devil Canyon Stage II Dam (**)

(i) Construction Impacts (***)

As with Stage I Watana Dam, the most significant long-term impact associated with Devil Canyon Dam will be the increase in fishing pressure. Other impacts resulting from construction activities will be transitory and are not expected to significantly affect fish populations.

(ii) Reservoir Filling (**)

Filling the Devil Canyon reservoir will inundate portions of clear-water tributaries, two of which (Tsusena and Fog Creeks) presently provide summer habitat within the reaches to be inundated for approximately 1100 grayling longer than 8 inches (20 cm) Table E.3.2.24). Aquatic habitats in the reservoir are expected to support more productive resident fish populations than those in the Watana reservoir because of the timing and magnitude of the annual draw-down cycle. The reservoir will be filled while maintaining Case E-VI flow constraints downstream. Downstream impacts are not expected during this period.

(iii) Operation Impacts (**)

No significant impacts (other than those imposed by filling) are expected upstream from Devil Canyon Dam. The reservoir is expected to support very limited populations of lake trout, Dolly Varden, Arctic grayling, burbot, whitefish, and longnose sucker.

The most significant downstream impact resulting from the addition of Devil Canyon Dam will be the change in winter water temperature, which will result in the maximum ice front extent to be near RM 133 in an average year as compared to RM 139 in Stage I. The maximum upstream extent of the ice cover may be a few miles downstream or upstream of this in a warmer or colder winter, respectively (Exhibit E, Chapter 2, Section 4.2.3(c)(ii). The river stage in the open-water reach will be lower than the stage present under an ice cover. This change will reduce available habitat in areas that previously formed an ice cover, as was discussed for impacts associated with Watana Stage I Dam (Section 2.3.1.c).

With the addition of impacts of Devil Canyon Dam, habitats between Talkeetna and Cook Inlet are not expected to increase over conditions for Watana Stage I.

2.3.3 - Anticipated Impacts on Aquatic Habitat Associated With Stage III - Watana/Devil Canyon Dams (***)

Stage III of the development of the Susitna Hydroelectric Project will consist of raising Watana Dam such that the normal minimum operating water surface elevation is at el. 2,185. The Watana reservoir is expected to begin filling in year 2011 and the Stage III will become operational in 2012. Once the reservoir is full and operational, the project will be nearly the same as the completed project described in the original License Application (APA 1983b).

Impacts on aquatic habitats as a result of construction of the Stage III Watana Dam will be of lesser magnitude than those occurring during the construction and operation of Stage I or Stage II. Little or no instream work will be required and the support facilities will already be in place. Filling of the reservoir to el. 2,185 will require approximately three to seven years and will increase the effects of the Watana Reservoir further upstream in the mainstem and tributaries.

(a) Construction Impacts Stage III (***)

(i) Watana Stage III Construction Effects (***)

The period of construction considered for the proposed Stage III Watana Dam consists of those activities related to the initial lowering of the reservoir to allow for the raising of the dam, the spillway and the intake structures and the raising of the reservoir to el. 2,185 feet. An additional 27.5 million cubic yards (21.1×10^6 m^3) of material will be required to construct the Watana Dam to its ultimate height of el. 2,205 feet. During the construction of Stage III, river diversion will not be required. Operation of the power facilities would continue during construction of Stage III.

- Alteration of Water Bodies (***)

The greatest alteration of aquatic habitat during construction of Stage III Watana Dam would again be the borrow activities at Borrow Site E at the mouth of Tsusena Creek. The degree of change will depend on the mining procedure used to remove the material needed to complete this stage of the project. Removal of riparian and upland material will increase the surface area of the lake created by Stage I mining activities; a dredging operation will result in a deepening of the lake. Both operations will result in temporary increases in turbidity and sedimentation in the lake, the introduction of small amounts of hydrocarbons from equipment, and a permanent change in the geomorphology of the lake. BMP manual guidelines and techniques (APA 1985a) will be incorporated into contractual documents to ensure that the environmental goals of the Applicant are met.

- Water Quality Changes (***)

The movement of fill materials and the process of constructing the Stage III dam will contribute to an increase in turbidity and sedimentation. Introduction of material into the mainstem Susitna River will be less severe than during Stage I due to the smaller total volume of material deposited for dam construction. Some material will settle out in the Watana Reservoir, further reducing the influx of material into the mainstem Susitna River. Some material will pass downstream during construction but most of this will become trapped in the Devil Canyon Reservoir preventing any increase in siltation or sedimentation rates in anadromous fish habitats downstream.

The production of concrete for raising of the spillway and power intake, and for grouting will generate concrete-batching waste water. Adjustment of the pH of this waste water will be necessary to prevent detrimental effects on fish populations and habitat. The measures that will be taken to minimize concrete contamination of the water during Stage II construction are discussed in Exhibit E, Chapter 2, Section 4.3.1(c)(vii).

The possibility of contamination of waterbodies by petroleum products is similar to that during Stage I construction. Fuel leaks, vehicle accidents, and handling of hazardous materials (solvents, antifreeze, hydraulic oil, paints, waste oil, and grease) are possible sources of petroleum contamination. BMP manual techniques and guidelines (APA 1985b) incorporated into contractual documents will reduce or elminate the possibility of impacts from these sources.

- Other Effects on Fish Populations (**)

Withdrawal of water from local sources for production of concrete, processing of gravel, and dust control could result in entrainment and impingement of juvenile fish. Use of low volume pumps equipped with proper intake screens will minimize the number of fish affected. Dewatering fish habitat in either the summer or winter low flow period could occur, but will be minimized by pumping from streams with relatively high flows.

~~No instream blasting is currently planned.~~ Blasting for areas 500 feet or more from streams may occur. Such blasting may disrupt normal fish behavior temporarily, but no mortalities are anticipated. Secondary effects of blasting may include increased turbidity and siltation of streams by loosened dirt and dust. The extent of such effects would depend upon the location and amount of blasting.

(ii) Operation of Stage III Watana Camp, Village and Airfield (**)

During peak construction activities for the Stage III Watana Dam, facilities to house approximately 2,000 people are anticipated. The same facilities used during Stage I will be reopened for Stage III.

A 6,500 foot permanent airfield will be available for use during Stage III construction.

Impacts associated with reopening the camp will be significantly less than during its construction.

- Alteration of Water Bodies (***)

  Operation of the camp and airfield is not expected to result in the alteration of waterbodies.

  Water for camp use will again be withdrawn from Deadman Creek, with little or no impact on fish habitat (see Section 2.3.1.ii).

- Water Quality Changes (***)

  During camp operations, the most significant impacts on water quality will result from discharge of treated wastewater into Deadman Creek, oily and silty runoff from the camps, water used for dust control, and accidental fuel spills. Section 2.3.1 (ii) describes these impacts in details.

(b) Anticipated Impacts on Aquatic Habitats of Filling Stage III Watana/Devil Canyon (***)

Filling of Watana Reservoir from el. 2,000 to el. 2,185 will require approximately three to seven summers to complete. During this period of time, discharge from the reservoir will be maintained within the E-VI constraints. During the filling period, effects of the reservoir will be extended upstream in the mainstem and tributary habitats. Downstream of the project, the effects will be similar to those encountered during operation under Stage II. Therefore, detailed discussions of the habitat conditions in the reservoir and downstream from the project are presented in Section 2.3.3.c, Effects of Operation of Stage III Watana/Devil Canyon Dams. A brief description of the filling of Stage III Watana Reservoir is presented here.

(i) Watana Reservoir Filling (***)

During the operation of Stages I and II, the annual refilling of the Watana Reservoir was complete when the reservoir water surface elevation reached el. 2,000 ft. After the reservoir was filled excess inflow was released downstream. Once the Watana Dam is completed to its full height, the inflow, previously released, will be stored and the water surface will be allowed to rise to el. 2,185 ft. Because the storage volume in the upper 185 ft. of the reservoir is quite large, it will require three to seven summer filling cycles to raise the water surface to the maximum level. As the reservoir is filled above el. 2,000, additional mainstem tributary and lake habitats will be inundated. Since the reservoir and dams will be operated to generate power during this period, the effects of the impoundment are appropriately discussed in Section 2.3.3.c.i. A comparison of the area to be inundated once the reservoir achieves el. 2,185 with the reservoir area at el. 2,000 is presented in Figure E.3.2.103.

(ii) Devil Canyon to Talkeetna (***)

- Effects of Altered Flow Regime (***)

Discharge from Watana and Devil Canyon Dams will remain within the Case E-VI flow constraints throughout the filling of the Stage III Watana Reservoir. However, flows will generally be near the Case E-VI minimum constraints during the summers of filling as water normally released through the outlet works will be used to raise the water level in Watana. Because the project will remain operational during filling discussion of the impacts will be the same as that of the operational effects. Therefore, the effects of the altered flow regime on the principle evaluation species/habitat combinations and the other evaluation species/habitat combinations in the middle river are discussed under the effects of operation of Stage III in Section 2.3.3.c.ii.

- Effects of Altered Temperature/Ice Regime (***)

During the filling of Stage III Watana Reservoir, the capacity to select the water temperature to be discharged will be maintained and the outlet works releases will be minimal. This, in combination with the flows which are redcued from operation of Stage II will result in warmer downstream temperatures in the summer than in Stage II (see Exhibit E, Chapter 2, Section 4.3.2(d)(i)). Because the project will be operational during the filling of Stage III, discussions of the temperature differences and the effects on evaluation species/habitat combinations are appropriately presented as part of the effects of Stage III operation in Section 2.3.3(c)(ii).

- Effects of Altered Suspended Sediment Regime (***)

The Stage III filling process involves raising maximum reservoir surface stage from el. 2,000 MSL to el. 2,185 MSL. During the three to seven year filling period for Watana Stage III, the project will still be generating power. During the Stage III filling process the maximum Watana Reservoir water surface elevations may increase by between 75 and 25 feet per year each year the rate decreasing with each year as filling approaches the range between el. 2,000 and el 2,185. Erosion of particulates from the fluctuating reservoir shorelines is expected to contribute an additional unquantifiable amount of suspended sediment and turbidity to the reservoir water. At present this addition of suspended particulate material is expected to be minimal when compared to that derived from riverine influents.

As a consequence of the previously mentioned erosive actions, slightly increased levels of suspended sediment and turbidity will be measureable in waters released from the Watana and Devil Canyon Reservoirs during Stage III filling. However, the effects on the downstream aquatic biological community are expected to be negligible and relatively shortlived. In general effects will be similar to those discussed under the Stage I filling and operations sections.

- Effects of Other Altered Water Quality Factors (***)

No additional water quality changes, other than those previously discussed in Exhibit E, Chapter 2 and previous sections of Chapter 3, are expected during Stage III-Filling. Effects on aquatic biological communities downstream from the Devil Canyon Dam are expected to be negligible.

Increased concentrations of particulate organic carbon (POC) and dissolved organic carbon (DOC) are expected to occur in downstream releases due to inundation, erosion, and leaching of allochthanous organic matter from newly inundated shorelines. Increased organic matter concentrations in project releases will likely serve as an additional nutritional base for detritus processing microbial and macroinvertebrate populations in downstream riverine habitats. The effects of the increased organic nutritional base, however, are not expected to be long-lived in relation to the project's operational lifetime, nor are the effects expected to be quantifiable with respect to the riverine fish community.

(iii) Talkeetna to Cook Inlet (***)

- Effects of Altered Flow Regime (***)

Effects of changes to the flow regime in the lower river during filling of Stage III Watana Reservoir will be essentially the same as the effects of operation of Stage III. The effects of the altered flow regime during filling of Stage III Watana Reservoir in the lower river are, therefore, appropriately discussed in Section 2.3.3.c.iii.

- Effects of Altered Temperature/Ice Regimes (***)

As discussed previously in Section 2.3.3.b.ii, water temperatures in the middle river and, therefore, the lower river are expected to be somewhat warmer during filling and operation of Stage III than during operation of Stage II. Because the project will continue operation through the filling of Stage III Watana Reservoir, the effects of altered temperature/ice regimes on aquatic habitats in the lower river are appropriately discussed in Section 2.3.3.c.iii of Stage III of the project.

- Effects of Altered Suspended Sediment Regime (***)

During the months of May through September the suspended sediment concentrations of the middle river reach will be less than the normal amount of suspended sediments occurring under natural conditions. With-project flows from the middle river reach may dilute TSS concentrations downstream of RM 96 during the summer. Changes in the suspended sediment regimes in habitats in the lower river during May through September, however, are not expected to be biologically significant because of the influence of the Chulitna, Talkeetna and other glacical tributaries.

During the winter the suspended sediment concentrations and turbidities of the middle river reach will be greater than the natural levels. With-project flows from the middle river reach will increase TSS concentrations and turbidity values downstream of RM 96. However, the biological effects of the TSS concentrations during the winter are expected to decrease with increasing distance downstream from the mouth of the middle reach (RM 98.5) because of the dilution by the relatively clear water from the lower river tributaries. Biological effects are expected to be limited primarily to riverine habitats directly affected by mainstem flows and ice processes.

Direct effects on resident and rearing juvenile fish are expected to be stressful, but not lethal. Indirect effects to fish because of changes at lower trophic levels are both unpredictable and unquantificable.

Tributary habitats, as previously noted, will not be affected by Stage III-Filling.

- Effects of Other Altered Water Quality Factors (***)

Additional water quality changes due to Stage III-Filling that have not already been discussed, which will cause biologically significant habitat changes within the lower river reach.

As previously discussed, concentrations of POC and DOC are expected to increase in lower river habitats inundated by riverine flows which are influence by Stage III-Filling releases. The anticipated increased organic matter concentrations in lower river aquatic habitat will likely serve as an additional organic nutritional base for microbial and macroinvertebrate detritus processors. As discussed previously (see middle river discussion sections), these effects are expected to be short-lived in relation to he. project's operational lifetime and their effects are expected to be negligible with respect to the lower river fish community.

(iv) Estuary at Cook Inlet (***)

Stage III-Fillng effects on the Cook Inlet estuary area at the Susitna River mouth are expected to be limited to mildly increased fertilization of biological production during the winter. The mild fertilization effect is expected to be due to nutrients associated with the suspended particulates carried to the estuary by constantly turbid riverine flows.

As discussed previously, high marine environment ion concentrations and relatively strong inlet currents will rapidly disperse, dilute and precipitate the suspended particulates. Ecological effects on the inlet are expected to be minimal.

(c) Anticipated Impacts on Aquatic Habitats of Operation of Stage III Watana/Devil Canyon Dams (***)

The impacts on aquatic habitats during operation of Stage III of the Susitna Project are continuations of the impacts associated with Stage II. Some changes to the reservoir operations will be implemented as described in Section 2.3.3.c.i, below. Changes to the flow regime will result from the increased capacity to generate power as a result of Stage III. The flow regime, however, will remain limited by the Case E-VI constraints.

(i) Impacts of Stage III Watana Reservoir Operation (***)

Completion of the Stage III Watana Dam will raise the reservoir to a normal maximum water surface el. of 2,185 ft MSL, the same elevation proposed in the original License Application (APA 1983b). The Stage III Watana Reservoir will increase the total inundated reaches of the Susitna River to 48 miles (54 miles along the river before impounding). The lengths of reaches of the four named tributaries affected by the Stage I reservoir will be increased and the lower portions of two additional tributaries, Goose Creek and Oshetna River, will be affected (total of 11 mi additional). Twenty-four additional lakes and ponds will be inundated by the higher Watana Reservoir including Sally Lake, a 55 acre lake located near the confluence of Watana Creek with the Susitna River. The maximum surface area of the Watana Reservoir will be increased by 17,000 acres to a total surface area of 38,000 acres. The Stage III reservoir area is depicted on Figure E.3.2.103.

The drawdown-refill cycle of the Stage III reservoir will be similar to the cycle described for the Stage I reservoir. A major difference is that the maximum drawdown under Stage III will be 120 ft. rather than 150 ft. This difference is due primarily to the larger volume of water per foot of depth with higher water surface elevations in the reservoir. The average rate of drawdown in the reservoir will be decreased to 0.5 ft. per day and the average rate of rise in the surface elevation during refill will decrease to 1.0 ft. per day. A schematic of the drawdown-refill cycle in Watana Reservoir during the early years of Stage III operation and when the project is operated at full capacity in later years of project operation is presented as Figure E.3.2.104.

Devil Canyon Reservoir will also be drawdown periodically in a manner similar to that described for Stage II operation. A schematic of the expected drawdown of the Devil Canyon Reservoir in early Stage III operational years and late Stage III operational years and is presented as Figure E.3.2.105.

With the increased length of the reservoir due to construction of the Stage III Watana Dam, the deposition of sediments will occur primarily the newly inundated reaches of the Susitna River. Deposition and redistribution of the sediments will be similar to those described for the Stage I Watana Dam and Reservoir. Turbidity in the larger reservoir will approximate that described for the Stage I reservoir. Turbidity in the downstream portion of the reservoir may be somewhat less than with the Stage I due to the increased storage capacity and the consequent increase in the residence time of the water.

The water temperature regime in the larger Stage III reservoir will be similar to that described for the Stage I.

- <u>Effects on Mainstem Habitats</u> (***)

With the raising of the Watana Reservoir, mainstem habitats, upstream to approximately RM , will be inundated. Additional burbot, and longnose sucker habitats will be inundated with end results similar to those described for the Stage I reservoir. Also, additional overwintering habitats for Arctic grayling and Dolly Varden will be lost as a result of the impoundment.

- <u>Effects on Tributary Habitats</u> (***)

At the maximum water surface elevation of the Stage III Watana Reservoir at el. 2,185 ft. MSL, the reservoir will be extended further into the tributaries previously affected by the Stage I Reservoir. Also, the Stage III Reservoir will affect two additional named tributaries. The locations, lengths and gradients of the tributaries affected by the Stage III Reservoir are summarized in Table E.3.2.105. The increases from the Stage I and Stage II reservoir in the lengths of the tributaries affected by Stage III are also presented.

Although the total lengths of tributaries inundated by the reservoir will increase after Stage III is completed, the lengths of the tributaries within the drawdown zone will be less. This is because the reservoir will not be drawn down as far. Summaries of the tributary lengths in the drawdown zone that are permanently inundated are presented in Table E.3.2.105.

Based upon the estimated populations of the Arctic grayling in the tributaries under natural conditions an additional 4,000 fish will be affected by raising Watana Reservoir to el. 2,185. Most of the additional fish affected by the higher reservoir inhabit the Oshetna River and Goose Creek. The actual populations affected by the Stage III reservoir will be dependent, in part, on how well grayling populations succeed in the Stage I Reservoir.

- Effects on Lake Habitats (***)

As stated previously, 24 additional lakes and ponds will be affected by the Stage III Reservoir. The only lake known to support fish populations is Sally Lake. This lake has populations of lake trout and grayling that appear to be stunted (ADF&G 1981f, 1983b). Since grayling populations are not usually associated with glacial lakes or turbid water, they will likely be lost. Lake trout will be able to survive in the reservoir if an adequate food base exists. Lake trout are found in glacial lakes, including Chakachamna and Kontrashibuna Lakes (Bechtel Civil and Minerals, Inc. 1981, Russell 1980), with physical characteristics similar to those expected in the Watana reservoir.

(ii) Devil Canyon to Talkeetna (***)

- Effects of Altered Flow Regime (***)

When Watana Dam is raised to its full height, the Watana Reservoir maximum water surface elevation will be raised to el. 2,185. Since this additional height will greatly increase the storage capacity of the reservoir, the capacity of the project to regulate discharge in the river will also be increased. During the early years of operations of Stage III Watana Dam (i.e. once the reservoir is filled), the discharge regime is expected to be quite similar to that experienced during Stages I and II. This flow regime is characterized by some annual variation in discharge with somewhat higher discharges occurring in the summer months than in winter months. As the demand for energy increases, discharge from the Watana/Devil Canyon Dams will gradually assume a more constant discharge through the year. In other words, discharge during the winter months will gradually increase as demand for power increases. Additionally, demand for power during the summer months will also increase. As a result, more of the inflow to the Watana Reservoir will be required for generation of electric power. Hence, the time required for refilling the reservoir during the summer months will be extended and the mean discharge during the summer months will gradually decline toward the minimum flows allowed by Case E-VI. When the demand for power reaches the total capacity of the project, discharge from the dams will be nearly constant through the year as indicated by the discharge presented in Table E.3.2.106 for the late years of Stage III operations.

The flow regime associated with initial years of operation of the Stage III project is represented by simulation of project operation given a forecasted energy demand expected to occur early in the Stage III operational period. For this purpose, an annual energy demand of 6,100 GWH and an average annual energy production from the project of approximately 5,540 GWH was used in deriving the expected from regime of Gold Creek. Average monthly discharges from the project for the 34 years of record are presented in Exhibit E, Chapter 2, Section 4.3.3.a. The possible maximum, minimum and mean average monthly discharges at Gold Creek for this demand level are summarized in Table E.3.2.106.

It is expected that the demand for power will reach maximum capacity of the project sometime between the years 2030 and 2040. In order to evaluate the discharge regime when the project reaches its maximum production capacity, an annual energy demand of approximately 8,300 GWH were and a maximum average annual energy production for the system of approximately 6,850 GWH were selected for evaluation of the flow regime associated with the maximum energy production possible from project operation. Possible average monthly discharges at Gold Creek for this demand level are presented in Exhibit E, Chapter 2, Section 4.3.3.a.

Maximum, minimum and mean average monthly flows at Gold Creek for late Stage III operation are summarized in Table E.3.2.106.

. Effects on Principal Evaluation Species/Habitat Combinations (***)

.. Chinook Rearing Habitats (***)

Total chinook habitat areas for the summer months were derived by translating the weekly average discharges at Gold Creek for early Stage III and late Stage III demand levels into habitat areas, using the chinook rearing habitat area response curve presented in Table E.3.2.46 and Figure E.3.2.64. As discussed previously, total habitat areas are calculated only for the summer period, June through September.

During the early years of operation of Stage III, the total chinook rearing habitat area will be similar to that available during Stage I and Stage II operation. Total habitat areas which are 90 percent likely, 50 percent likely, and 10 percent likely to be equalled or exceeded given the forecasted energy demand during early Stage III operation are presented in Table E.3.2.107 and are depicted graphically in Figure E.3.2.106. Habitat areas estimated for the natural flow regime are also presented for comparison.

Comparison of these values with those presented in Table E.3.2.74 and Table E.3.2.92 indicates that no immediate change in the total chinook rearing habitat area during the summer months is expected with initial operation of the Project. As discussed previously, for Stage I and II, the total chinook rearing habitat area in the middle river during initial Stage III operation is expected to be slightly less than what is available under natural conditions during the first half of the summer. Again, by mid-summer, when juvenile chinook become prevalent in mainstem affected areas, the range of habitat areas available in these areas will be nearly the same as under the natural flow regime (See Figure E.3.2.106). However, the week to week and year to year variation in total habitat area is expected to be somewhat less under the early Stage III flow regime than under the natural flow regime.

As the demand for power increases through time, summer discharge in the middle river is expected to decline to an average of approximately 10,000 cfs through the summer (Table E.3.2.106). Even with the gradual decrease in the summer flow regime, total chinook rearing habitat area is expected to remain relatively the same through the summer. Total chinook rearing habitat areas that are 90 percent, 50 percent and 10 percent likely to be equaled or exceeded, given the forecasted Stage III flow regime when the project is operating at maximum capacity, are presented in Table E.3.2.108 and are depicted graphically in Figure E.3.2.107. Comparison of the habitat area values for the late Stage III flow regime with those for the early Stage III flow regime indicates a very slight reduction in the median habitat areas available through the summer period. The major difference between the habitat area values for early and later Stage III operation is the reduction in the year to year variation in the amount of habitat available. This is evident particularly during the months of July and August (Weeks 28-34). It is important to recognize here that the apparent reduction in the habitat area available from early Stage III to late Stage III will occur gradually over 15-20 years. Hence, it is likely that the juvenile chinook population will adjust to the change with no appreciable adverse effect. Again, it is emphasized that the equivalent habitat area values resulting from this analysis only indicate the amount of habitat area available for use by juvenile chinook and does not make any prediction as to whether or not all of the area will be utilized.

A somewhat different trend emerges if only the habitat areas included Representative Groups 2, 3, and 4 are considered. Translation of the early Stage III flow regime into habitat areas were made using the habitat response curve for the three representative groups presented in Table E.3.2.46. Median, 90 percent and 10 percent exceedance values of habitat area in the three representative groups resulting from the translations are presented in Table E.3.2.109 and are depicted graphically on Figure E.3.2.108. Comparison of these values with similar values for the natural flow regime, also presented in Table E.3.2.109, and for the Stage I and Stage II flow regimes indicates that habitat for juvenile chinook rearing will be greater under Stage III project operation than under the natural flow regime. A notable feature of the rearing habitat areas is that there is essentially no week to week and year to year variation expected during the first part of the summer (through July) during the refilling period. Considerably more variation is expected during the later part of the summer.

Similar results are obtained for the flow regime expected late in Stage III operation, once the energy production from the project reaches capacity. Median, 90 percent and 10 percent exceedance values of habitat area in Representative Groups 2, 3, and 4 are presented for late Stage III operation in Table E.3.2.110 and are depicted graphically in Figure E.3.2.109. Again, total rearing habitat areas available in the three representative sites will be greater than under the natural flow regime. The reduction in week to week and year to year variation, observed for the first part of the summer in the early Stage III operation, is extended through the entire season. Hence, it is expected that not only will the available rearing habitat be greater under project operation, but the availability will be more reliable than under natural conditions.

During the winter months, Stage III discharge in the initial years of operation will be similar to that described for Stages I and II. A difference that will be observed during the first years of Stage III operation is that the ice front will form somewhat later and will not progress as far upstream than during Stage II. As a result it is expected that overwintering habitats used by juvenile chinook in the ice free reach of the Middle Susitna River will increase because more of the habitat will not be affected by ice. Consequently, survival of the juveniles could increase.

In the reach of the river with an ice cover, staging of the water surface elevation associated with the ice cover will not be as great as during Stage I or Stage II and, therefore, the likelihood that overwintering habitat areas will be overtopped and influenced by 0°C water will be less. As discharges increase during the winter months with the long term increase in the energy demand, the progression of the ice front is expected to decrease both in rate and in upstream extent. Hence, the duration of the open water period in the reach will gradually increase and the effects of staging will decrease. In addition, particularly in the upper portion of the middle river upstream of RM 130, backwater areas at the mouths of overwintering habitats will increase due to the higher mainstem discharges during the winter. Also, in areas adjacent to ice covered reaches of the mainstem, rates of groundwater upwelling will be greater (APA 1984d). Consequently, it is expected that overwintering habitat areas will be greater than during Stages I, II and the initial years of Stage III once the energy production from the project reaches capacity. These habitat areas are also expected to be greater than those available under natural conditions. The overall result is that overwinter survival of chinook juveniles is expected to increase.

.. <u>Chum Spawning/Incubation Habitats</u> (***)

During the initial operating years of Stage III of the project, chum access conditions, and spawning and incubation habitats will be nearly the same as that described for Stages I and II of the project.

Access at the mouths of sites traditionally used by chum for spawning are expected to be nearly the same as conditions during Stages I and II. The status of access at selected sites in the middle river during initial Stage III operation, represented by the range of discharges expected during early Stage III operation (Table E.3.2.106), are summarized in Table E.3.2.111. The status of access for maximum, mean and minimum average monthly discharges in August and September which occur naturally are also provided in the table for comparison. Based upon the evaluation of passage conditions presented in Table E.3.2.111, 6 passage reaches will present more difficult conditions than natural for a mean discharge year in August. Only one reach will be more difficult during Stage III operation than during natural mean flows in September.

As the demand for energy increases, average monthly discharges during August and September, represented by the discharges for late Stage III, are expected to decrease. Consequently, access conditions at many of the mainstem affected passage reaches in the selected spawning habitats will deteriorate. The status of access conditions at the selected passage reaches given the possible maximum, mean and minimum average monthly discharges in August and September expected during late Stage III operation are summarized in Table E.3.2.111. Based on these analyses, over half (14) of the 24 passage reaches will present more difficult conditions than natural under mean discharge conditions in August. six reaches will present more difficult conditions in September. When maximum discharge conditions prevail, seven and four passages reaches in August and September, respectively, will present more difficult conditions. Under minimum flow conditions, no difference in access conditions between late Stage III and natural are expected.

The availability of chum spawning habitat area during the initial Stage III operation, represented by the probable discharges associated early Stage III operation, is expected to be approximately the same as during Stage II operations. Weekly average spawning habitat area for the early Stage III flow regime in August and September were calculated from the average weekly discharges and the total habitat response curve for sites traditionally used by chum salmon for spawning and were included in the modeled sites (Table E.3.2.47 and Figure E.3.2.59). The weekly average habitat areas that are 90 percent, 50 percent and 10 percent likely to be equalled or exceeded given the energy demand and average energy production in early Stage III are presented in Table E.3.2.112 and are depicted graphically in Figure E.3.2.110. Comparison of these values with those presented for Stage II operation (Table E.3.2.95 and Figure E.3.2.90) indicates that, initially, little change in the available spawning habitat area from Stage II is expected during the initial operation of Stage III. The spawning habitat area available in the traditional spawning sites during the initial Stage III operation will be nearly the same as that available under the natural flow regime. These are also presented on Table E.3.2.112 and Figure E.3.2.116 for comparison. Also, the range of week to week and year to year variation during the initial Stage III operation will be nearly the same as that which occurs naturally and under Stage II operation.

As the energy production from the project reaches capacity, represented by the energy demand and average energy production expected during later Stage III operation, average discharge from the project in August and September will be less (Table E.3.2.106). The total chum spawning habitat area in the modeled sites will also decline. The total spawning habitat area in the modeled sites expected to be equalled or exceeded 90 percent, 50 percent, and 10 percent of the time are presented in Table E.3.2.112 and depicted on Figure E.3.2.111. Once the energy production from the project reaches capacity during late Stage III operation, the spawning habitat area in the modeled sites will, on the average, be less in August and will gradually increase through September. A major difference in the availability of spawning habitat area is that more habitat will be available 90 percent of the time, represented by the bottom line in Figure E.3.2.106. This is due principally to the fact that peak flows, greater than the optimum flow, will be reduced in frequency because the filling of the reservoir will be achieved later in the year. Hence, high flows in August will be stored in the reservoir rather than released downstream as was done during Stages I and II. The result is that the week to week and year to year variation in the spawning habitat area will be less than that expected during Stages I and II and during the initial years of Stage III operation.

A similar analysis was conducted using the chum spawning habitat response curve for sites included in Representative Groups 2, 3 and 4 presented in Table E.3.2.48 and Figure E.3.2.63. The total habitat areas in August and September likely to be equalled or exceeded 90 percent, 50 percent, and 10 percent of the time early and late in Stage III operation are presented in Table E.3.2.113 and are depicted graphically in Figures E.3.2.112 and E.3.2.113, respectively. As discussed for the spawning habitat in the modeled sites, the total habitat area available in the three Representative Groups is expected to decline slightly as the flows change from early Stage III to late Stage III operation. Also, the range of week to week and year to year variation, particularly during August, is expected to decrease from early to later Stage III operation as more time is needed to refill the Watana Reservoir.

The effects of the Stage III flow regime on the incubation of chum embryos are similar to those described for Stage I and II. As described for the other Stages of development, the total area that will be maintained through the early winter months for incubating chum embryos during the first years of Stage III operation will be similar to that maintained in Stages I and II. Again using the assumption that spawning area is a good estimate of incubation area for chum embryos, the total habitat areas that are 90 percent, 50 percent and 10 percent likely to be equalled or exceeded in the modeled chum salmon spawning sites (Table E.3.2.46 and Figure E.3.2.59) under the early Stage III discharge regime were calculated. The results are presented in Table E.3.2.114 for the months of October and November and are depicted graphically in Figure E.3.2.114.

With the increase in the demand for energy, the winter discharge regime will gradually increase. As a result, the availability of area in the modeled sites having suitable conditions for incubation will also increase. This is indicated by comparing the habitat areas 90, 50 and 10 percent likely to occur given the late Stage III flows with same values for early Stage III discharges in October and November. The habitat values for the late Stage III flow regime are presented in Table E.3.2.114 and are depicted graphically in Figure E.3.2.115.

Another facet of the spawning/incubation habitat area, given the discharge regime expected during late Stage III operation, is that habitat available for spawning in August and September, even though it is less than that available earlier in Stage III or under natural conditions, will be maintained at a constant level into the incubation period. Hence, habitat sites where embryos are deposited will not be as likely to dewater or freeze as under natural or earlier project operational regimes. This is because under the other regimes, discharge declines from the August-September period to the October-November period. Under the late Stage III flow regime, habitat area available for spawning in August and September will be retained in October and November. Hence, the survival of chum embryos is expected to increase.

Another factor leading to the conclusion that the survival of the embryos is expected to increase is that the ice front is expected to move into the middle river later and not extend as far upstream during Stage III as under the natural Stage I or Stage II flow regime. Hence, the ice-free habitat area upstream of the ice front is expected to be greater than under the other flow regimes. Consequently embryos present in the sites are not as likely to be subjected to the diversion of 0°C water into the sites.

Downstream of the ice front, staging effects are expected to be less during the late Stage III flow regime than the early Stage III flow regime or other flow regimes and, hence, the embryos deposited in sites within the ice covered reach are less likely to be affected by overtopped conditions.

Analysis of the incubation areas using the aggregate spawning habitat response curve for Representative Groups 2, 3 and 4 (Table E.3.2.48 and Figure E.3.2.63) leads to conclusions similar to those observed for the modeled sites. Total habitat areas in the three Representative Groups expected to be equalled or exceeded 90 percent, 50 percent and 10 percent of the in early and late during Stage III operation are presented in Table E.3.2.115 and are depicted in Figures E.3.2.116 and E.3.2.117 respectively.

- <u>Effects on Other Evaluation Species/Habitat Combinations</u> (***)

The habitat conditions for other evaluation species/habitat combinations are not expected to be changed from Stage II as a result of the initial operation of Stage III of the project.

Hence, the habitat conditions described for Stages I and II will be maintained into Stage III operation.

The gradual decline of summer mainstem discharges and the gradual increase in winter discharges (Table E.3.2.106) are not expected to affect overwintering juvenile salmon, salmon embryos or resident fish species. Hence, the additional changes to these species/habitat combinations associated with the flow regime when the project is operated at maximum capacity are not expected to be significant.

- Effects of Altered Temperature/Ice Regime (***)

With Watana Reservoir at el. 2,185, and as project energy demands increase and late summer outlet works releases are reduced, the capacity of the Project to regulate the temperature of the water released from Watana Reservoir will be increased. The temperature of water released from Devil Canyon Dam during early Stage III will be slightly lower than for Stage II during the July to October period and slightly higher than for Stage II during the December to April period. During late Stage III the Devil Canyon release temperature will be slightly warmer than Stage II in June and July, slightly cooler than Stage II in August and September, and warmer than for Stage II in December through April. Release temperatures in late Stage III will be closer to natural than in Stage II or early Stage III.

Expected water temperatures at several locations in the middle river through the summer months are presented in Table E.3.2.116 and E.3.2.117 for the natural flow and climate years 1981 and 1982, respectively. The temperatures presented in these tables are estimated assuming the flow regime expected late in Stage III operation . Comparison of these tables with the similar tables for natural (Tables E.3.2.83 and E.3.2.84), Stage I (Tables E.3.2.81 and E.3.2.82), and Stage II (Tables E.3.2.99 and E.3.2.100) conditions illustrates that, in general, temperatures are expected to be 2-3 °C higher than under Stage II operation July and slightly cooler in the August to October period. Stage III temperatures are slightly cooler than Stage I temperatures during the May through

August period and slightly warmer the rest of the year. During Stage III higher temperatures are expected to persist somewhat longer in the September through November time frame than during Stage I operation. Winter temperatures are expected to be higher than for either Stage I or II by about 1°C.

The prolongation of warmer water releases in the fall will, in turn, delay the formation of ice cover in the winter. Initial ice cover formation in the middle river is expected to occur 4-6 weeks later than under natural conditions and 2-3 weeks later than under Stage II conditions. Simulation of ice cover formation, progression and recession, assuming the 1981-1982 winter climate, is presented in Figure E.3.2.118. This simulation is for late Stage III operation and an average winter. The ice front was simulated to extend upstream to RM 114. Depending on climatic conditions, the ice front's maximum upstream extent would be a few miles upstream or downstream in a cold or warm winter, respectively (Exhibit E, Chapter 2, Section 4.3.3(c)(ii)).

In conclusion, water temperatures in the mainstem during operation of late Stage III are expected to be higher than Stage II mainstem temperatures in June and July and cooler than Stage II in September and October. Higher temperatures are expected to persist longer in the fall during Stage III operation than during Stage I. Ice cover is expected to form later in the fall and recede earlier in the spring under Stage III operation than under Stage II. Finally, the maximum upstream progression of the ice front during late Stage III operation is expected to be about 20 miles downstream of the limit expected during Stage II operation.

. Effects on Principal Evaluation Species/Habitat Combinations (***)

.. Effects on Juvenile Chinook Rearing Habitats (***)

The expected increases in mainstem water temperatures from Stage II operation to Stage III operation are expected to benefit juvenile chinook salmon inhabiting side channel habitats

(Representative Groups 3 and 4). The warmer temperatures may promote growth processes of the juveniles to some extent. However, as discussed in Section 2.3.1.c.ii, specific conclusions regarding the effects of altered temperature on chinook growth cannot be made.

Overall, impacts of the changes in water temperatures associated with Stage III are expected to be less severe than those expected under Stage II and the response of juvenile chinook rearing is expected to be similar to that described for Stage I operation.

Similarly, effects on juvenile chinook overwintering habitats in side sloughs and side channels (Representative Groups 2 and 3) are expected to be similar to those described under Stage I and Stage II operation. A major difference is that overwintering habitats located downstream from the ice front are not as likely to be overtopped as under Stage I or Stage II operation. Estimates of sites in the middle river expected to be breached during Stage III operation given the 1981-1982 winter climate conditions are presented in Table E.3.2.118. These are compared with the sites expected to be breached during operation of Stage II under similar climatic conditions.

Upstream of the ice front, survival of juvenile chinook during the winter is expected to be greater than under natural conditions as described in Section 2.3.1.c.ii.

.. Effects on Chum Spawning and Incubation Habitats (***)

The effects of the altered temperature/ice regime during Stage III of the Susitna Hydroelectric Project operation are expected to be similar to those described for Stage I and Stage II of project operation. The major difference is that chum salmon embryos deposited in sloughs and side channels upstream of the expected ice front progression under Stage III but within the potentially affected reach during Stage II will be more likely to survive than under Stages I or II conditions.

° Effects on Other Evaluation Species/Habitats Combination (***)

The changes in water temperature/ice regimes associated with Stage III of project operation are expected to affect the other species/habitats combinations in a manner similar to those described in Sections 2.3.1.c.ii and 2.3.2.c.ii. The prolongation of higher water temperatures in the fall and the reduced progression of the ice front upstream in the winter will further enhance the effects described previously for the other salmon species and resident fish. No additional effects to upstream migration, spawning and incubation, rearing and overwintering or outmigration are expected.

- Effects of Altered Suspended Sediment Regimes (***)

Downstream water releases during Stage III operations are expected to be less turbid and to contain less inorganic suspended sediments than water releases during other project operational conditions. Total suspended sediment concentrations and estimated turbidity levels under Stage III operations are presented in Table E.3.2.119. During the open water season of May through September the middle river mainstem flows should be somewhat less turbid, and the suspended sediment concentrations are expected to be substantially reduced relative to natural conditions. During the October through April season, however, the project water releases are expected to contain greater than natural concentrations of suspended sediments and turbidity values.

The direct effects of project induced alterations of the TSS and turbidity regimes to juvenile and adult fish in the middle river reach are expected to be stressful, but not lethal during any seasonal period. Juvenile and adult fish which are chronically exposed to turbid mainstem flows are expected to survive. The indirect effects to the fish community of disturbances of detrital, primary producer and secondary producer trophic levels by the altered sediment regime are presently uncertain and unquantifiable.

It is anticipated that most salmonid spawning and incubation subjected to chronically turbid conditions will be substantially curtailed. Mainstem and peripheral habitat spawning and incubation sites not protected by clear upwelling flows and subjected to chronically turbid mainstem waters fall into this category.

- Effects of Other Altered Water Quality Changes (***)

No additional water quality changes attributed to Stage III operations are anticipated to cause biologically significant habitat changes within the middle river reach.

(iii) Talkeetna to Cook Inlet (***)

- Effects of Altered Flow Regime (***)

In general, the flow regime in the lower river during Stage III Operation is not expected to be significantly different from the flow regimes described for Stages I and II. The gradual increase in winter discharge and decrease in summer discharge described for the early and late Stage III flow regimes in the middle river will be reflected in the respective flows regimes in the lower river. Summaries of the maximum, mean and minimum average monthly discharges expected at the Sunshine Station during early and late Stage III operation are presented in Table E.3.2.120. Summaries for the Susitna Station in the lower river are presented in Table E.3.2.121.

. Effects on Principal Evaluation Species/Habitat Combination (***)

.. Chinook Rearing Habitats (***)

During Stage III-Operation in the lower river, chinook rearing habitats will be approximately the same as that described for Stages I and II. Habitat areas in side channel and side slough habitats are expected to be slightly greater than under natural conditions. Habitat areas in tributary mouths are expected to be less than under natural conditions. This is evident from the comparison of the average discharges at Sunshine presented in Table E.3.2.120 with the aggregate habitat quality relationships provided for lower river modeled sites in Figures E.3.2.83 and E.3.2.84. A summary of the estimated rearing habitat indices for side channel side slough complexes under the natural flow regime and the Stage III flow regimes is presented in Table E.3.2.122. Estimated rearing habitat indices for tributary mouths are also presented for the natural and Stage III flow regimes in Table E.3.2.122.

The slightly greater discharges during the winter months for the late Stage III flow regime are expected to increase the survival of juvenile chinook in overwintering areas for the reasons discussed for the middle river habitats in Section 2.3.3.c.ii. Hence, no significant changes to chinook rearing habitats are expected to occur in the lower river between the Stage II and Stage III flow regimes.

.. Chum Spawning/Incubation Habitats (***)

As discussed previously, little chum spawning activity occurs in habitats influenced by the lower river mainstem discharge. Hence, the changes in habitat conditions associated with the Stage III operational flow regime are not expected to affect chum spawning populations.

. Effects on Other Evaluation Species/Habitat Combinations (***)

Because the differences in flow regime between Stage II and Stage III in the lower river are not great, effects of the Stage III flow regime to other evaluation/species/habitat combinations are not expected to be significant.

- Effects of Altered Temperature/Ice Regime (***)

During operation of Stage III of the project changes in the temperature and ice regimes from those expected during Stage II operation are expected to be minimal. Therefore, the effects on Evaluation species/habitat combination in the lower river are not expected to differ from those expected during Stage II operation. Summer temperatures are expected to be within the ranges present under natural conditions principally because of the influence of the Chulitna and Talkeetna Rivers. Winter ice processes will, likewise, be similar to those experience during Stage II.

Overall no additional effects beyond those described in Sections 2.3.1.c.iii and 2.3.2.c.iii are expected which are attributable to changes in water temperature.

- Effects of Altered Suspended Sediment Regime (***)

Conditions in the lower river during Stage III - Operations are essentially like those described for Stage II - Operations (Section 2.3.2.c.iii) except that the suspended sediment concentrations and turbidity values are expected to be lower.

Direct effects on juvenile and adult fish will be stressful, but not lethal. Lower trophic level biological activities are expected to be more productive than during natural conditions during May through September, but less productive than during natural conditions from October through April. The indirect effects of changes in the temporal regime of biological activities of the lower trophic level organisms on the fisheries populations is unknown.

- Effects of Other Altered Water Quality Factors (***)

Stage III - Operational conditions are not expected to cause major water quality changes other than those previously discussed which would be of biological significance to riverine habitats within the lower river reach.

(iv) Estuary at Cook Inlet (***)

As previously discussed, all project filling and operational conditions are expected to cause continuous (i.e. during all seasons) riverine transport of suspended sediments to the river estuary at Cook Inlet. Ecological effects on the estuary are expected to be minimal, as previously discussed in sections regarding Stage I and II.

(d) <u>Summary of Impacts Associated with Stage III Watana Dam</u> (***)

(i) <u>Construction Impacts</u> (***)

The effects of construction of the Stage III Watana Dam will be significantly less than those during Stage I and Stage II, since project roads and the camps will be constructed prior to the beginning of this stage. Some transitory impacts, such as increase in turbidity and sedimentation of local waterbodies, will occur during the excavation and movement of the dam fill material. These are not expected to have a significant effect on fish populations.

Increased fishing pressure without specific harvest regulations will continue to affect local fish population.

Borrow Site E will create a lake at the expense of riparian and upland habitat. Rehabilitation measures will be undertaken to convert this lake into productive aquatic habitat.

(ii) <u>Filling</u> (***)

The primary impact associated with filling of the Watana - Stage III reservoir will be the additional loss of clear water tributary habitat. The incremental loss of grayling is estimated to be at least 8,800. The reservoir is not expected to provide any replacement habitat.

Flows downstream of Devil Canyon Dam will remain within the Case E-VI flow constraints throughout the filling process. With increased storage, the capability of the Project to regulate downstream flows will be greatly increased. As project energy production increases and outlet works releases are reduced water temperatures can be regulated to be more closely aligned with the natural temperature in the summer months. Warmer releases are expected to persist longer into the fall (September to November) with ice cover formation occurring later and receding earlier in the spring. These conditions are expected to benefit downstream fisheries resources.

(iii) Operation (***)

Potential impacts are expected to be similar to those for operation of the Devil Canyon Dam (see Section 2.3.2.c) and those for filling of Watana reservoir (see previous Section 2.3.3.b.i). Case E-VI flow constraints will be followed throughout operation. Measures implemented in Watana - Stage I will continue to mitigate for impacts.

2.3.4 - Impacts Associated with Access Roads, Site Roads, and Railroads (**)

(a) Construction (**)

(i) Construction of Watana Access Road and Auxiliary Roads (**)

The main access to the Watana damsite will be from the Denali Highway (APA 1982a). The Watana access road will depart the Denali Highway at Milepost 114 and will run 41.6 miles (69.3 km) south to the dam and campsites (Figures E.3.2.14 and E.3.2.15). The northern portion of the route traverses high, rolling, tundra-covered hills. The road will cross numerous small streams such as Lily Creek, Seattle Creek, and Brushkana Creek (Table E.3.2.21). The northern streams, which are part of the Nenana River drainage, contain grayling and other resident species. The southern part of the road will cross and parallel Deadman Creek, which also contains grayling and other resident species.

The gravel road will have a crown width of 24 feet (7.3 m). Before road construction is begun, a corridor at least 10 feet (3 m) wide on either side of the road itself will be cleared.

Short access roads will be needed to reach material sites and disposal sites. The locations and alignments of these auxiliary access roads will be determined when material sites and disposal sites are identified during final road design.

Prior to access construction, ADOT/PF plans to upgrade the Denali Highway from Cantwell to Paxson. Upgrading will include straightening road curves, improving bridges, and topping the road with more gravel.

Within the project area, the Denali Highway crosses several small drainages, side channels of the Nenana River, Edmonds Creek, and Jack River. Jack River contains grayling and the Nenana River in this region supports several species of resident fish (Table E.3.2.56).

Any bridge work or straightening associated with road upgrading will have the potential to cause impacts similar to those resulting from new construction. Extension of culverts in places where the road is widened could affect fish passage.

- Alteration of Water Bodies (**)

  Stream crossings can be a cause of adverse impacts. Bridges and culverts used to cross streams containing primarily grayling on the main access road need to be properly sized and bedded to ensure fish passage. This subject is discussed further in Section 2.4.3. Other causes of adverse road construction impacts can result from the following:

  . Clearing (**)

    Areas of dense or tall vegetation will have to be cleared before road building begins. In some upland areas with tundra vegetation, clearing will be minimal. Clearing causes degradation of habitat when:

    o Cleared areas near streams and lakes are not stabilized and erode into the water body;

    o cleared material is pushed into water bodies causing blockage of fish movements, deposition of organics on substrates, and localized erosion; and

    o clearing along streams affects cover, availability of food organisms, and temperatures in the stream.

  . In-Stream Activity (**)

    During road construction, it is often necessary for heavy equipment to enter water bodies. This can alter the substrate and can cause local and turbidity sedimentation problems.

- Erosion (**)

  Erosion can result from in-stream use of heavy equipment, placement of fill with high organic and/or fines content, lack of stabilization or revegetation on fills and cuts, and incorrectly placed or sized culverts. The increased sedimentation that may result can degrade downstream habitats.

- Fill Placement (**)

  Fills that are placed within floodplains and streams can remove habitat previously used by fish. The severity of the impact depends upon the type and amount of habitat covered.

  Roads can block sheet flow to or across wetlands. When a road with insufficient drainage bisects a wetland, one side becomes ponded while the other side dries. The change in water quantity affects the vegetation and the nature of the wetland. Some wetlands that are contiguous with streams provide rearing habitat for juvenile fish. If the wetlands are dewatered, that habitat can be reduced or lost.

- Changes in Water Quality (**)

As with dam construction, impacts on water quality during road construction will result mainly from erosion and petroleum product spills. Erosion may occur as the result of excavation for placement of drainage structures in streams, runoff from borrow sites, or unstabilized fills, placement of material within water bodies, and heavy equipment operating within streams.

Since many of the systems to be crossed by the road are clear-water grayling streams, they will be among the habitats more sensitive to increases in turbidity, sedimentation, and petroleum products. When equipment is operated in streams or if refueling of equipment takes place within a floodplain, petroleum products may enter a waterbody. Chronic or large spills into these streams during construction could have severe effects upon the biota, either causing mortalities or avoidance of contaminated areas (Maynard and Weber 1981; Weber et al. 1981).

- Disruptions of Fish Populations (**)

Fish will tend to avoid areas where in-stream work is being conducted, areas contaminated by petroleum products or, depending on the circumstance, areas experiencing excessive turbidity or sedimentation. Temporary barriers to fish movements and migrations can be created when streams are diverted, flumed, or blocked during installation of drainage structures. Fish can also be prevented from moving upstream if drainage structures are incorrectly installed. Pumping of water from streams can adversely affect local populations by entraining juvenile fish or by reducing localized flows.

During road construction, the area between the Denali Highway and the Watana damsite will be occupied by hundreds of workers. Although this area has been recreationally utilized in past years, it has never experienced such a large influx of people. This influx could increase fishing pressure on the streams and lakes in the area.

(ii) Construction of Devil Canyon Access Road and Auxiliary Roads (**)

Access to the Devil Canyon damsite will be by road north of the Susitna River from Watana and by rail from Gold Creek along the south side of the Susitna River. The road will depart from the Watana road north of the Watana townsite at mile 38.5, and will parallel Tsusena Creek for approximately 1.5 miles (2.5 km). The route then roughly follows the 2900-foot (878-m) contour west to Devil Creek. The road turns south along Devil Creek for about 2 miles (3 km) and proceeds southwesterly to intersect the Susitna River at approximately RM 150. The road crosses the Susitna and parallels an unnamed creek for a short distance, ending at the construction camp and village site. The road between Watana and Devil Canyon will be constructed in the same manner as the segment from the Denali Highway (see Section 2.3.4.a.i).

The Devil Canyon access road traverses high tundra throughout most of its length. Dense shrub vegetation and trees are encountered when the road nears the Susitna River crossing downstream from Devil Canyon. The road crosses numerous small streams between Tsusena and Devil Creeks. A waterfall 3 miles upstream of the confluence of Tsusena Creek and the Susitna River divides Tsusena Creek into an upper and lower watershed. The lower watershed contains grayling and sculpin, while the upper watershed contains stunted Dolly Varden and sculpins. The road crosses Tsusena Creek approximately 3 miles upstream of the waterfall (ADF&G 1984a). A waterfall on Devil Creek 1.5 miles above its mouth presents a barrier to fish migrations. Grayling are present below this barrier, while only sculpin were found upstream, in the area of the road crossing (ADF&G 1984a). Between Devil Creek and the Susitna River, there appear to be few areas that provide habitat for fish. The road between Watana and Devil Canyon will be constructed in the same manner as the Denali to Watana segment.

The railroad access will depart from the existing railroad at Gold Creek and proceed north and east to the construction campsite (Figure E.3.2.17). It will remain on the south side of the Susitna River. The railroad will cross Gold Creek, known to contain chinook and pink salmon (ADF&G 1983a, 1984h, 1985b); Waterfall Creek, known to contain grayling, chinook salmon, and sculpin in its lower reaches; an unnamed tributary of Slough 21 that contains chinook fry and sculpin in its lower reaches; and three tributaries of Jack Long Creek, which is known to contain chinook, pink, chum, and coho salmon, rainbow trout, Arctic grayling, and sculpin (ADF&G 1984h). The railroad parallels Jack Long Creek for approximately 3 miles (5 km) to the railroad terminus and turnaround at Devil Canyon, adjacent to the upper reaches of Jack Long Creek.

- <u>Alterations of Water Bodies</u> (**)

  Impacts to aquatic habitat can result from stream crossings and other instream activities. Flood-plain and side-channel habitat in Devil Creek, Tsusena Creek, and Jack Long Creek could be affected by road and railroad alignment. Stream crossings and drainage structures are discussed in Section 2.4.1.c. Impacts identified for the Denali Highway to Watana segment are also applicable to the Devil Canyon access.

  Railroad construction between Devil Canyon and Gold Creek would have impacts similar to road construction: aquatic habitat could be affected by fills, clearing, and stream crossings.

- Changes in Water Quality (**)

It is expected that water quality could be affected by turbidity and petroleum product spills as was discussed for Watana access.

- Disruptions of Fish Populations (**)

Fish populations in areas affected by the Devil Canyon road, auxiliary roads, or the railroad could experience disruptions similar to those previously described for Watana access.

(b) Use and Maintenance of Roads (**)

(i) Use and Maintenance of Watana Access Road and Auxiliary Roads (**)

- Alteration of Water Bodies (**)

Impacts on water bodies during road operation could occur as a result of continued maintenance activities. Maintenance involves road grading and replacement of material. Improper maintenance techniques can result in gravel being pushed off the roadway into streams and wetlands and in increased erosion. Road maintenance can have a greater impact on the smaller streams, such as Deadman Creek, than on the Susitna River.

This section considers only the road section from the Denali Highway to Watana Dam; therefore, impacts resulting from road construction will be confined to streams along this road alignment.

- Changes in Water Quality (**)

During continued road use, changes in water quality can occur as a result of fuel spills and erosion from poorly stabilized road surfaces and fill areas. Large fuel spills would have the greatest impact on the aquatic habitat.

The Watana access road will cross numerous streams, some of which contain grayling. In areas where the road crosses or encroaches on a waterbody, an accident involving transport vehicles, including those carrying petroleum products, could occur. The impacts associated with spills will depend upon the season, the type and amount of substance spilled, the size of the waterbody into which the spill occurs, and the fish species present.

Erosion from unstable road cuts could be locally chronic; however, these activities are not expected to cause major impacts. The measures planned to minimize these impacts are discussed in Exhibit E, Chapter 2, Section 4.4 and 6.11.

- Disturbance of Fish Populations (**)

Fish have been known to avoid areas contaminated with petroleum products (Maynard & Weber 1981; Weber et al. 1981) and areas of excessive sedimentation or turbidity (Iwamoto et al. 1978). Chronic seepage of oil into streams or lakes could render some areas unusable. Obstruction of fish passage caused by either physical or velocity barriers have been discussed under Section 2.3.4.a.i).

The adverse impacts upon fish populations from the increased accessibility of fish streams and lakes to fishing pressure via the network of access roads could be a greater impact than that resulting from construction and maintenance of the road system. As stated in Section 2.3.4.a.i, the Watana access road will cross Brushkana, Lily, Seattle, and Deadman Creeks as well as other small, unnamed streams. These creeks are clear-water streams and many are inhabited by grayling. Deadman Creek, in particular, is known for its abundant population of large grayling. The reach of Deadman Creek between the falls and Deadman Lake is considered prime grayling habitat. By subjecting this stream to increased fishing pressure, many of the larger, older fish will be removed from the population, altering the age structure and possibly reducing reproductive potential. A similar impact may occur to other grayling streams in the area.

(ii) Use and Maintenance of Devil Canyon Access Road, Site Roads and Railroad (**)

Aquatic habitat and fish populations will be influenced by the existence of roads and railroads through activities such as road traffic and road maintenance.

- Alteration of Water Bodies (**)

  The majority of adverse impacts will have occurred during road construction. Activities such as road grading and replacement of drainage structures could continue to affect stream systems.

- Changes in Water Quality (**)

  The impacts on water quality that may occur during operation of the Watana access road, are also applicable to the Devil Canyon access road and site roads.

- Disruptions of Fish Populations (**)

  Disruptions of fish populations that could result from operation of the Devil Canyon access road, auxiliary roads, and railroad are: avoidance of areas of unacceptable turbidity, sedimentation, and contamination; blockages of fish passage; and increased angling pressure.

2.3.5 - Transmission Lines Impacts (**)

~~(a) Construction of Transmission Line (**)~~

(i) Stage I Watana Dam (**)

A detailed description of the Stage I transmission facilities is presented in Exhibit A, Section 5.

- Alteration of Water Bodies (**)

  Adverse impacts to water bodies during construction of the Stage I transmission lines could result primarily from clearing stream crossings, road construction, and instream activities associated with installation of the towers and conductors. Permanent roads may be built to provide all-season access. The effects of clearing a right-of-way, and heavy equipment traffic on an aquatic environment have been previously discussed in Section 2.3.4.

  The transmission system can be divided into four segments: central (Watana to Gold Creek), Intertie

(Willow to Healy), northern (Healy to Ester), and southern (Willow to Anchorage). In the central section, the lines will closely parallel the Watana-Devil Canyon access road and railroad spur for much of their length. They will cross Tsusena Creek, Jack Long Creek and several small tributaries of the Susitna River. The impact of constructing transmission line through this area will be similar to, but less than, that of the access road. See Section 2.3.4 for a description of river and streams to be crossed in the central segment.

In the Intertie segment, the lines cross the Nenana, Talkeetna, Susitna, and Kashwitna Rivers, Chunila Creek and other smaller streams. The waterbodies crossed and their fish resources are described in the Environmental Assessment Report prepared for the construction of the Anchorage-Fairbanks Intertie (Commonwealth et al. 1982).

In the southern segment, the lines will cross several Susitna River tributaries, Knik Arm and Ship Creek. Table E.3.2.57 lists the major streams to be crossed and the species that inhabit them. The streams and fish species for the northern leg are listed in Table E.3.2.58.

During the transmission line construction, it will be necessary for heavy equipment such as hydroaxes and drill rigs to cross streams. Several factors will influence the severity of impact on the aquatic habitat.

- o Season in which construction takes place;
- o Size of the stream;
- o Type of habitat in the crossing area;
- o Species present;
- o Frequency of crossing;
- o Type of crossing (i.e. temporary bridge, temporary culvert, low water crossing);
- o Streambank configuration; and
- o Streambed composition.

It is expected that small, confined streams will be more susceptible to adverse impacts from transmission line construction than will larger streams.

If "all-weather" access is maintained for the transmission line, a gravel road would be built along their entire length and permanent stream crossings installed, with attendant, long-lasting impacts. The road and stream crossings would have to be monitored to ensure that fish passage is maintained and aquatic habitat is not degraded. Although the transmission corridor would be many times longer than the access road previously described, the range of possible impacts is similar.

The access points for construction of the transmission lines will be decided during the detailed design. The Willow to Healy section will probably use access established during construction of the Intertie. It is likely that access will require crossing streams and wetlands.

Details of the installation of the cable under Knik Arm are to be developed during final design. Knik Arm is primarily a migration route for anadromous species that utilize the Knik and Matanuska River drainages, including five species of Pacific salmon, Dolly Varden, eulachon, and Bering cisco. Benthic organisms and other resident species are sparse because of the excessive amounts of glacial material on the sea floor. It is unlikely that installation of the underwater cable in this area will have any effect upon resident or anadromous species.

- Changes in Water Quality (**)

It is expected that temporary increases in turbidity and sedimentation will occur in streams subjected to instream activities during construction of transmission lines. Small, clear water systems will most likely be affected to a greater extent than will large systems. The effects are not expected to be long-term.

In addition, streams that are crossed will be exposed to possible contamination by petroleum products due primarily by vehicle accidents. The measures planned to minimize the impacts on water quality are discussed in Exhibit E, Chapter 2, Sections 4.5 and 6.11.

- Disturbance of Fish Populations (**)

Avoidance reactions associated with increased turbidity and sedimentation may occur. Fish may also avoid areas where instream activities occur and, depending upon the timing, migrations could be affected. Where transmission lines cross a stream, clearing may remove overhanging vegetation that provides cover for fish.

Construction of the lines could result in increased fishing pressure. During construction, this will most likely be confined to workers. The effects will be greater in the northern and central segments where access has previously been limited.

(ii) Stage II Devil Canyon Dam (**)

A detailed description of the Stage II and Stage III transmission facilities is presented in Exhibit A, Sections 10 and 15, respectively. Significant new impacts are not expected with these additions, since the majority of the system will be completed during Stage I (see Exhibit A, Section 5.2.1).

(b) Operation of the Transmission Line (**)

(i) Stage I Watana Dam (**)

Once the transmission lines have been built, there will be few activities associated with routine maintenance of towers and lines that could adversely affect aquatic habitat. However, maintenance of all-weather roads would entail efforts similar to that for the access road.

- Alteration of Water Bodies (**)

Some localized habitat disruption could occur when maintenance vehicles need to cross wetlands and streams to repair damaged lines or towers. Where roads are not built in conjunction with transmission lines, some revegetation is allowed to proceed around the towers. This is usually limited to grasses, shrubs, and small trees by selective clearing so that vehicles are able to follow the cleared area associated with the lines. Streams may need to be forded in order to effect repairs. Depending on the season, crossing location, type and frequency of vehicle traffic, aquatic habitat in the immediate vicinity of the crossing could be affected. In addition, downstream reaches may be affected by increased sedimentation caused by erosion.

- Changes in Water Quality (**)

Changes in water quality during maintenance of the transmission lines may result from increased turbidity and sedimentation, instream activities and fuel contamination.

- Disturbance of Fish Populations (**)

Instream activities associated with line repair and maintenance could cause disruptions of fish populations in limited areas. The greatest disruption would result from the increased accessibility to some fishing areas via the cleared transmission corridor. Because the vegetation would be kept relatively low, hikers and all terrain vehicles could use the corridors as trails. In winter, snow machines would also be able to traverse these cleared areas. This would result in greater numbers of fishermen being able to reach areas previously experiencing little or no fishing pressure. This effect would be more acute in areas where the new transmission route diverges from existing roads and transmission lines, such as south of Willow and north of Healy. The area between Healy and Willow has been subjected to disturbance and increased fishing pressure during construction of the Anchorage/Fairbanks Intertie. Any increased fishing pressure along the Intertie as a result of the Susitna lines being added to the corridor would probably be minor. The presence of a transmission cable under Knik Arm should cause no impacts to fish populations.

(ii) Stage II Devil Canyon Dam and Stage III Watana Dam (**)

The addition of lines following construction of Stage II Devil Canyon Dam and Stage III Watana Dam is not expected to result in significant incremental maintenance impacts over those for Stage I the Watana Dam.

2.4 - Mitigation Issues and Mitigating Measures (**)

2.4.1 - Approach to Mitigation (**)

The objective of fisheries mitigation planning for the Susitna Hydroelectric Project is to provide habitat of sufficient quality and quantity to maintain natural reproducing populations where compatible with project objectives. This is consistent with the mitigation goals of the USFWS and the ADF&G (Table E.3.1.1).

The priorities for aquatic mitigation, as discussed in Section 1.3 (Figure 3.1.1), were determined by employing the hierarchical approach to mitigation contained in the Applicant's, USFWS and ADF&G mitigation policies. The five basic mitigative actions, in order of priority, are:

- o Avoid impacts through design features or schedule activities to prevent loss of resources.
- o Minimize impacts by carefully scheduling and locating operations, timing and controlling flow releases, and control impacts through best management practices.
- o Rectify impacts by repairing disturbed areas to provide optional fish habitat and reestablishing fish in repaired areas.
- o Reduce or eliminate impacts over time through monitoring, maintenance, and proper training of project personnel.
- o Compensate for impacts by conducting habitat construction activities that rehabilitate altered habitat or by managing resources on project or nearby public lands to increase habitat values.

Avoidance of impacts to the aquatic environment has been considered throughout project studies. During the initial site selection screening process (Exhibit E, Chapter 10), the proposed project was selected from 91 potential sites as the most favorable for meeting the future energy requirements for Southcentral Alaska. One of the key criteria amongst other environmental, engineering and economic criteria was whether or not significant anadromous runs existed upstream of the site. The proposed site scored high because no anadromous fish pass upstream of the Watana site and only a few (less than 100) pass upstream of the Devil Canyon site. Therefore, the selection process showed that the location of the proposed site would avoid many of the potential impacts that would be found at other sites where large numbers of anadromous fish migrate upstream of the site.

Avoidance or minimization of impacts were also heavily considered in the initial design of the dams. The two most prominent mitigation features incorporated into the dams are fixed cone valves used to avoid downstream dissolved gas supersaturation and multi-level intakes which are used to minimize any potential impacts from an altered water temperature regime. These features will be incorporated into both dams. Details about them are provided in Exhibit E, Chapter 2.

Once site selection and initial design features were considered, the main priority for aquatic mitigation was through flow regulation. Habitat improvement measures that increase the productivity of the habitat or provide additional habitat within the Susitna Basin were the next priority. These measures will be used for impacts that cannot be mitigated by flow regulation. Fish propagation facilities would be proposed as compensation, the least preferred mitigation option.

Each of the following impact issues is addressed in terms of the five mitigation actions. Table E.3.2.123 summarizes mitigation features for major impact issues associated with operation of the project.

2.4.2 - Selection of Project Evaluation Species (**)

Selection of evaluation species is a necessary step in assessing impacts and in developing mitigation plans. 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, and mitigation plans for one species may conflict with those proposed for another. Selection of evaluation species can provide a mechanism to resolve potential conflicts and provide direction for analysis and planning.

The evaluation species were selected after initial baseline studies and impact assessments had identified the dominant species and potential impacts on available habitats throughout the year. Mitigation plans designed to reduce impacts on habitat parameters that control populations were then developed.

Fishery resources of the Susitna River and activities associated with the proposed project were reviewed. Evaluation species were selected on the basis of the following criteria:

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

Species with high regional visibility and commercial, sport, subsistence, or aesthetic value were given priority. Within this category, species sensitive to project effects were rated at a high level of importance. Since the evaluation species play a dominant role in the ecosystem, they may serve as indicator species. By maintaining critical habitats for evaluation species, many of the potential impacts on less sensitive species or species with a lower evaluation priority will be mitigated.

Five species of Pacific salmon (chum, chinook, coho, sockeye and pink) were designated as evaluation species for the Susitna River downstream from Devil Canyon. In addition, rainbow trout, burbot and Dolly Varden were included as evaluation species. Arctic grayling was selected as the evaluation species for the impoundment zone.

Since the greatest changes in downstream habitats are expected in the reach from Devil Canyon to Talkeetna, fish using that portion of the river were considered to be the most sensitive to project effects. Because of the differences in their seasonal habitat requirements, not all fish species nor life stages would be equally affected by the proposed project. In the middle river, chum and sockeye salmon spawning, incubation, and early rearing in sloughs and juvenile chinook salmon rearing in the mainstem appear to be most vulnerable because of their dependence on these habitats. Between chum and sockeye, the former is the most dominant species in the middle river.

Spawning and incubation life stages for chinook and coho salmon occur in tributaries. This habitat type will not be affected by the project. Much of the chinook rearing occurs in tributaries (again, not affected by the project) and in turbid mainstem side channels. Coho rearing occurs in tributaries and upland sloughs, both of which should not be affected. Chum spawning and incubation occurs in both tributaries and side sloughs. It is only those that spawn in the sloughs that will be potentially affected. Sockeye salmon in the middle river only spawn in sloughs. Spawning in these areas is considered atypical because this species generally spawns in streams that have nearby access to a lake for rearing. No such lakes exist in the middle Susitna River, however, the few sockeye that do spawn in the middle river are able to utilize upland sloughs for rearing. While some pink salmon spawn in slough habitats in the middle river, most of these fish utilize tributary habitats.

Mitigation measures proposed to maintain chum salmon productivity will allow sockeye and pink salmon to be maintained as well. Maintenance of chinook rearing habitat will provide sufficient habitat for less numerous resident species with similar life stage requirements.

The greatest change to resident fish will occur in the impoundment zone. In the impoundment zone, Arctic grayling was selected as the evaluation species because of their abundance in the area, their sensitivity to impacts during all seasons and life stages, and their desirability as a sport fish.

Based on the habitat utilization by various life stages, certain evaluation species were given more emphasis in the analysis because some of these life stages would be directly affected by the project and this could be critical to their survival. As a consequence, the evaluation species and life stages selected for the Susitna Hydroelectric Project are:

(a) Devil Canyon to Cook Inlet Reach (**)

PRIMARY

Chum Salmon

- Spawning adults
- Embryos and pre-emergent fry

Chinook Salmon

- Rearing juveniles

SECONDARY

Chum Salmon

- Returning adults
- Rearing juveniles
- Out-migrant juveniles

Chinook Salmon

- Returning adults
- Out-migrant juveniles

Sockeye Salmon

- Returning adults
- Spawning adults

- Embryos and pre-emergent fry
- Rearing juveniles
- Out-migrant juveniles

<u>Coho Salmon</u>

- Returning adults
- Rearing juveniles
- Out-migrant juveniles

<u>Pink Salmon</u>

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

<u>Arctic Grayling</u>

- Adults
- Juveniles

<u>Rainbow Trout</u>

- Adults
- Juveniles

<u>Dolly Varden</u>

- Adults

<u>Burbot</u>

- Adults
- Juveniles

(b) <u>Impoundment Area</u> (**)

PRIMARY

<u>Arctic Grayling</u>

- Adults
- Juveniles

2.4.3 - Mitigation of Construction Impacts Upon Fish and Aquatic Habitats (*)

Mitigation of construction impacts is achieved primarily by incorporating environmental criteria into pre-construction planning and design, and by good construction practices. Best Management Practices (BMP) manuals (APA 1985a through 1985e) and a report on bridge and culvert design (HE 1985b) have been prepared through a coordinated effort involving federal, state and local government agencies and special interest groups. These manuals contain environmental guidelines and techniques to be incorporated into contractual documents prepared for the construction of the Susitna Hydroelectric Project.

The aquatic studies program will continue to make major contributions to pre-construction planning and design. Studies will be used in siting, design and scheduling of project facilities and activities. For example, the final alignment of the Watana access road will take into consideration the fish streams along its route. The route will be sited to avoid encroachment on streams and to minimize cut banks.

Biological information has been incorporated into the BMP manuals. A high degree of communication and cooperation will be maintained between environmental staffs and design and construction personnel in order to facilitate continued integration of biological criteria into designs, specifications, and construction practices.

Monitoring of the construction facilities and activities (as described in Section 2.6.1) will ensure that impacts to the aquatic environment are avoided or minimized. Monitoring can identify areas that may need rehabilitation or maintenance and areas where previous mitigation measures are proved inadequate and remedial action is needed. Costs associated with construction monitoring are outlined in Table E.3.2.124.

Potential impacts are identified in Section 2.3. The following is a discussion of the impact issues and the mitigation measures that will be applied during and after construction. Those issues considered to have the greatest potential for adverse impact to the aquatic environment are discussed first. Avoidance, minimization, rectification and reduction of impacts are discussed. There are no direct costs associated with these mitigations because they will be implemented as part of construction activities.

(a) Stream Crossings and Encroachments (*)

(i) Impact Issue(*)

Improperly constructed stream crossings can block fish movements and/or increase siltation in the stream. Roads with inadequate drainage structure can alter run-off patterns of nearby wetlands and streams. Encroachments on stream courses can alter hydraulic characteristics and increase siltation of streams, thereby affecting fish habitat.

(ii) Mitigation(*)

The objective of constructing stream crossings is to maintain the natural stream configuration and flow (Lauman 1976) so that passage of fish is assured. Maintenance of fish passage is required under AS-16.05.840. Procedures and guidelines prepared by the Applicant (APA 1985a) and HE (1985b) will be utilized to design and construct stream crossings. Appropriate control measures will be undertaken as part of routine maintenance to insure that beaver dams and accumulated debris do not interfere with fish passage needs. For the project area, the evaluation species used in developing criteria for stream crossings is Arctic grayling.

- Presence or Absence of Fish/Fish Habitats (*)

Streams having documented fish or fish habitat at or upstream from the road crossing will be designed to pass fish. Only those streams without fish or fish habitat at, or upstream from, the road crossing will be designed solely on the basis of hydrologic and hydraulic criteria.

- Location of Crossing (*)

Project roads will be aligned and located to minimize the number of stream crossings. When crossings are unavoidable, they will be located, whenever possible, at a right angle across the stream in a straight stretch with narrow, stable banks that do not require cutting or excessive stabilization. The crossings will be located so as to avoid, to the greatest extent practicable, important habitats, such as spawning beds and overwintering areas.

- Type of Crossing Structure (*)

Bridges will be utilized wherever streamflows are large. Open-bottom arch culverts, which maintain the natural substrates, will be installed wherever possible (Figure E.3.2.119). Multiplate elliptical and oversized circular culverts can also be used to maintain the natural streambed (Joyce et al. 1980a; Lauman 1976) and will be used when open-arch culverts are not feasible. Standard-size circular culverts will only be used in drainages that are not considered fish habitat.

During winter transmission line construction, snow and ice bridges will be used to cross streams. These will be removed before breakup to avoid blocking stream flows.

- Flow Regime (*)

Culverts will be designed to allow grayling passage at critical times using the velocity criteria detailed in the "Drainage Structure and Waterway Design Guidelines Report" (HE 1985b). Multiplate elliptical and oversized circular culvert inverts will be set below the streambed elevation to avoid perching and will be armored, when necessary, to minimize erosion at the outlet. Natural stream substrate will be placed on the bottom of the culverts over their entire length.

- Methods of Installation (*)

When culverts other than open-bottom arches are used, streams will be diverted around the work area until the crossing is completed. On small systems, the stream may be flumed. Diversion or fluming will reduce the amount of siltation downstream from the construction area. Diversion will be accomplished using the procedures detailed in the BMP Manual entitled "Erosion and Sedimentation Control" (APA 1985a) and "Drainage Structure and Waterway Design Guidelines" (HE 1985b) and will adhere to ADF&G permit requirements.

In some areas, roads and transmission lines must parallel a stream or river. The alignment will be away from the floodplain to the greatest extent feasible. Where this is not possible, the road will be aligned to preclude channelization of the stream. Culverts and drainage structures will be installed under the fill to maintain the integrity of the road and the existing water drainage patterns.

The transmission towers will be spaced and aligned so that structures are out of streams and floodplains to the best extent practicable. Instream activities will be confined to installation of drainage structures on access routes using guidelines to minimize impacts (APA 1985a, and HE 1985b). Where practicable, construction will be scheduled for winter months when heavy equipment can cross frozen creeks without elaborate constructed crossings. Stream crossings at major fish streams will be avoided by utilizing secondary trails from existing roads and railroad corridors.

(b) Increased Fishing Pressure (*)

(i) Impact Issue (*)

The sport fishing pressure on the local streams and lakes will substantially increase. The access road and transmission line will allow fishermen to reach areas that previously received limited use.

(ii) Mitigation (*)

During the construction phase, access to the streams will be limited by closing roads to unauthorized project personnel and the general public. Some watersheds, such as the Deadman Creek/Deadman Lake system, may require modification of current regulations if stocks are to be maintained. These changes may take the form of reduced seasons or catch limits, imposition of maximum size limits, or control of fishing methods. Since public health regulations will not allow sport-caught fish to be stored or prepared at public food service facilities, the project policy will be that all fishing by project personnel be restricted to catch-and-release.

(c) Erosion Control (*)

(i) Impact Issue (*)

Sustained high levels of sediment in a system can change the species composition and productivity of the system (Bell 1973, Alyeska Pipeline Service Company 1974). Siltation can affect development of fish eggs and benthic food organisms.

(ii) Mitigation (*)

The primary mitigation measures that will be used to minimize construction erosion are detailed in the BMP Manual entitled "Erosion and Sedimentation Control" (APA 1985a).

The natural vegetation is a major factor in preventing erosion (Alyeska Pipeline Service Company 1974). Clearing for roads, transmission lines, and other facilities will be confined to the minimum area and level necessary. For transmission lines, only taller trees and shrubs will be removed; the lower vegetation will not be disturbed. Adjacent to streams, especially small systems, clearing will be done by hand. Cleared material will be removed from the floodplain to approved disposal sites, salvaged or burned onsite.

Disposal sites that contain cleared slash, substandard materials, and overburden will be located and configured so that neither run-off during breakup nor rainfall will wash silty material into streams. This may entail run-off control structures, surrounding the disposal site with berms, or channeling run-off through containment ponds.

To preclude run-off from carrying silt to water bodies near construction sites, drainage control will direct silty water into settling basins. Clarified water will be discharged into receiving waters in accordance with the Alaska Department of Environmental Conservation (ADEC) permit requirements (AS-46.03.100).

Prompt grading, mulching, and revegetation of cut-and-fill areas will also be used to minimize erosion.

(d) Material Removal (*)

(i) Impact Issue (*)

Removal of floodplain gravel can cause erosion, siltation, increased turbidity, increased ice buildup caused by ground water overflow, fish entrapment, and alteration of fish habitat.

(ii) Mitigation (**)

Adverse impacts on aquatic habitats will be avoided or minimized by application of guidelines contained in the BMP Manual entitled "Erosion and Sedimentation Control" (APA 1985a).

Buffer zones will be retained at stream margins. Instream activities will be restricted to the installation of stream crossings; material removal from active channels will not be necessary if the material quantity and quality at other sites is as expected.

Surface runoff and water used in material washing will be circulated through sediment settling ponds and reused in material washing. Runoff control structures will be installed at borrow sites.

Discharged water will conform to the water quality standards of the ADEC (18 AAC 70) and the USEPA.

Material will be stockpiled outside the floodplain or armored to avoid erosion. Overburden will be stockpiled for use in borrow site rehabilitation. Material stored in areas which will be inundated will be stabilized and covered with riprap prior to inundation.

The Tsusena Creek material site (Borrow Site E) will be rehabiliated following the cessation of excavation activities at the completion of Stage III. Man-made objects will be removed; exposed slopes will be contoured and revegetated. The site will be shaped to enhance fish habitat (Figure E.3.2.120). This area will be monitored to ensure that grading, revegetation and other mitigation measures are effective.

The Cheechako Creek borrow site (Borrow Site G) will be inundated by the Devil Canyon reservoir and will not require rehabilitation beyond that needed to control erosion.

(e) Oil and Hazardous Material Spills (*)

(i) Impact Issue (*)

Spills of oil and other hazardous substances into streams can be toxic to fish and their food organisms.

(ii) Mitigation (*)

A Spill Prevention Containment and Countermeasure Plan (SPCC) will be developed as required by USEPA (40 CFR 112.7), using the information contained in the BMP manual entitled "Oil Spill Contingency Planning" (APA 1985b).

Equipment refueling or repair will not be allowed in or near floodplains without adequate provisions to prevent the escape of petroleum products. Waste oil will be removed from the site and be disposed of using ADEC/USEPA-approved procedures. The guideline and techniques for handling fuel and hazardous wastes are described in a BMP manual (APA 1985d). Fuel storage tanks will be located away from waterbodies and within lined and bermed areas capable of containing the tank volume plus freeboard for precipitation. Fuel tanks will be metered and all outflow of fuel accounted for. All fuel lines will be located in aboveground or ground surface utilidors to facilitate location of ruptured or sheared fuel lines.

Vehicle accidents, although difficult to fully protect against, can be minimized by constructing the roads with properly designed curves to accommodate winter driving conditions. The roads will be adequately signed, and during the winter, difficult stretches will be regularly cleared and sanded. In summer, dust control will be accomplished with water.

State law requires that all spills, no matter how small, be reported to the ADEC (18AAC70.080). Personnel will be assigned to monitor the storage and transfer of oil and fuel, and to identify and clean up spilled oil and other hazardous material.

All personnel employed on the project, especially field personnel, will be trained to respond to fuel spills in accordance with an approved oil spill contingency plan. The plan will describe:

- o Actions to take as a first response in the event of a fuel spill.
- o Persons to contact in the construction organization and in state agencies.
- o Locations of sensitive habitats.
- o Location of all oil spill control and cleanup equipment, the types of equipment at each location and appropriate procedures.
- o Records to keep during an oil spill and cleanup operation.

Oil spill equipment will be prepositioned and adequate to handle the largest spill expected. Personnel will be trained in the operation of the equipment, and the equipment will be inventoried and tested regularly to make sure it is in proper working order in the event of an emergency.

Impacts from any major oil spill will be assessed in conjunction with monitoring activities (see Section 2.6). Appropriate mitigation measures will be negotiated in consultation with the involved resource management agencies.

(f) Water Removal (*)

(i) Impact Issue (*)

Fish fry and juveniles can be impinged on intake screens or entrained into hoses and pumps when water is withdrawn from water bodies for miscellaneous uses during construction.

(ii) Mitigation (*)

Measures to be employed during water removal are detailed in the BMP manual entitled "Water Supply" (APA 1985e).

If possible, surface water withdrawal will be from streams or lakes that do not contain fish. If water must be withdrawn from a fish-bearing water body, the Alaska Department of Fish and Game intake design criteria will be incorporated into contractual documents.

The ADF&G criteria are that: (1) all intakes should be screened; (2) openings in the screen should not exceed 0.04 sq in; and (3) water velocity at the screen should not exceed 0.1 ft/sec (0.03 m/sec). No more than 20 percent of the instantaneous flow will be removed at any time.

(g) Blasting (*)

(i) Impact Issue (*)

Blasting in or near fish streams can rupture swim bladders and damage incubating embryos.

(ii) Mitigation (*)

The ADF&G has standard blasting guidelines that establish the distance from water bodies at which charges can be detonated without harming fish. Blasting will be accomplished using these guidelines (Table E.3.2.125).

(h) Susitna River Diversions (*)

(i) Impact Issue (*)

The high diversion tunnel velocities and the heavy bedload of the river make screening of the diversion tunnels infeasible. Fish passing downstream through the diversion tunnels are expected to be lost due to injuries caused by the high velocities encountered in the tunnel. During summer, relatively few fish are present in the vicinity of the tunnel entrance. During winter, resident fish are expected to be entrained into the diversion intake and passed downstream.

The Devil Canyon diversion tunnels will act as barriers to the upstream migration of the few chinook salmon (less than 100) that spawn in tributary habitats upstream of this site.

(ii) Mitigation (*)

The segment of the fish population lost in the diversion tunnel would be lost subsequent to reservoir filling, because of lost tributary habitat and the expected low habitat value in the reservoir (see Section 2.3.1.b). Mitigation for these losses will be achieved by additional impoundment mitigation efforts, as discussed under Mitigation for Inundation Impacts in Section 2.4.4(c).

The loss of chinook habitats above Devil Canyon will be offset by the increased survival of juvenile chinook due to the improvement of mainstem and mainstem-associated habitats downstream of the dam.

(i) Water Quality Changes (*)

(i) Impact Issue (*)

Discharge of camp effluents result in increased levels of metals and nutrient loading. Concrete batching plants release high alkaline effluents.

(ii) Mitigation (*)

Effluents will comply with ADEC/USEPA effluent standards (AS 46.03.100; 18 AAC 70.020; 18 AAC 72.010).

The concrete batching effluent will be neutralized and treated prior to discharge to avoid impacts related to pH and toxic substances (see Exhibit E, Chapter 2, Sections 4.1.1(g), 4.2.1(g) and 4.3.1(g).

(j) Clearing the Impoundment Area (*)

(i) Statement of Issue (*)

The major adverse impact associated with removing vegetation from the impoundment areas is accelerated erosion into the streams.

(ii) Migitation (*)

Clearing will be scheduled annually as close to reservoir filling as is feasible. Vegetation will be cleared to the elevation of the high water level anticipated for each year of filling. Disturbance to the vegetated mat will be avoided. Erosion control methods described in the BMP manual "Erosion and Sedimentation Control" (APA 1985a) will be employed to minimize potential impacts to the aquatic habitats.

2.4.4 - Mitigation of Filling and Operation Impacts (***)

(a) Mitigation of Downstream Impacts Associated with Flow Regime (***)

(i) Impact Issue (***)

As described in the Exhibit A, the proposed project would be constructed in three stages. Stage I would be a dam constructed at the Watana site to an elevation of 2,025 feet resulting in a full pool elevation of 2,000 ft. Stage II will add the Devil Canyon facility. Stage III would raise the full pool elevation of Stage I at Watana to 2,185 ft.

Even though Case E-VI flow constraints will be in effect, the actual flow release schedule for initial filling and operation will vary between each stage. The reasons for this are the differences in runoff patterns, storage capabilities, and energy requirements. Accordingly, impacts would differ in magnitude as well as time of occurrence.

One criterion that influences the establishment of the flow constraints is the choice of the key fish species and/or life stages to be protected. In the reach between Talkeetna and Devil Canyon, chum salmon spawning and juvenile chinook salmon rearing were given primary consideration (Section 2.4.2).

As discussed in Section 2.3, a major fishery concern is the provision of flows between Devil Canyon and Talkeetna that:

- Allow adult salmon passage into and within slough and side channel spawning habitat;
- Maintain a suitable water depth on the spawning beds throughout the spawning period;
- Maintain flow through the spawning gravels during the incubation and preemergence period;
- Provide flow of sufficient quantity to allow the out-migration of fry; and
- Maintain overwintering and summer rearing habitat for juvenile chinook.

Additional fisheries concerns related to instream flow needs of resident and other juvenile anadromous fishes include the need to:

- o Maintain overwintering and summer rearing habitat; and
- o Maintain access to tributary spawning and rearing habitat.

The aquisition of additional information on the relationships between physical processes and habitat utilization of these two species in the middle river subsequent to submittal of the original License Application has permitted addressing these concerns and has resulted in refinement of the original Case C flow regime. Eight environmental flow cases were developed, each designed to achieve specific environmental goals (APA 1984b). These environmental flow cases can be grouped into three broad categories of which Case C, Case E-V, and Case E-VI are representative. These three flow regimes were evaluated and compared in the Fish Mitigation Plan (WCC 1984a). Case C emphasized providing flows that allowed chum salmon access into sloughs for spawning. Case E-V was designed to minimize impacts to both chum salmon spawning and chinook salmon rearing. Case E-VI, the Applicant's preferred regime, was designed primarily to minimize impacts to chinook rearing.

Although the flows under Case E-V minimize impacts to chum spawning, some habitat modification measures would still be necessary to rectify the residual impacts. Furthermore, the effort expended on habitat modification measures necessary to offset the residual impacts to spawning habitat under the Case E-VI regime would not be substantially greater than those for Case E-V. The primary difference between the two regimes, therefore, would be the degree to which impacts to chinook juvenile habitat are minimized or avoided. The hierarchical approach to mitigation option analysis that follows considers flow release schedules for each stage of development with Case E-VI constraints in effect.

(ii) Measures to Avoid Impacts (***)

Adverse impacts to fishery resources resulting from flow alteration will be avoided or minimized through selection of an appropriate flow regime. While hydroelectric developments with storage facilities alter the natural flow regime in the river, changes in streamflow patterns do not necessarily result in adverse impacts to fish populations. For example, if low flows are limiting fish populations, then supplementing low flow may result in enhancement to that population. However, under the proposed flow regimes for filling and each stage of development, passage into sloughs by adult salmon may be impaired and mitigation measures in addition to flow regulation are needed to reduce these impacts.

(iii) Measures to Minimize Impacts (***)

The Case E-VI flow constraints are designed to minimize impacts to juvenile chinook rearing. Loss of spawning habitat for chum salmon, however, would not be minimized by Case E-VI flows. The minimum discharge constraint for Case E-VI is greater than natural flows in the winter months and less than natural discharges in the summer months.

- Winter Flow Regime (October-April) (***)

  - Stage I - Filling (1998) (***)

    Filling of Watana reservoir is scheduled to occur in the first spring-summer runoff period. During the first winter following filling, November 1998 to March 1999, the reservoir level would be held constant or reduced as energy is produced so that releases would equal or exceed inflow. Since no impacts are anticipated, mitigation measures are not proposed.

  - Stage I - Operation (1999) (***)

    Winter flows during the first year of operation would range from approximately 7,000 to 10,000 cfs. As the winter ice cover forms, the staging associated with the higher than natural flows would result in increased upwelling benefitting incubation but might also result in near -0°C mainstem water overtopping some sloughs and possibly retarding the growth and delaying the emergence of embryos that ordinarily incubate at 2-3°C. This upstream progression of the ice front and potential for overtopping would extend to RM 139 in an averge year and would be a few miles upstream or downstream of this in a cold or average year, respectively. Mitigation measures would be necessary for those sloughs with a high likelihood of overtopping.

- <u>Stage II and III - Filling and Operation</u> (***)

  Case E-VI flow constraints will continue to be followed. Since measures to mitigate impacts are based on these constraints and were in place during Stage I, no additional measures would be necessary.

- <u>Spring Flow Regime (May-June)</u> (***)

With-project, the ice cover is expected to substantially melt in place rather than break-up as under natural conditions. During the May-June period flows would be reduced under project flow regimes. Project flows of sufficient quantity would be provided to allow salmon fry to outmigrate from natal sloughs and side channels.

- <u>Summer Flow Regime (July-September)</u> (***)

- <u>Stage I - Filling (1998)</u> (***)

  Summer flow release levels during July and August would depend on the hydrologic conditions of that year. September flows would be within Case E-VI flow constraints. Under dry conditions, flow releases in July and August would be at the Case E-VI dry year minimum of 8,000 cfs. In an average year, July and August flows would be about 12,000 cfs and 13,000 cfs, respectively, somewhat higher than E-VI minimum (9,000 cfs) yet reduced from average natural flows of 24,000 cfs and 22,000 cfs. In a wet year, flow releases would increase to 15,000 cfs and 20,000 cfs, closer to the average natural condition.

  Chum salmon enter spawning areas during the summer. Most of the spawning in the Devil Canyon to Talkeetna reach is confined to sloughs and tributaries. Access to slough spawning areas is apparently provided by a combination of high summer flows in the Susitna River mainstem and local surface inflow. Flow into the sloughs is at least partly controlled by water levels in the mainstem. Upwelling ground water in the sloughs attracts adults, maintains the permeability of spawning gravels, and provides a stable winter flow and temperature during the embryo incubation period.

Detailed analyses of mainstem flows required for successful passage into the major chum salmon spawning sloughs have been conducted by ADF&G (1984r). However, a quantitative assessment of the availability of successful passage conditions during reservoir filling using this information is not possible for average and wet years since the available flow data, mean monthly flows, mask the monthly variability caused by short-term rainstorm events that often provide passage. It can be assumed, however, that since the mean monthly flows for filling are less than those for natural years in August and September for average and wet years that the frequency of successful passage conditions may be reduced. In a dry year, with Case E-VI minimum flows during the spawning period, and assuming no local runoff (no variability around the minimum flow value), passage would be possible at only two passage reaches of the seven sites evaluated - one in Slough 8A and one in Side Channel 21. Additional mitigation measures would be necessary to offset these impacts.

. Stage I -- Operation (1996) (***)

Stage I summer flows would be less than natural, although the flows are substantially greater than E-VI minimum constraints during the chum salmon spawning season (August 12 - September 12). A reduction in the frequency of occurrence of successful passage conditions and availability of suitable habitat would occur. The extent of these reductions for the major chum producing sloughs and side channels (Sloughs 8A, 9, 9A, 11, 21 and Upper Side Channel 11 and Side Channel 21) were analyzed. The results are found in the mitigation plan (WCC 1984a). Mitigation measures in addition to flow regulation would be necessary to reduce the impacts.

. Stages I and II - Filling and Operation (**)

Case E-VI flow constraints will continue to be followed. Since measures to mitigate for impacts are based on these constraints and were in place during Stage I, no additional measures would be necessary.

(iv) Rectification of Impacts (**)

- Winter Flows (**)

Impacts to chum salmon embryos resulting from overtopping of sloughs and side channels during the winter will be rectified by construction of berms at the head of the slough.

The ice staging with Stage I flow will require construction of berms such as those described in the Fish Mitigation Plan (WCC 1984a). Details of the length, height, location and cost of berming that may be necessary for passage are being discussed through consultation with the respective resource agencies. Habitat modification measures proposed for spawning (summer flows) are also being discussed. Cost estimates for berms only at the head of sloughs range from $24,000 to $161,000.

- Spring Flows (**)

If it is shown through monitoring (Section 2.6) that salmon fry require a high flow at breakup in order to stimulate out-migration, a properly timed pulse of sufficient magnitude may be provided.

- Summer Flows (**)

Impacts to salmon spawning areas will occur if mitigation measures are not employed in coordination with the proposed project flows (or the alternative regime of short-term augmented flows). The rectification methods selected are (1) to maintain access to the sloughs; and (2) to ensure suitable spawning and incubation habitat by physically modifying the sloughs, to maximize use of reduced filling and operational summer flows. The following habitat enhancement measures will be applied either singly or in combination on sloughs, depending on the type of impacts that limits salmon production. These methods will maintain salmon productivity in the sloughs.

. Slough Excavation (**)

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

On a larger scale, mechanical excavation to lower the profile of the entire slough is expected to increase the amount of upwelling. Increasing the difference in water level between ithe mainstem and the habitat area would result in additional local flow in the slough.

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

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

. Channel Barriers (**)

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

Channel barriers will be used on long slopes to create fish resting pools, as shown in Figure E.3.2.121). These barriers, with heights of 10 to 14 inches, act as weirs. They have a section of decreased height to improve fish passage between pools. The barriers are constructed of various materials. Concrete, cobbles, or boulders placed to create a sill may be used. Logs or gabions may also be attached to the banks and anchored securely to the bed to prevent movement at high discharges (Lister et al. 1980).

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

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

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

- Channel Width Modifications (**)

Channeling slough flow will improve fish access through passage reaches by constricting the width and increasing the depth of the channel. This is especially useful in modifying short, wide passage reaches (Figure E.3.2.122. Wing deflectors extending out from the channel bank or rock gabions restructuring the cross section of the natural channel may be used to constrict the flow width (Bell 1973).

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

. Wing Deflectors (**)

Wing deflectors will be used to divert the flow in a channel. Two wing deflectors placed on opposite banks will funnel the flow from a wider to a narrower cross section as shown in Figure E.3.2.122. The narrowed channel is designed to provide fish passage at a minimum flow. At higher flows, the wing deflectors are inundated; fill between the banks and the wing deflector walls is sized to prevent scouring at higher discharges. Fill will typically be composed of large cobbles available at the sloughs.

Wing deflector walls will be constructed either of rock or gabions formed of wire mesh and filled with cobbles. Another alternative is the use of 12-inch-diameter timbers, anchored to the banks and channel bed. A wing deflector costs $31,000 when constructed of rock, approximately $24,000 when constructed with gabions, and $22,000 if timber logs available on site are used. For sites where timber is not available, a log wing deflector would cost $23,000. Estimates are based on a typical passage reach of approximately 200 feet for a slough on the Middle Susitna River (Figure E.3.2.122).

. Rock Gabion Channel (**)

Reshaping the original cross section of the channel with rock gabions is an alternative method of channelizing the slough flow. The channel is excavated and gabions are used to establish the new configuration. The new channel shape is designed to maximize depth at minimum flows; at higher discharges, the gabions prevent scouring of the channel banks. Figure E.3.2.122 illustrates a typical cross section for a reshaped passage reach. For long passage reaches, resting areas are created by widening the channel between the rock gabions forming the minimum discharge channel. The gabions are provided throughout the length of the passage reach and protected upstream by riprap or wing wall gabions. The gabion banks extend higher than the height of the maximum slough discharge to prevent collapse from erosion.

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

- Prevention of Slough Overtopping (**)

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

An influx of cold mainstem water into the habitat used for incubation in the Slough 8A in 1982 caused adverse impacts (ADF&G 1983e). To prevent overtopping, the height of the slough berms will be increased as shown in Figure E.3.2.123.

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

- Gated Water Supply System (**)

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

The gated water supply system consists of a corrugated pipe with a gate valve structure. The pipe intake is protected by a riprap cover to prevent the entrainment of fish and debris. The riprap will stabilize the bank of the berm at the intake by preventing scour. Large riprap at the outlet will create turbulent conditions for improved air entrainment and the dissipation of energy to prevent excessive channel bed erosion. The gate valve structure will enable the manual opening of the pipe to allow large flows into the channel. In order to provide the required flow, the pipe system will be operated at a high mainstem discharge. To prevent the influx of turbid water during chum spawning or near-freezing water during incubation, the pipe gate valve will remain closed during the fall and winter months.

The water supply system will be designed to provide as much flow as necessary to maintain the substrate in clean condition and to prevent scour of spawning gravels. The pipe diameter and length will depend on the hydraulic conditions in the mainstem and slough. The estimated cost of a system with 3-foot diameter pipe and a 2,500 foot length is $100,000.

A set of criteria has been developed to establish a means of ranking sloughs for modification on a benefit-cost basis. The criteria applied to each slough include the relative utilization, the frequency of overtopping, the extent of berming required to prevent overtopping, and the location and extent of passage reach modifications. The use of these criteria in a decision making flow chart is presented in Figure E.3.2.124. As indicated in the chart, a slough with higher relative utilization, low probability of winter overtopping, and minor passage reach modification requirements will receive the highest ranking. As information on the extent of berming necessary for each site is acquired, this set of criteria will be applied to each of the major chum salmon producing sloughs.

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

(v) Reduction of Impacts Over Time (o)

A monitoring program will be conducted to evaluate the effectiveness of mitigation measures (see Section 2.6).

(vi) Compensation for Impacts (**)

It is anticipated that flow-related impacts will be adequately reduced with the preceeding mitigation measures. However, if for some reason they do not work, the Applicant will compensate for the lost fishery resources. The goal of this compensation will be to produce the number of fry expected to be lost from the impacted area.

A technique for incubating chum salmon eggs currently in use in British Columbia referred to as an incubation chamber is proposed. The subsurface incubation chamber consists of a wooden box 10 x 20 x 5 ft deep set to a depth of 3 feet below the lowest water table elevation. A slotted wood floor installed in the bottom of the box approximately 6 inches above the base intercepts the groundwater flow.

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

It is estimated that one or two of these incubation chambers would replace all of the chum salmon that might be impacted by the proposed project. The total cost for these chambers would be from $50,000 to $70,000. Although this is the least preferred mitigation option, it is the least costly. The reason that this option is not proposed is that it includes artificial propagation which is the Applicant's third priority mitigation option.

(b) Mitigation of Downstream Impacts Associated with Altered Water Temperature Regime (*)

(i) Impact Issue (*)

The creation of Watana and Devil Canyon Reservoirs will change the downstream temperature regime of the Susitna River. Reservoirs act as heat sinks, reducing the annual variability and the rate of change in water temperatures by moderating summer and winter temperatures and introducing a time lag. The magnitude of change in the thermal regime downstream depends on the thermal stratification of the reservoir and the design of the power intake and release structures.

Some seasonal stratification is expected to occur in Watana Reservoir. (See Exhibit E, Chapter 2, Section 4.1.3(c)(i)). The water temperatures downstream from the dam are set in part by the elevation of the intake structures, which in turn determine the temperature of the water drawn from the reservoir. Since growth rate of many aquatic organisms is temperature-dependent, changes in the thermal regime can affect aquatic communities. Potential adverse effects of higher winter temperatures include acceleration of incubation and early emergence of salmonid embryos and benthic invertebrates. The impact of lower summer temperatures includes slower growth of invertebrates, juvenile anadromous, and resident fish. Changes in the thermal character and its effects will decrease downstream as tributaries contribute to the flow and as the temperature regime approaches an equilibrium state. The impacts related to the thermal changes are expected to be confined to the Talkeetna to Devil Canyon reach.

(ii) Measures to Avoid Impacts (o)

The only mitigative alternative that would completely avoid temperature changes downstream from the project is the no project alternative. Hydroelectric projects involving reservoir storage dams will alter the natural temperature regimes.

(iii) Measures to Minimize Impacts (*)

The impacts associated with alteration of the temperature regime during reservoir operation will be minimized by incorporating multiple-level gates in the power intake. Multiple level intakes have successfully regulated temperature of downstream releases (Nelson et al. 1978).

The success of temperature regulation depends on the thermal structure of the reservoir and the location of the intake ports. A reservoir operation model was used in the design of the multi-level intake structure. Results of the modelling show that the multi-level intake will maintain downstream water temperatures within acceptable limits. Details of the modelling are provided in Exhibit E, Chapter 2. The cost of providing multi-level intake structure for temperature control is provided in Table E.3.2.126.

(c) Mitigation of Inundation Impacts on Mainstem and Tributary Habitats (**)

(i) Impact Issue (**)

The Arctic grayling population in the impoundment area of both reservoirs was estimated to be approximately 20,000 grayling greater than 8 inches (20 cm) (Tables E.3.2.127 and E.3.2.128). This population uses the clearwater tributaries as spawning and rearing habitat and the tributaries and Susitna River mainstem as overwintering habitat. A major project impact will be the loss of grayling spawning and rearing habitat in the inundated portion of the tributaries. Some grayling that will be displaced from inundated tributary habitats are expected to utilize habitats in tributaries above the impoundment water levels or in the impoundment near tributary mouths. Although fishery resources are expected to exist at some level of productivity, for planning purposes, the Applicant is assuming that all existing grayling habitat in the reaches of clearwater tributaries to be inundated will be lost. Although the Stage I Watana impoundment will affect somewhat less area, the Stage III Watana impoundment will ultimately inundate the same area described in the original License Application.

(ii) Measures to Avoid Impacts (o)

The only mitigation alternative that will avoid impoundment impacts for the proposed project is the no project alternative.

(iii) Measures to Minimize Impacts (*)

Mitigation measures that would substantially minimize impoundment impacts to fish populations would be to substantially lower the surface elevation of the reservoir or to maintain water levels during the grayling spawning and incubation period (May through June). Neither measure is economically feasible.

(iv) Measures to Rectify Impacts (*)

Since the impoundment is essentially a permanent impact, rectification measures are not feasible. Rectifying measures, such as providing replacement grayling spawning habitat within the impoundment are not considered feasible because of the timing and magnitude of the drawdown cycle.

(v) Reduction of Impacts (o)

Impacts cannot be reduced over time since no effective mitigation measures have been identified.

(vi) Compensation for Impacts (***)

Measures to compensate for the loss of grayling habitat are the only feasible options proposed for impoundment mitigation planning. Compensation measures have been refined to reflect the Alaska Department of Fish and Game's preferred measures of compensation. In a letter to the Applicant dated 31 December 1984, the Department indicated that acquisition of public access to the Susitna River and its eastside tributaries below Talkeetna and the enhancement of spawning habitat for salmon are preferred mitigation measures. Compensation by propagating and stocking rainbow trout is not preferred. Therefore, impoundment mitigation options to compensate for lost grayling habitat include:

- acquisition of public access to the lower Susitna River and its eastside tributaries; and

- improvement of habitat for selected salmon and resident fish stocks in the middle and lower river reaches.

Acquisition of public access to the lower Susitna River or its eastside tributaries would provide additional recreational opportunities in the basin as public access to the Susitna River below the Parks Highway bridge (RM 84) is presently limited to a private boat launch at Kashwitna (RM 61) and some eastside tributaries along the George Parks Highway. The Alaska Department of Fish and Game has proposed the acquisition process as a mitigation measure to offset impoundment area impacts. The Applicant considers the acquisition of public access a feasible option and will evaluate site selections in coordination with resource agencies. A recreational plan prepared in late 1984 by the State of Alaska recommends the acquisition of several land parcels in the Susitna Basin to insure public access to present and future fishing areas (Alaska Department of Natural Resources 1985). This recreational plan and any subsequent planning documents on public access in the Susitna Basin will be used in the site selection process.

Habitat improvements for selected salmon and resident fish in the middle and lower reaches of the Susitna River have the potential to compensate for lost habitat in the impoundment area. Such enhancement could include opening presently unutilized areas to access by fish or modifying sloughs in the middle river to improve rearing or overwintering conditions for juvenile salmon and resident fish. The Applicant plans to evaluate potential habitat improvement sites in further detail.

The propagation and stocking of Arctic grayling is not a proposed measure to compensate for lost habitat in the impoundments at this time. The agencies have noted that hatchery production of grayling fingerlings is presently in the developmental stage and cannot be fully relied on to provide compensation. Reasons for this position have been: (1) the lack of reliable egg sources; (2) low survival from the green egg to fry stage; (3) unsuccessful attempts to rear grayling fry to fingerling in hatcheries; and (4) the inability to evaluate survival of stocked fry because of their small size. However, the Applicant has continued to evaluate this option because of the desireability of in-kind compensation. Moreover, recent studies at Clear Hatchery, Alaska, suggest that large scale fingerling production of grayling is feasible. Fingerling production at Clear Hatchery apparently hinges on the rearing of fry to the fingerling stage with acceptable survival rates, as egg sources and incubation technology are adequate and appear to be somewhat secure in the future (Parks et al. 1985). In 1984, over 100,000 two-gram fingerling were produced at Clear Hatchery with an average fry-to-fingerling survival rate of 22 percent (Parks et al. 1985). However, in feeding experiments that tested various kinds of commercial feeds, the survival rate exceeded 70 percent for fish fed a diet of krill. This success would appear to make artificial propagation and stocking of Arctic grayling a viable option for compensation.

Since compensation for lost grayling habitat is the primary concern in impoundment mitigation planning, the costs developed in the original License Application for propagating and stocking grayling can be used as a basis to budget for the acquisition of public access and habitat improvements. The costs associated with public access acquisitions and habitat improvements are presented in Table E.3.2.126.

(d) Mitigation of Downstream Impacts Associated with Nitrogen Supersaturation (o)

(i) Impact Issue (o)

Nitrogen supersaturation in outflow waters has caused significant fish mortalities from gas bubble disease. Water passing over a high spillway into a deep plunge pool entrains air. Nitrogen passes into solution at depth and a state of supersaturation exists when the water returns to the surface. The degree to which this occurs depends on the depth of the plunge pool, height of the spillway, amount of water being spilled, and downstream turbulence. Supersaturated water is unstable and eventually will return to equilibrium levels if exposed to the air. However, travel time downstream during high flow periods can be fairly short, causing supersaturation to extend considerable distances downstream.

(ii) Measures to Avoid Impacts (o)

Gas supersaturation will be avoided by including fixed-cone valves in the outlet facilities. These valves, in combination with flood storage pools at

Watana and Devil Canyon Dams and the powerhouse flows, will discharge all flood flows up to the 1:50-year flood without causing supersaturation to exceed naturally occurring levels. A discussion of the effectiveness of the cone valves is in Exhibit E, Chapter 2, Section 6.4.4. Costs associated with providing the gas supersaturation control structures are provided in Table E.3.2.126.

(iii) Measures to Minimize Impacts (o)

The likelihood of creating gas supersaturation downstream from the dam will be further minimized through reservoir management. Releases occur when the reservoir is full and inflow exceeds releases required for power and instream flow requirements. The reservoir must reach maximum storage level by September 30 to meet winter power demands. Storms do occur in the Susitna drainage that may require release of water; however, the structures and operation criteria have been designed to minimize releases and spills.

2.4.5 - Cumulative Effectiveness of Mitigations (o)

(a) Construction Mitigation (o)

Through siting and design of project facilities, appropriate construction practices, and careful scheduling of activities as discussed in Section 2.4.3, adverse impacts to aquatic habitats resulting from project construction will be avoided or minimized. The indirect impacts caused by increased access to harvestable fish populations will be reduced during construction by instituting a catch-and-release policy for project workers, and by supporting such harvest regulations as the Alaska Board of Fisheries imposes. It is expected that impacts will not be totally avoided and that increased access will have long-term impacts on fish populations caused by the increased harvest pressure.

Aquatic habitat will be altered by removing gravel from the floodplain. These impacts will be rectified by rehabilitation practices discussed in Section 2.4.3.

Fuel spills and road runoff may decrease water quality in streams downhill from project roads. These impacts will be reduced by having a properly trained and equipped spill response team at the construction site.

Monitoring during construciton (see Section 2.6.1) will verify that environmentally acceptable construction practices, as defined by the bid specifications, required permits and the BMP manuals are being followed. Monitoring will be conducted during project construction to recommend changes in construction practices or mitigation features to further avoid, minimize, or reduce impacts.

(b) Operation Mitigation (**)

(i) Mitigations of Access and Impoundment Impacts (**)

Road access to the project area will result in increase resource use. Angling pressure will be controlled by the Board of Fisheries through fisheries management techniques, perhaps including catch limits, restrictive capture techniques (e.g., fly fishing only and single hook), and adjustments in the open season.

The loss of clearwater tributary habitats in the impoundment zones will be compensated by the following mitigation measures: (1) acquisition of public access to the lower Susitna River and its eastside tributaries; and (2) enhancement of habitat for selected salmon and resident species in the middle and lower Susitna River reaches. Mitigation measures offsetting the expected losses for the Stage I, II and III developments will be implemented during the Stage I measures because the greatest impacts in the project area are expected with the initial development.

The acquisition of public access to the lower Susitna River and its eastisde tributaries will provide additional fishing opportunities in the basin and will help even out resource utilization. Habitat improvements that enhance important sport species of salmon (chinook and coho) or important resident species (rainbow trout and Arctic grayling) would offset expected habitat losses in the impoundment zones. Sites will be selected after field evaluations of potential sites are done.

(ii) Mitigation of Downstream Impacts (*)

The goal of the downstream mitigation program is to provide adequate habitat downstream from Devil Canyon Dam that will minimize adverse impacts on fish resources. It is anticipated that the mitigation program will fully maintain, and probably enhance, salmon productivity in the Devil Canyon to Talkeetna reach. Essentially all proposed mitigation measures for downstream impacts will be implemented with Stage I Watana, primarily because the mitigation measures needed for this stage will be sufficient for Stages II and III. To assure that the measures meet their intended purpose, a monitoring plan will be implemented (see Section 2.6).

Several project features have been incorporated into the design of the project to avoid or reduce impacts. Fixed-cone valves will be installed in the outlet facilities to minimize the potential for gas supersaturation to exceed naturally occurring levels. The multiple-level power intake gates will allow water to be withdrawn from the upper levels of the water column over the full drawdown range. This ability to withdraw water from the upper levels will allow control over downstream temperatures to remain within acceptable levels.

The Case E-VI flow constraints will alter the hydraulic characteristics of the sloughs, thereby reducing ease of access and available spawning area for adult salmon and increasing embryo mortality if the sloughs dewater or freeze after spawning is completed.

The project operational flows will allow downstream impacts to be minimized when used in conjunction with proposed rectifying and compensating measures (WCC 1984a). The primary rectifying measure is to use stream enhancement techniques to modify natural slough habitats to maintain natural salmon spawning and fry production. The slough enhancement process is composed of a series of steps to rectify the loss of natural slough habitat. These steps may be used singly or in combination in any particular area, depending on the controlling factors in an affected slough. These steps are (WCC 1984a):

- Provide an upstream berm that will prevent the river from entering the enhanced slough during winter staging. This control maintains the integrity of the spawning gravels and reduces thermal impacts.

- Select a slough that retains ground water flow with suitable thermal characteristics under operational flow levels. The selection process is evaluating a number of criteria to assess the potential for the slough to maintain sufficient ground water flow under operational flows to maintain salmon embryos through the winter and allow properly timed development. Emphasis will be on sloughs that are currently most productive.

- Provide adult salmon with access into the slough by enhancing the backwater effect at the slough mouth and lowering the slough profile.

- If ground water flow cannot be naturally maintained by lowering the slough profile, areas where the ground water flow can be artificially maintained will be considered.

The extent and type of habitat enhancement depends on natural site characteristics, such as ground water flow rates, size of natural features, and factors that appear to limit salmon productivity in each slough. The number of sloughs modified will depend on the desired level of production. It is the Applicant's intent to maintain production at historical levels.

2.5 - Aquatic Studies Program (**)

Aquatic studies are an integral part of the continuing planning and design for the Susitna Hydroelectric Project. The information presented in this document is based primarily on results of the 1981 through 1984 studies. The mitigation plan (WCC 1984a) has been refined based on these studies and analyses.

The emphasis for the aquatic studies program has shifted toward developing design criteria needed to implement the mitigation features and to baseline monitoring (see Section 2.6). These studies, described in the following section, can be divided into preconstruction, construction, filling, and operational phases of the project.

2.5.1 - Preconstuction Phase (**)

During the preconstruction phase, the aquatic studies program will:

- Provide supplemental information required for pre-project baseline monitoring;

- o Refine the proposed mitigation measures.

The need for specific tasks will be translated into study programs.

2.5.2 - Construction Phase (*)

During the planning for construction, information will be needed to properly design site facilities and schedule construction activites to avoid impacts to aquatic habitats. Incorporating environmental design criteria into design, siting, and scheduling activities is a major feature of the construction mitigation plan. Review of proposed actions and facilities will generate the need for some additional data and information. These needs will be incorporated into the study program. Environmental design criteria will be incorporated during the planning stage in order to avoid or minimize impacts.

2.5.3 - Filling and Operation Phases (o)

During filling and operation, monitoring studies, as discussed below, will permit refinement of mitigation features to improve performance.

2.6 - Monitoring Studies (**)

As discussed in Section 1.3, monitoring studies are recognized as an essential project mitigation feature that provides for a reduction of impacts over time. Monitoring will be conducted during project construction and operation:

- o To insure that good construction practices are being employed on the project;
- o To evaluate the effectiveness of the operation and maintenance of mitigation features; and
- o To recommend changes in construction practices or mitigation features to further avoid, minimize, or reduce impacts.

Aquatic monitoring for this project is divided into two broad categories:

- o Construction monitoring and regulatory compliance
- o Long-term monitoring

Construction monitoring will be extensively involved in assuring that the licensing and permitting stipulations for construction activities are carried out. Long-term monitoring will be conducted primarily to:

- Evaluate impact projections

- Assess levels of resource production to ensure that these levels are maintained

- Evaluate the effectiveness of project mitigation measures for areas downstream of the project and within the impoundment zones

- Provide input needed to refine operation and mitigation measures

- Provide supplemental baseline information

During the development of the dams, there will be considerable overlap of pre-project, construction, and operational periods. Due to this overlap, some construction monitoring and long-term monitoring will occur concurrently. (For example, fish monitoring will be needed for both categories of monitoring but because it is believed that such monitoring will be needed for a period of time after construction is complete, fish monitoring is grouped into long-term monitoring.) Even though this overlap will exist, construction monitoring and long-term monitoring will be considered separate categories for monitoring.

2.6.1 - Construction Monitoring (***)

Construction monitoring activities will cover all project facilities, including access road construction and maintenance, transmission line construction, camp and village construction, material removal, material washing operations, reservoir clearing, and rehabilitation needed due to construction activities. Monitoring will be done to ensure that proper construction practices are being followed and that project facilities are being properly maintained.

The Applicant has prepared five Best Management Practices (BMP) manuals (APA 1985a, 1985b, 1985c, 1985d, 1985e) to be used in the design, construction and maintenance of the Applicant's projects:

- Oil Spill Contingency Planning
- Erosion and Sedimentation Control
- Liquid and Solid Waste
- Fuel and Hazardous Materials
- Water Supply

These manuals are the result of a coordinated effort involving Federal, state and local government agencies, and other groups. The manuals are compendiums of typical practices that can be used to avoid or minimize environmental impacts from construction, operation, and maintenance of the Applicant's energy projects. In addition, a report entitled "Drainage Structure and Waterway

Design Guidelines" (HE 1985b) has been prepared for the specific purpose of assuring that culverts and bridges are designed to meet the Alaska Department of Fish and Game's proposed regulations for these structures.

The BMP manuals will be provided to the design engineer, who will utilize them in the preparation of both design and construction documents. The Applicant intends that guidelines contained in these Best Management Practice manuals be incorporated where appropriate into the contractual documents of the project. In this way, they become an integral part of the contract requirements for construction activities.

Construction monitoring will be implemented to ensure that proper construction practices, as detailed in the BMP manuals and Drainage Structure and Waterway Design Guidelines, are being followed and that project facilities are being properly maintained.

It is anticipated that environmental concerns and regulations during construction will be addressed through a continuing process of consultation between the Applicant and the resource agencies. This process has been ongoing since the Applicant initiated project-related studies. Agencies have already been involved in the review of the BMP manuals and Drainage Structure Guidelines, initial design of project features (as presented in feasibility reports and the original License Application), and other project documents. It is anticipated that this process will continue through the design, construction, and operation periods.

The Applicant will continue its practice of regular consultation with individual agencies and other project participants. The Applicant envisions that these meetings will be held at least once every two months and will be the forum in which participants will be apprised of the current status of the work. These meetings will also provide for interactive discussions with the Applicant and its design contractors.

During the design process, specific features will be described in detail. For each major project feature (e.g. dam, spillway, camp, etc), design memoranda will be developed based on the criteria and plans presented in this License Application Amendment. In areas where environmental concerns may be involved, these memoranda will be distributed to resource agencies for review and comment. Prior to construction, the agencies will also review the final design and means of construction with regard to permits, permit stipulations, and design and construction criteria. This will ensure conformance to approved practices.

Construction of the main access road will begin in April 1990. From that time until all stages of the project are complete, construction monitoring will occur. To build the project, the Applicant will hire a firm that will manage construction. This firm will hire contractors needed to build the project. To provide overall onsite responsibility for the Applicant, there will be a resident manager, at the site; for the construction manager there will be a resident engineer. One of the main responsibilities of the resident manager will be to assure adherence to requirements of the FERC license and other agency permits and regulations. This will be implemented through the resident manager.

Mitigation measures for construction will be part of contractual documents and will be adhered to just the same as any other contractual requirement (e.g., safety procedures required by OSHA). By incorporating the environmental concerns in the contract documents, the Federal, state, and local agencies can be assured that these concerns will be enforced in the field. In order that environmental and regulatory concerns receive the same level of attention as is being devoted to other phases of project development, the Applicant has formed the position of Director of Environment and Licensing (DEL). The DEL has the same stature as the Director of Engineering, Director of Construction, and the Director of Administration. All of the aforementioned directors, as well as the Susitna Project Manager, are responsible to the Associate Executive Director of Projects.

As the onsite representative of the DEL, the Applicant intends to have at least one member of its staff designated as an Environmental Field Officer (EFO). The EFO will be required to be thoroughly familiar with plans and specifications, as well as the special regulatory permit stipulations and general environmental statutes and regulations. It will be the EFO's responsibility to enforce those portions of the construction contract documents that incorporate the environmental stipulations specified in the permits and license.

The EFO will directly interface with the Applicant's resident engineer and the construction manager. The onsite construction manager will be thoroughly familiar with the regulatory requirements and plans and specifications. These quality control assurance personnel will give equal weight to technical and environmental concerns in carrying out their field inspection responsibilities. The EFO through the DEL will be the Applicant's field liaison with resource/regulatory agencies.

The Applicant is committed to working with an interagency review team and will support its effort by providing data, analysis and technical support. The resource agencies may, at their own discretion and funding, have an observer onsite to assure themselves that agency interests are maintained. The Applicant will provide this observer with field support as needed. It will be the responsibility of the resource agencies to select this observer. If the observer sees a problem, he can relate this directly to the EFO, the agency concerned, or the FERC. Whether or not the resource agencies desire an onsite observer, the DEL will contact the appropriate agencies prior to the contractor beginning a major work item, in order that the agency may have the opportunity to request a site inspection.

The EFO will have a staff that assists him in assuring that environmental requirements of the contracts are carried out. If a violation of the contract occurs (such as principles of the BMP Manuals are not being followed), the EFO will take action by notifying the appropriate person in the construction manager's organization. If no response occurs, the EFO will notify the DEL and the resident manager. The resident manager, in turn, will notify the construction manager to take corrective action. It is envisioned that this entire procedure will require only a short period of time (minutes). Depending on the incident, the appropriate resource agency will also be notified.

Once construction has begun, onsite changes in permit stipulations may be required because of changes in construction techniques or unforeseen problems that are not included in contracts. If a variance is required, the agency observer onsite should have the authority to authorize field actions that were not specified in the permits. It is strongly suggested that the observer have this authority because offsite decisions would require time and potential costly delays. After facilities or portions of facilities have been constructed, the EFO will review the designs and verify that the facility is in compliance with contracts, permits, and license stipulations.

If a facility or activity is found not to be in compliance with existing stipulations and if a variance was not requested prior to implementing the activity, a certificate of non-compliance will be issued and all responsible parties will be notified.

The construction schedule and proximity of activities will dictate the size of the EFO's staff. During Stage I Watana construction the staff will be large since activities will include construction of the access road and, soon after, the Watana dam.

This level will be high through Stage II Devil Canyon completion. During the Stage III Watana Dam construction, EFO staff and the extent of their coverage will be reduced since most activities will be limited to the damsite. As indicated by the current schedule, construction activities, including the construction monitoring program, will end in 2012.

The Applicant believes that the above procedures are a prudent approach since both the Applicant and the resource agencies will need flexibility to resolve the day-to-day implementation of monitoring plans in an expeditious and cost effective manner. Regardless of how many contingency plans are developed, some of the field problems that occur during implementation are typically resolved as they occur. Therefore, some procedural flexibility is necessary in order to develop workable solutions.

2.6.2 - Long-term Monitoring (***)

Long-term monitoring will focus on areas downstream of the project and in the impoundment zones. The purposes of this plan will be to:

- o Evaluate the effectiveness of mitigation measures
- o Provide input to refine operation and mitigation measures
- o Provide supplemental baseline information

The general approach to long-term monitoring will be to monitor selected natural conditions for a number of years (in some cases, monitoring for natural conditions is complete). The length of time needed and the data requirements will depend on the parameter or situation to be monitored. Conditions will then be monitored after Stage I Watana Dam construction begins and will continue through project completion. The natural and with-project information will then be compared to determine if significant impacts have occurred and to determine the effectiveness of mitigation measures. The parameters that will be monitored will only be those that are considered good indicators of change (for the system) and are readily measured and analyzed. Costs associated with long-term monitoring are provided in Table E.3.2.129.

Project planning is separated into the following time periods:

- o Existing conditions
- o Stage I Watana Dam
  - a. Construction of Stage I Watana Dam
  - b. Operation
- o Stage II Devil Canyon Dam

a. Construction of Devil Canyon Dam and operation of Stage I Watana Dam
b. Operation of Devil Canyon and Stage I Watana Dams

- o Stage III Watana Dam

a. Construction of Stage III Watana Dam and operation of Devil Canyon Dam
b. Operation of Stage III Watana and Devil Canyon Dams

Long term monitoring of the aquatic environment in each of these periods is necessary. Prior to initiation of project construction, existing conditions will be monitored to establish baseline conditions. For the Susitna Project, a major portion of this baseline monitoring has already been accomplished, primarily since 1980, when field studies were initiated by the Applicant. Once construction begins, monitoring of the other periods will be necessary to determine if pre-project projections are correct and to assure that mitigation measures are successful in achieving their intended goals.

During project development, there will be considerable overlap of pre-project, construction, and operational periods. Due to this overlap, some construction monitoring (Section 2.5) and long-term monitoring will occur concurrently. For example, fish monitoring will be needed for both categories of monitoring but because it is believed that such monitoring will be needed for a period of time after construction is complete, fish monitoring is grouped into long-term monitoring.

The plan outlined in this section will begin with the 1985 field season (Table E.3.2.130). This will not preclude the possible analysis and use of previously collected data. The plan will continue through project construction with some of the studies continuing into project operation.

The with-project monitoring schedule will depend on the specific parameters to be monitored and the degree of precision necessary to determine if project-induced changes have been detected at an acceptable level.

The long-term monitoring plan encompasses the entire project period and not any one stage. The reason for this is that once construction begins, the environment of the project area will be altered. This will then continue through all construction phases and into operation. This plan should not be considered unchangeable however, because studies will be refined through consultation with resource agencies, both individually and in the interagency group forum. Likewise, the effectiveness of mitigation measures will be determined through monitoring.

Should mitigation measures require modification, the resource agencies as a group, or individually, will be consulted and agreement will be reached on specific modifications.

During construction and initial project operation, the Applicant will, on an annual basis, submit a report on aquatic monitoring to the FERC and resource agencies for review and comment. This report will describe the results of monitoring for the year and provide an analysis of whether or not mitigation measures are achieving their purposes. The need for continued monitoring will be reviewed periodically. It is envisioned that as the project matures, any significant impacts will be fully mitigated and the need for field studies/monitoring will decrease, i.e., portions of the aquatic monitoring program will be terminated when the need for further mitigation is considered unnecessary. Consequently, the need for reports on an annual basis may also decrease.

2.6.3 - Long-term Monitoring Elements (***)

As a result of studies, analyses, and agency consultation, specific elements of project development and operation that will need long-term monitoring were identified. These monitoring elements include:

- o Water quality upstream and downstream of the project including:

  1. Dissolved Gas Supersaturation
  2. Temperature/Ice
  3. Turbidity
  4. Mercury/Heavy Metals

- o Critical fish life history stages including:

  1. Adult salmon
  2. Egg incubation, juvenile rearing, and outmigration
  3. Resident fish

- o Fluvial geomorphology

- o Structural alteration of habitat, such as slough modifications

The plans proposed for long term monitoring are primarily concerned with areas downstream of the project area. A monitoring plan will be developed to evaluate the efficacy of the proposed impoundment area mitigation program. This will be done following finalization of mitigation plans for this area.

The following sections provide additional details on the scope and activities associated with the various monitoring elements.

(a) Dissolved Gas Supersaturation (***)

Dissolved gas supersaturation from dams primarily occurs when water is released over a spillway and plunges into a pool. This entrains air and carries it to depth where the hydrostatic head forces it into solution. If the hydrostatic head at depth is sufficient, the air will stay in solution. At shallower depths, however, supersaturated gas comes out of solution as the gases equilibrate with the atmosphere, thus causing bubbles to form. If the gas comes out of solution within a fish, it may cause mortality, or sublethal stress.

To avoid potential impacts from supersaturation (and minimize the need to spill water over the spillway), the Project will provided means for storing and releasing all floods with recurrence intervals of 50 years or less without the need for using spillway discharges. One of the means will be to provide fixed cone valves for both dams (all project stages). Releases from these valves would be dispersed as a spray and, therefore would not plunge to depth nor be expected to cause gas saturations in excess of 110 percent downstream.

Six cone valves are planned for Watana Dam (same valves for both Stages). These valves will have a 24,000 cubic feet per second (cfs) discharge capacity (maximum). Devil Canyon will have seven cone valves with a 38,500 cfs discharge capacity.

Natural turbulence in Devil Canyon causes supersaturation, with higher discharges resulting in higher dissolved gas concentrations (Figure E.3.2.125). These concentrations can exceed the State of Alaska maximum allowable standard of 110 percent total gas saturation when flows in the river are greater than about 15,000 to 20,000 cfs. Naturally occurring gas supersaturation levels decrease by approximately 50 percent in the first 20 miles downstream of Devil Canyon. Fish collected in the area of highest gas concentrations have not exhibited any of the signs associated with bubble disease (ADF&G 1983n).

The data collected thus far is sufficient to provide a general understanding of the relationships concerning dissolved gas concentrations in the Devils Canyon reach. Additional pre-project data will be needed to provide a more complete record of baseline conditions.

The primary purpose of this portion of the monitoring plan will be to evaluate cone valve operation in order to assure that significant impacts due to gas supersaturation do not occur.

The main objectives of the dissolved gas saturation monitoring will be to:

- o Document the relationship between flows and natural dissolved gas concentrations
- o Monitor fixed-cone valve operation to determine if with-project dissolved gas concentrations agree with projections
- o Evaluate the effects of spillway discharges on dissolved gas concentrations.

To complete the evaluation of the fixed-cone valve operation, the following sources of information will be utilized:

- o Baseline data on dissolved gas concentrations previously collected on the Susitna River by the ADF&G
- o Additional pre-project monitoring of dissolved gas concentrations
- o Data from monitoring of dissolved gas concentrations during testing of the cone valves and spillways at both Watana and Devil Canyon Dams

Monitoring to complete baseline data collection will occur during the 1985 field sampling season (Table E.3.2.130). With-project monitoring will occur when each stage of the project is completed.

(b) Temperature/Ice (***)

The Watana (Stages I and III) and Devil Canyon Reservoirs will cause temperatures in the river downstream from the dams to differ from natural conditions (see Exhibit E, Chapter 2, Section 4.0). Water temperatures in the spring are expected to be below natural by a few degrees Celsius (C). In mid-summer, they will be near natural. In the fall, water temperatures will be above natural by a few degrees C. In the winter, due to releases of water ranging from 0 to 4°C from the reservoir, a large portion of the river downstream of the dams will remain free of ice. When the three stages are complete, the open water is estimated to be about 15 to 35 miles downstream from the dam. In this ice-free area, temperatures may remain above natural (0°C) by up to 3°C throughout the winter. The variation from natural will be greatest near the dam, and will decrease with distance downstream. Under the ice cover, temperatures will be 0°C, the same as for natural conditions (AEIDC 1984c).

During the winter, warmer releases will cause the ice front progression up the middle reach to be delayed by 2 to 6 weeks. Higher than natural winter discharges will result in elevated water levels downstream of the ice front. Upstream of the with-project ice front, water levels will be lower than natural because natural staging due to the ice cover will be eliminated.

Changes from natural conditions will result in the more frequent overtoppings of slough berms wherever an ice cover forms. This overtopping will introduce cold (0°C) water and ice into the sloughs. Plans to prevent this overtopping include increasing the height of the berms at the upper ends of the sloughs (WCC 1984a). The Applicant has included multi-level intakes in the designs for both the Watana (both low and high phases) and Devil Canyon developments to mitigate for these potential temperature impacts. These intakes will be operated to provide as near natural temperatures as possible.

The purposes for monitoring water temperature and ice will be to:

- o Determine the range of temperatures experienced in the Susitna under natural conditions
- o Monitor with-project temperatures
- o If necessary, refine multi-level intake and cone valve operation after actual with-project conditions have been observed
- o Monitor with-project ice conditions
- o Monitor occurrences of ice-induced slough overtopping with-project conditions

The main objective will be to determine if the water temperatures and ice conditions downstream of the projects agree with pre-project projections.

The primary sources of data will be:

- o Temperature and ice data already collected by the Applicant at various locations throughout the Susitna Basin
- o Additional pre-project data
- o Data collected when the dams begin filling and operating

(c) Turbidity/Sediment (***)

During the ice-covered season, the natural turbidity and suspended sediment concentrations of the Susitna River are near zero. During much of the open water season, the river is highly turbid and carries large volumes of suspended sediments. Open water suspended sediments average approximately 700 mg/l (HE 1984c). Peak turbidity values may be as high as several thousand nephelometric turbidity units (NTU's).

Most sediments that presently depend on the river's tractive force for downstream transport are expected to be trapped upstream of the dams. Particles passing downstream through the dams will be fewer and smaller, and the average mineral composition and three- dimensional shapes will be altered. The present suspended sediment and turbidity regimes should become more seasonally continuous and less variable. Enhancement of biological productivity is possible if sufficiently clearer water can be combined with river temperatures and a flow regime which protects critical aquatic habitats during appropriate seasons.

Biological changes are expected to occur at all trophic levels in aquatic habitats directly affected by project-induced changes in suspended sediment and turbidity regimes. Because changes in these parameters can either positively or negatively affect fishery resources, it is important to understand how much change will occur.

The purpose for monitoring turbidity and suspended sediment concentrations under existing and with-project conditions will be to determine whether or not changes in these parameters significantly affect fishery resources downstream of the project. Significant amounts of information have already been recorded concerning baseline turbidity and suspended sediment levels (HE 1984c).

The main objectives of these studies will be to:

- o Determine if with-project conditions agree with pre-project predictions
- o Determine the seasonal changes in turbidity and suspended sediments that occur due to the project
- o To the extent possible, determine how these changes have affected the fishery resources downstream of the project

One year of pre-project monitoring will be needed to establish a better record and understanding of natural conditions. Most efforts will be applied to the open water season. Another year will be necessary when Watana (Stage I) begins operation and at least one additional year when Devil Canyon and Watana (Stage III) begin operation. Monitoring of turbidity and suspended sediments will likely be required as part of the construction monitoring program and during reservoir filling. Therefore, it is expected that this program will be almost continuous from the start of construction through early operation of both dams.

(d) Heavy Metal Concentrations in Fish (***)

A number of metals naturally exist in the Susitna River at detectable levels. The most biologically significant of these metals are mercury, copper, cadmium, and zinc. Post-impoundment water quality studies in existing reservoirs have shown that only one of these metals, mercury (Hg), systematically bioaccumulates to relatively high concentrations in fish tissue as a direct result of impoundment (Bodaly et al. 1984, Meister et al. 1979). These concentrations in fish tissue might exceed (greater than 0.5 mg-mercury/mg of fish tissue) those that are considered safe for human consumption. After impoundment, microbial methylation of mercury associated with the organic matter in soils and newly inundated detritus of the project reservoirs may result in higher than natural mercury concentrations in reservoir fish. Several environmental factors in the project reservoirs will tend to minimize mercury biomethylation and subsequent concentration in the tissues of fish and higher trophic level organisms such as man and vertebrate predators:

- o Low year-round water temperature
- o Low rates of benthic microbiological activity

- o Blanketing of inundated organic matter with a layer of inorganic sediments

- o Relatively limited fish populations

Although information exists on mercury concentrations in fish in impoundment areas, no comparable information exists on mercury concentrations in fish downstream of dams, at least not directly related to a dam. If concentration of mercury potentially occurs in fish downstream of the project, resident fish, in contrast to anadromous species, might be more affected by freshwater mercury concentration because anadromous species (such as salmon) will acquire most of their mercury tissue burden from the marine environment and will therefore be relatively less affected by the project.

Cadmium, in contrast to mercury, is not present in high concentrations in the Susitna River. Thus, it is not likely that appreciable concentrations will be leached from the soils inundated by the impoundment. Therefore, although cadmium is known to bioaccumulate (principally in non-muscle tissues: liver, kidney, etc.), the element is not likely to have adverse effects on the fish or fish predators in the Susitna River. Zinc and copper are quite toxic but not consistently known to bioaccumulate in fish tissue in newly impounded reservoirs.

Leaching of heavy metals is neither predictable nor quantifiable. Leaching will be exacerbated by the presence of humic substances, which are abundant in the watershed, but the toxicity of metals bound to humics is usually much lower than that of free metal ions (Jackson, et al. 1978, Moore and Ramamoorthy 1984).

The purpose for monitoring mercury and other metals will be to identify whether or not uptake and bioaccumulation occur as a result of the project.

The main objective will be to analyze sufficient numbers of preproject and with-project fish tissue samples to determine if mercury and/or other metal bioaccumulation has occurred and the extent of the occurrence.

Preproject data will be developed from two sources:

- o A review of scientific literature with application of this information to the Susitna Project

- Laboratory analyses to determine the present status of mercury (and possibly other metals) in resident sport fish in the Susitna River and adjacent lakes

With-project data will be used for comparison to natural conditions. Fish muscle tissue burdens of toxic metals will be developed from laboratory analyses of metal concentrations in resident sport fish in the Susitna basin, both in the Watana Reservoir and downstream.

Preproject sampling will begin with the 1990 field season (see Table E.3.2.130). It is expected that sufficient samples will be collected within one season to provide baseline data.

Samples will be taken following filling of Watana (Stage I) reservoir and then again after Devil Canyon and Watana (Stage III) Reservoirs are filled. It is expected that these samplings will be completed within one year. Plans will be made to collect samples approximately five years after Watana (Stage III) begins operation and periodically thereafter, if necessary. This set of data will be used for long-term comparisons.

(e) Dissolved Oxygen, pH, Organic Nitrogen (Total, Particulate - Organic and Inorganic, and Dissolved), and Phosphorus (Total, Particulate - Organic and Inorganic, and Dissolved) (***)

Collection of data on these parameters is useful to understanding changes that may occur in fish resources as a result of the project. Sampling of both natural and with-project conditions will take place coincidentally with turbidity sampling. Winter sampling will be needed for natural conditions to define baseline levels that in general will otherwise be excluded for turbidity sampling.

(f) Water Quantity (***)

As part of normal project operation, mainstem discharges will be continuously monitored at several locations, including:

- Upstream of the Watana impoundment zone
- Watana Dam
- Devil Canyon Dam
- Gold Creek

o Sunshine Station

This information is needed to assure that minimum and maximum flow constraints are met.

(g) Fish Resources (***)

(i) Impoundment Area (***)

It is assumed that all existing habitat and fish populations within the impoundment zone will be altered as the river changes from a flowing water system to two reservoirs. It is also assumed that although fish will inhabit the reservoir, the productivity of the impoundments will be low. Furthermore, it was assumed that the potential for effective mitigation measures in the impoundment zones is low, primarily because the reservoirs will not be highly productive. Therefore, offsite mitigation is proposed. The need, scope, and extent of monitoring for offsite mitigation will largely depend on the mitigation option that will be pursued.

(ii) Areas Downstream of the Project (***)

Based on aquatic baseline studies, impact assessments, and harvest contributions, five species of Pacific salmon (chum, sockeye, chinook, coho, and pink), and Arctic grayling, rainbow trout, Dolly Varden char, and burbot have been identified as evaluation species for this project (see Section 2.4.2).

Not all species will be equally affected by the proposed project. Mitigation measures have been designed to avoid or minimize impacts to these species with special emphasis given to juvenile chinook and adult chum salmon because of their dependence during certain life stages on habitats directly influenced by mainstem flows. Once initial site selection was made and preliminary designs completed, the priorities for developing mitigation measures have been:

- o Flow regulation to maintain habitat
- o Structural habitat modifications, such as slough modifications, to assure continued production from natural systems

o Artificial propagation

Studies have shown that flow regulation accompanied by habitat modification will have a high likelihood of success in achieving the goal of no net loss in habitat value. The Applicant would implement artificial propagation as a last resort if the other means of mitigation did not meet the Applicant's goal of no net loss. To assure that this goal is met, monitoring of both salmon and resident fish will be implemented.

The primary study area for the fish monitoring program is the middle reach of the Susitna River (from Devil Canyon downstream to the confluence with the Talkeetna and Chulitna Rivers). Of the downstream areas, the fish populations in this reach are the most likely to be affected by the project. Therefore, concentrating monitoring efforts on this reach will provide the best opportunity to determine if mitigation measures are achieving their goal. Chances of detecting changes in the lower river (Cook Inlet to Talkeetna) due to operation of the project are greatly reduced because the lower river is influenced to a much greater extent by non-project related instream and tributary conditions.

The primary emphasis of the Applicant's mitigation plan has been to achieve no net loss in habitat value due to the project. Therefore, it is felt that the best indicator for this will be to monitor the number of juvenile salmon produced from a given escapement. In addition to the monitoring of salmon populations, key resident species will also be monitored.

The Alaska Department of Fish and Game (ADF&G) has performed adult salmon spawner escapement studies on the Susitna River dating back to 1974. Escapement estimates were derived from survey data for the years 1974, 1975, 1977, and 1981-1984. The escapement estimates were determined from tag recovery data and spawning ground surveys conducted by helicopter, fixed-wing aircraft, and ground surveys. Survey techniques and sampling designs were refined periodically over the years, taking advantage of increased understanding gained with each year of study. Emphasis has gradually changed from a general coverage of the entire system to more concentrated coverage of the middle reach.

A study program has been conducted over the past several years to provide information on the habitat and seasonal distribution and abundance of juvenile salmon in the middle Susitna River. In 1983, the SuHydro Study Team (part of ADF&G) initiated a program to provide estimates of fry-smolt production. The program entailed marking outmigrant salmonids (primarily chinook, chum and sockeye) in tributary creeks and sloughs, and then recovering them downstream at the Talkeetna Station (River Mile 103). Methodology and statistical considerations have been developed to the point where reasonably good estimates can be obtained from a nominal survey effort.

Abundance and distribution of resident fish have been extensively examined in the middle reach since 1982 (ADF&G 1984c). These studies have primarily involved sampling at fixed sites between river miles (RM) 98.6 and 132.0. Three major macrohabitats (mainstem, slough, and tributary mouths) have been examined using multiple gear types (electroshocking, seining, hook-and-line, traps, fishwheels, outmigrant traps, and trotlines). Although sampling has been intensive, only limited success has occurred in developing estimates of population numbers, primarily because recapture numbers have been low. However, extensive information has been developed on catch-per-unit effort, size, age, distribution and relative abundance of fish species.

Objectives:

Resident Fish. The objective of the resident fish monitoring program is to provide an index of pre-project and with-project populations of rainbow trout and Arctic grayling. To the extent possible, other species will be examined. For example, although Dolly Varden are also evaluation species, estimates of population numbers are difficult if not impossible because so few have been captured over four years of intensive sampling at multiple locations using a wide variety of sampling methods. For burbot, a similar situation exists in that few fish have been captured and to capture those few has generally required use of sampling techniques that sacrifice the fish. Therefore, because low numbers of burbot are present, it is not justified to use methods that could significantly impact the resource.

The monitoring period will extend over a period of years encompassing natural and with-project conditions. Trends in population numbers will be related to the index. These trends will then be used to determine if project effects have occurred. To the extent possible, it will also be necessary to follow patterns in the sport fishery harvest which is anticipated to increase whether or not the Susitna Project proceeds.

Salmon

- Adults

The objective of the adult salmon monitoring program is to provide spawning population estimates (escapement estimates) of five salmon species over a period of years encompassing natural and with-project conditions. The estimates will be used to assess the effect of the project on the populations. The extended number of years is necessary to detect "real" trends in escapement patterns that naturally vary considerably. It will also be necessary to follow patterns in commercial and sport fishery harvest that with time vary in their effect on escapement. Determining what factor or factors are affecting or controlling population levels will be difficult. The level of detectability will depend of the "natural" variability in the population, the degree of change induced by the various factors controlling the population, the variability induced by the sampling program, and the number of years of study.

Sub-objectives include the following:

- o Monitor the long-term trend in catch at fixed fishwheel stations
- o Monitor the long-term trend in spawning ground counts
- o Monitor the long-term trend in age and sex composition of spawners
- o Relate trends to physical, chemical and biological changes in the system, including changes induced by the project

- Juveniles

The objective of the juvenile salmon monitoring program is to provide estimates of fry and smolt production in the middle river over a period of years encompassing natural and with-project conditions. Production estimates and changes in production patterns over the years can be compared directly with changes in physical conditions due to project operation. In addition to production estimates, survival rates obtained from the ratio of egg production to fry-smolt production can be monitored over the pre- and with-project period.

Sub-objectives include the following:

- o Monitor long-term trends in the timing of emergence and outmigration of juvenile salmon
- o Monitor long-term trends in the development, growth, and relative condition of young salmon

Monitoring Locations:

Resident Fish. Resident fish sampling stations will be located at the twelve sites between RM 98.6 and 132.0 that have been examined since 1982. In addition to continuing sampling at these index sites, it has been proposed to sample three additional sites, beginning with the 1985 field season. This will provide a total of 15 fixed sites. Furthermore, any resident fish sampled during the salmon studies (such as those captured in the fishwheels and outmigrant traps) will be incorporated into the analysis.

Salmon. Spawning populations in the middle river will be studied from just upstream of the confluence of the three main tributaries near the town of Talkeetna to the Watana Dam site, including tributary creeks and sloughs. Sampling by fishwheels will be conducted at Curry Station and Sunshine Station. Spawning ground counts will be concentrated on sloughs, side channels, mainstem areas, and tributaries of the middle river. Additional counts will be made, as needed, in peripheral areas such as the Chulitna and Talkeetna subbasins.

The study area for the juvenile salmon monitoring program includes the middle river and many of its tributary creeks and sloughs. Young salmon will be collected and marked in selected creeks and sloughs. Recovery samples will be obtained at Talkeetna Station.

Techniques:

Resident Fish. The type of sampling gear will depend on the site to be sampled. Sampling methods will include electrofishing, seining, fishwheels, outmigrant traps, and hook-and-line. The type of gear will be the same from year to year to maintain consistency for analysis. The data analysis will be focused on providing information on relative abundance, distribution, and densities. This information will be developed through a mark-recapture program. Migrational patterns will be analyzed by tag-and-recapture of tagged adult resident fish.

Salmon. Fishwheels will be used to capture adult migrant salmon on their way upstream. Fish will be counted by species and sex, and tagged with individually numbered tags. Length of each fish will be recorded. Weights and scale samples (for determining the age of fish) will be obtained from a subsample of each fish species collected.

If found to be feasible, sonar counters will be used near the fishwheels to provide an independent estimate of escapement. These counters may eventually be used to replace some of the fishwheel operations.

Spawning ground surveys will be primarily conducted in the middle river. Air and ground visual surveys will be the main survey method. Counts by species will be obtained. Tag data (type, color, and identification number) will also be recorded when possible.

Emergence and outmigration studies in spawning areas will be conducted. Salmon fry will be captured using seines, minnow traps, and/or electrofishing gear. Fry will be marked using tags (e.g., coded-wire tags, cold-branding, dye).

Salmon fry and smolts will be recovered in juvenile traps located at Talkeetna Station. Total fry production for each species will be estimated.

Timing will be determined from catch-per-effort data compiled from spawning area samples and from the downstream traps.

Schedule:

The preproject monitoring schedule for both salmon and resident programs will begin during the 1985 field sampling season and continue each year into the construction phase of the project (see Table E.3.2.130). With-project monitoring will commence in the year immediately following the last preproject year.

Data Analysis/Interpretation:

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

(h) Monitoring of Structural Habitat Modifications (***)

The Applicant has proposed plans for specific structural habitat modifications to protect middle river fish resources (WCC 1984a). One of the higher priority mitigation options will be to structurally modify slough habitats so that they continue to provide fish habitat at existing or higher levels. If this option is implemented, the following monitoring plan for slough modifications is proposed.

The various features incorporated for slough habitat enhancement will be monitored to determine whether they are meeting their intended function and are operating properly. Mitigation features designed to allow adult salmon access into the sloughs will be inspected annually after breakup to identify and implement any needed repairs prior to the adults' return. Annual monitoring of returning adults will identify access problems or passage delays and appropriate corrective actions will be taken.

Slough modification designed to maintain spawning areas will be inspected annually prior to the spawning season to verify that the area contains suitable spawning conditions such as adequate flow (depth and velocity)and suitable substrate. If flows diminish so that spawning is no longer possible, appropriate corrective action will be taken so that adequate flow and substrate are restored. The annual slough monitoring program will include an evaluation of general slough conditions including beaver occupation and general condition of the spawning and rearing areas. Appropriate corrective actions will be performed to maintain slough productivity. For example, if productivity is decreased due to increased silt deposition, gravel cleaning in the slough will be undertaken.

The number of spawning adults returning to the modified sloughs will be monitored annually to determine if the combination of minimum flow and slough modifications is maintaining natural levels of production. This monitoring will also serve to determine whether the capacity of the modified areas is being exceeded. Fry production will be monitored annually to verify incubation success. Fry monitoring will include an assessment of out-migration timing and success.

Following initiation of river flow regulation by Stage I Watana Dam, representative sloughs will be instrumented with temperature and flow recording instruments to monitor physical characteristics of the sloughs throughout the year. Monitoring of the physical processes will be continued until slough conditions stabilize under the regulated flow regime. This physical process monitoring will be used in part to determine whether further modifications to the physical habitat can be made to assist in maintaining slough productivity.

(i) Fluvial Geomorphology (***)

The Susitna River is a dynamic system that is undergoing continual morphological changes due to physical processes such as ice and floods. These changes will be altered by with-project flow regulation. Therefore, it is important to document these changes on a periodic basis.

The primary means of providing this documentation will be through detailed air photography of the river from the upper end of the Watana Reservoir to Cook Inlet. Numerous photo series of the basin are already available.

Existing photos of the middle and lower river will be used as a baseline. For comparison, additional photos will be taken periodically. This will be performed in conjunction with air photography for wildlife studies.

(j) Special Monitoring Studies (***)

It is anticipated that there may be a need for other additional monitoring studies or modifications to this proposed draft. During the annual review process with the resource agencies, proposals for these studies will be considered. If approved, these proposals will be implemented during following years.

(k) Contingency Planning (***)

Although long-term monitoring results will be reviewed on an annual basis, there may be some unforeseen instances in which additional monitoring may need to be initiated on a short-term notice. In those cases, the Director of Environment and Licensing (DEL) (see Section 2.6.1) will notify the appropriate agency or agencies and the situation will be discussed and agreed upon action taken. If the unforeseen instance is first observed by the resource agency (e.g., by ADF&G fishwheel crews), the agencies should notify the DEL and request a meeting to address the situation. It is the intent of the Applicant to resolve these situations on a case-by-case basis with the appropriate agencies. For cases that cannot be resolved in this manner, the FERC will be consulted.

2.7 - Cost of Mitigation (***)

To develop estimates of mitigation cost, 1985 cost estimates were prepared for each activity (Tables E.3.2.124, E.3.2.126, E.3.2.129). These cost estimates were based upon unit cost information derived from recent experience in Alaska or upon experience elsewhere and/or earlier, and escalated to arrive at 1985 cost estimates for Southcentral Alaska. Costs for the mitigation program were separated into construction cost and average annual operating cost. For the major mitigation activities, these costs are:

Construction Cost

Downstream Mitigation (Table E.3.2.126)	$ 1,088,000
Impoundment Mitigation (Table E.3.2.126)	940,000
Dam Structure-Multi-level intakes and fixed cone valves (Table E.3.2.126)	80,100,000
Water & Fisheries Quality Monitoring (Table E.3.2.124)	11,600,000
Total Construction Cost	$ 93,728,000

Average Annual Operating Costs

Longterm Fisheries Monitoring (Table E.3.2.129)	$1,220,000
Operation and Maintenance of Facilities (Table E.3.2.126)	50,000
Total Average Annual Operating Cost	$1,270,000

These costs do not include any contingency costs or owner's administrative costs.

The costs for downstream mitigation (Table E.3.2.126) are based on modifications to Sloughs 8A, 9, 9A, 11, 21 and side channels 11 and 21. Details of these costs are provided in Table E.3.2.131.

The schedule for implementing the aquatic monitoring program is described in Table E.3.2.132.

2.8 - Agency Consultation on Fisheries Mitigation Measures (**)

Four agencies, USFWS, ADF&G, Alaska Department of Natural Resources (ADNR) and National Marine Fisheries Service (NMFS) have provided comments on fisheries mitigation measures. The following sections contain comments by the agencies and responses by the Applicant concerning aquatic mitigation. These are the major comments made prior to submission of this license amendment. Additional comments and consultation are described in Chapter 11.

2.8.1. - U.S. Fish and Wildlife Service (**)

The USFWS provided formal comments on fisheries mitigation measures on October 5, 1982, January 14, 1983 and December 18, 1984. The USFWS comments are divided into construction-related mitigations and operation-related mitigations.

(a) Construction Mitigations (o)

Construction mitigations primarily concern siting, design, and scheduling. The comments are:

- Siting and Design (o)

  The access road and transmission line between Watana and Devil Canyon should use the same corridor.

  The diversion tunnel should be screened to avoid entraining fish. The siting of construction and permanent villages and other facilities should be reviewed with the goal of minimizing impacts.

o Scheduling (***)

Construction activities and reservoir clearing should occur in the winter to minimize impacts. Work in aquatic systems should be scheduled to avoid conflicts with sensitive life history stages.

These comments are addressed in Section 2.4.3. The BMP manuals, prepared by the Applicant in coordination with the resource agencies, specify environmentally acceptable construction practices to be used throughout project construction. During the detailed design phase of the project, a criteria manual will be prepared to present the siting and design criteria. This manual will include the timing and scheduling of construction activities based on the identified sensitive periods and the needs of the construction contractor.

(b) Operation Mitigations (**)

Comments on operation mitigations were divided into those concerning reservoir mitigations and downstream mitigations.

(i) Reservoir Mitigations (**)

Recommendation: The viability of a reservoir fishery needs to be evaluated.

Response: The Watana and Devil Canyon reservoirs were evaluated in terms of their suitability as fish habitat. It was concluded that the drawdown cycle and turbidity levels in the reservoirs will limit fish populations and will probably not support a quality reservoir fishery. A grayling fishery, however, would develop in, and at the mouths of, tributaries discharging into the reservoir.

(ii) Downstream Mitigations (**)

Recommendation: Mitigation options for the dewatered area between the Devil Canyon dam and its powerhouse need to be considered.

Response: The habitat lost between Devil Canyon dam and the powerhouse is typified by velocities between 9 and 16 ft/sec (2.7 and 4.8 m/sec), the substrate is bedrock. The area is not expected to provide significant fish habitat, thus the dewatering of the section is not expected to result in substantial impacts. The few chinook that migrate through the canyon will be blocked by the dam. Milling areas will still be available at the powerhouse outlet. Because of these factors, mitigation measures are not proposed.

Recommendation: The potential to establish/expand the salmon fishery between the Devil Canyon and Watana damsites, in the absence of a Devil Canyon dam, needs to be addressed.

Response: The flows downstream from Watana Dam are expected to permit chinook salmon to ascend to Tsusena Creek, at the base of the dam. If the Devil Canyon dam is eventually eliminated from the planned development, it would be possible to establish a fishery in this reach. Since Devil Canyon dam is a part of the present plan, developing these chinook stocks for the period between Watana development and Devil Canyon development is not considered cost-effective mitigation.

Recommendation: Adjustments to the Watana reservoir filling schedule to minimize impacts to fish resources should be considered. Addition of a low-level intake port should be evaluated.

Response: Initial filling of the Watana-Stage I reservoir is expected to take one season, whereas Stage III is expected to slowly fill over several years. With these filling schedules, Case E-VI flow constraints will be followed, thereby maintaining downstream aquatic habitat. Any additional lengthening of the filling period would only delay but would not reduce impacts to grayling. Lengthening the filling period would potentially increase downstream impacts to salmon, if Case E-VI constraints could not be met. A low-level intake port is not considered necessary due to the revised filling schedule of the three stage project which eliminates the cold tempertures due to the second year of filling.

Recommendation: An expanded discussion of the salmon hatchery mitigation option should be provided.

Response: The salmon hatchery mitigation option is a low priority compensation alternative. It is anticipated that the proposed mitigation will maintain salmon populations in the historical locations and that a hatchery will not be needed. Nevertheless, an independent hatchery siting study has been completed for the Fishery Rehabilitation and Enhancement Division (FRED) of ADF&G. (Kramer, Chin and Mayo, Inc. 1983).

Recommendation: Slough modifications to increase fish habitat need to be demonstrated. It has been suggested that a demonstration project be developed in the middle reach of the Susitna River.

Response: At an appropriate time, the Applicant intends to test slough modification measures with a demonstration project.

Recommendation: Impacts to species listed in the F&WS Categories 3 and 4 should be discussed.

Response: Potential impacts for all secondary evaluation species/life stages are addressed in the draft Middle River Fish Mitigation Plan (APA 1985g).

2.8.2 - Alaska Department of Fish and Game (**)

The Alaska Department of Fish and Game (ADF&G) provided comments on mitigation measures on July 27, 1982, January 13, 1983 and December 31, 1984. The ADF&G comments related to mitigation of lost grayling habitat and mitigation for alterations to downstream salmon habitat.

Recommendation: Increasing access and public facilities for recreational fishing in the Susitna Basin, along with habitat improvements to enhance salmon spawning habitat, are the preferred compensation measures to offset losses in the impoundment zones. ADF&G does not support stocking the impoundments and does not favor a rainbow trout stocking program as a mitigation option.

Response: The approach to impoundment mitigation has been modified to reflect the ADF&G's preferred measures of compensation. The option of stocking rainbow trout has been dropped.

Recommendation: Instream flows and temperatures required to maintain present populations should be carefully evaluated to provide a basis for further mitigation measures.

Response: Extensive studies and analyses on instream flow and temperatures have been made (see Section 2.3). These have been used to formulate the Fish Mitigation Plan (WCC 1984a).

Recommendation: If onsite mitigation of fisheries impacts cannot be accomplished, hatcheries should be considered.

Response: The salmon hatchery option is a low priority compensation alternative. It is anticipated that mitigation in the form of instream flow releases and habitat modifications will be effective at maintaining production of slough and mainstem spawning salmon. These mitigation measures are presented in the Fish Mitigation Plan (WCC 1984a).

Recommendation: The ADF&G supports the selection of chum spawning and chinook rearing as the species/life stages of primary importance. Impacts to other anadromous and resident species/life stages need to be evaluated.

Response: Potential impacts for all secondary evaluation species/life stages are addressed in the draft Middle River Fish Mitigation Plan (APA 1985g).

Recommendation: The ADF&G's preferred mitigation options to avoid or minimize downstream impacts are to provide sufficient instream flows to maintain habitat requirements of species/life stages and implement structural habitat modications.

Response: The Applicant is pleased that the Department agrees that instream flows combined with habitat modifications is a feasible approach to achieving the goal of no net loss of habitat value.

Recommendation: The mitigation plan should contain a detailed monitoring and contingency plan.

Response: A monitoring plan has been prepared and outlines the evaluation process for determining the success of mitigation measures. If mitigation measures are not effective in achieving their intended goal, contingency plans will be in place to either improve the measures or implement other mitigation options.

Recommendation: A pilot program to test the effectiveness and feasibility of mitigation measures should be undertaken.

Response: At an appropriate time, the Applicant intends to test slough modification measures with a demonstration project.

Recommendation: During habitat modifications riparian vegetation must be rehabilitated if disturbed, and stipulations for the disposal of gravel and spoils should be developed.

Response: The Applicant has prepared a BMP manual on Erosion and Sedimentation Control which details methods to dispose of gravels and spoils and rehabilitate disturbed sites. These practices will be a required stipulation of all projects undertaken by the Applicant.

2.8.3 - Alaska Department of Natural Resources (**)

The Alaska Department of Natural Resources' comments of January 13, 1983, requested that downstream mitigation, other than slough modifications, be included. The discussion of downstream mitigation has been substantially revised to indicate more clearly that a series of habitat enhancement techniques will be undertaken, rather than construction of an artificial spawning channel. Also, replacement habitats will provide new habitat in previously unutilized areas.

2.8.4 - National Marine Fisheries Service (***)

The National Marine Fisheries Service (NMFS) provided formal comments of fisheries mitigation planning on December 31, 1984. The NMFS comments related to downstream mitigation planning.

Recommendation: Clarification should be provided on primary and secondary evaluation species and how these species were selected.

Response: The rationale for selecting evaluation species has been presented in the Fish Mitigation Plan (WCC 1984a). Mitigation measures will be developed for secondary species if impacts are identified.

Recommendation: The NMFS expressed concern about dewatering incubating embryos during winter with minimum project flows. Refinement of project flow releases are needed.

Response: Project release schedules have the objective of establishing minimum flows such that survival of embryos deposited at spawning flows will not be compromised at reduced incubation flows. Under natural conditions, redd dewatering is known to occur. It is anticipated that with-project flows will alter this natural condition and provide positive benefits by maintaining flows for redd sites.

Recommendation: The mitigation plan should address rearing habitats in greater detail and discuss mitigation measures designed to maintain rearing conditions in known important rearing areas.

Response: At this time, it is anticipated that mitigation for rearing can be achieved by flow releases. Should flow releases prove to be inadequate in maintaining or replacing rearing habitats, additional mitigation measures will be developed and incorporated into the fish mitigation plan.

Recommendation: Support the inclusion of additional sloughs and side channels for habitat modifications.

Response: It is anticipated that the habitat modifications proposed at selected sloughs and side channels will improve the habitat value substantially beyond that which is presently available.

Recommendation: The periodic removal of fines and organic material should be discussed further.

Response: Removal of fines and organic material from sloughs that would not be overtopped under project flows can be accomplished by: (1) the spawning action of fish themselves; (2) the use of gated berms to provide flushing flows; and (3) the use of a mechanical gravel cleaning machine as proposed in the original License Application.

Recommendation: An evaluation of project impacts from an altered temperature regime should be discussed in the Fish Mitigation Plan.

Response: Control over downstream temperatures through multi-level intake structures is an important mitigation feature and has been extensively analyzed by the Applicant. Discussion of the results of these analyses are presented in Chapter 2 of Exhibit E.

Recommendation: Impacts associated with filling flows of the Watana Reservoir and load following should be addressed in The Fish Mitigation Plan.

Response: Impacts and mitigation measures associated with filling the Watana Reservoir and load following will be incorporated into an updated Fish Mitigation Plan.

Recommendation: NMFS supports a demonstration project to test the effectiveness of the mitigations options.

Response: The Applicant intends to test the effectiveness and feasibility of mitigation measures proposed for slough modifications at an appropriate time.

TABLES

TABLE E.3.2.1: COMMON AND SCIENTIFIC NAMES OF FISH SPECIES RECORDED FROM THE SUSITNA BASIN

Scientific Name	Common Name
12	
Petramyzontidae	
Lampetra japonica	Arctic Lamprey
Salmonidae	
Coregonus laurettae	Bering Cisco
Coregonus pidschian	Humpback Whitefish
Oncorhynchus gorbuscha	Pink Salmon
Oncorhynchus keta	Chum Salmon
Oncorhynchus kisutch	Coho Salmon
Oncorhynchus nerka	Sockeye Salmon
Oncorhynchus tshawytscha	Chinook Salmon
Prosopium cylindraceum	Round Whitefish
Salmo gairdneri	Rainbow Trout
Salvelinus malma	Dolly Varden
Salvelinus namaycush	Lake Trout
Thymallus arcticus	Arctic Grayling
Osmeridae	
Thaleichthys pacificus	Eulachon
Esocidae	
Esox lucius	Northern Pike
Catostomidae	
Catostomis catostomus	Longnose Sucker
Gadidae	
Lota lota	Burbot
Gasterosteidae	
Gasterosteus aculeatus	Threespine Stickleback
Pungitius pungitius	Ninespine Stickleback
Cottidae	
Cottus sp.	Sculpin

Source: Morrow 1980

TABLE E.3.2.2: COMMERCIAL CATCH OF UPPER COOK INLET SALMON IN NUMBERS OF FISH BY SPECIES, 1954 - 1984.

Year	Chinook	Sockeye	Coho	Pink	Chum	Total
1954	63,780	1,207,046	321,525	2,189,307	510,068	4,291,726
1955	45,926	1,027,528	170,777	101,680	248,343	1,594,254
1956	64,977	1,258,789	198,189	1,595,375	782,051	3,899,381
1957	42,158	643,712	125,434	21,228	1,001,470	1,834,022
1958	22,727	477,392	239,765	1,648,548	471,697	2,860,129
1959	32,651	612,676	106,312	12,527	300,319	1,064,485
1960	27,512	923,314	311,461	1,411,605	659,997	3,333,889
1961	19,210	1,162,303	117,778	34,017	349,628	1,683,463
1962	20,210	1,147,573	350,324	2,711,689	970,582	5,200,378
1963	17,536	942,980	197,140	30,436	387,027	1,575,119
1964	4,531	970,055	452,654	3,231,961	1,079,084	5,738,285
1965	9,741	1,412,350	153,619	23,963	316,444	1,916,117
1966	9,541	1,851,990	289,690	2,006,580	531,825	4,689,626
1967	7,859	1,380,062	177,729	32,229	296,037	1,894,716
1968	4,536	1,104,904	470,450	2,278,197	1,119,114	4,977,201
1969	12,398	692,254	100,952	33,422	269,855	1,108,881
1970	8,348	731,214	275,296	813,895	775,167	2,603,920
1971	19,765	636,303	100,636	35,624	327,029	1,119,357
1972	16,086	879,824	80,933	628,580	630,148	2,235,571
1973	5,194	670,025	104,420	326,184	667,573	1,773,396
1974	6,596	497,185	200,125	483,730	396,840	1,584,476
1975	4,780	684,818	227,372	336,359	951,796	2,205,135
1976	10,867	1,664,150	208,710	1,256,744	469,807	3,610,278
1977	14,792	2,054,020	192,975	544,184	1,233,733	1,049,704
1978	17,303	2,622,487	219,234	1,687,092	571,925	5,118,041
1979	13,738	924,415	265,166	72,982	650,357	1,926,658
1980	12,497	1,584,392	283,623	1,871,058	387,078	4,138,648
1981	11,548	1,443,294	494,073	127,857	842,849	2,919,621
1982	20,636	3,237,376	777,132	788,972	1,428,621	6,252,737
1983	20,396	5,003,070	520,831	73,555	1,124,421	6,742,273
1984 (1)	8,800	2,103,000	443,000	623,000	684,000	3,861,800
Average	19,247	1,340,339	263,785	even-1,576,646 odd- 120,416	659,190	3,059,170

(1) ADF&G Preliminary Data.

Source: ADF&G 1984p

TABLE E.3.2.3: SUMMARY OF COMMERCIAL AND SPORT HARVESTS ON SUSITNA RIVER BASIN ADULT SALMON RETURNS

Species	Commercial Harvest						Sport Harvest	
	Upper Cook Inlet Harvest[1]	Estimated Percent Susitna Contribution[2]		Estimated Susitna Harvest	Estimated Susitna Escapement	Estimated Total Run	Susitna Basin Sport Harvest[4]	Percent of Escapement
Sockeye		Mean	Range					
81	1,443,000	20	(10-30)	288,600	287,000[3]	575,600	1,283	0.4
82	3,237,000	20	(10-30)	647,400	279,000[3]	926,400	2,205	0.8
83	5,003,000	10	(10-30)	500,300	185,000[3]	685,300	5,537	3.0
84	2,103,000	20	(10-30)	420,600	605,800[5]	1,026,400	---	---
Pink								
81	128,000	85		108,800	127,000[3]	235,800	8,660	6.8
82	789,000	85		670,650	1,318,000[3]	1,988,650	16,822	1.3
83	74,000	85		62,900	150,000[3]	212,900	4,656	3.1
84	623,000	85		529,550	3,629,900[5]	4,159,450	---	---
Chum								
81	843,000	85		716,550	297,000[3]	1,013,550	4,207	1.4
82	1,429,000	85		1,214,650	481,000[3]	1,695,650	6,843	1.4
83	1,124,000	85		955,400	290,000[3]	1,245,400	5,233	1.8
84	684,000	85		581,400	812,700[5]	1,394,100	---	---
Coho								
81	494,000	50		247,000	68,000[3]	315,000	9,391	13.8
82	777,000	50		388,500	148,000[3]	536,500	16,664	11.3
83	521,000	50		260,500	45,000[3]	305,500	8,425	18.7
84	443,000	50		221,500	190,100[5]	411,600	---	---
Chinook								
81	11,500	10		1,150	---	---	7,576	---
82	20,600	10		2,060	---	---	10,521	---
83	20,400	10		2,040	---	---	12,420	---
84	8,800	10		880	250,000[6]	251,000	---	---

1 Source: ADF&G Commercial Fisheries Division
2 B. Barrett, ADF&G Su Hydro, February 15, 1984 Workshop Presentation
3 Yentna Station + Sunshine Station estimated escapement + 5% for sockeye, + 48% for pink, + 5% for chum + 85% for coho (Source: B. Barrett, ADF&G Su Hydro, February 15, 1984 Workshop Presentation).
4 Mills 1982, 1983, 1984
5 Flathorn Station (RM 22) Escapements (ADF&G 1985b)
6 Source: ADF&G 1985b

TABLE E.3.2.4: ANNUAL SUSITNA BASIN SPORT FISH HARVEST AND EFFORT BY FISHERY AND SPECIES - 1978 TO 1983.

Locations	Days Fished	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1978											
Willow Creek	22,682	47	905	56	18,901	2,458	913	280	0	208	9
Caswell Creek	---										
Montana Creek	25,762	408	2,451	85	15,619	4,429	1,193	633	0	958	9
Sunshine Creek	---										
Clear (Chunilna) Creek	5,040	12	2,200	28	2,074	1,912	1,501	1,817	0	859	27
Sheep Creek	11,869	256	478	14	6,981	1,697	470	108	0	461	18
Little Willow Creek	5,687	0	151	28	3,142	1,015	334	63	0	334	0
Deshka River	9,111	850*	1,798	0	697	0	3,634	0	0	579	0
Lake Creek	8,767	326*	2,212	254	2,833	1,015	2,721	154	36	2,115	45
Alexander Creek	6,914	769*	2,401	183	1,146	215	2,640	136	0	1,871	0
Talachulitna River	732	12*	88	141	31	234	0	235	0	99	0
Lake Louise, Lake Susitna, Tyone River	13,161	0	0	0	0	0	0	0	2,522	2,278	2,947
Others	14,970	163	2,388	56	3,994	2,692	1,519	2,739	877	3,770	208
1978 Total	124,695	2,843	15,072	845	55,418	15,667	14,925	6,165	3,435	13,532	3,263
1979											
Willow Creek	18,911	459	462	94	3,445	582	1,500	618	0	1,654	18
Caswell Creek	3,710	156	624	0	100	9	282	91	0	354	0
Montana Creek	22,621	312	1,735	346	2,472	745	1,536	527	0	791	9
Sunshine Creek	3,317	10*	774	157	700	55	382	264	0	0	45
Clear (Chunilna) Creek	5,125	312	1,248	31	645	355	1,373	827	0	1,045	9
Sheep Creek	6,728	10	462	31	2,418	682	573	127	0	645	64
Little Willow Creek	5,171	0	262	141	745	118	345	336	0	1,091	0
Deshka River	13,236	2,811	973	0	109	0	3,182	0	0	1,463	82
Lake Creek	13,881	1,796	2,671	440	882	136	4,527	164	9	1,963	109
Alexander Creek	8,284	712	1,560	79	236	45	1,182	182	0	745	145
Talachulitna River	2,185	293	125	47	100	55	0	155	0	664	45
Lake Louise, Lake Susitna, Tyone River	12,199	0	0	0	0	0	0	0	2,618	2,936	2,363
Others	12,639	39	1,997	220	664	1,245	3,472	909	472	4,918	282
1979 Total	128,007	6,910	12,893	1,586	12,516	4,072	18,354	4,200	3,099	13,342	3,171

* Chinook less than 20 inches

TABLE E.3.2.4 (Page 2 of 3)

Locations	Days Fished	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1980											
Willow Creek	29,011	289	1,207	83	23,638	989	1,168	636	0	1,868	0
Caswell Creek	4,963	215	1,124	77	1,663	19	154	83	0	353	26
Montana Creek	19,287	559	2,684	257	8,230	571	854	167	0	655	13
Sunshine Creek	5,208	132	1,534	116	2,408	225	193	39	0	0	39
Clear (Chunilna) Creek	4,388	172	661	6	622	385	950	751	0	1,348	32
Sheep Creek	8,041	45*	430	9	6,362	648	385	83	0	725	45
Little Willow Creek	8,190	32*	494	77	6,420	270	353	122	0	1,156	0
Deshka River	19,364	3,685	2,290	0	689	0	4,305	0	0	1,817	224
Lake Creek	8,325	775	2,351	267	2,101	69	2,144	121	9	1,972	0
Alexander Creek	6,812	1,438	999	52	809	121	1,945	353	0	1,145	0
Talachulitna River	2,542	121	491	112	276	17	379	982	0	1,713	0
Lake Louise, Lake Susitna, Tyone River	10,539	0	0	0	0	0	0	0	2,609	4,477	6,612
Others	12,216	45*	2,234	257	3,403	1,445	2,658	790	267	4,854	212
1980 Total	138,886	7,389	16,499	1,304	56,621	4,759	15,488	4,127	2,876	22,083	7,203

Locations	Days Fished	Chinook Salmon*	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1981												
Willow Creek	14,060	144	441	747	77	2,797	1,533	1,475	249	0	1,188	48
Caswell Creek	3,860	77	172	901	38	335	0	326	38	0	144	0
Montana Creek	16,657	239	422	2,261	182	1,782	805	1,111	240	0	891	0
Sunshine Creek	3,062	57	0	968	220	958	125	249	10	0	57	115
Clear (Chunilna) Creek	3,584	86	287	422	29	19	57	1,226	1,418	0	996	0
Sheep Creek	6,936	0	0	326	105	1,236	987	201	57	0	872	0
Little Willow Creek	3,845	0	0	29	67	604	192	374	48	0	623	0
Deshka River	13,248	738	2,031	632	0	19	0	3,631	10	0	1,255	96
Lake Creek	6,471	163	632	1,035	211	412	48	2,874	67	19	1,600	29
Alexander Creek	6,892	278	843	891	67	57	10	2,290	287	0	1,130	29
Talachulitna River	1,378	57	0	240	172	29	0	0	0	0	479	0
Lake Louise, Lake Susitna, Tyone River	14,397	0	0	0	0	0	0	0	0	4,093	4,892	5,29[illegible]
Others	7,850	277	0	939	115	412	450	3,851	814	287	7,089	5[illegible]
1981 Total	102,240	2,748	4,828	9,391	1,283	8,660	4,207	13,757	3,238	4,399	21,216	5,66[illegible]

* Chinook less than 20 inches.

TABLE E.3.2.4 (Page 3 of 3)

Locations	Days Fished	Chinook Salmon*	Chinook Salmon	Coho Salmon	Sockeye Salmon	Pink Salmon	Chum Salmon	Rainbow Trout	Dolly Varden	Lake Trout	Arctic Grayling	Burbot
1982												
Willow Creek	19,704	220	409	1,069	94	4,789	2,086	891	262	0	1,520	63
Caswell Creek	5,101	178	293	776	52	1,092	0	189	73	0	252	0
Montana Creek	23,645	126	115	3,060	514	3,595	1,708	2,243	356	0	849	0
Sunshine Creek	3,787	52	0	1,719	189	1,132	231	545	42	0	42	73
Clear (Chunilna) Creek	3,856	52	398	996	115	220	31	608	1,069	0	943	0
Sheep Creek	9,093	0	0	367	88	2,599	1,750	325	409	0	723	0
Little Willow Creek	5,579	0	0	398	105	1,520	199	335	189	0	377	0
Deshka River	18,391	1,142	3,165	2,463	0	377	0	3,804	0	0	1,457	252
Lake Creek	8,649	356	1,289	1,603	252	398	199	3,134	482	0	1,955	0
Alexander Creek	10,748	681	1,825	1,907	335	482	0	2,505	42	0	1,582	84
Talachulitna River	1,911	0	0	524	63	220	0	0	31	0	587	0
Lake Louise, Lake Susitna, Tyone River	14,024	0	0	0	0	0	0	0	0	4,056	3,532	5,565
Others	9,980	220	0	1,782	398	398	639	2,400	1,666	335	5,041	63
1982 Total	134,468	3,027	7,494	16,664	2,205	16,822	6,843	16,979	4,621	4,391	18,860	6,100
1983												
Willow Creek	13,405	136	398	576	425	1,647	1,490	1,689	336	0	1,794	21
Caswell Creek	5,048	10	262	408	151	126	0	231	157	0	315	31
Montana Creek	17,109	199	305	1,402	534	902	1,311	1,332	325	0	336	0
Sunshine Creek	3,429	105	0	722	685	241	42	178	84	0	31	367
Clear (Chunilna) Creek	7,564	252	682	836	534	73	650	1,836	1,962	0	1,553	84
Sheep Creek	6,237	0	0	596	370	682	902	409	52	0	839	1[illegible]
Little Willow Creek	2,791	0	0	52	110	157	147	514	73	0	84	[illegible]
Deshka River	23,174	934	3,955	1,036	0	21	0	2,434	0	0	1,280	12[illegible]
Lake Creek	14,749	535	1,888	1,392	726	430	52	2,287	262	0	2,224	28[illegible]
Alexander Creek	9,425	672	1,039	408	69	126	0	608	136	0	483	[illegible]
Talachulitna River	4,556	63	273	84	41	0	0	0	105	0	3,178	[illegible]
Kashwitna River	1,344	231	0	52	0	0	0	357	304	0	514	[illegible]
Lake Louise, Lake Susitsna Tyone River	12,948	0	0	0	0	0	0	0	0	3,210	4,217	4,07[illegible]
Others	12,367	303	178	861	1,892	251	639	4,625	1,067	287	3,387	53[illegible]
1983 Total	134,156	3,440	8,980	8,425	5,537	4,656	5,233	16,500	4,863	3,497	20,235	5,52[illegible]

* Chinook less than 20 inches

Source: MILLS 1979, 1980, 1981, 1982, 1983, 1984

Table E.3.2.5 Sport fish harvest for Southcentral Alaska and Susitna Basin in numbers of fish by species, 1978-1983.

Year	Arctic Grayling		Rainbow Trout		Pink Salmon		Coho Salmon		Chinook Salmon		Chum Salmon		Sockeye Salmon	
	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitna Basin	South-central	Susitr Basir
1978	47,866	13,532	107,243	14,925	143,483	55,418	81,990	15,072	26,415	2,843	23,755	15,667	118,299	84
1979	70,316	13,342	129,815	18,354	63,366	12,516	93,234	12,893	34,009	6,910	8,126	4,072	77,655	1,58
1980	69,462	22,083	126,686	15,488	153,794	56,621	127,958	16,499	24,155	7,389	8,660	4,759	105,914	1,30
1981	63,695	21,216	149,460	13,757	64,163	8,660	95,376	9,391	35,822	7,576	7,810	4,207	76,533	1,28
1982	60,972	18,860	142,579	16,979	105,961	16,822	136,153	16,664	46,266	10,521	13,497	6,843	128,015	2,20
1983	56,896	20,235	141,663	16,500	47,264	4,656	87,935	8,425	57,094	12,420	11,043	5,233	170,799	5,53
Average	61,535	18,211	132,908	16,000	even-134,413 odd-58,264	even-42,954 odd-8,611	103,774	13,157	37,294	7,943	12,149	6,797	112,869	2,1

Source: MILLS 1979, 1980, 1981, 1982, 1983, 1984

TABLE E.3.2.6: ESCAPEMENTS BY SPECIES AND SAMPLING LOCATIONS FOR 1981-84

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	1,017,000	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	2,220	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 1985b

TABLE E.3.2.7: ANALYSIS OF CHINOOK SALMON AGE DATA BY PERCENT FROM ESCAPEMENT SAMPLES COLLECTED AT SEVERAL SUSITNA RIVER STATIONS

1981

Collection Site	Sample Size	Age Class 1/								
		3_1	3_2	4_1	4_2	5_1	5_2	6_1	6_2	7_2
Susitna Station	33	3.3	36.1	-	39.4	-	12.1	-	9.1	-
Yentna Station	37	-	18.9	-	40.5	-	13.5	-	27.1	-
Sunshine Station	414	2.0	25.6	1.4	30.5	1.2	21.8	0.3	16.6	0.5
Talkeetna Station	70	3.1	12.6	2.6	27.1	-	21.4	5.6	24.4	2.9
Curry Station	227	3.7	14.8	4.5	29.8	2.1	25.7	1.4	18.0	-

1982

Collection Site	Sample Size	Age Class 1/							
		3_1	3_2	4_1	4_2	5_1	5_2	6_2	7_2
Susitna Station	10	-	40.0	-	40.0	-	10.0	10.0	-
Yentna Station	67	-	43.3	-	29.9	-	14.9	11.9	-
Sunshine Station	1351	0.2	14.8	0.2	27.2	0.4	20.5	36.1	0.4
Talkeetna Station	358	0.6	20.1	0.6	35.2	1.1	19.5	22.3	0.6
Curry Station	441	1.1	15.9	0.8	28.5	2.5	20.0	30.8	0.5

1983

Collection Site	Sample Size	Age Class 1/							
		3_1	3_2	4_1	4_2	5_1	5_2	6_2	7_2
Yentna Station	15	-	33.3	-	13.3	-	13.3	26.7	13.3
Sunshine Station	1307	-	1.5	-	3.9	0.1	38.9	45.0	10.6
Talkeetna Station	664	1.4	21.1	0.2	9.2	1.1	32.9	27.9	6.2
Curry Station	712	0.3	9.1	-	3.9	-	24.4	43.5	18.8

1984

Collection Site	Sample Size	Age Class 1/										
		3_1	3_2	4_1	4_2	4_3	5_1	5_2	6_1	6_2	7_1	7_2
Flathorn Station	30	-	56.7	-	16.7	-	-	16.7	-	10.0	-	-
Yentna Station	13	-	7.7	-	38.5	-	-	7.7	-	46.2	-	-
Sunshine Station	1245	0.5	6.6	0.2	4.9	0.1	0.2	18.0	0.5	44.3	0.1	24.7
Talkeetna Station	652	0.2	0.9	0.6	4.3	-	0.3	17.5	0.6	47.1	-	28.5
Curry Station	468	0.9	9.8	-	6.0	-	-	13.3	-	40.6	0.2	29.3

1/ Gilbert-Rich Notation.

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.8: CHINOOK SALMON PEAK SURVEY ESCAPEMENT COUNTS OF SUSITNA RIVER BASIN STREAMS FROM 1976 TO 1984

Stream	1976	1977	1978	1979	1980	1981	1982	1983	1984
	Year								
Alexander Creek	5,412	9,246	5,854	6,215	a/	a/	2,546	3,755	4,620
Deshka River	21,693	39,642	24,639	27,385	a/	a/	16,000e/	19,237	16,892
Willow Creek	1,660	1,065	1,661	1,086	a/	1,357	592d/	777	2,789
Little Willow Creek	883	598	436	324c/	a/	459	316d/	1,042	b
Kashwitna River (North Fork)	203	336	362	457	a/	557	156d/	297	111c/
Sheep Creek	455	630	1,209	778	a/	1,013	527d/	945	1,028
Goose Creek	160	133	283	b/	a/	262	140d/	477	258
Montana Creek	1,445	1,443	881	1,094c/	a/	814	887d/	1,641	2,309
Lane Creek	b/	b/	b/	b/	b/	40	47	12	22
Indian River	537	393	114	285	a/	422	1,053	1,193	1,456
Portage Creek	702	374	140	190	a/	659	1,253	3,140	2,341
Prairie Creek	6,513	5,790	5,154	a/	a/	1,900	3,844	3,200e/	9,000
Clear Creek	1,237	769	997	864c/	a/	a/	982	806	1,520c/
Chulitna River (East Fork)	112	168	59	a/	a/	a/	119d/	b/	b/
Chulitna River (MF)	1,870	1,782	900	a/	a/	a/	644d/	3,846	4,191
Chulitna River	124	229	62	a/	a/	a/	100d/	b/	b/
Honolulu Creek	24	36	13	37	a/	a/	27d/	b/	b/
Byers Creek	53	69	a/	28	a/	a/	7d/	b/	39
Troublesome Creek	92	95	a/	a/	a/	a/	36d/	b/	b/
Bunco Creek	112	136	a/	58	a/	a/	198	523	51d/
Petters Creek	2,280	4,102	1,335	a/	a/	a/	a/	2,272	a/
Lake Creek	3,735	7,391	8,931	4,196	a/	a/	3,577	7,057	a/
Talachulitna River	1,319	1,856	1,375	1,648	a/	2,129	3,101	10,014	6,138c/
Canyon Creek	44	135	b/	b/	b/	84	b/	575	b/
Quartz Creek	b/	8	b/	b/	b/	8	b/	b/	b/
Red Creek	b/	1,511	385	b/	b/	749	b/	b/	b/
TOTAL	50,615	77,937	54,790	44,645	-	10,453	36,152	60,827	52,765

a/ No total count due to high turbid water
b/ Not counted
c/ Poor counting conditions
d/ Counts conducted after peak spawning
e/ Estimated peak spawning count

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.9: CHINOOK SALMON PEAK ESCAPEMENT COUNTS FOR TRIBUTARY STREAMS ABOVE RIVER MILE 98.6

Stream	River Mile	Peak Count 1981	1982	1983	1984
Whiskers Creek	101.4	b/	0	3	67
Chase Creek	106.9	b/	15	10	3
Lane Creek	113.6	40	47	12	23
5th of July Creek	123.7	b/	3	0	17
Sherman Creek	130.8	b/	3	0	0
4th of July Creek	131.1	b/	56	6	92
Gold Creek	136.7	b/	21	23	23
Indian River	138.6	422	1053	1193	1456
Jack Long Creek	144.5	b/	2	6	7
Portage Creek	148.9	659	1253	3140	5446
Cheechako Creek	152.5	b/	16	25	29
Chinook Creek a/	156.8	b/	5	8	15
Devil Creek a/	161.0	b/	0	1	0
Fog Creek a/	176.7	b/	b	b	2

a/ Above Devil Canyon Dam Site
b/ Not Surveyed

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.10: NUMBER OF FISH, MEAN LENGTH, AND RANGE OF LENGTHS FOR AGE 0+ CHINOOK SALMON BY SAMPLING PERIOD ON THE SUSITNA RIVER BETWEEN TALKEETNA AND DEVIL CANYON

Sampling Period	1982 Mainstem Susitna River			1984 Mainstem Susitna River[a]			1984 Mainstem Indian River		
	No.	Mean (mm)	Range (mm)	No.	Mean (mm)	Range (mm)	No.	Mean (mm)	Range (mm)
May	0	-	-	60	40.8	35-45	b/	-	-
June 1-15	1	40	40	b/	-	-	b/	-	-
June 16-30	19	49	34-70	b/	-	-	b/	-	-
July 1-15	67	55	36-74	100	47.8	38-67	50	48.9	42-64
July 16-31	139	154	36-77	50	52.2	42-69	50	54.9	47-67
August 1-15	84	161	39-88	50	52.4	40-77	100	58.8	47-90
August 16-31	65	64	42-94	100	56.1	43-72	100	61.1	49-80
September 1-15	100	69	41-95	100	57.6	47-88	100	63.8	47-90
September 15 - October 15	42	69	47-100	200	61.0	45-90	300	65.5	50-89

a/ Includes all mainstem, slough, and side channel sites sampled during the coded wire tagging and cold branding studies in the middle reach of the Susitna River.

b/ Not Sampled.

Source: ADF&G 1983m, 1985c

TABLE E.3.2.11: ANALYSIS OF SOCKEYE SALMON AGE DATA BY PERCENT FROM ESCAPEMENT SAMPLES COLLECTED AT SEVERAL SUSITNA RIVER STATIONS

1981

Collection Site	Sample Size	Age Class 1/									
		3_1	3_2	4_1	4_2	4_3	5_1	5_2	5_3	6_2	6_3
Susitna Station	1709	0.0	0.6	0.0	8.4	0.0	0.0	83.9	2.7	0.1	4.3
Yentna Station	1193	0.1	0.7	0.7	7.5	0.4	1.9	80.0	3.5	2.4	2.0
Sunshine Station	976	0.0	1.1	0.6	21.0	0.6	0.0	70.2	2.6	0.2	3.7
Talkeetna Station	110	0.0	0.0	1.8	22.8	0.0	0.0	70.2	1.8	1.8	1.8
Curry Station	270	0.0	0.7	1.1	27.4	0.0	0.0	65.9	3.4	0.0	1.5

1982

Collection Site	Sample Size	Age Class 1/										
		3_1	3_2	4_1	4_2	4_3	5_1	5_2	6_1	6_2	7_1	7_2
Susitna Station	996	0.1	0.4	0.1	22.4	0.2	0.1	65.8	2.1	–	8.8	–
Yentna Station	708	0.4	3.5	0.4	27.7	0.4	–	52.7	4.0	0.6	10.3	–
Sunshine Station		–	–	–	–	–	–	–	–	–	–	–
First Run	314	–	–	–	6.4	–	–	89.5	–	–	4.1	–
Second Run	648	0.3	2.8	1.2	22.1	0.5	–	69.8	0.9	0.3	2.0	0.2
Talkeetna Station	373	–	4.3	–	21.2	2.1	–	70.8	0.8	–	0.8	–
Curry Station	105	1.0	21.9	–	30.5	9.5	–	32.4	4.8	–	–	–

1983

Collection Site	Sample Size	Age Class 1/									
		3_1	3_2	4_1	4_2	4_3	5_1	5_2	5_3	6_2	6_3
Yentna Station	1024	0.4	4.7	0.4	66.8	0.9	0.5	22.6	1.8	0.2	1.7
Sunshine Station											
First Run	290	–	–	–	26.9	–	–	71.4	0.7	1.0	–
Second Run	994	0.1	–	0.1	63.4	0.5	0.1	33.7	1.7	–	0.4
Talkeetna Station	344	0.3	4.1	–	50.9	4.9	–	38.1	1.7	–	–
Curry Station											

1984

Collection Site	Sample Size	Age Class 1/										
		3_1	3_2	4_1	4_2	4_3	5_1	5_2	6_1	6_2	7_1	7_2
Flathorn Station	1780	1.0	5.8	–	1.5	43.3	1.1	1.0	40.3	4.4	0.1	1.4
Yentna Station	2253	0.2	1.3	–	1.6	23.7	0.3	–	59.7	6.5	0.1	6.7
Sunshine Station												
First Run	365	–	–	–	0.3	3.0	–	0.3	96.2	–	0.3	–
Second Run	970	0.8	3.3	0.1	2.2	59.3	1.0	–	29.3	3.3	–	0.7
Talkeetna Station	452	0.7	0.4	–	4.4	79.0	0.4	0.4	12.6	1.5	–	0.4
Curry Station	212	1.9	1.9	–	3.8	65.1	3.8	0.5	16.5	5.7	0.5	0.5

1/ Gilbert-Rich Notation.

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.12: ESTIMATED SOCKEYE SALMON ESCAPEMENTS TO SLOUGHS ABOVE RIVERMILE 98.6

		1981		1982		1983		1984	
Slough	River Mile	Slough Escapement	% Curry Station Escapement	Slough Escapement	% Curry Station Escapement	Slough Escapement	% Curry Station Escapement	Slough Escapement	% Curry Station Escapement
1	99.6	0	0	0	0	0	0	26	0.8
2	100.2	0	0	0	0	0	0	18	0.6
3B	101.4	0	0	0	0	10	0.5	36	1.1
3A	101.9	13	0.5	0	0	0	0	29	0.9
5	107.6	0	0	0	0	0	0	3	0.1
8	113.7	0	0	0	0	0	0	5	0.2
8C	121.9	0	0	5	0.4	0	0	0	0
8B	122.2	0	0	13	1.0	0	0	0	0
Moose	123.5	0	0	20	1.5	31	1.6	0	0
8A	125.1	195	7.0	131	10.1	130	6.8	532	16.6
B	126.3	a/	-	20	1.5	10	0.5	23	0.7
9	128.3	18	0.6	13	1.0	0	0	16	0.5
9B	129.2	212	7.6	0	0	0	0	18	0.6
9A	133.8	4	0.1	0	0	0	0	0	0
11	135.3	1,620	57.9	1,199	92.2	564	29.7	1,280	40.0
15	137.2	0	0	0	0	0	0	3	0.1
17	138.9	11	0.4	0	0	11	0.6	26	0.8
19	139.7	42	1.5	0	0	10	0.5	29	0.9
21	141.1	63	2.3	87	6.7	294	15.5	154	4.8
22	144.5	a/	-	a/	-	0	0	5	0.2

a/ Not Survyed

Source: ADF&G 1984h, 1985b

TABLE E.3.2.13: SUMMARY OF LENGTHS OF AGES 0+ AND 1+JUVENILE SOCKEYE SALMON BY SAMPLING PERIOD DURING 1984

	Lengths of Age 0+ Sockeye					
	At Talkeetna			At Flathorn		
Sampling Period	n	Mean (mm)	Range (mm)	n	Mean (mm)	Range (mm)
May	213	32.0	26-41	134	32.8	27-45
June 1-15	305	36.5	28-60	284	40.4	29-60
June 16-30	509	41.9	25-71	343	42.7	25-70
July 1-15	570	48.8	30-75	313	49.2	25-80
July 16-31	748	53.4	35-87	337	52.2	30-85
August 1-15	547	51.8	33-88	239	53.0	29-85
August 16-31	90	58.6	42-79	185	52.8	30-93
September 1-15	95	59.8	40-91	41	55.6	42-75
September 16 thru October 15	15	60.4	48-90	37	57.2	38-81

	Length of Age 1+ Sockeye		
	Devil Canyon to Cook Inlet		
	n	Mean (mm)	Range (mm)
May	32	71.3	56-99
June 1-15	40	71.3	61-100
June 16-30	15	77.8	71-91
July	3	91.7	81-102

Source: ADF&G 1985c

TABLE E.3.2.14: ANALYSIS OF COHO SALMON AGE DATA BY PERCENT FROM ESCAPEMENT SAMPLES COLLECTED AT SEVERAL SUSITNA RIVER STATIONS

1981

Collection Site	Sample Size	Age Class 1/							
		3_1	3_2	3_3	4_2	4_3	4_4	5_2	5_4
Susitna Station	224	0.0	22.0	0.4	0.9	68.8	1.3	0.0	6.6
Yentna Station	323	0.0	16.1	0.0	0.0	82.9	0.0	0.0	1.0
Sunshine Station	424	0.0	31.8	0.0	0.0	65.1	0.0	0.0	3.1
Talkeetna Station	164	0.0	11.6	0.6	0.0	84.8	0.0	1.2	1.8
Curry Station	77	1.3	27.3	0.0	0.0	68.8	0.0	0.0	2.6

1982

Collection Site	Sample Size	Age Class 1/					
		3_2	3_3	4_2	4_3	4_4	5_4
Yentna Station	311	14.5	1.6	0.3	79.1	1.0	3.5
Sunshine Station	516	35.9	-	0.2	63.1	-	0.8
Talkeetna Station	231	39.4	-	0.4	60.2	-	-
Curry Station							

1983

Collection Site	Sample Size	Age Class 1/			
		3_2	4_3	4_4	5_4
Susitna	299	33.8	64.6	-	1.7
Yentna Station	422	31.8	66.8	-	1.4
Sunshine Station	342	49.3	50.1	0.3	0.3
Talkeetna Station	212	59.0	41.0	-	-
Curry Station	98	54.0	46.0	-	-

1984

Collection Site	Sample Size	Age Class 1/							
		3_1	3_2	3_3	4_2	4_3	4_4	5_2	5_4
Susitna Station	845	0.4	31.4	2.5	0.1	61.9	2.4	1.1	0.4
Yentna Station	377	-	27.9	-	-	69.5	0.5	2.1	-
Sunshine Station	562	-	34.2	-	0.2	64.2	-	1.4	-
Talkeetna Station	309	-	31.7	-	-	67.3	-	1.0	-
Curry Station	166	-	46.4	-	-	51.8	0.6	1.2	-

1/ Gilbert-Rich Notation.

Source: AFD&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.15: COHO SALMON PEAK ESCAPEMENT COUNTS FOR TRIBUTARY STREAMS ABOVE RIVER MILE 98.6

Stream	River Mile	Peak Count 1981	1982	1983	1984
Whiskers Creek	101.4	70	176	115	301
Chase Creek	106.9	80	36	1	239
Slash Creek	111.2	a/	6	2	5
Gash Creek	111.6	141	74	19	234
Lane Creek	113.6	3	5	2	24
Little McKenzie Creek	116.2	56	133	18	24
Little Portage Creek	117.7	a/	8	0	0
4th of July Creek	131.1	1	$	3	8
Gold Creek	136.7	0	1	0	0
Indian River	138.6	85	101	53	465
Jack Long Creek	144.5	0	1	1	6
Portage Creek	148.9	22	88	15	128

a/ Not Surveyed

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.16: NUMBER OF FISH, MEAN LENGTH, AND RANGE OF LENGTHS FOR COHO SALMON BY SAMPLING PERIOD ON THE SUSITNA RIVER DURING 1984

Age 0+ Fish

Sampling Period	Flathorn Station n	Flathorn Station Mean	Flathorn Station Range	Talkeetna Station n	Talkeetna Station Mean	Talkeetna Station Range
May	o	-	-	35	39.7	35-46
June 1-15	10	42.7	32-60	40	39.6	30-51
June 16-30	19	48.7	32-64	156	43.9	31-58
July 1-15	11	49.3	36-65	242	47.8	32-63
July 16-31	38	58.6	44-73	439	51.8	33-69
August 1-15	30	62.1	49-79	221	54.1	41-74
August 16-31	181	66.8	40-89	198	61.5	42-80
September 1-15	84	75.0	55-94	212	60.5	42-85
Sep. 16 - Oct. 15	67	75.1	57-94	39	69.1	51-90

Age 1+ Fish

Sampling Period	Flathorn Station n	Flathorn Station Mean	Flathorn Station Range	Talkeetna Station n	Talkeetna Station Mean	Talkeetna Station Range
May	0			139	69.4	51-105
June 1-15	7	87.4	62-110	332	71.8	52-102
June 16-30	15	78.1	65-96	340	76.1	59-115
July 1-15	12	84.9	70-111	192	77.8	64-118
July 16-31	39	89.8	75-120	252	82.2	70-125
August 1-15	16	92.8	80-112	28	93.5	79-120
August 16-31	68	103.4	91-122	96	101.9	81-131
September 1-15	68	109.4	95-129	14	99.6	86-127
Sep. 16 - Oct. 15	53	112.9	95-133	21	114.4	93-135

Age 2+ Fish*

Sampling Period	Number of Fish	Mean Length	Range of Lengths
May	5	133.2	120-160
June 1 -15	7	135.6	114-157
June 16 -30	1	136.0	136
July 1 - 15	2	130.0	130
July 16 - 31	0	--	--
August 1 - 15	1	126.0	126
August 16 - 31	13	138.0	125-176
September 1 - 15	2	134.0	134
Sep. 16 - Oct. 15	13	141.0	135-150

*From Cook Inlet to Devil Canyon

Source: ADF&G 1985c

TABLE E.3.2.17: ANALYSIS OF CHUM SALMON AGE DATA BY PERCENT FROM ESCAPEMENT SAMPLES COLLECTED AT SEVERAL SUSITNA RIVER STATIONS

1981

Collection Site	Sample Size	Age Class 1/		
		3_1	4_1	5_1
Susitna Station	158	3.2	88.6	8.2
Yentna Station	754	6.6	84.1	9.3
Sunshine Station	1088	4.1	88.7	7.2
Talkeetna Station	438	4.1	85.2	10.7
Curry Station	632	1.9	84.0	14.1

1982

Collection Site	Sample Size	Age Class 1/			
		3_1	4_1	5_1	6_1
Yentna Station	553	2.2	88.6	51.3	0.4
Sunshine Station	1043	0.3	40.1	58.4	1.2
Talkeetna Station	620	0.8	30.3	68.7	0.2
Curry Station	456	0.8	30.3	72.1	---

1983

Collection Site	Sample Size	Age Class 1/		
		3_1	4_1	5_1
Susitna Station	333	4.5	84.4	11.1
Yentna Station	629	3.3	90.3	6.3
Sunshine Station	906	5.5	91.1	3.4
Talkeetna Station	526	4.9	87.1	8.0
Curry Station	480	2.1	85.8	12.1

1984

Collection Site	Sample Size	Age Class 1/				
		2_1	3_1	4_1	5_1	6_1
Flathorn Station	1363	---	15.5	73.9	10.2	0.4
Yentna Station	702	0.1	19.7	69.2	10.2	0.7
Sunshine Station	711	---	6.5	69.2	22.9	1.4
Curry Station	576	---	10.4	7.11	16.7	1.9

1/ Gilbert-Rich Notation

Source: ADF&G 1981a, 1983a, 1984h, 1985b.

TABLE E.3.2.18: CHUM SALMON PEAK ESCAPEMENT COUNTS FOR TRIBUTARY STREAMS ABOVE RIVER MILE 98.6

Stream	River Mile	Peak Count 1981	1982	1983	1984
Whiskers Creek	101.4	1	0	0	0
Chase Creek	106.9	1	0	0	1
Lane Creek	113.6	76	11	6	31
Little McKenzie Creek	116.2	14	0	1	23
Little Portage Creek	117.7	0	31	0	18
5th of July Creek	123.7	0	1	6	2
Skull Creek	124.7	10	1	0	4
Sherman Creek	130.8	9	0	0	6
4th of July Creek	131.1	90	191	148	193
Indian River	138.6	40	1,346	811	2,447
Jack Long Creek	144.5	0	3	2	4
Portage Creek	148.9	0	153	526	1,285

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.19: ESTIMATED CHUM SALMON ESCAPEMENTS TO SLOUGHS ABOVE RIVER MILE 98.6

Slough	River Mile	1981 Slough Escapement	1981 % Curry Station Escapement	1982 Slough Escapement	1982 % Curry Station Escapement	1983 Slough Escapement	1983 % Curry Station Escapement	1984 Slough Escapement	1984 % Curry Station Escapement
1	99.6	10	0.1	0	0	0	0	46	0.1
2	100.2	43	0.3	0	0	96	0.5	188	0.4
3B	101.4	0	0	0	0	0	0	109	0.2
6A	112.3	19	0.2	5	<0.1	0	0	0	0
8	113.7	695	5.3	0	0	0	0	217	0.4
Bushrod	117.8	a/	a/	a/	a/	a/	a/	161	0.3
8D	121.8	0	0	53	0.2	0	0	60	0.1
8C	121.9	0	0	108	0.4	8	0.1	207	0.4
8B	122.2	0	0	99	0.3	261	1.2	860	1.7
Moose	123.5	222	1.7	59	0.2	86	0.4	284	0.6
A1	124.6	200	1.5	0	0	155	0.7	217	0.4
A	124.7	81	0.6	0	0	4	<0.1	8	0.1
8A	125.1	480	3.7	1,062	3.6	112	0.5	2,383	4.8
8B	126.3	a/	a/	104	0.4	14	0.1	168	0.3
9	128.3	368	2.8	603	2.1	430	2.0	304	0.6
9B	129.2	277	2.1	12	0.1	0	0	132	0.3
9A	133.8	140	1.1	86	0.3	231	1.1	528	1.1
10	133.8	0	0	0	0	0	0	90	0.2
11	135.3	1,119	8.5	1,078	3.7	674	3.2	3,418	6.9
13	135.9	7	0.1	0	0	8	0.1	16	0.1
14	135.9	0	0	0	0	0	0	4	0.1
15	137.2	0	0	0	0	4	<0.1	67	0.1
16	137.3	5	<0.1	0	0	0	0	20	0.1
17	138.9	135	1.0	23	0.1	166	0.8	204	0.4
18	139.1	0	0	0	0	0	0	42	0.1
19	139.7	5	<0.1	0	0	6	<0.1	102	0.2
20	140.0	24	0.2	28	0.1	103	0.5	329	0.7
21	141.1	657	5.0	1,737	5.9	481	2.3	4,245	8.6
22	144.5	a/	a/	a/	a/	105	0.5	187	0.4
21A	145.3	14	0.1	0	0	0	0	38	0.1

a/ Not Surveyed

Source: ADF&G 1984h, 1985b

TABLE E.3.2.20: PINK SALMON PEAK ESCAPEMENT COUNTS FOR TRIBUTARY STREAMS ABOVE RIVER MILE 98.6

Stream	River Mile	Peak Count 1981	1982	1983	1984
Whiskers Creek	101.4	1	138	0	293
Chase Creek	106.9	38	107	6	438
Slash Creek	111.2	1/	0	0	3
Gash Creek	111.6	0	640	0	6
Lane Creek	113.6	291	0	28	1,184
Clyde Creek	113.8	1/	1/	-	34
Maggot Creek	115.6	1/	1	-	107
Little McKenzie Creek	116.2	0	23	17	585
McKenzie Creek	116.7	0	17	0	11
Little Portage Creek	117.7	1/	140	7	162
Fromunda Creek	119.3	1/	1/	-	40
Downunda Creek	119.4	1/	1/	-	6
Dead Horse Creek	120.8	0	1/	-	337
Tulip Creek	120.9	1/	1/	-	8
5th of July Creek	123.7	2	113	9	411
Skull Creek	124.7	8	12	1	121
Sherman Creek	130.8	6	24	0	48
4th of July Creek	131.1	29	702	78	1,842
Gold Creek	136.7	0	11	7	82
Indian River	138.6	2	738	886	9,066
Jack Long Creek	144.5	1	21	5	14
Portage Creek	148.9	0	169	285	2,707

1/ Not Surveyed

Source: ADF&G 1981a, 1983a, 1984h, 1985b

TABLE E.3.2.21: FISH SPECIES INHABITING STREAMS WITHIN THE ACCESS AND TRANSMISSION LINE CORRIDORS (Page 1 of 3)

Stream Number and/or Name	Date	Species Observed	Number Captured	Range (mm)
Denali High to Watana				
1 1/	830817	Dolly Varden	9	85 - 150
		Sculpin	1	70
2 - Lily Creek	830817	Dolly Varden	10	105 - 190
		Sculpin	2	60 - 85
3 - Seattle Creek	830817	Dolly Varden	50	70 - 195
		Arctic grayling	9	100 - 310
		Sculpin	3	70 - 95
4	830817	Dolly Varden	3	80 - 125
5	830817	NONE	-	--
6	830818	NONE	-	--
7	830818	a	-	--
8 - Brushkana Creek	830818	Arctic grayling	3	350 - 385
		Sculpin	2	80 - 95
9	830818	Arctic grayling	9	60 - 380
		Sculpin	10	60 - 95
10	830818	Dolly Varden	30	90 - 205
		Arctic grayling	20	95 - 285
		Sculpin	10	80 - 95
11	830818	a	-	--
12 - Deadman Creek	830818	Arctic grayling	3	240 - 365
		Sculpin		50 - 95
13	830813	a	-	--

a - did not sample

1/ Location of numbered streams identified in Figures E.3.2.14 thru 17.

~~Source: ADF&G 1984a~~

TABLE E.3.2.21 (Page 2 of 3)

Stream Number and/or Name	Date	Species Observed	Number Captured	Range (mm)
Denali High to Watana				
14	830813	a	-	--
15	830813	a	-	--
16	830813	a	-	--
17	831813	a	-	--
18	831813	Dolly Varden	3	105 - 170
		Sculpin	1	85
19	831813	Sculpin	2	80 - 95
20	831814	Dolly Varden	1	45
		Arctic grayling	1	105
		Sculpin	5	50 -90
21	831814	a	-	--
22	830814	a	-	--
Watana to Devil Canyon				
23 - Tsusena Creek	831818	Dolly Varden	1	50
		Sculpin	1	55
24	830814	Dolly Varden	11	105 - 180
		Sculpin	3	75 - 90
25	830814	a	-	--
26	830815	a	-	--
27	830815	a	-	--

a - did not sample

TABLE E.3.2.21 (Page 3 of 3)

Stream Number and/or Name	Date	Species Observed	Number Captured	Length Range (mm)
Watana to Devil Canyon				
28	831815	Dolly Varden	1	105
		Sculpin	1	65
29	830815	Dolly Varden	1	80 - 100
		Sculpin	1	65
30	830815	a	-	--
31	830815	Dolly Varden	20	90 - 190
		Sculpin	6	50 - 90
32	830815	Dolly Varden	15	150 - 375
		Sculpin	2	60 - 80
33	830815	Sculpin	1	65
34 - Devil Creek	830815	Sculpin	2	75 - 80
35	830815	Dolly Varden	1	155
		Sculpin	1	65
36	830815	Dolly Varden	1	140
Devil Canyon to Gold Creek				
37	830813	Sculpin	1	60
38	830816	a	-	--
39	830816	a	-	--
40	830816	Chinook salmon	20	40 - 60
		Sculpin	3	50 - 95
41 - Waterfall Creek	831816	Arctic grayling	1	140
		Chinook salmon	30	40 - 60
		Sculpin	8	40 - 85
42 - Gold Creek	830816	a	-	--

a - did not sample

TABLE E.3.2.22: FISH SPECIES INHABITING LAKES WITHIN THE ACCESS AND TRANSMISSION LINE CORRIDORS

Lake	Geographic Code	Date	Species Observed	Number Captured	Length Range (mm)
Ridge Lake	F 22S 05W 25 DCA	830917	a		
Beaver Lake	S 33N 05W 34 DDC	830917	Burbot	1	275
			Arctic grayling	3	260 - 335
			Sculpin	3	65 - 90
Long Lake	S 32N 05W 15 CAC	830915	Sculpin	1	85
Round Lake	S 32N 05W 15 CCC	830915	NONE		
Swimming Bear Lake	S 32N 07W 04 BAB	830916	Dolly Varden	13	125 - 380
			Sculpin	7	65 - 95
High Lake	S 32N 02E 20 DBB	830918	Rainbow Trout	15	160 - 430
			Sculpin	2	60 - 85
Little High Lake	S 32N 02E 19 AAC	830918	Rainbow Trout	7	160 - 285
			Sculpin	1	65
Island Lake	S 32N 01E 25 ABD	830918	Dolly Varden	20	300 - 445
			Sculpin	2	65 - 95
Highest Lake	S 32N 01E 14 ADD	830920	Dolly Varden	7	115 - 245
			Sculpin	1	75

a - Observed school of fish 6-10" long.

Source: ADF&G 1984a

TABLE E.3.2.23: ARCTIC GRAYLING HOOK AND LINE CATCH IN TRIBUTARIES WITHIN THE IMPOUNDMENT ZONE BY LOCATION AND MONTH

	1981 CATCH					
Tributary	May	June	July	August	September	Total
Oshetna River	19	92	155	73	167	506
Goose Creek	121	136	82	37	6	382
Jay Creek	3	178	70	16	50	317
Kosina Creek	136	246	143	67	187	779
Watana Creek	1	49	16	172	28	266
Deadman Creek	53	86	42	6	3	190
Tsusena Creek	23	19	74	18	1	135
Fog Creek	22	17	23	5	5	72
TOTAL CATCH	378	823	605	394	447	2,647

Tributary	1982 CATCH					
	May	June	July	August	September	Total
Oshetna River	10	-	288	243	172	713
Goose Creek	-	38	91	76	2	207
Jay Creek	3	79	130	108	4	324
Kosina Crek	37	232	491	604	320	1,684
Watana Creek	-	128	175	208	36	547
Deadman Creek	-	40	51	110	1	203
Tsusena Creek	7	10	29	26	7	79
Fog Creek	-	1	5	17	2	25
TOTAL CATCH	58	528	1,260	1,392	544	3,782

Source: ADF&G 1981f, 1983b

TABLE E.3.2.24: ARCTIC GRAYLING POPULATION ESTIMATES FOR THE REACH OF MAJOR TRIBUTARIES IN THE WATANA AND DEVIL CANYON IMPOUNDMENT AREAS

		Petersen Population Estimate 1/		
Stream	Reservoir	1981 2/	1982 3/ Number	1982 Number per mile
Oshetna River	Watana	2,017	2,426	1,103
Goose Creek	Watana	1,327	949	791
Jay Creek	Watana	1,089	1,592	455
Kosina Creek	Watana	2,787	5,544	1,232
Watana Creek	Watana	--	3,925	323
Deadman Creek	Watana	979	734	1,835
Tsusena Creek	Devil Canyon	1,000	--	440
Fog Creek	Devil Canyon	176	--	664

1/ Estimates for tributary reaches below El. 2135 ft. MSL in Watana Reservoir area and below El. 1455 MSL in Devil Canyon Reservoir.

2/ 1981 Estimate based on Arctic grayling greater than 8 inches (200 mm) long.

3/ 1982 Estimate based on all ages, but underestimates ages 1 and 2.

Source: ADF&G 1983b

TABLE E.3.2.25: PETERSEN POPULATION ESTIMATE FOR ARCTIC GRAYLING BY AGE GROUP IN THE WATANA IMPOUNDMENT AREA, SUMMER 1982

Age	Number Marked	Number Recaptured	Number Caught	Estimated Number in Age Group
1 & 2	91	3	84	1,955
3	226	10	222	4,602
4	263	23	263	2,904
5	321	44	342	2,454
6	204	48	270	1,134
7	81	16	107	521
7 and above	27	7	41	180
Totals	1,281	153	1,337	13,750

Source: ADF&G 1983b

TABLE E.3.2.26: SUSITNA HYDROELECTRIC PROJECT INFLUENCE OF MAINSTEM FLOW AND WATER QUALITY ON CHARACTERISTICS OF AQUATIC HABITAT TYPES

	Physical Characteristics					
Habitat Type	Hydraulic1/	Hydrologic	Temp.	Turbidity	Ice	Total
Mainstem (MS)	4	4	4	4	4	20
Side Channel (SC)	3	4	4	3	4	18
Tributary Mouth (TM)	3	3	2	2	3	13
Side Slough (SS)	2	2	2	2	2	10
Upland Slough (US)	1	1	0	0	0	2
Tributary (T)	0	0	0	0	0	0
Lake (L)	0	0	0	0	0	0

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

1/ Depth, velocity, wetted area, etc.

Source: HE 1985a

TABLE E.3.2.27: SUSITNA HYDROELECTRIC PROJECT LOCATIONS OF NAMED TRIBUTARIES OF THE SUSITNA RIVER IN THE RESERVOIR AREA

Tributary	Susitna River Confluence (River Mile)
Oshetna River	233.4
Goose Creek	231.3
Jay Creek	208.5
Kosina Creek	206.8
Watana Creek	194.1
Deadman Creek	186.7
Tsusena Creek	181.3
Fog Creek	176.7
Devil Creek	161.4
Chinook Creek	157.0
Cheechako Creek	152.4

Source: ADF&G 1983d

TABLE E.3.2.28: IMPORTANT USES OF HABITAT TYPES BY EVALUATION SPECIES

Evaluation Species	Habitat Type					
	MS[1]	SC	TM	SS	US	T
Chinook Salmon						X
Migrate	X		X			X
Spawn-incubate						X
Rear		X		X		
Coho Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear					X	X
Chum Salmon						
Migrate	X	X	X	X		X
Spawn-incubate		X		X		X
Rear	X			X		X
Sockeye Salmon						
Migrate	X			X		
Spawn-incubate				X		
Rear				X	X	
Pink Salmon						
Migrate	X		X			X
Spawn-incubate						X
Rear						
Arctic Grayling						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Rainbow Trout						
Migrate	X		X			X
Spawn-incubate						X
Rear	X		X			X
Burbot						
Migrate	X		X			
Spawn-incubate						
Rear	X					
Dolly Varden						
Migrate	X	X				X
Spawn-incubate						X
Rear	X					

MS=Mainstem, SC=Side Channel, TM=Tributary Mouth, SS=Side Sloughs, US=Upland Sloughs, Tributary

Source: HE 1985a

TABLE E.3.2.29: TOTAL SURFACE AREAS BY HABITAT TYPE WITHIN THE TALKEETNA-DEVIL CANYON REACH OF THE SUSITNA RIVER

	Surface Area (acres) by Discharge						
Habitat Type	5,100 cfs	7,400 cfs	10,600 cfs	12,500 cfs	16,000 cfs	18,000 cfs	23,000 cfs
Mainstem	2,458.1	2,599.6	2,805.9	2,850.4	3,158.5	Data	3,737.2
Side Channel	729.7	768.7	968.7	1,095.5	1,222.2	not	1,240.7
Side Slough	121.4	144.0	134.2	118.1	85.8	Avail-	52.5
Upland Slough	15.3	22.9	19.6	23.6	22.6	able at	24.4
Tributary Mouth	15.9	15.1	18.6	26.2	25.3	Time of	12.1
Gravel Bar	2,518.5	2,301.2	1,848.4	1,727.7	1,419.2	Publi-	815.8
Vegetated Bar	1,945.4	2,130.5	2,080.2	1,919.1	2,011.4	cation	1,718.4

Source: EWT&A 1985b

TABLE E.3.2.30: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP I

Description: Habitat character is dominated by high breaching flow (40,000 cfs). This group includes all upland sloughs and Slough 11 (RM 135.6R). Specific area hydraulics are characterized by pooled clear water with velocities frequently near zero and depths greater than 1 ft. Pooled areas are commonly connected by short riffles where velocities are less than 1 fps and depths are less than 0.5 feet.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
102.2L		>35,000	0.83	--
105.2R		>35,000	0.64	--
107.6L	Slough 5	>35,000	0.44	RJHAB
108.3L		>35,000	0.70	--
112.5L	Slough 6A	>35,000	0.68	RJHAB
119.4L		>35,000	0.45	--
120.0R		>35,000	0.50	--
121.9R		>35,000	0.83	--
123.1R		>35,000	0.45	--
123.3R		>35,000	0.67	--
127.2M		>35,000	0.58	--
129.4R		>35,000	0.44	--
133.9L		>35,000	0.67	--
134.0L	Slough 10	>35,000	0.99	--
135.5	Slough 12	>35,000	0.32	--
135.6R	Slough 11	>35,000	0.54	--
136.9R		>35,000	0.69	--
139.0L		>35,000	0.45	--
139.9R		>35,000	0.74	--

RJHAB = ADF&G Habitat Model
-- = Data not available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.31: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP II

Description: Habitat character is dominated by relatively high breaching flows (20,000 - 40,000 cfs) and the presence of upwelling ground water sources that persist throughout winter. This group includes the specific areas that are commonly called sloughs. These specific areas typically have relatively large channel length to width ratios.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
100.6R		33,000	0.60	--
101.4L	Slough 3B	22,000	0.54	RJHAB
101.8L		22,000	0.60	--
113.1R		26,000	0.43	--
113.7R	Slough 8	24,000	0.51	RJHAB
115.6R		23,000	0.54	--
117.9L		22,000	0.62	--
118.0L		22,000	0.39	--
121.8R	Slough 8D	22,000	0.27	--
122.4R		26,000	0.29	--
122.5R	Slough 8B	20,000	0.51	--
123.6R	Moose Slough	25,500	0.43	--
125.1R		20,000	0.48	--
125.9R		26,000	0.56	--
126.0R	Slough 8A	33,000	0.51	IFG
126.3R	Slough B	27,000	0.59	--
131.8L		26,900	0.45	--
133.9R		30,000	0.50	--
135.3L		23,000	0.30	--
137.5R		22,000	0.44	DIHAB
137.5L		29,000	0.60	--
137.8L		20,000	0.64	--
137.9L		21,000	0.50	--
140.2R		26,500	0.50	--
142.1R		23,000	0.65	--
142.2R		32,000	0.52	--
143.4L		30,000	0.55	--
144.4L	Slough 22	21,000	0.60	RJHAB

DIHAB = EWT&A Direct Input Model
IFG = Instream Flow Group Habitat Model
RJHAB = ADF&G Habitat Model
-- = Data not available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.32: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP III

Description: Habitat character is dominated by intermediate breaching flows (5,100 cfs - 20000 cfs) and relatively broad channel sections. This group includes side channels which become nonbreached at intermediate mainstem discharge levels and transform into slough habitat at lower discharges. Breaching flows are typically lower than for Group II, upwelling is present and the length to width ratios of the channels are generally less than ratios for Group II.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
100.4R		12,500	0.51	--
100.6L		9,200	0.48	--
101.2R	Whisker's Creek Side Channel	9,200	0.56	IFG
101.6L	Lower Whisker's Creek Side Channel	14,000	0.61	--
101.7L	Upper Whisker's Creek Side Channel	9,600	0.46	DIHAB
110.4L	Oxbow V	12,000	0.67	--
115.0R	Mainstem II	12,000	0.55	DIHAB
117.8L	Curry Side Channel 21	8,000	0.48	--
119.3L	Oxbow II Side Channel	16,000	0.56	--
128.5R	Side Channel 9	10,400	0.48	--
128.7R		15,000	0.49	--
128.8R	Slough 9	16,000	0.34	IFG
130.2L		8,200	0.64	DIHAB
130.2R		12,000	0.60	--
132.6L	Side Channel 10A	10,500	0.49	IFG, RJHAB
133.7R		11,500	0.44	DIHAB
137.2R		10,400	0.49	--
141.4R	Side Channel 21	11,500	0.56	IFG

DIHAB = Direct Input Model Developed by EWT&A
IFG = Instream Flow Group Habitat Model
RJHAB = ADF&G Habitat Model
-- = Data Not Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.33: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP IV

Description: Habitat character is dominated by low breaching flows (<5100 cfs) and intermediate mean reach velocities. This group includes the specific areas that are commonly called side channels. These specific areas possess mean reach velocities ranging from 2-5 fps at a mainstem discharge of approximately 10000 cfs.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
100.7R		<5,000	0.49	--
108.7L		<5,000	0.53	--
110.8M		<5,000	0.48	--
111.5R		<5,000	0.48	--
112.6L	Side Channel 6A	<5,000	0.60	IFG
114.0R		<5,000	0.43	--
116.8R		<5,000	0.48	--
119.5L		5,000	0.54	--
119.6L		<5,000	0.53	--
121.7R		<5,000	0.48	--
124.1L		<5,000	0.46	--
125.2R	Side Channel 8A	<5,000	0.61	DIHAB
127.0L		<5,000	0.65	--
127.4L		<5,000	0.46	--
129.5R		<5,000	0.56	--
131.7L	4th of July Creek Side Channel	<5,000	0.47	IFG
134.9R	Lower Side Channel	<5,000	0.56	IFG
136.0L	Doug's Delight Side Channel	<5,000	0.55	IFG
139.4L		<5,000	0.61	DIHAB
139.6L		<5,000	0.51	--
140.4R		<5,000	0.48	--
145.3R		<5,000	0.53	--

IFG = Instream Flow Group Habitat Model
DIHAB = Direct Input Model Developed by EWT&A
-- = Data Not Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.34: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP V

Description: Habitat character is dominated by channel morphology. This group includes shoal areas at higher flows which transform to slough or clearwater habitats at lower flows as mainstem discharge decreases.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
101.71L		10,000	0.86	DIHAB
117.0M		15,500	0.55	--
118.9L	Lower Little Rock Spawning Site	<5,000	0.86	DIHAB
124.0M		23,000	0.91	--
132.8R		19,500	1.02	--
139.0L		<5,000	0.77	DIHAB
139.7R		22,000	0.91	--
141.6R	Slough 21	21,000	1.00	IFG
143.0L		7,000	0.55	--

IFG = Instream Flow Group Habitat Model
DIHAB = Direct Input Model Developed by EWT&A
-- = Data Not Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.35: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP VI

Description: Habitat character is dominated by channel morphology. This group includes overvlow channels that parallel the adjacent mainstem, usually separated by a sparsely vegetated gravel bar. These specific areas may or may not possess an upwelling of groundwater source.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
102.6L		6,500	0.69	--
106.3R		4,800	0.53	--
107.1L		9,600	0.69	--
117.9R		7,300	0.49	--
119.7L		23,000	0.51	--
133.8L	Slough 10 Side Channel	17,500	0.49	IFG
135.7R		27,500	0.32	--
136.3R		13,000	0.54	IFG
138.0L		8,000	0.53	--
138.8R		6,000	0.31	--
139.5R		8,900	0.31	--
140.6R		12,000	0.61	--
142.0R		10,500	0.53	--

IFG = Instream Flow Group Habitat Model
-- = Data Not Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.36: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP VII

Description: Habitat character is dominated by a characteristic riffle/pools sequence. The Little Rock IFG modeling site (RM 119.2R) is typical with a riffle just downstream of the side channel head that flows into a large backwater pool near the mouth.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
114.1R	Lane Creek Spawning Site	<5,100	0.31	DIHAB
119.2R	Little Rock Side Channel	10,000	0.41	IFG
121.1L		7,400	0.43	--
123.0L		<5,100	0.39	--
125.6L		<5,100	0.52	--
127.5M		<5,100	0.31	--
131.3L		8,000	0.31	DIHAB

IFG = Instream Flow Group Habitat Model
DIHAB = Direct Input Model developed by EWT&A
-- = No Data Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.37: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP VIII

Description: Habitat character is dominated by the tendency of these channels to tidewater at a relatively high mainstem discharge. Channels in this group are frequently oriented with a 30°+ angle to the mainstem flowline at their heads.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
101.3M		9,200	0.57	--
102.0L		10,000	0.43	--
104.3M		21,000	0.48	--
109.5M		16,000	0.49	--
112.4L		22,000	0.27	--
117.1M		15,500	0.32	--
117.2M		23,000	0.32	--
118.6M		14,000	0.26	--
119.8L		15,500	0.51	--
120.0L		12,500	0.32	--
121.5R		19,500	0.32	--
121.6R		15,500	0.60	--
123.2R		23,000	0.26	--
124.8R		19,500	0.46	--
125.6R		26,000	0.54	--
128.4R		9,500	0.56	--
132.5L		14,500	0.57	--
135.0R		23,000	0.44	--
135.1R		20,000	0.44	--
140.0M		22,000	0.31	--
145.6R		22,000	0.62	--
146.6L		26,500	0.48	--

-- = No Data Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.38: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP IX

Description: Habitat character is dominated by low breaching flows and relatively swift velocities. This group includes specific areas that were categorized as mainstem at 5100 cfs, as well as side channels (Category 5) and indistinct side channels (Category 6) with mean velocities greater than 5 fps at 10,000 cfs mainstem.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
101.5L	Whisker's Creek West Side Channel	<5,000	0.45	IFG
104.0R		<5,000	0.48	--
105.7R		<5,000	0.53	--
108.9L		<5,000	0.58	--
109.4R		<5,000	0.45	--
111.0R		<5,000	0.35	--
113.8R		<5,000	0.53	--
117.7L		<5,000	0.41	--
127.1M		<5,000	0.53	--
128.3R		<5,000	0.63	--
129.3L		<5,000	0.62	--
129.8R		<5,000	0.56	--
131.2R		<5,000	0.59	--
135.0L		<5,000	0.48	--
139.2R		<5,000	0.61	--
141.2R		<5,000	0.69	--
141.3R		<5,000	0.69	--
142.8R		<5,000	0.56	--
144.0R		<5,000	0.96	--
144.2L		<5,000	0.53	--
147.1L	Fat Canoe Island	<5,000	0.57	IFG

IFG = Instream Flow Group Habitat Model
-- = No Data Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.39: MIDDLE RIVER HABITAT SITES IN REPRESENTATIVE GROUP X

Description: Habitat character is dominated by channel morphology. This group includes large mainstem shoals, and mainstem margin areas that had open leads in the March 1983 photography.

Specific Area	Known As	Breaching Flow (cfs)	Structural Habitat Index	Model
105.81L		MSS	0.57	HAB
109.3M		MSS	0.48	--
111.6R		11,500	0.49	--
113.6R		10,500	0.55	--
113.9R		7,000	0.48	--
119.11L		MSS	0.41	HAB
121.1R		MSS	0.47	--
133.81R		MSS	0.48	HAB
138.71L		MSS	0.57	HAB
139.3L		MSS	0.56	--
139.41L		MSS	0.41	HAB
142.8L		MSS	0.36	--
148.2R		MSS	0.48	--

MSS = Mainstem Shoal
HAB = Direct Input Model developed by EWT&A
-- = No Data Available

Source: EWT&A and AEIDC 1985

TABLE E.3.2.40: SUSITNA HYDROELECTRIC PROJECT
PRIMARY UTILIZATION OF SENSITIVE HABITAT TYPES
BY EVALUATION SPECIES

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

S - spawning/incubation
R - rearing

Source: HE 1985a

TABLE E.3.2.41: COVER SUITABILITY CRITERIA RECOMMENDED FOR USE IN JUVENILE CHINOOK HABITAT UNDER CLEAR AND TURBID WATER CONDITIONS

Percent Cover	No Cover	Emergent Veg.	Aquatic Veg.	Debris & Deadfall	Over Hanging Riparian	Undercut Banks	Large Gravel	Rubble 3"-5	Cobble or Boulders <5"
				Clear Water					
0-5%	0.01	0.01	0.07	0.11	0.06	0.10	0.07	0.09	0.09
6-25%	0.01	0.04	0.22	0.33	0.20	0.32	0.21	0.27	0.29
26-50%	0.01	0.07	0.39	0.56	0.34	0.54	0.35	0.45	0.49
51-75%	0.01	0.09	0.53	0.78	0.47	0.75	0.49	0.63	0.69
76-100%	0.01	0.12	0.68	1.00	0.61	0.97	0.63	0.81	0.89
				Turbid Water					
0-5%	0.31	0.31	0.31	0.48	0.26	0.44	0.31	0.39	0.39
6-25%	0.31	0.31	0.39	0.58	0.35	0.56	0.37	0.47	0.51
26-50%	0.31	0.31	0.46	0.67	0.41	0.65	0.42	0.54	0.59
51-75%	0.31	0.31	0.52	0.77	0.46	0.74	0.48	0.62	0.68
76-100%	0.31	0.31	0.58	0.85	0.52	0.82	0.54	0.69	0.76

Sources: ADF&G 1984c, EWT&A and WCC 1985

Table E.3.2.42: JUVENILE CHINOOK REARING HABITAT AVAILABILITY AT IFG AND RJHAB MODELED SITES

Mainstem Discharge	Site Locations By River Mile Designation (Representative Group)									
	101.2R (RG 3)	101.4L (RG 2)	101.5L (RG 9)	107.6L (RG 1)	112.5L (RG 1)	112.6L (RG 4)	113.7R (RG 2)	119.2R (RG 7)	126.0R (RG 2)	128.8R (RG 3)
(cfs)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)
4000	0.00	145.25	39.00	119.10	41.70	317.50	133.40	185.99	176.40	20.60
5000	0.00	145.25	39.00	118.75	41.70	317.50	132.45	185.99	176.40	20.60
6000	0.00	145.25	41.80	118.49	41.70	258.70	131.58	185.99	176.40	20.60
7000	31.66	145.25	43.90	117.86	41.70	227.80	131.36	185.99	176.40	20.60
8000	95.00	145.25	42.80	116.85	41.70	185.90	133.07	226.21	176.40	20.60
9000	158.34	145.25	52.70	115.48	41.70	144.40	136.61	306.64	176.40	20.60
10000	313.71	145.25	49.60	113.76	41.70	109.00	141.60	387.10	176.40	20.60
11000	326.44	145.25	46.60	111.69	41.70	73.55	146.81	394.50	176.40	20.60
12000	271.48	145.25	40.70	109.30	41.70	55.30	152.29	344.70	176.40	20.60
13000	218.77	145.25	41.60	106.60	41.70	48.80	158.46	353.50	176.40	20.60
14000	177.51	145.25	41.50	103.61	41.70	45.00	165.87	301.80	176.40	20.60
15000	147.55	145.25	39.50	100.38	41.70	50.70	176.37	250.50	176.40	20.60
16000	121.45	145.25	37.70	96.93	41.70	53.30	185.92	199.10	176.40	20.60
17000	112.39	145.25	34.10	93.29	41.70	53.90	195.63	159.20	176.40	43.90
18000	104.35	145.25	34.50	89.48	41.70	47.50	204.00	137.00	176.40	101.66
19000	97.17	145.25	36.10	85.53	41.70	40.80	213.84	111.70	176.40	263.90
20000	90.73	145.25	36.10	81.34	41.70	35.20	224.56	85.60	176.40	278.80
21000	84.92	145.25	42.00	76.79	41.70	31.00	235.08	73.32	176.40	262.60
22000	79.65	145.25	43.70	72.02	41.70	27.10	244.04	63.23	176.40	242.20
23000	74.85	158.20	44.70	68.17	41.70	24.70	251.67	54.72	176.40	214.90
24000	70.47	185.71	44.80	65.48	41.70	22.20	257.72	47.51	176.40	169.30
25000	66.45	253.70	45.70	58.88	41.70	20.60	259.44	43.23	176.40	139.90
26000	62.75	322.79	50.60	54.00	41.70	19.10	267.58	41.17	176.40	111.60
27000	59.34	346.47	51.80	54.77	41.70	17.60	283.56	39.26	176.40	83.90
28000	56.19	347.54	52.50	56.32	41.70	16.20	312.19	37.48	176.40	61.40
29000	53.26	330.02	51.70	57.42	41.70	14.80	360.16	35.82	176.40	60.90
30000	50.55	298.34	49.30	57.64	41.70	13.70	403.44	34.27	176.40	60.90
31000	48.02	269.23	47.30	58.01	41.70	12.80	425.53	32.81	176.40	67.90
32000	45.66	246.60	46.60	57.94	41.70	11.90	424.34	31.45	176.40	68.70
33000	43.45	229.15	44.90	57.88	41.70	11.00	407.45	30.16	242.60	80.70
34000	41.39	215.96	43.20	57.90	41.70	10.90	387.73	28.95	232.60	78.10
35000	39.45	206.38	41.70	57.35	41.70	10.70	369.38	27.80	225.10	76.30
36000	37.40	201.20	40.20	57.35	41.70	10.50	351.03	26.70	217.60	74.50
37000	35.40	181.00	38.50	57.35	41.70	10.30	332.68	25.60	210.10	72.70
38000	33.30	161.60	36.80	57.35	41.70	10.10	314.33	24.50	202.60	70.90
39000	31.30	142.90	35.10	56.70	41.70	9.90	295.98	23.40	195.10	69.10
40000	29.30	130.90	33.40	56.70	41.70	9.70	277.63	22.30	187.60	67.30
41000	27.20	119.60	31.70	56.70	41.70	9.50	259.28	21.20	180.10	65.50
42000	25.20	108.70	30.00	56.70	41.70	9.30	240.93	20.10	172.60	63.70
43000	23.20	101.30	28.30	56.10	41.70	9.10	222.58	19.00	165.10	61.90
44000	21.10	94.20	26.60	56.10	41.70	8.90	204.23	17.90	157.60	60.10
45000	19.10	87.40	24.90	56.10	41.70	8.70	185.88	16.80	150.10	58.30

TABLE E.3.2.42: (CONTINUED)

Mainstem Discharge	Site Locations By River Mile Designation (Representative Group)									
	131.7L (RG 4)	132.6L (RG 3)	133.8L (RG 6)	134.9R (RG 4)	136.0L (RG 4)	136.3R (RG 6)	141.4R (RG 3)	141.6R (RG 5)	144.4L (RG 2)	147.1L (RG 9)
(cfs)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)	(WUA/1000 sq.ft.)
4000	278.20	0.00	106.60	171.50	287.10	106.30	189.00	134.00	35.62	31.90
5000	278.20	0.00	106.60	149.00	253.30	106.30	189.00	134.00	35.62	29.40
6000	298.20	0.00	106.60	126.50	219.50	106.30	189.00	134.00	35.60	26.90
7000	313.30	37.25	106.60	100.20	184.70	106.30	189.00	134.00	35.54	24.30
8000	332.60	74.50	106.60	103.80	154.10	106.30	189.00	134.00	35.46	23.80
9000	328.50	111.75	106.60	81.40	131.70	106.30	189.00	134.00	35.35	26.30
10000	296.20	149.00	106.60	61.60	110.80	106.30	184.16	134.00	35.21	25.40
11000	256.80	283.30	106.60	59.40	87.00	106.30	179.75	134.00	35.03	25.10
12000	250.80	270.90	106.60	45.80	111.20	106.30	175.70	134.00	34.82	23.30
13000	237.60	262.00	106.60	39.70	108.10	106.30	140.50	134.00	34.57	24.80
14000	215.50	251.70	106.60	32.60	100.90	180.39	134.20	134.00	34.29	27.60
15000	202.40	243.10	106.60	28.10	83.80	238.47	135.90	134.00	33.97	24.40
16000	187.90	219.60	106.60	26.30	79.60	285.20	122.50	134.00	33.62	28.00
17000	179.60	205.80	106.60	24.90	72.40	250.50	110.20	134.00	33.23	24.90
18000	167.30	180.80	192.38	23.70	64.30	256.10	104.70	134.00	32.82	28.80
19000	158.10	151.70	218.20	21.90	63.80	225.10	88.80	134.00	32.44	30.50
20000	152.00	134.20	213.30	17.50	71.50	208.80	96.20	134.00	32.75	29.50
21000	147.92	132.90	229.50	17.20	70.90	196.10	90.50	134.00	41.14	28.70
22000	141.09	114.00	203.60	17.90	69.70	185.80	81.60	201.40	90.07	31.30
23000	134.60	105.80	185.60	18.60	67.60	174.30	76.30	257.42	178.44	32.80
24000	128.45	106.60	150.40	19.20	66.20	185.10	76.80	304.90	241.78	36.00
25000	122.59	99.10	140.10	19.90	64.10	177.90	71.50	297.70	277.05	36.20
26000	116.91	91.80	150.30	20.50	59.70	170.90	60.70	280.70	297.40	35.70
27000	111.63	91.20	146.00	20.70	59.10	156.90	58.90	251.80	287.83	35.40
28000	106.64	92.40	132.80	21.20	58.40	154.50	56.30	202.00	247.84	34.80
29000	101.89	88.70	113.60	21.40	57.00	178.40	57.70	166.30	189.13	32.20
30000	97.38	82.70	150.70	21.50	55.70	179.70	56.00	137.80	140.18	32.20
31000	92.19	78.47	143.00	22.70	56.10	179.50	55.50	106.90	105.13	35.40
32000	88.31	75.85	126.90	23.50	55.20	178.60	55.40	86.00	77.01	34.60
33000	84.95	73.37	118.00	23.90	54.30	185.00	55.70	70.60	58.19	32.10
34000	81.73	71.04	103.50	24.20	53.60	189.30	54.60	61.10	45.53	30.10
35000	78.64	68.84	95.80	24.30	53.03	195.20	54.90	57.40	36.57	28.30
36000	76.70	62.30	88.10	24.30	52.40	190.00	53.50	53.90	27.70	26.50
37000	74.80	57.70	80.40	24.40	51.80	185.00	53.00	50.40	18.80	24.70
38000	72.90	54.20	72.70	24.30	51.30	180.00	52.00	46.90	9.90	22.90
39000	71.00	50.80	65.00	24.20	50.80	175.00	51.00	43.40	9.00	21.10
40000	69.10	47.40	57.30	24.10	50.30	170.00	50.00	36.90	8.10	19.30
41000	67.20	45.10	49.60	23.90	49.70	165.00	49.00	33.40	7.20	17.50
42000	65.30	42.90	41.90	23.80	49.30	160.00	48.00	29.90	6.30	15.70
43000	63.40	40.70	34.20	23.90	48.70	155.00	47.00	26.40	5.40	13.90
44000	61.50	38.80	26.50	24.00	48.20	150.00	46.00	22.90	4.50	12.10
45000	59.60	37.00	18.80	24.00	47.70	145.00	45.00	19.40	3.60	10.30

TABLE E.3.2.43: RESPONSE OF CHUM SPAWNING HABITAT AREA IN IFG AND DIHAB MODELLED SITES

Mainstem Discharge	Whiskers West SC 101.7L	105.8L	114.1R	MS II SC 115.0R	118.9L	119.1L	125.2R	Slough 9 128.8R	4 July SC 131.3L
	Gp 3	Gp 10	Gp 7	Gp 3	Gp 5	Gp 10	Gp 4	Gp 3	Gp 7
(cfs)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)
4000	0	0	206	926	363	0	0	2367	4
5000	0	0	206	926	444	0	0	2367	4
6000	0	59	206	926	525	211	6670	2367	4
7000	0	117	206	926	606	445	14082	2367	4
8000	0	288	359	1071	677	723	18622	2367	4
9000	0	513	838	1524	728	1096	17060	2367	4
10000	8187	737	1316	1976	778	1469	15497	2367	4
11000	28655	961	1795	2429	983	1738	13935	2367	51
12000	36103	1218	1768	2882	1253	1961	12372	2367	209
13000	34871	1488	1741	2953	1524	2185	10810	2367	366
14000	33639	1759	1714	3024	1795	2409	9571	2367	524
15000	32407	2030	1687	3161	2066	2633	8817	2367	682
16000	30082	2047	1387	3366	1995	2694	8064	2367	839
17000	27288	1955	1058	3571	1885	2737	7310	2978	1073
18000	24495	1863	756	3776	1781	2780	6557	3588	1315
19000	22599	1897	708	3981	1724	2823	5803	4199	1557
20000	21602	2058	659	4186	1667	2866	4567	5466	1749
21000	20605	2218	610	4390	1610	2909	3277	6493	1485
22000	19608	2379	562	4595	1552	2952	1987	7108	1221
23000	18610	2539	513	4800	1495	2995	697	7508	957
24000	17613	2700	464	5005	1444	3038	0	8014	693
25000	16616	2861	416	5210	1393	3081	0	8219	429
26000	15618	3021	367	5414	1341	3124	0	8954	165
27000	14621	3182	318	5619	1290	3167	0	9005	0
28000	13624	3342	270	5824	1239	3210	0	8559	0
29000	12627	3503	221	6029	1188	3253	0	7436	0
30000	11629	3663	173	6234	1136	3296	0	5852	0
31000	10632	3824	124	6439	1085	3339	0	4541	0
32000	9635	3984	75	6643	1034	3382	0	3229	0
33000	8638	4145	27	6848	983	3425	0	1918	0
34000	7640	4305	0	7053	931	3468	0	606	0
35000	6643	4466	0	7258	880	3511	0	0	0

Source: ADF&G 1984b; EWT&A 1985c

TABLE E.3.2.43 (CONTINUED)

Mainstem Discharge	133.7R	SC 10 133.8L	133.8R	LSC 11 134.9R	USC 11 136.3R	137.5R	138.7L	139.0L	SC 21 141.4R	Slough 21 141.6R
	Gp 3	Gp 6	Gp 10	Gp 4	Gp 6	Gp 2	Gp 10	Gp 1	Gp 3	Gp 5
(cfs)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)	(sq.ft. WUA)
4000	96	0	168	6248	1644	0	202	250	1260	5231
5000	96	0	183	7811	2055	0	407	250	1575	5231
6000	106	0	197	8934	2465	1	611	250	1890	5231
7000	117	0	211	9640	2876	3	816	250	2205	5231
8000	126	0	221	9921	3284	4	1021	250	2520	5231
9000	134	0	231	10137	4028	5	1226	250	2835	5231
10000	141	0	260	10140	4769	7	1431	250	3159	5231
11000	133	0	290	9816	5334	8	1758	266	3465	5231
12000	116	0	291	9462	5899	9	2167	293	3850	5231
13000	98	0	272	9087	6434	11	2576	320	3708	5231
14000	81	0	253	8569	6968	12	2985	347	3665	5231
15000	63	0	234	8300	7567	14	2965	366	3464	5231
16000	46	0	216	7929	8165	15	2516	378	3252	5231
17000	41	0	197	7588	9876	20	2068	389	2845	5231
18000	37	0	167	7248	11323	25	1630	400	2482	5231
19000	33	162	137	6907	12470	30	1290	400	2132	5231
20000	30	722	106	6566	13280	45	1196	372	1828	5231
21000	26	958	77	6226	13671	60	1103	344	1632	5231
22000	23	2056	69	5885	14127	75	1009	316	1480	6261
23000	19	3408	61	5545	14311	90	915	289	1337	7292
24000	15	4960	53	5204	13516	105	822	261	1203	8207
25000	12	6228	44	4863	12437	120	728	233	1186	10134
26000	8	7310	36	4523	11242	135	634	205	1253	11205
27000	5	9392	28	4182	10048	150	541	177	1366	13902
28000	1	9474	20	3842	8853	165	447	149	1650	16083
29000	0	10556	11	3501	7659	180	353	121	2366	16164
30000	0	11638	3	3160	6464	195	260	93	3118	14572
31000	0	12720	0	2820	5269	210	166	66	3884	12444
32000	0	13472	0	2479	4075	225	72	38	4653	10097
33000	0	14884	0	2139	2880	240	0	10	5421	7666
34000	0	15966	0	1798	1686	255	0	0	6190	5237
35000	0	17048	0	1457	491	270	0	0	6958	2808

Source: ADF&G 1984b; EWT&A 1985c

TABLE E.3.2.44: RESPONSE OF CHUM SPAWNING HABITAT (WUA PER 1000 SQ.FT.) AT IFG AND DIHAB MODELED SITES INCLUDED IN REPRESENTATIVE GROUPS (RG) 2, 3, AND 4.

Mainstem Discharge (cfs)	101.7L Whisker's West SC (RG 3)	115.0R MS II SC (RG 3)	125.2R (RG 4)	126.0R Slough 8A (RG 2)	128.8R Slough 9 (RG 3)	133.7R (RG 3)	134.9R Lower SC 11 (RG 4)	137.5L (RG 2)	141.4R SC 21 (RG 3)
4000	0.0	11.2	0.0	35.7	36.7	8.8	45.0	30.8	19.3
5000	0.0	11.2	0.0	35.7	36.7	9.5	44.8	30.8	19.3
6000	0.0	11.2	33.2	35.7	36.7	10.2	44.7	30.8	19.3
7000	0.0	11.2	46.4	35.7	36.7	10.8	42.2	30.8	19.3
8000	0.0	12.9	49.6	35.7	36.7	11.3	39.7	33.4	19.3
9000	0.0	18.1	44.5	35.7	38.4	11.2	38.5	36.1	19.3
10000	50.8	23.3	39.6	35.7	40.1	11.1	37.4	38.7	19.3
11000	125.2	28.4	34.9	35.7	42.6	10.9	34.9	41.2	24.1
12000	136.4	33.3	30.4	35.7	45.0	10.5	32.3	54.3	28.8
13000	124.8	26.2	26.1	35.7	47.3	9.8	30.8	51.8	27.0
14000	114.3	21.8	22.6	35.7	49.6	9.1	29.2	56.3	25.1
15000	104.9	19.2	20.3	35.7	51.8	8.4	27.7	60.7	23.0
16000	92.2	17.6	18.1	35.7	54.1	7.8	26.2	65.1	20.9
17000	79.1	16.5	16.0	35.7	56.3	7.1	24.9	69.3	17.6
18000	67.4	15.5	14.0	35.7	58.4	6.0	23.6	73.2	14.4
19000	59.2	14.8	12.1	35.7	66.0	4.9	22.3	77.1	12.0
20000	53.9	14.2	9.3	35.7	73.5	3.8	21.1	81.1	9.5
21000	49.2	13.7	6.5	38.7	78.4	2.7	19.9	85.1	8.3
22000	44.8	13.2	3.9	41.8	83.3	2.5	18.6	88.7	7.2
23000	40.8	12.9	1.3	44.8	82.8	2.2	17.5	91.5	6.4
24000	37.1	12.5	0.0	47.8	82.2	1.9	16.3	94.0	5.7
25000	33.7	12.2	0.0	62.9	82.3	1.6	15.1	94.4	5.7
26000	30.5	12.0	0.0	60.0	82.4	1.3	13.9	94.2	5.7
27000	27.6	11.8	0.0	65.2	77.3	1.0	12.7	93.9	6.4
28000	24.8	11.6	0.0	70.4	72.2	0.7	11.6	91.5	7.1
29000	22.3	11.4	0.0	75.4	58.5	0.4	10.6	86.6	9.9
30000	19.9	11.2	0.0	80.3	44.9	0.1	9.5	78.5	12.8
31000	17.6	11.1	0.0	84.9	34.0	0.0	8.4	70.7	15.6
32000	15.5	10.9	0.0	89.4	23.1	0.0	7.3	60.4	18.4
33000	13.5	10.8	0.0	94.0	20.0	0.0	6.2	50.1	15.7
34000	11.6	10.7	0.0	98.6	18.0	0.0	5.1	39.8	14.5
35000	9.8	10.6	0.0	102.8	17.5	0.0	4.0	29.5	13.3
36000	8.0	10.5	0.0	106.0	17.0	0.0	2.9	19.2	12.1
37000	6.2	10.4	0.0	109.0	16.5	0.0	1.8	8.9	9.9
38000	4.4	10.3	0.0	109.4	16.0	0.0	0.7	0.0	8.7
39000	2.6	10.2	0.0	109.2	15.5	0.0	0.0	0.0	7.5
40000	0.9	10.1	0.0	108.8	15.0	0.0	0.0	0.0	6.3
41000	0.0	10.0	0.0	106.0	14.5	0.0	0.0	0.0	5.1
42000	0.0	9.9	0.0	100.4	14.0	0.0	0.0	0.0	3.9
43000	0.0	9.8	0.0	91.0	13.5	0.0	0.0	0.0	2.7
44000	0.0	9.7	0.0	82.0	13.0	0.0	0.0	0.0	1.6
45000	0.0	9.6	0.0	70.0	12.5	0.0	0.0	0.0	1.1

Source: ADF&G 1984b; EWT&A 1985c

TABLE E.3.2.45: RESPONSE OF CHINOOK REARING HABITAT AREA TO DISCHARGE IN EACH OF THE REPRESENTATIVE GROUPS

Mainstem Discharge	Weighted Usable Area								
	RG1	RG2	RG3	RG4	RG5	RG6	RG7	RG8	RG9
(cfs)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
5000	58382	211176	153979	3677949	21019	95987	280801	0	360966
6000	61249	218344	163299	3863286	36522	111160	319996	0	373281
7000	63491	225752	188181	4007191	52449	142146	319897	0	378925
8000	65213	238554	229113	4258077	66314	186170	367372	0	384095
9000	66487	257475	294676	4175694	76593	217614	377098	0	463673
10000	67361	270380	402029	3797023	86794	251758	387789	24873	453914
11000	69512	287565	658174	3363307	120917	292143	381298	37412	447278
12000	69891	310749	856488	3347555	150913	360336	350522	51880	410868
13000	71233	339377	1173219	3239630	177206	426912	333379	63942	436612
14000	72256	373909	1294098	3004490	177463	486412	292832	69686	468255
15000	72907	395242	1359539	2871869	173343	543176	249206	115099	436154
16000	73164	417797	1353576	2744514	165896	564189	219042	196152	464664
17000	73486	444568	1329916	2672308	160448	601939	188665	205595	422027
18000	73193	473671	1295405	2521406	168233	655729	163502	212097	465300
19000	72625	513739	1296231	2415302	168962	674804	144490	219207	495807
20000	71702	554029	1268329	2351648	164835	687275	127988	238956	491800
21000	70338	601492	1237917	2316387	167174	703190	118041	274356	525173
22000	68667	662735	1179275	2245428	192991	744392	109088	347437	565358
23000	67931	754585	1108650	2177461	216495	755478	103862	429862	591065
24000	67708	866243	1062812	2111344	262627	761507	99894	517133	627531
25000	64491	1008703	1019704	2047623	296116	798554	96847	596966	640311
26000	62257	1169711	972946	1977679	319718	864035	94536	648188	671899
27000	64045	1314448	925935	1917723	317828	894882	92256	658388	681802
28000	66273	1406222	905280	1861423	299814	949701	90014	642629	685405
29000	67891	1444974	901735	1803063	279143	991364	87814	607215	659181
30000	68818	1462318	887624	1746746	242398	1065805	85655	539873	647658
31000	69848	1458037	889489	1689974	214603	1095351	83542	471030	670398
32000	70504	1438566	879814	1645426	191810	1123087	81475	416385	661724
33000	71144	1451848	867872	1604911	167887	1138026	79457	369505	628836
34000	71836	1397423	846441	1567743	151771	1138884	77481	322716	600512
35000	72034	1313099	857061	1530289	141533	1126165	75551	282871	575164

SOURCE: EWT&A 1985a

TABLE E.3.2.46: TOTAL CHINOOK REARING HABITAT AREA RESPONSE TO DISCHARGE IN ALL REPRESENTATIVE GROUPS AND IN REPRESENTATIVE GROUPS 2, 3 AND 4

Mainstem Discharge	Total Weighted Usable Area: All Representative Groups	Total Weighted Usable Area: Representative Groups 2,3, and 4
(cfs)	(sq ft)	(sq ft)
5000	4860259	4043104
6000	5147138	4244929
7000	5378032	4421124
8000	5794908	4725744
9000	5929310	4727845
10000	5741921	4469432
11000	5657606	4309046
12000	5909202	4514792
13000	6261510	4752226
14000	6239400	4672497
15000	6216535	4626649
16000	6198995	4515888
17000	6098952	4446792
18000	6028537	4290482
19000	6001167	4225272
20000	5956562	4174006
21000	6014068	4155796
22000	6115371	4087438
23000	6205389	4040696
24000	6376799	4040400
25000	6569315	4076030
26000	6780969	4120336
27000	6867308	4158107
28000	6906761	4172926
29000	6842379	4149772
30000	6746895	4096688
31000	6642272	4037500
32000	6508791	3963806
33000	6379487	3924631
34000	6174806	3811607
35000	5973767	3700449
36000	5770350	3588400
37000	5566933	3476351
38000	5363516	3364302
39000	5160099	3252253
40000	4956682	3140204
41000	4753265	3028155
42000	4549848	2916106
43000	4346431	2804057
44000	4143014	2692008
45000	3939597	2579959

TABLE E.3.2.47: RESPONSE OF MIDDLE RIVER CHUM SPAWNING AREA REPRESENTED IN IFG AND DIHAB MODELED SITES

Mainstem Discharge (cfs)	Total WUA in Modelled Sites (sq.ft)
4000	18965
5000	21554
6000	30653
7000	40102
8000	46690
9000	48205
10000	57720
11000	79214
12000	87451
13000	86041
14000	84911
15000	84052
16000	80588
17000	78110
18000	75454
19000	74083
20000	74195
21000	72925
22000	73265
23000	73381
24000	73316
25000	74209
26000	74557
27000	76993
28000	76752
29000	75168
30000	71487
31000	67562
32000	63094
33000	59223
34000	55137
35000	51791

TABLE E.3.2.48: RESPONSE OF CHUM SPAWNING HABITAT IN REPRESENTATIVE GROUPS 2, 3, AND 4

MAINSTEM DISCHARGE	WEIGHTED USEABLE AREAS IN REPRESENTATIVE GROUPS			Total Habitat Area in Groups
	GROUP 2	GROUP 3	GROUP 4	
(cfs)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
4000	56035	26538	398699	481271
5000	57530	29778	434326	521634
6000	59030	33402	596691	689123
7000	60548	37889	658767	757205
8000	64581	44927	675473	784981
9000	71346	55924	667328	794598
10000	77846	94752	655907	828505
11000	85560	157839	622324	865723
12000	100418	186273	583403	870095
13000	112454	189401	556573	858428
14000	130125	193207	529487	852820
15000	145288	198148	507110	850546
16000	158600	197312	483362	839275
17000	175686	193239	461484	830409
18000	200945	188456	438668	828068
19000	220704	190576	415029	826309
20000	245802	196412	387124	829338
21000	277165	201763	358172	837100
22000	312625	209780	327165	849570
23000	344436	210301	299101	853837
24000	372750	211019	275098	858866
25000	409889	215585	257668	883141
26000	425942	220196	239687	885825
27000	445208	218058	221189	884455
28000	461654	215509	203963	881125
29000	470803	199854	188083	858740
30000	471975	182797	170040	824811
31000	467095	166205	151612	784911
32000	457526	149012	132819	739358
33000	441734	139506	113679	694919
34000	420823	133950	94207	648981
35000	393133	130802	74419	598353
36000	358573	123937	54328	536838
37000	321432	123226	33947	478605
38000	279346	118950	13287	411583
39000	248864	114936	0	363799
40000	220502	110381	0	330883
41000	193579	106762	0	300341
42000	167421	106045	0	273466
43000	138447	101538	0	239985
44000	110969	98809	0	209778
45000	91822	97402	0	189223

TABLE E.3.2.49: TOTAL CHINOOK REARING HABITAT IN ALL REPRESENTATIVE GROUPS DURING SUMMER WEEKS UNDER NATURAL FLOW REGIME

Calendar Week	Natural Flow Regime — Total Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)
22	5887756	6131097	6843402
23	5476820	6222510	6893240
24	3494928	6151734	6780969
25	5218277	6187294	6840933
26	5958463	6372627	6892074
27	5960915	6245443	6836489
28	5963999	6108808	6790478
29	5954151	6240076	6873055
30	5971538	6137691	6847559
31	5517503	6294162	6815705
32	5954772	6171091	6823350
33	4956682	6063121	6376799
34	5561034	6096961	6376799
35	5517503	6138112	6292156
36	5685606	6000258	6316496
37	5690184	6008042	6228691
38	5292193	5960600	6259540
39	4987661	5809273	6216278

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.50: TOTAL CHINOOK REARING HABITAT IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER NATURAL FLOW REGIME

Calendar Week	Natural Flow Regime — Total Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
22	3853133	4125226	4543200
23	3426713	4124438	4449608
24	2335020	4071885	4488465
25	3284299	4076823	4581977
26	3828240	4113942	4220266
27	4025392	4119204	4230208
28	3976770	4125798	4258885
29	3853137	4091048	4245477
30	3966421	4137456	4240463
31	3449123	4101473	4181791
32	4039301	4138079	4230401
33	3140204	4171382	4496151
34	4040200	4176297	4629213
35	4037705	4332384	4712545
36	4096153	4398222	4734924
37	4151235	4528447	4721533
38	4145776	4450270	4718252
39	4116902	4504139	4720054

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.51: SUMMARY OF LOCAL AND MAINSTEM DISCHARGES AT SUCCESSFUL AND UNSUCCESSFUL THRESHOLDS FOR CHUM SALMON ACCESS TO SPAWNING HABITATS

Site Name	River Mile Designations(a)	Representative Group	Passage Reach(b)	Local Discharge Thresholds(c) Successful (cfs)	Local Discharge Thresholds(c) Unsuccessful (cfs)	Mainstem Discharge Backwater Thresholds(d) Successful (cfs)	Mainstem Discharge Backwater Thresholds(d) Unsuccessful (cfs)
Whisker's Creek Slough	101.4L	2	I	14	6	e	e
			II	5	1	e	e
Mainstem II	115.0R	3	I	1	0.5	9200	8600
			II	5	1	12500	11800
			III	13	4	e	e
			IVL	4	1	e	e
		2	IVR	11	3	19700	18800
			VR	4	2	e	e
			VIR	2	0.8	e	e
			VIIR	7	3	e	e
			VIIIR	2	0.7	e	e
Slough 8A	126.0R	2	I	2	0.8	7700	7200
			II	5	2	16000	14600
			III	4	1	19000	17600
			IVL	f		25000	23600
			IVR	6	2	e	e
			VR	6	2	e	e
			VIR	3	0.6	e	e
			VIIR	7	3	e	e
			VIIIR	11	3	e	e
			IXR	4	0.8	e	e
			XR	2	0.8	e	e
Slough 9	128.8R	3	I	5	4	11600	10900
			II	6	3	e	e
			III	5	2	e	e
			IV	3	1	e	e
			V	0.9	0.9	e	e
Slough 9A	133.9R	1	I	9	4	11500	10800
			II	3	2	e	e
			III	4	2	e	e
			IV	4	2	e	e
			V	4	3	e	e
			VI	6	3	e	e
			VII	4	1	e	e
			VIII	9	3	e	e
			IX	3	0.8	e	e
			X	2	0.6	e	e
			XI	9	3	e	e

TABLE E.3.2.51: (CONTINUED)

Site Name	River Mile Designations(a)	Represent Group	Passage Reach(b)	Local Discharge Thresholds(c) Successful (cfs)	Local Discharge Thresholds(c) Unsuccessful (cfs)	Mainstem Discharge Backwater Thresholds(d) Successful (cfs)	Mainstem Discharge Backwater Thresholds(d) Unsuccessful (cfs)
Side Channel 10	133.8L	6	I	f	f	18500	17700
			II	f	f	e	e
			III	f	f	e	e
			IV	f	f	e	e
			V	f	f	e	e
			VI	f	f	e	e
Slough 11	135.6R	1	I	4	1	16500	15400
			II	1.4	g	19400	18300
			III	9	3	33400	32000
			IV	3	1	40300	38800
			V	3	1	e	e
			VI	2	0.6	e	e
			VII	0.5	0.4	e	e
Upper Side Channel 11	136.3R	6	I	8	2	e	e
			II	g	g	e	e
Slough 19	139.7R	5	I	g	g	e	e
			II	g	g	e	e
			III	g	g	e	e
			IV	g	g	e	e
			V	g	g	e	e
	139.9R	1	VI	2	0.6	13000	13000
			VII	2	0.7	15300	14500
			VIII	2	0.9	19000	18100
			IX	4	1	25600	24800
Slough 20	140.2R	2	I	2	0.6	13000	12300
			II	2	0.5	21100	20000
			III	3	1	e	e
			IV	g	g	e	e
			V	g	g	e	e
			VI	10	4	e	e
Side Channel 21	141.4R	3	I	5	2	7800	7100
			II	7	3	10300	9700
			III	7	3	e	e
			IV	4	1	e	e
			V	4	1	e	e
			VI	17	4	e	e
			VII	20	5	e	e
	141.6R	5	VIII	7	2	e	e
			IX	5	2	e	e

TABLE E.3.2.51: (CONTINUED)

Site Name	River Mile Designations(a)	Represent Group	Passage Reach(b)	Local Discharge Thresholds(c) Successful (cfs)	Local Discharge Thresholds(c) Unsuccessful (cfs)	Mainstem Discharge Backwater Thresholds(d) Successful (cfs)	Mainstem Discharge Backwater Thresholds(d) Unsuccessful (cfs)
Slough 21	142.1R	2	I	4	1	e	e
			II	2	0.4	e	e
			IIIL	3	0.8	e	e
			IIIR	g	g	e	e
Slough 22	144.4L	2	I	3	1	17800	16000
			II	2	0.7	22700	21900
			III	4	2	e	e

a/ Source: EWT&A and AEIDC 1985
b/ Source: ADF&G 1985l Designations of "L" and "R" refer to passage reaches in left and right channels, looking upstream.
c/ Source: ADF&G 1985l
d/ Source: ADF&G 1985l
e/ Influence of backwater was not evaluated since breaching flow occurs at discharges lower than those required for providing backwater influence.
f/ Values not available
g/ No cross section data available.

TABLE E.3.2.52: TOTAL CHUM SPAWNING HABITAT IN IFG AND DIHAB MODELED SITES DURING SUMMER MONTHS UNDER NATURAL FLOW REGIME

Calendar Week	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
32	72935	74117	76821
33	35061	73755	78712
34	45002	74129	84101
35	44286	76030	85363
36	47448	75257	86202
37	47448	76554	85219
38	36322	74376	86928
39	26285	62440	86438

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.53: TOTAL CHUM SPAWNING HABITAT
IN REPRESENTATIVE GROUPS 2, 3, AND 4
DURING SUMMER WEEKS
UNDER NATURAL FLOW REGIME

Calendar Week	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	 50%	 10%
	(sq ft)	(sq ft)	(sq ft)
32	826654	849978	883525
33	330883	832670	858434
34	689191	836728	862500
35	620955	852626	868158
36	789790	840645	866908
37	789790	840943	864098
38	729972	844361	867598
39	608728	825264	865603

Calendar Week 32 = Week Beginning August 5 .

TABLE E.3.2.54: TOTAL CHUM SPAWNING HABITAT AVAILABLE FOR INCUBATION OF EMBRYOS IN IFG AND DIHAB MODEL SITES UNDER NATURAL FLOW REGIME

Calendar Week	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)
40	21116	44783	80392
41	19923	38552	49157
42	15404	21348	42731
43	11066	20021	29479
44	8127	16393	21148
45	7586	13242	19511
46	7112	12294	16391
47	6230	11547	15172
48	5552	10872	14053

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.55: TOTAL CHUM SPAWNING HABITAT IN REPRESENTATIVE GROUPS 2, 3, AND 4 AVAILABLE FOR INCUBATION OF EMBRYOS DURING EARLY WINTER WEEKS UNDER NATURAL FLOW REGIME

	Natural Flow Regime Modelled Habitat Area Exceeded		
Calendar Week	90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)
40	514813	776940	855079
41	496205	746040	797989
42	390912	518425	768288
43	280822	497739	667517
44	206225	415999	515297
45	192508	336047	489788
46	180477	311984	415938
47	158098	293034	385017
48	140892	275889	356622

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.56: STREAMS CROSSED BY DENALI HIGHWAY (CANTWELL TO WATANA ACCESS JUNCTION)

Stream	Miles from Richardson Highway	Species Present
Trib. to Jack R.	132.5	grayling
Trib. to Jack R.	132	grayling
Unnamed Creek (Jack R. System)	128	not sampled
Edmonds Creek	121	Various species from the Nenana River, including grayling, northern pike, burbot, whitefish, and sculpin.
Nenana R. Oxbow	119.75	"
Nenana R. Oxbow	119.5	"
Trib. to Nenana R.	118	"
Trib. to Nenana R.	117.8	"
Trib. to Nenana R.	116.8	"
Unnamed Creek (Nenana System)	114.5	"

TABLE E.3.2.57: WATER BODIES TO BE CROSSED BY THE SUSITNA TRANSMISSION LINE (ANCHORAGE TO WILLOW)

Stream	Fish Species Present
Ship Creek	pink, chinook, coho, chum, and sockeye salmon; Dolly Varden; rainbow trout.
Fossil Creek	none
Otter Creek	rainbow trout
Knik Arm	pink, chinook, coho, chum, and sockeye salmon; Dolly Varden; Bering cisco; enlachon; lamprey
Unnamed Creek (T, R4W, Sec. 18)	unknown
Little Susitna River	coho, pink, chinook, chum, and sockeye salmon; rainbow trout; Dolly Varden; grayling
Tributary to Fish Creek (T17N, R5W, Sec. 18, 19)	unknown
Fish Creek	chinook, sockeye, pink, and coho salmon; rainbow trout
Unnamed Creek (T18N, R5W, Sec. 8)	unknown
Unnamed Creek (T18N R5W, Sec. 5)	unknown
Unnamed Creek (T19N, R5W, Sec.)	unknown
Willow Creek	coho, chum, pink, and chinook salmon; grayling; rainbow trout; Dolly Varden; whitefish

TABLE E.3.2.58: WATER BODIES TO BE CROSSED BY THE SUSITNA TRANSMISSION LINE (HEALY TO FAIRBANKS)

Stream	Fish Species Present
Nenana River #1	coho salmon, grayling, round whitefish, longnose sucker, slimy sculpin, burbot, Dolly Varden
Dry Creek	unknown
Panguinge Creek	coho salmon, longnose sucker, round whitefish, Dolly Varden, grayling, slimy sculpin
Little Panguinge Creek	coho salmon, grayling, round whitefish, slimy sculpin, Dolly Varden, longnose sucker
Slate Creek	unknown
Tributary to Slate Creek	unknown
Rock Creek	unknown
Unnamed Creek T9S, R9W, S36, FM	unknown
June Creek	unknown
Bear Creek	unknown
Nenana River #2	grayling; northern pike; slimy sculpin; chum, chinook and coho salmon; inconnu; whitefish; burbot
Unnamed Creek T8S, R8W, S31, FM	unknown
Windy Creek	unknown
Tributary to Windy Creek	unknown
Unnamed Creek T82, R9W, S1, FM	unknown
Unnamed Creek T7S, R8W, S18, FM	unknown
Unnamed Creek T72, R7W, S8, FM	unknown
Unnamed Creek T7S, R7W, S5, FM	unknown

TABLE E.3.2.58 (Page 2 of 3)

Stream	Fish Species Present
Unnamed Creek T6S, R7W, S32, FM	unknown
Tributary to Fish Creek T6S, R7W, S21, FM	unknown
Tributary to Fish Creek T6S, R7W, S22, FM	unknown
Fish Creek	grayling, round whitefish, slimy sculpin, Dolly Varden, longnose sucker
Unnamed Creek (2 crossings) T6S, R7W, S10, FM	unknown
Unnamed Creek (2 crossings) T6S, R7W, S3, FM	unknown
Unnamed Creek T4S, R7W, S34, FM	unknown
Unnamed Creek T4S, R7W, S28, FM	unknown
Tanana River complex	chum, coho and chinook salmon; inconnu; northern pike; grayling; whitefish; burbot
Tanana Tributary complex	unknown
Little Goldstream Creek	grayling, round whitefish, blackfish, longnose sucker, slimy sculpin
Little Goldstream Tributary T3S, R6W, S4, FM	unknown
Little Goldstream Tributary R3S, R6W, S3 FM	unknown
Little Goldstream Tributary T3S, R6W, S2, FM	unknown
Little Goldstream Tributary T3S, R6W, S1, FM	unknown
Little Goldstream Tributary T2S, R5W, S32, FM (2 crossings)	unknown
Bonanza Creek Tributary T2S, R5W, S33, 34, 36, FM (3 crossings)	unknown

TABLE E.3.2.58 (Page 3 of 3)

Stream	Fish Species Present
Ohio Creek Tributary T2S, R5W, S7, FM	unknown
Ohio Creek Tributary T2S, R4W, S5, FM (2 crossings)	unknown
Ohio Creek Tributary T1S, R4W, S33, FM	unknown
Ohio Creek Tributary T1S, R4W, S27, FM	unknown
Ohio Creek Complex	unknown
Ohio Creek Complex	unknown
Alder Creek Complex	unknown
Emma Creek	unknown
Alder Creek Tributary T1S, R3W, S13, FM	unknown

Sources: ADF&G 1982g
Tarbox et al. 1978

TABLE E.3.2.59: SUSITNA HYDROELECTRIC PROJECT
FLOW CONSTRAINTS FOR ENVIRONMENTAL
FLOW REQUIREMENT CASE E-VI

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

Note: 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: HE 1985a

TABLE E.3.2.60: ESTIMATED MONTHLY MEAN DISCHARGE AT GOLD CREEK DURING FILLING OF STAGE I - WATANA RESERVOIR

Month	Gold Creek Natural Flow (cfs)	Gold Creek Constraint (cfs)	Gold Creek Filling Flow (cfs)
Low Discharge Year (Dry)			
May	13,051	4,903	3,903 1/
June	21,763	8,800	7,800
July	19,126	9,000	8,000
August	17,392	9,000	8,000
September	10,422	6,800	5,800
October	4,515	5,032	4,032
Average Discharge Year			
May	13,240	4,903	4,903
June	27,815	8,800	8,800
July	24,445	9,000	12,740
August	22,228	9,000	12,415
September	13,221	6,800	6,800
October	5,771	5,032	5,032
High Discharge Year (Wet)			
May	15,032	4,903	4,900
June	31,580	8,800	10,752
July	27,753	9,000	20,547
August	25,236	9,000	15,505
September	15,124	6,800	6,800
October	6,552	5,032	5,032

1/ Corresponds to E-VI constraints in dry years presented in Table E.3.2.59.

TABLE E.3.2.61: ESTIMATED CHANGES IN CHINOOK REARING HABITAT AREA IN ALL REPRESENTATIVE GROUPS DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge Natural (cfs)	Discharge Filling (cfs)	Rearing Habitat Area Natural (Sq. ft.)	Rearing Habitat Area Filling (sq. ft.)	Changes[1/] (%)
Dry Year					
June	21,763	7,800	6,093,614	4,692,353	-76.6
July	19,126	8,000	5,984,241	5,794,908	-3.2
August	17,392	8,000	6,084,911	5,794,908	-4.8
September	10,422	5,800	5,698,238	5,080,689	-10.8
October	4,515	4,032	4,388,814	3,919,313	-10.7
Average Year					
June	27,815	8,800	6,096,150	5,900,251	-3.2
July	24,445	12,740	6,464,314	6,219,065	-3.8
August	22,228	12,415	6,140,326	6,133,661	-0.1
September	13,221	6,800	6,260,495	5,335,052	-14.8
October	5,771	5,032	5,071,054	4,867,987	-4.0
Wet Year					
June	31,580	10,752	6,558,257	5,673,755	-13.5
July	27,753	20,547	6,905,438	5,970,578	-13.5
August	25,236	15,505	6,612,478	6,216,007	-6.0
September	15,124	6,800	6,216,513	5,335,052	-14.2
October	6,552	5,032	5,281,892	4,867,987	-7.8

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.62: ESTIMATED CHANGES IN CHINOOK REARING HABITAT AREA IN REPRESENTATIVE GROUP 2, 3, AND 4 DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge Natural (cfs)	Discharge Filling (cfs)	Rearing Habitat Area Natural (sq. ft.)	Rearing Habitat Area Filling (sq. ft.)	Change[1/] (%)
Dry Year					
June	21,763	7,800	4,130,942	4,641,503	+12.4
July	19,126	8,000	4,216,389	4,725,744	+12.1
August	17,392	8,000	4,376,438	4,725,744	+8.0
September	10,422	5,800	4,405,591	4,203,558	-4.6
October	4,515	4,032	3,650,922	3,260,358	-10.7
Average Year					
June	27,815	8,800	4,170,847	4,730,676	+13.4
July	24,445	12,740	4,055,560	4,735,806	+16.8
August	22,228	12,415	4,077,757	4,685,654	+14.9
September	13,221	6,800	4,739,112	4,387,290	-7.4
October	5,771	5,032	4,197,559	4,049,400	-3.5
Wet Year					
June	31,580	10,752	3,991,031	4,351,079	+9.0
July	27,753	20,547	4,170,150	4,170,911	0.0
August	25,236	15,505	4,084,473	4,600,640	+12.6
September	15,124	6,800	4,620,411	4,387,290	-5.0
October	6,552	5,032	4,345,335	4,049,400	-6.8

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.63: COMPARISON OF PASSAGE CONDITIONS OF PASSAGE REACHES AFFECTED BY MAINSTREAM MAINSTEM DISCHARGE UNDER NATURAL AND FILLING WET CONDITIONS FOR DRY, AVERAGE, AND WET YEARS (Page 1 of 4)

Site Name	River Mile Designations[a]	Passage Reach[b]	Dry Year				Average Year				Wet Year			
			Natural		Filling		Natural		Filling		Natural		Filling	
			Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.
Whisker's Creek Slough	101.4L	I	--	--	--	--	--	--	--	--	--	--	--	--
		II	--	--	--	--	--	--	--	--	--	--	--	--
Mainstem II	115.ØR	I	S[c]	S	S/D	U	S	S	S	U	S	S	S	U
		II	S	S	U	U	S	S	S/D	U	S	S	S	U
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IVL	--	--	--	--	--	--	--	--	--	--	--	--
		IVR	U	U	U	U	U	U	U	U	S	U	U	U
		VR	--	--	--	--	--	--	--	--	--	--	--	--
		VIR	--	--	--	--	--	--	--	--	--	--	--	--
		VIIR	--	--	--	--	--	--	--	--	--	--	--	--
		VIIIR	--	--	--	--	--	--	--	--	--	--	--	--
Slough 8A	126.ØR	I	S	S	S	U	S	S	S	U	S	S	S	U
		II	S	U	U	U	S	U	U	U	S	S/D	S/D	U
		III	U	U	U	U	S	U	U	U	S	U	U	U
		IVL	U	U	U	U	U	U	U	U	S	U	U	U
		IVR	--	--	--	--	--	--	--	--	--	--	--	--
		VR	--	--	--	--	--	--	--	--	--	--	--	--
		VIR	--	--	--	--	--	--	--	--	--	--	--	--
		VIIR	--	--	--	--	--	--	--	--	--	--	--	--
		VIIIR	--	--	--	--	--	--	--	--	--	--	--	--
		IXR	--	--	--	--	--	--	--	--	--	--	--	--
		XR	--	--	--	--	--	--	--	--	--	--	--	--

TABLE E.3.2.63 (Page 2 of 4)

Site Name	River Mile Designations[a]/	Passage Reach[b]/	Dry Year Natural Aug.	Dry Year Natural Sep.	Dry Year Filling Aug.	Dry Year Filling Sep.	Average Year Natural Aug.	Average Year Natural Sep.	Average Year Filling Aug.	Average Year Filling Sep.	Wet Year Natural Aug.	Wet Year Natural Sep.	Wet Year Filling Aug.	Wet Year Filling Sep.
Slough 9	128.8R	I	S	U	U	U	S	S	S	U	S	S	S	U
		II	--	--	--	--	--	--	--	--	--	--	--	--
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
Slough 9A	133.9R	I	S	U	U	U	S	S	S	U	S	S	S	U
		II	--	--	--	--	--	--	--	--	--	--	--	--
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
		VI	--	--	--	--	--	--	--	--	--	--	--	--
		VII	--	--	--	--	--	--	--	--	--	--	--	--
		VIII	--	--	--	--	--	--	--	--	--	--	--	--
		IX	--	--	--	--	--	--	--	--	--	--	--	--
		X	--	--	--	--	--	--	--	--	--	--	--	--
		XI	--	--	--	--	--	--	--	--	--	--	--	--
Side Channel 10	133.8L	I	U	U	U	U	S	U	U	U	S	U	U	U
		II	--	--	--	--	--	--	--	--	--	--	--	--
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
		VI	--	--	--	--	--	--	--	--	--	--	--	--

TABLE E.3.2.63 (Page 3 of 4)

Site Name	River Mile Designations[a]/	Passage Reach[b]/	Dry Year				Average Year				Wet Year			
			Natural		Filling		Natural		Filling		Natural		Filling	
			Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.
Slough 11	135.6R	I	S	U	U	U	S	U	U	U	S	U	S/D	U
		II	U	U	U	U	S	U	U	U	S	U	U	U
		III	U	U	U	U	U	U	U	U	U	U	U	U
		IV	U	U	U	U	U	U	U	U	U	U	U	U
		V	--	--	--	--	--	--	--	--	--	--	--	--
		VI	--	--	--	--	--	--	--	--	--	--	--	--
		VII	--	--	--	--	--	--	--	--	--	--	--	--
Upper Side Channel 11	136.3R	I	--	--	--	--	--	--	--	--	--	--	--	--
		II	--	--	--	--	--	--	--	--	--	--	--	--
Slough 19	139.7R	I	--	--	--	--	--	--	--	--	--	--	--	--
		II	--	--	--	--	--	--	--	--	--	--	--	--
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
	139.9R	VI	S	U	U	U	S	S	U	U	S	S	S	U
		VII	S	U	U	U	S	U	U	U	S	S/D	S	U
		VIII	U	U	U	U	S	U	U	U	S	U	U	U
		IX	U	U	U	U	U	U	U	U	S/D	U	U	U
Slough 20	140.2R	I	S	U	U	U	S	S	S/D	U	S	S	S	U
		II	U	U	U	U	S	U	U	U	S	U	U	U
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
		VI	--	--	--	--	--	--	--	--	--	--	--	--

TABLE E.3.2.63 (Page 4 of 4)

Site Name	River Mile Designations[a/]	Passage Reach[b/]	Dry Year Natural Aug.	Dry Year Natural Sep.	Dry Year Filling Aug.	Dry Year Filling Sep.	Average Year Natural Aug.	Average Year Natural Sep.	Average Year Filling Aug.	Average Year Filling Sep.	Wet Year Natural Aug.	Wet Year Natural Sep.	Wet Year Filling Aug.	Wet Year Filling Sep.
Side Channel 21	141.4R	I	S	S	S	U	S	S	S	U	S	S	S	U
		II	S	S	U	U	S	S	S	U	S	S	S	U
		III	--	--	--	--	--	--	--	--	--	--	--	--
		IV	--	--	--	--	--	--	--	--	--	--	--	--
		V	--	--	--	--	--	--	--	--	--	--	--	--
		VI	--	--	--	--	--	--	--	--	--	--	--	--
		VII	--	--	--	--	--	--	--	--	--	--	--	--
	141.6R	VIII	--	--	--	--	--	--	--	--	--	--	--	--
		IX	--	--	--	--	--	--	--	--	--	--	--	--
Slough 21	142.1R	I	--	--	--	--	--	--	--	--	--	--	--	--
		II	--	--	--	--	--	--	--	--	--	--	--	--
		IIIL	--	--	--	--	--	--	--	--	--	--	--	--
		IIIR	--	--	--	--	--	--	--	--	--	--	--	--
Slough 22	144.4L	I	S/D	U	U	U	S	U	U	U	S	U	U	U
		II	U	U	U	U	S/D	U	U	U	S	U	U	U
		III	--	--	--	--	--	--	--	--	--	--	--	--

a/ Source: EWT&A and AEIDC 1985
b/ Source: ADF&G 19851
c/ S = Successful Conditions
S/D = Successful with Difficulty
U = Unsuccessful Conditions

TABLE E.3.2.64: ESTIMATED CHANGES IN CHUM SPAWNING HABITAT AREA IN MODELLED SITES DUE TO FILLING OF THE WATANA - STAGE I RESERVOIR

Month	Discharge Natural (cfs)	Discharge Filling (cfs)	Chum Spawning Area Natural (sq. ft.)	Chum Spawning Area Filling (sq. ft.)	Chum Spawning Area Changes[1/] (%)
Dry Year					
August	17,392	8,000	77,069	46,690	-39.4
September	10,422	5,800	66,790	28,833	-56.8
Average Year					
August	22,228	12,415	73,291	86,866	+18.5
September	13,221	6,800	85,791	38,212	-55.4
Wet Year					
August	25,236	15,505	74,209	82,220	+10.8
September	15,124	6,800	83,622	38,212	-54.3

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.65: ESTIMATED CHANGES IN CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUP 2 DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge Natural (cfs)	Discharge Filling (cfs)	Chum Spawning Area Natural (sq. ft)	Chum Spawning Area Filling (sq. ft.)	Chum Spawning Area Changes[1/] (%)
Dry Year					
August	17,392	8,000	185,588	64,581	-65.2
September	10,422	5,800	81,101	58,730	-27.6
Average Year					
August	22,228	12,415	312,625	104,413	-66.3
September	13,221	6,800	116,359	60,244	-48.2
Wet Year					
August	25,236	15,505	413,678	152,010	-63.2
September	15,124	6,800	146,939	60,244	-59.0

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.66: ESTIMATED CHANGES IN CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUP 3 DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge		Chum Spawning Area		
	Natural (cfs)	Filling (cfs)	Natural (sq. ft)	Filling (sq. ft.)	Changes 1/ (%)
Dry Year					
August	17,392	8,000	191,364	44,927	-76.5 1/
September	10,422	5,800	121,375	32,677	-73.1
Average Year					
August	22,228	12,415	209,899	187,571	-10.6
September	13,221	6,800	190,242	36,992	-80.6
Wet Year					
August	25,236	15,505	216,673	197,726	-8.7
September	15,124	6,800	198,044	36,992	-81.3

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.67: ESTIMATED CHANGES IN CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUP 4 DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge		Chum Spawning Area		
	Natural (cfs)	Filling (cfs)	Natural (sq. ft.)	Filling (sq. ft.)	Changes1/ (%)
Dry Year					
August	17,392	8,000	452,540	675,473	+49.3
September	10,422	5,800	641,735	564,218	-12.1
Average Year					
August	22,228	12,415	320,766	572,268	+78.4
September	13,221	6,800	550,587	646,352	+17.4
Wet Year					
August	25,236	15,505	253,424	495,117	+95.4
September	15,124	6,800	504,165	646,352	+28.2

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.68: ESTIMATED CHANGES IN CHUM SPAWNING HABITAT AREA IN AGGREGATE AREA OF REPRESENTATIVE GROUPS DUE TO FILLING UNDER DRY, AVERAGE AND WET CONDITIONS

Month	Discharge Natural (cfs)	Discharge Filling (cfs)	Chum Spawning Area Natural (sq. ft.)	Chum Spawning Area Filling (sq. ft.)	Changes[1/] (%)
Dry Year					
August	17,392	8,000	829,491	784,981	- 5.4
September	10,422	5,800	835,133	655,625	-21.5
Average Year					
August	22,228	12,415	850,543	865,253	+1.7
September	13,221	6,800	857,189	743,589	-13.2
Wet Year					
August	25,236	15,505	883,744	844,854	-4.4
September	15,124	6,800	849,148	743,589	-12.4

1/ Percent change calculated as $\left(\frac{HA_{filling}}{HA_{natural}} - 1\right) \times 100$, where HA is the spawning habitat area.

TABLE E.3.2.69: PERIPHYTON GENERA EXPECTED TO COMPOSE THE MAJORITY OF AUFWUCHS COMMUNITIES IN MAINSTEM AND PERIPHERAL HABITATS WITH SOLID SUBSTRATES OF THE SUSITNA RIVER, ALASKA

Algal Classifications	Genera
Cyanophyta	Nostoc sp., Calothrix sp., Phomidium sp., Lynghya sp., Nodularia sp., Anabaena sp., Arthrospina sp., Rivularia sp.
Chlorophyta	Spirogyra sp., Zygnema sp., Ulothriz sp., Hydrurus sp., Stigeoclonium sp., Cladophora sp., Microspora sp., Chaetophora sp.
Bacillariophyta	Cymbella sp., Coconeis sp., Gomphonema sp., Achnanthes sp., Meridian sp., Navicula sp., Fragillaria sp., Nitzschia sp., Diatoma sp., other pennate diatoms

TABLE E.3.2.70 WEIGHTED USABLE AREAS AND HABITAT INDICES FOR JUVENILE CHINOOK SALMON IN LOWER SUSITNA RIVER MODEL SITES.

ROLLY CREEK MOUTH

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	84900	3900	0.05
15000	84900	3900	0.05
18000	84900	3900	0.05
21000	84900	3900	0.05
24000	85300	3900	0.05
27000	88300	3900	0.04
30000	93200	3900	0.04
33000	99800	4100	0.04
36000	108900	4200	0.04
39000	121000	4300	0.04
42000	135000	4400	0.03
45000	152600	4500	0.03
48000	178500	7300	0.04
51000	198800	14100	0.07
54000	213000	20100	0.09
57000	223200	23400	0.10
60000	229800	25800	0.11
63000	235000	29000	0.12
66000	238700	30000	0.13
69000	241600	31500	0.13
72000	243200	32800	0.13
75000	243600	33500	0.14

CASWELL CREEK MOUTH

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	16200	800	0.05
15000	16200	800	0.05
18000	16200	800	0.05
21000	16200	800	0.05
24000	16200	800	0.05
27000	16300	900	0.05
30000	16700	1100	0.07
33000	17300	1600	0.09
36000	18000	2200	0.12
39000	18900	2700	0.14
42000	19800	3200	0.16
45000	21000	3700	0.18
48000	21800	4200	0.19
51000	22700	4700	0.21
54000	23700	5200	0.22
57000	24600	5700	0.23
60000	25500	6200	0.24
63000	26300	6700	0.25
66000	27200	7200	0.26
69000	27900	7600	0.27
72000	28900	8000	0.28
75000	29700	8400	0.28

BEAVER DAM SLOUGH

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	11600	1300	0.11
15000	11600	1300	0.11
18000	11600	1300	0.11
21000	11700	1300	0.11
24000	11900	1300	0.11
27000	12200	1300	0.11
30000	12500	1300	0.10
33000	13000	1300	0.10
36000	13400	1300	0.10
39000	13900	1400	0.10
42000	14400	1500	0.10
45000	15000	1800	0.12
48000	15700	2100	0.13
51000	16300	2600	0.16
54000	16800	3000	0.18
57000	17600	3700	0.21
60000	18500	4200	0.23
63000	19700	4600	0.23
66000	20800	4800	0.23
69000	21600	5000	0.23
72000	22100	5100	0.23
75000	22600	5200	0.23

HOOLIGAN SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	63400	500	0.01
15000	63400	500	0.01
18000	63400	500	0.01
21000	63400	500	0.01
24000	79800	7600	0.10
27000	86900	7200	0.08
30000	90800	6700	0.07
33000	96500	6100	0.06
36000	104800	5500	0.05
39000	113700	4900	0.04
42000	122900	4200	0.03
45000	131300	3600	0.03
48000	141200	2900	0.02
51000	152000	2200	0.01
54000	163000	2000	0.01
57000	174100	2000	0.01
60000	186800	1900	0.01
63000	200800	1800	0.01
66000	213300	1800	0.01
69000	226000	1800	0.01
72000	239000	1800	0.01
75000	250900	1800	0.01

KROTO SLOUGH HEAD

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	48200	100	.00
15000	48200	100	.00
18000	48200	100	.00
21000	48200	100	.00
24000	48200	100	.00
27000	48200	100	.00
30000	48200	100	.00
33000	48500	100	.00
36000	57900	2700	0.05
39000	67900	4800	0.07
42000	77500	6200	0.08
45000	86800	7300	0.08
48000	95100	8100	0.09
51000	102200	7900	0.08
54000	106700	6900	0.06
57000	110200	6000	0.05
60000	113500	5100	0.04
63000	116600	4300	0.04
66000	119000	3400	0.03
69000	120100	2900	0.02
72000	121000	2500	0.02
75000	121400	2200	0.02

BEARBAIT SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	3100	20	0.01
15000	3100	20	0.01
18000	3100	20	0.01
21000	3100	20	0.01
24000	3100	20	0.01
27000	3100	20	0.01
30000	3100	20	0.01
33000	3100	20	0.01
36000	5700	200	0.04
39000	10800	350	0.03
42000	14600	530	0.04
45000	17900	650	0.04
48000	21100	720	0.03
51000	23800	790	0.03
54000	26400	800	0.03
57000	29000	750	0.03
60000	31500	700	0.02
63000	33900	650	0.02
66000	36300	610	0.02
69000	38300	590	0.02
72000	40000	570	0.01
75000	41500	560	0.01

SOURCE: ADF & G 1985c

TABLE E.3.2.70 (Page 2 of 3)

LAST CHANCE S. C.			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	17500	110	0.01
15000	17500	110	0.01
18000	17500	110	0.01
21000	17500	110	0.01
24000	17500	110	0.01
27000	31700	200	0.01
30000	50600	370	0.01
33000	63900	540	0.01
36000	73200	700	0.01
39000	80000	900	0.01
42000	85900	1030	0.01
45000	90600	1220	0.01
48000	94000	1520	0.02
51000	96300	1990	0.02
54000	98500	2560	0.03
57000	100200	2620	0.03
60000	101800	2540	0.02
63000	103200	2460	0.02
66000	104400	2350	0.02
69000	105500	2240	0.02
72000	106300	2100	0.02
75000	107000	1900	0.02

RUSTIC WILDERNESS S. C.			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	4800	30	0.01
15000	4800	30	0.01
18000	4800	30	0.01
21000	31900	4800	0.15
24000	49500	5100	0.10
27000	60700	4300	0.07
30000	69700	3700	0.05
33000	76800	3000	0.04
36000	83300	2400	0.03
39000	89900	1900	0.02
42000	97000	1500	0.02
45000	104000	1200	0.01
48000	109000	900	0.01
51000	114000	700	0.01
54000	117400	500	.00
57000	119200	500	.00
60000	120700	600	.00
63000	121700	600	.00
66000	122200	600	.00
69000	122700	700	0.01
72000	123000	700	0.01
75000	123500	800	0.01

ISLAND SIDE CHANNEL			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	31500	400	0.01
15000	31500	400	0.01
18000	31500	400	0.01
21000	31500	400	0.01
24000	31500	400	0.01
27000	31500	400	0.01
30000	31500	400	0.01
33000	31500	500	0.02
36000	44600	3500	0.08
39000	48100	4800	0.10
42000	53200	4100	0.08
45000	58900	3400	0.06
48000	65500	2900	0.04
51000	72000	2400	0.03
54000	79400	2100	0.03
57000	86700	1800	0.02
60000	93100	1700	0.02
63000	99800	1800	0.02
66000	106200	2100	0.02
69000	111900	2400	0.02
72000	118200	2600	0.02
75000	123300	2700	0.02

MAINSTEM WEST BANK			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	61603	1082	0.02
15000	61603	1082	0.02
18000	61603	1082	0.02
21000	73426	10041	0.14
24000	80904	8325	0.10
27000	93353	5224	0.06
30000	108613	4045	0.04
33000	114738	3959	0.03
36000	117696	3861	0.03
39000	120505	3775	0.03
42000	123397	3855	0.03
45000	129211	4113	0.03
48000	133649	4630	0.03
51000	136885	5080	0.04
54000	140761	5554	0.04
57000	144269	6217	0.04
60000	147899	6728	0.05
63000	151842	7092	0.05
66000	154205	7598	0.05
69000	156425	7913	0.05
72000	158522	8078	0.05
75000	160818	8438	0.05

GOOSE 2 SIDE CHANNEL			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	0	0	0.00
15000	0	0	0.00
18000	0	0	0.00
21000	0	0	0.00
24000	0	0	0.00
27000	0	0	0.00
30000	9600	1500	0.16
33000	21500	2900	0.13
36000	34300	4000	0.12
39000	47800	5100	0.11
42000	61400	6100	0.10
45000	72000	6900	0.10
48000	81400	7000	0.09
51000	87800	6700	0.08
54000	93200	6000	0.06
57000	97100	4600	0.05
60000	99900	3100	0.03
63000	102000	2700	0.03
66000	103200	2400	0.02
69000	104200	2100	0.02
72000	104800	1800	0.02
75000	105100	1600	0.02

CIRCULAR SIDE CHANNEL			
MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	59464	747	0.01
15000	59464	747	0.01
18000	59464	747	0.01
21000	59464	747	0.01
24000	59464	747	0.01
27000	59464	747	0.01
30000	59464	747	0.01
33000	59464	747	0.01
36000	71590	8717	0.12
39000	76534	8404	0.11
42000	80557	8013	0.10
45000	85140	7472	0.09
48000	92944	7077	0.08
51000	102530	6998	0.07
54000	113323	6999	0.06
57000	125753	6634	0.05
60000	134218	6516	0.05
63000	143575	6906	0.05
66000	150869	7926	0.05
69000	154657	8561	0.06
72000	157074	8840	0.06
75000	159211	8854	0.06

TABLE E.3.2.70 (Page 3of3)

SAUNA SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	42093	165	.00
15000	42093	165	.00
18000	42093	165	.00
21000	42093	165	.00
24000	42093	165	.00
27000	42093	165	.00
30000	42093	165	.00
33000	47611	5470	0.11
36000	48790	5713	0.12
39000	49127	5759	0.12
42000	49758	5740	0.12
45000	50289	5503	0.11
48000	50889	4980	0.10
51000	51451	4470	0.09
54000	52011	4046	0.08
57000	52678	3645	0.07
60000	53294	3365	0.06
63000	54275	3116	0.06
66000	55184	2947	0.05
69000	56053	2757	0.05
72000	57142	2678	0.05
75000	61018	2714	0.04

SUCKER SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	0	0	0.00
15000	0	0	0.00
18000	0	0	0.00
21000	0	0	0.00
24000	0	0	0.00
27000	1600	0	0.00
30000	8500	1060	0.12
33000	14900	1600	0.11
36000	16900	1570	0.09
39000	19400	1510	0.08
42000	23600	1450	0.06
45000	29600	1550	0.05
48000	37100	2070	0.06
51000	46600	2940	0.06
54000	57900	4230	0.07
57000	66900	4680	0.07
60000	71300	4490	0.06
63000	73900	4230	0.06
66000	75900	3940	0.05
69000	77300	3610	0.05
72000	78100	3270	0.04
75000	78300	3010	0.04

BEAVER DAM SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	18900	50	.00
15000	18900	50	.00
18000	18900	50	.00
21000	18900	50	.00
24000	18900	50	.00
27000	18900	50	.00
30000	18900	50	.00
33000	18900	50	.00
36000	18900	50	.00
39000	18900	50	.00
42000	18900	50	.00
45000	19900	50	.00
48000	22400	820	0.04
51000	28000	2370	0.08
54000	32600	3560	0.11
57000	35700	3840	0.11
60000	38000	3570	0.09
63000	39600	3060	0.08
66000	40800	2510	0.06
69000	41500	2260	0.05
72000	41900	2100	0.05
75000	42100	2000	0.05

SUNSET SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	49562	568	0.01
15000	49562	568	0.01
18000	49562	568	0.01
21000	49562	568	0.01
24000	49562	568	0.01
27000	64118	3928	0.06
30000	69129	4091	0.06
33000	78488	4378	0.06
36000	89472	4420	0.05
39000	97943	4630	0.05
42000	106320	4984	0.05
45000	122338	5436	0.04
48000	135476	5846	0.04
51000	149248	5868	0.04
54000	165990	5768	0.03
57000	173483	5487	0.03
60000	188419	5931	0.03
63000	194419	6000	0.03
66000	203000	6231	0.03
69000	206972	6263	0.03
72000	210728	6157	0.03
75000	215861	5848	0.03

SUNRISE SIDE CHANNEL

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	0	0	0.00
15000	0	0	0.00
18000	0	0	0.00
21000	0	0	0.00
24000	0	0	0.00
27000	0	0	0.00
30000	0	0	0.00
33000	0	0	0.00
36000	19000	610	0.03
39000	53900	3250	0.06
42000	78500	5660	0.07
45000	97100	6090	0.06
48000	115400	4270	0.04
51000	131100	3820	0.03
54000	146900	3540	0.02
57000	160600	3250	0.02
60000	175600	3180	0.02
63000	192000	3460	0.02
66000	207300	3760	0.02
69000	221400	4080	0.02
72000	229000	4190	0.02
75000	233300	4210	0.02

TRAPPER CREEK S. C.

MAINSTEM DISCHARGE	SITE AREA	CHINOOK WUA	CHINOOK H. I.
12000	73300	1100	0.02
15000	73300	1100	0.02
18000	73300	1100	0.02
21000	73300	1100	0.02
24000	73300	1100	0.02
27000	73300	1100	0.02
30000	73300	1100	0.02
33000	73300	1100	0.02
36000	75600	2000	0.03
39000	85100	9100	0.11
42000	97100	8300	0.09
45000	108700	7100	0.07
48000	119100	5700	0.05
51000	128900	4000	0.03
54000	137400	2700	0.02
57000	143300	1800	0.01
60000	148800	1300	0.01
63000	154800	1300	0.01
66000	160700	1300	0.01
69000	166100	1300	0.01
72000	169800	1300	0.01
75000	172600	1300	0.01

TABLE E.3.2.71: SUMMARY OF EFFECTS OF STAGE I FILLING FLOWS ON JUVENILE CHINOOK REARING HABITATS IN THE LOWER SUSITNA RIVER FROM TALKEETNA TO COOK INLET

Site Name	May	June	July	August	September	October
Rolly Creek Mouth	0	---	-	--	0	0
Caswell Creek Mouth	0	--	-	--	-	0
Beaver Dam Slough	0	---	--	--	0	0
Hoologan Side Channel	---	++	+	++	++	0
Kroto Slough Head	0	++	+	0	0	0
Bearbait Side Channel	0	0	+	-	0	0
Last Chance Side Channel	0	---	+	--	-	0
Rustic Wilderness Side Channel	---	+	0	+	+++	0
Island Side Channel	0	++	0	++	0	0
Mainstem West Bank	--	--	-	--	++	0
Goose 2 Side Channel	0	+++	++	++	--	0
Circular Side Channel	0	0	-	+	0	0
Sauna Side Channel	0	++	+	++	---	0
Sucker Side Channel	0	---	++	---	--	0
Beaver Dam Side Channel	0	---	++	---	0	0
Sunset Side Channel	--	--	-	-	-	0
Sunrise Side Channel	0	++	-	++	0	0
Trapper Creek Side Channel	0	+++	++	+++	0	0

TABLE E.3.2.72: SUSITNA HYDROELECTRIC PROJECT
FEATURES OF NAMED TRIBUTARIES
IN THE STAGE I WATANA RESERVOIR AREA[1/]

Tributary	Susitna River Confluence (River Mile)	Total Length Affected (mi)	Stream Gradient (ft/mi)	Approximate Length in Drawdown Zone (mi)	Approximate Length Permanently Inundated (mi)
Deadman Creek	186.7	2.0	253	.6	1.4
Watana Creek	194.1	7.5	60	2.5	5.0
Kosina Creek	206.8	2.8	118	1.3	1.5
Jay Creek	208.5	2.1	143	1.0	1.1

1/ Stage I Watana River Surface Elevation: 2000 ft. MSL

Source: Adapted from ADF&G 1983b

TABLE E.3.2.73: MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT GOLD CREEK (CFS) DURING STAGE I OPERATION

Month	Natural Conditions			Stage I Flows		
	Max	Min	Mean	Max	Mean	Min
Oct	8,212	3,124	5,825	9,958	5,124	7,903
Nov	4,192	1,215	2,578	9,519	4,686	7,800
Dec	3,264	866	1,828	11,420	5,922	9,120
Jan	2,452	724	1,524	9,529	5,181	8,135
Feb	2,028	723	1,309	8,490	5,175	7,591
Mar	1,900	713	1,173	6,677	4,050	5,732
Apr	2,650	745	1,441	5,292	2,830	4,108
May	21,890	3,745	13,483	10,186	5,012	6,380
Jun	50,580	15,500	27,795	16,736	8,470	13,324
Jul	34,400	16,100	24,390	23,575	8,045	14,492
Aug	37,870	8,879	21,911	35,192	8,251	18,276
Sep	21,240	5,093	13,493	20,028	7,027	14,230
Annual	11,961	5,596	9,781	12,004	6,594	9,774

TABLE E.3.2.74: TOTAL CHINOOK REARING HABITAT AREA IN ALL REPRESENTATIVE GROUPS DURING SUMMER WEEKS UNDER STAGE I FLOW REGIME

Calendar Week	Stage I Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
22	5171857	5771260	6055777	5887756	6131097	6843402
23	5668626	5929310	6250932	5476820	6222510	6893240
24	5725980	6161086	6258065	3494928	6151734	6780969
25	5767946	6195761	6251396	5218277	6187294	6840933
26	5850003	6206316	6256064	5958463	6372627	6892074
27	5795649	6187609	6260385	5960915	6245443	6836489
28	5795575	6186378	6259993	6963999	6108808	6790478
29	5706604	6209704	6261246	5954151	6240076	6873055
30	5712567	6077043	6321585	5971538	6137691	6847559
31	5769172	6212813	6799170	5517503	6294162	6815705
32	5738414	6177955	6593384	5954772	6171091	6823350
33	5306173	6078478	6246680	4956682	6063121	6376799
34	5722170	5994016	6260493	5561034	6096961	6376799
35	5727222	6064021	6259540	5517503	6138112	6292156
36	5707805	6012659	6316796	5685606	6000258	6316496
37	5715499	6015482	6255674	5690184	6008042	6228691
38	5700721	5993625	6255846	5292193	5960600	6259540
39	5707155	6033980	6248407	4987661	5809273	6216278

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.75: TOTAL CHINOOK REARING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER STAGE I FLOW REGIME

Calendar Week	Stage I Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
22	4246945	4476442	4734032	3853133	4125226	4543200
23	4327181	4662600	4727844	3426713	4124438	4449608
24	4271442	4613678	4738400	2335020	4071885	4488465
25	4324062	4552383	4719153	3284299	4076823	4581977
26	4411665	4634967	4732680	3828240	4113942	4220266
27	4436364	4661693	4743006	4025392	4119204	4230208
28	4248194	4658602	4744736	3976770	4125798	4258885
29	4073957	4660950	4741395	3853137	4091048	4245477
30	4037894	4461505	4746239	3966421	4137456	4240463
31	4047213	4546587	4740669	3449123	4101473	4181791
32	4040695	4224526	4738638	4039301	4138079	4230401
33	3332716	4279622	4735541	3140204	4171382	4496151
34	4040200	4322421	4703242	4040200	4176297	4629213
35	4037705	4396104	4712545	4037705	4332384	4712545
36	4145789	4420596	4740480	4096153	4398222	4734924
37	4165806	4540606	4717551	4151235	4528447	4721533
38	4172012	4552071	4728496	4145776	4450270	4718252
39	4294032	4597813	4735962	4116902	4504139	4720054

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.76: SUMMARY OF ACCESS CONDITIONS FOR THE CHUM SPAWNING SITES DURING STAGE I OPERATION BASED ON MEAN AVERAGE MONTHLY FLOW, MAXIMUM AND MINIMUM AVERAGE MONTHLY FLOWS

Site Name	River Mile Designations[a]	Representative Groups	Passage Reach[b]	Natural Discharge						Stage I Flow Regime					
				Maximum		Mean		Minimum		Maximum		Mean		Minimum	
				Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep
Whisker's Creek Slough	101.4L	2	I	–[c]	–	–	–	–	–	–	–	–	–	–	–
			II	–	–	–	–	–	–	–	–	–	–	–	–
Mainstem II	115.ØR	3	I	S[d]	S	S	S	S/D	U	S	S	S	S	U	U
			II	S	S	S	S	U	U	S	S	S	S	U	U
			III	–	–	–	–	–	–	–	–	–	–	–	–
			IVL	–	–	–	–	–	–	–	–	–	–	–	–
		2	IVR	S	S	S	U	U	U	S	S	U	U	U	U
			VR	–	–	–	–	–	–	–	–	–	–	–	–
			VIR	–	–	–	–	–	–	–	–	–	–	–	–
			VIIR	–	–	–	–	–	–	–	–	–	–	–	–
			VIIIR	–	–	–	–	–	–	–	–	–	–	–	–
Slough 8A	126.ØR	2	I	S	S	S	S	S	U	S	S	S	S	S	U
			II	S	S	S	U	U	U	S	S	S	U	U	U
			III	S	S	S	U	U	U	S	S	S/D	U	U	U
			IVL	S	U	U	U	U	U	S	U	U	U	U	U
			IVR	–	–	–	–	–	–	–	–	–	–	–	–
			VR	–	–	–	–	–	–	–	–	–	–	–	–
			VIR	–	–	–	–	–	–	–	–	–	–	–	–
			VIIR	–	–	–	–	–	–	–	–	–	–	–	–
			VIIIR	–	–	–	–	–	–	–	–	–	–	–	–
			IXR	–	–	–	–	–	–	–	–	–	–	–	–
			XR	–	–	–	–	–	–	–	–	–	–	–	–

TABLE E.3.2.76 (Page 2 of 4)

Site Name	River Mile Designations[a/]	Representative Groups	Passage Reach[b/]	Natural Discharge						Stage I Flow Regime					
				Maximum		Mean		Minimum		Maximum		Mean		Minimum	
				Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.
Slough 9	128.8R	3	I	S	S	S	S	U	U	S	S	S	S	U	U
			II	-	-	-	-	-	-	-	-	-	-	-	-
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
Slough 9A	133.8R	1	I	S	S	S	S	U	U	S	S	S	S	U	U
			II	-	-	-	-	-	-	-	-	-	-	-	-
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
			VI	-	-	-	-	-	-	-	-	-	-	-	-
			VII	-	-	-	-	-	-	-	-	-	-	-	-
			VIII	-	-	-	-	-	-	-	-	-	-	-	-
			XI	-	-	-	-	-	-	-	-	-	-	-	-
			X	-	-	-	-	-	-	-	-	-	-	-	-
			XI	-	-	-	-	-	-	-	-	-	-	-	-
Side Channel 10	133.8L	6	I	S	S	S	U	U	U	S	S	S/D	U	U	U
			II	-	-	-	-	-	-	-	-	-	-	-	-
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
			VI	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.76 (Page 3 of 4)

Site Name	River Mile Designations[a]	Representative Groups	Passage Reach[b]	Natural Discharge						Stage I Flow Regime					
				Maximum		Mean		Minimum		Maximum		Mean		Minimum	
				Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.
Slough 11	135.6R	1	I	S	S	S	U	U	U	S	S	S	U	U	U
			II	S	S	S	U	U	U	S	S	S/D	U	U	U
			III	S	U	U	U	U	U	S	U	U	U	U	U
			IV	U	U	U	U	U	U	U	U	U	U	U	U
			V	-	-	-	-	-	-	-	-	-	-	-	-
			VI	-	-	-	-	-	-	-	-	-	-	-	-
			VII	-	-	-	-	-	-	-	-	-	-	-	-
Upper Side Channel 11	136.3R	6	I	-	-	-	-	-	-	-	-	-	-	-	-
			II	-	-	-	-	-	-	-	-	-	-	-	-
Slough 19	139.7R	5	I	-	-	-	-	-	-	-	-	-	-	-	-
			II	-	-	-	-	-	-	-	-	-	-	-	-
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
	139.9R	1	VI	S	S	S	S	U	U	S	S	S	U	U	U
			VII	S	S	S	U	U	U	S	S	S	U	U	U
			VIII	S	S	S	U	U	U	S	S	S/D	U	U	U
			XI	S	U	U	U	U	U	S	U	U	U	U	U
Slough 20	140.2R	2	I	S	S	S	S	U	U	S	S	S	S	U	U
			II	S	S	S	U	U	U	S	S/D	U	U	U	U
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
			VI	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.76 (Page 4 of 4)

				Natural Discharge						Stage I Flow Regime					
				Maximum		Mean		Minimum		Maximum		Mean		Minimum	
Site Name	River Mile Designations[a/]	Representative Groups	Passage Reach[b/]	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.	Aug.	Sep.
Side Channel 21	141.4R	3	I	S	S	S	S	S	U	S	S	S	S	S	U
			II	S	S	S	S	U	U	S	S	S	S	U	U
			III	-	-	-	-	-	-	-	-	-	-	-	-
			IV	-	-	-	-	-	-	-	-	-	-	-	-
			V	-	-	-	-	-	-	-	-	-	-	-	-
			VI	-	-	-	-	-	-	-	-	-	-	-	-
			VII	-	-	-	-	-	-	-	-	-	-	-	-
	141.6R	5	VIII	-	-	-	-	-	-	-	-	-	-	-	-
			IX	-	-	-	-	-	-	-	-	-	-	-	-
Slough 21	142.1R	2	I	-	-	-	-	-	-	-	-	-	-	-	-
			II	-	-	-	-	-	-	-	-	-	-	-	-
			IIIL	-	-	-	-	-	-	-	-	-	-	-	-
			IIIR	-	-	-	-	-	-	-	-	-	-	-	-
Slough 22	144.4L	2	I	S	S	S	U	U	U	S	S	S	U	U	U
			II	S	U	S/D	U	U	U	S	U	U	U	U	U
			III	-	-	-	-	-	-	-	-	-	-	-	-

a/ Source: EWT&A and AEIDC 1985

b/ Source: ADF&G 1985

c/ Influence of backwater was not evaluated since breaching flow occurs at discharges lower than those required for providing backwater influence.

d/ U = Unsuccessful condition, S/D = Successful with Difficulty and S = Successful.

TABLE E.3.2.77: TOTAL CHUM SPAWNING HABITAT IN IFG AND DIHAB MODEL SITES DURING SUMMER MONTHS UNDER STAGE I FLOW REGIME

Calendar Week	Stage I Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
32	71996	74257	86129	72935	74117	76821
33	40810	74173	86365	35061	73755	78712
34	46690	74944	85791	45002	74129	84101
35	46690	76725	85363	44286	76030	85363
36	56390	80021	86493	47448	75257	86202
37	51134	83756	87201	47448	76554	85219
38	52687	84683	87218	36322	74376	86928
39	47070	84763	87136	26285	62440	86438

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.78: TOTAL CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER STAGE I FLOW REGIMES

Calendar Week	Stage I Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
32	826534	855238	879186	826654	849978	883525
33	398113	847968	866300	330883	832670	858434
34	784981	836728	869498	689191	836728	862500
35	784981	851962	868158	620955	852626	868158
36	823765	856520	868428	789790	840645	866908
37	805035	851897	868813	789790	840943	864098
38	810568	855986	868730	729972	844361	867598
39	787395	859769	868758	608728	825264	865603

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.79: TOTAL CHUM SPAWNING HABITAT AVAILABLE FOR INCUBATION OF EMBRYOS IN IFG AND DIHAB MODEL SITES UNDER STAGE I FLOW REGIME

Calendar Week	Stage I Flow Regime Modelled Habitat Area Exceeded Percent of Time 90% (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded Percent of Time 90% (sq ft)	50% (sq ft)	10% (sq ft)
40	36757	81940	86899	21116	44783	80392
41	30653	44796	52392	19923	38552	49157
42	21554	39025	47219	15404	21348	42731
43	20326	40891	47516	11066	20021	29479
44	21266	43849	48178	8127	16393	21148
45	25117	47100	48187	7586	13242	19511
46	29616	44569	51107	7112	12294	16391
47	34075	46971	56224	6230	11547	15172
48	38842	47841	49004	5552	10872	14053

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.80: TOTAL CHUM SPAWNING HABITAT IN REPRESENTATIVE GROUPS 2, 3, AND 4 AVAILABLE FOR INCUBATION OF EMBRYOS DURING EARLY WINTER WEEKS UNDER STAGE I FLOW REGIMES

Calendar Week	Stage I Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	Stage I Flow Regime Modelled Habitat Area Exceeded 50% Percent of Time (sq ft)	Stage I Flow Regime Modelled Habitat Area Exceeded 10% Percent of Time (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 50% Percent of Time (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 10% Percent of Time (sq ft)
40	733104	863614	869337	684023	857300	933800
41	689123	776995	809517	605669	739687	807872
42	521634	749444	788972	457804	676018	754469
43	502494	760530	790226	414471	723848	762341
44	517146	773001	794429	446820	761343	788863
45	587223	787586	794486	513934	797933	812041
46	670029	776037	804940	585116	821592	838855
47	713782	786765	823175	649601	850131	866409
48	748123	792285	797446	710780	819360	877949

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.81: SUSITNA HYDROELECTRIC PROJECT
SIMULATED STREAM TEMPERATURES
STAGE I
WEATHER PERIOD: SUMMER 1981
CASE E-VI
FLOW REQUIREMENTS
STAGED CONSTRUCTION

RIVER MILE	MAY 31	32	33	34	35	JUNE 36	37	38	39	40	JULY 41	42	43	44
184 1/	2.2	2.8	3.8	4.8	6.6	8.1	8.8	10.3	9.5	8.4	8.4	10.2	10.5	10.5
173	2.5	2.8	3.5	4.7	6.4	7.7	8.8	10.3	9.4	8.4	8.4	9.9	10.4	10.4
162	2.8	3.6	4.2	5.3	7.0	7.9	9.1	10.6	9.6	8.7	8.6	10.1	10.6	10.5
150	3.1	3.7	4.2	5.4	7.1	7.9	9.3	10.8	9.7	8.9	8.7	10.1	10.7	10.7
140	3.3	3.9	4.3	5.5	7.2	7.9	9.4	10.9	9.8	9.0	8.8	10.1	10.7	10.7
130	3.6	4.3	4.6	5.8	7.3	7.8	9.4	10.9	9.6	9.0	8.6	9.8	10.4	10.5
120	4.0	4.9	5.3	6.4	7.9	8.1	9.8	11.3	9.9	9.3	8.9	10.1	10.7	10.7
110	4.3	5.5	5.8	6.9	8.4	8.3	10.2	11.6	10.1	9.5	9.1	10.3	11.0	10.9
99 2/	4.7	6.0	6.4	7.4	8.8	8.6	10.5	11.9	10.4	9.7	9.3	10.6	11.2	11.2
98 3/	4.4	5.7	6.2	6.7	7.7	7.0	8.5	9.4	8.5	8.5	8.2	8.6	9.0	9.3
84 4/	4.8	6.4	7.1	7.4	8.5	7.5	9.2	10.1	9.0	9.0	8.7	9.1	9.5	9.8

RIVER MILE	AUGUST 45	46	47	48	SEPTEMBER 49	50	51	52	OCTOBER 1	2	3	4	5
184 1/	9.7	9.1	8.3	9.2	8.8	7.9	8.0	7.1	6.1	5.1	4.8	4.3	3.7
173	9.8	9.1	8.4	9.2	8.8	7.8	7.9	6.9	5.7	4.7	4.1	3.6	3.0
162	9.9	9.1	8.5	9.4	8.9	7.9	7.9	6.7	5.4	4.5	3.8	3.3	2.5
150	10.1	9.3	8.7	9.5	9.0	8.0	8.0	6.7	5.3	4.4	3.6	3.1	2.2
140	10.2	9.3	8.8	9.6	9.1	8.0	8.0	6.5	5.1	4.2	3.4	2.9	1.8
130	10.2	9.2	8.8	9.6	9.0	7.9	7.9	6.3	4.9	4.0	3.2	2.6	1.4
120	10.4	9.3	8.9	9.8	9.2	8.0	7.9	6.2	4.7	3.9	3.1	2.5	.9
110	10.5	9.3	9.0	10.0	9.3	8.1	8.0	6.1	4.7	3.8	3.0	2.4	.5
99 2/	10.7	9.4	9.2	10.2	9.5	8.2	8.0	5.9	4.4	3.7	2.9	2.3	.1
98 3/	9.3	8.2	8.3	8.7	7.9	7.2	6.7	4.7	3.6	3.2	2.7	2.1	.1
84 4/	9.7	8.2	8.6	9.3	8.2	7.3	6.8	4.3	3.4	3.1	2.6	2.0	0.0

1/ Downstream of Watana Damsite

2/ Upstream of Chulitna-Susitna confluence

3/ Downstream of Chulitna-Susitna confluence

4/ At Sunshine stream gaging station

TABLE E.3.2.82: SUSITNA HYDROELECTRIC PROJECT
SIMULATED STREAM TEMPERATURES
WEATHER PERIOD: SUMMER 1982
2001 ENERGY DEMANDS
CASE E-VI FLOW REQUIREMENTS
STAGED CONSTRUCTION
STAGE I

RIVER		MAY					JUNE				JULY			
MILE	31	32	33	34	35	36	37	38	39	40	41	42	43	44
184 1/	2.6	2.7	2.9	3.2	3.7	5.2	6.3	6.6	8.7	10.9	10.6	9.9	9.9	9.4
173	2.9	2.5	2.6	2.9	3.7	5.1	6.2	6.7	8.7	10.8	10.6	10.1	9.8	9.6
162	3.4	2.9	3.3	3.4	4.3	5.5	6.4	7.1	9.1	11.0	10.8	10.4	10.0	9.9
150	3.6	3.0	3.4	3.5	4.5	5.6	6.5	7.3	9.3	11.0	10.9	10.6	10.2	10.1
140	3.8	3.0	3.5	3.6	4.7	5.7	6.6	7.4	9.4	11.1	11.0	10.8	10.2	10.3
130	4.2	3.3	3.7	3.8	4.9	5.8	6.6	7.5	9.4	10.9	10.8	10.7	9.9	10.1
120	4.7	3.7	4.3	4.3	5.4	6.2	6.9	7.9	9.8	11.2	11.2	11.1	10.1	10.5
110	5.2	4.0	4.8	4.8	5.9	6.5	7.1	8.2	10.2	11.5	11.4	11.4	10.4	10.8
99 2/	5.7	4.4	5.3	5.2	6.4	6.8	7.3	8.5	10.6	11.8	11.7	11.7	10.6	11.2
98 3/	5.2	4.3	5.2	5.3	6.2	6.7	6.5	7.2	9.1	9.2	9.0	9.3	8.3	9.0
84 3/	5.6	4.7	5.9	6.0	7.2	7.7	7.0	8.0	10.1	9.7	9.6	10.0	9.0	9.8

RIVER		AUGUST				SEPTEMBER		
MILE	45	46	47	48	49	50	51	52
184 1/	9.8	9.4	9.9	9.2	9.3	9.6	8.4	7.3
173	10.0	9.6	10.0	9.3	9.1	9.2	7.9	6.9
162	10.2	9.8	10.2	9.4	9.2	9.2	7.9	6.8
150	10.5	10.0	10.4	9.6	9.2	9.2	7.8	6.8
140	10.7	10.2	10.6	9.7	9.2	9.1	7.8	6.7
130	10.6	10.2	10.6	9.6	9.1	8.9	7.5	6.5
120	11.0	10.5	10.9	9.9	9.2	9.0	7.6	6.4
110	11.3	10.7	11.1	10.1	9.3	9.0	7.6	6.4
99 2/	11.7	11.0	11.4	10.3	9.4	9.1	7.7	6.4
98 3/	9.2	8.7	9.2	7.9	7.8	7.2	5.7	5.3
84 4/	9.8	9.3	9.8	8.5	8.0	7.2	5.9	5.1

1/ Downstream of Watana Damsite
2/ Upstream of Chulitna-Susitna confluence
3/ Downstream of Chulitna-Susitna confluence
4/ At Sunshine stream gaging station

TABLE E.3.2.83
STREAM TEMPERATURES
WEATHER PERIOD: SUMMER 1981
NATURAL CONDITIONS

WATER WEEK NO.

River	May					June				July				
Mile	31	32	33	34	35	36	37	38	39	40	41	42	43	44
184 1/	4.8	7.6	8.6	8.2	9.2	8.9	11.6	12.2	8.5	8.4	9.2	9.5	9.8	9.4
173	4.8	7.4	8.2	7.9	9.1	8.7	11.4	12.1	8.6	8.5	9.2	9.5	9.9	9.5
162	4.9	7.5	8.4	8.1	9.3	8.8	11.6	12.3	8.7	8.7	9.3	9.6	10.0	9.6
150 3/	5.0	7.6	8.3	8.1	9.3	8.9	11.6	12.4	9.0	8.9	9.5	9.9	10.2	9.9
140	5.1	7.6	8.3	8.1	9.4	8.9	11.6	12.5	9.1	9.0	9.5	9.9	10.3	10.0
130	5.1	7.5	8.2	8.1	9.4	8.8	11.5	12.3	9.1	9.0	9.4	9.9	10.3	10.0
120	5.3	7.7	8.4	8.4	9.7	9.0	11.7	12.6	9.3	9.3	9.6	10.1	10.5	10.2
110	5.5	7.9	8.6	8.6	9.9	9.1	11.9	12.8	9.6	9.5	9.7	10.2	10.7	10.4
99 3/	5.7	8.0	8.8	8.9	10.1	9.3	12.1	13.1	9.8	9.7	9.9	10.4	10.9	10.6
98 4/	5.0	7.2	7.9	7.8	8.8	7.7	9.5	10.2	8.5	8.6	8.8	9.1	9.5	9.3
84 5/	5.2	7.5	8.3	8.2	9.4	8.0	10.0	10.7	9.0	9.1	9.1	9.5	9.9	9.8

WATER WEEK NO.

River	August				September				October				
Mile	45	46	47	48	49	50	51	52	1	2	3	4	5
184 1/	9.4	6.8	7.5	9.9	7.2	7.0	6.2	1.6	0.3	0.3	1.2	0.5	0.0
173	9.5	7.0	7.6	9.9	7.3	7.0	6.2	1.8	0.5	0.4	1.2	0.4	0.0
162	9.6	7.1	7.7	10.0	7.5	7.1	6.2	1.7	0.5	0.4	1.2	0.4	0.0
150 2/	9.9	7.5	8.0	10.1	7.7	7.2	6.4	2.0	0.7	0.6	1.3	0.5	0.0
140	10.0	7.6	8.1	10.2	7.8	7.3	6.5	2.1	0.8	0.7	1.3	0.5	0.0
130	10.0	7.6	8.1	10.1	7.9	7.3	6.5	2.2	1.0	0.9	1.4	0.5	0.0
120	10.1	7.7	8.3	10.3	8.1	7.4	6.6	2.2	1.0	0.9	1.4	0.5	0.0
110	10.3	7.8	8.5	10.5	8.2	7.5	6.7	2.2	1.0	1.0	1.4	0.5	0.0
99 3/	10.5	8.0	8.6	10.7	8.4	7.6	6.8	2.2	1.0	1.0	1.4	0.5	0.0
98 4/	9.2	7.4	7.9	8.9	7.4	6.9	5.9	2.3	1.5	1.6	1.7	1.0	0.0
84 5/	9.6	7.7	8.3	9.4	7.8	7.1	6.1	2.3	1.7	1.8	1.9	1.1	0.0

1/ Downstream of Watana Dam Site
2/ Downstream of Devil Canyon Dam Site
~~3/ Upstream of Susitna - Chulitna confluence~~
4/ Downstream of Susitna - Chulitan confluence (full mixing assumed)
5/ At Sunshine stream gaging station at Parks Highway Bridge
SOURCE: APA 1984e

420723
840817

TABLE E.3.2.84
STREAM TEMPERATURES
WEATHER PERIOD: SUMMER 1982
NATURAL CONDITIONS

WATER WEEK NO.

River	May					June				July				
Mile	31	32	33	34	35	36	37	38	39	40	41	42	43	44
184 1/	5.5	4.9	7.2	7.1	8.8	9.2	8.0	9.6	11.9	10.2	10.6	10.6	9.7	10.5
173	5.2	4.6	6.8	6.7	8.5	8.9	7.9	9.5	11.7	10.2	10.7	10.7	9.7	10.6
162	5.5	4.7	6.9	6.9	8.6	9.0	8.0	9.6	11.8	10.4	10.8	10.9	9.8	10.7
150 2/	5.4	4.7	6.8	6.8	8.6	9.0	8.1	9.7	11.9	10.5	11.0	11.1	10.1	10.9
140	5.4	4.7	6.8	6.7	8.5	9.0	8.1	9.7	11.9	10.6	11.1	11.2	10.1	11.0
130	5.5	4.7	6.7	6.6	8.4	8.9	8.0	9.6	11.8	10.6	11.1	11.2	10.0	11.0
120	5.9	4.9	6.9	6.8	8.6	9.1	8.2	9.9	12.0	10.9	11.3	11.5	10.2	11.2
110	6.2	5.1	7.1	7.0	8.8	9.2	8.3	10.0	12.2	11.1	11.5	11.7	10.4	11.4
99 3/	6.6	5.3	7.3	7.2	9.0	9.3	8.5	10.2	12.5	11.4	11.7	12.0	10.6	11.7
98 4/	5.8	4.9	6.7	6.6	8.1	8.3	7.4	8.6	10.5	9.3	9.6	10.0	8.8	9.7
84 5/	6.1	5.2	7.0	6.9	8.4	8.6	7.6	9.0	11.0	9.8	10.1	10.5	9.3	10.2

WATER WEEK NO.

River	August				September				October				
Mile	45	46	47	48	49	50	51	52	1	2	3	4	5
184 1/	10.5	10.5	10.5	9.0	7.6	6.1	6.4	4.1	2.0	0.0	0.0	0.0	0.0
173	10.6	10.6	10.6	9.1	7.6	6.2	6.3	4.1	2.1	0.0	0.0	0.0	0.0
162	10.8	10.8	10.7	9.2	7.7	6.3	6.4	4.1	2.1	0.0	0.0	0.0	0.0
150 2/	11.1	11.0	10.9	9.4	7.9	6.5	6.6	4.3	2.2	0.2	0.0	0.0	0.0
140	11.2	11.1	11.0	9.5	8.0	6.6	6.6	4.4	2.3	0.2	0.0	0.0	0.0
130	11.2	11.0	11.0	9.5	8.0	6.7	6.6	4.4	2.3	0.3	0.0	0.0	0.0
120	11.5	11.2	11.3	9.7	8.1	6.8	6.7	4.5	2.3	0.2	0.0	0.0	0.0
110	11.7	11.4	11.5	9.9	8.3	6.9	6.7	4.5	2.3	0.2	0.0	0.0	0.0
99 3/	12.0	11.6	11.8	10.1	8.4	7.1	6.8	4.6	2.3	0.1	0.0	0.0	0.0
98 4/	9.6	9.1	9.4	8.0	7.3	6.3	5.6	4.4	2.5	0.8	0.2	0.0	0.0
84 5/	10.1	9.7	9.9	8.5	7.6	6.6	5.8	4.5	2.6	0.8	0.0	0.0	0.0

1/ Downstream of Watana Dam Site
2/ Downstream of Devil Canyon Dam Site
3/ Upstream of Susitna - Chulitna confluence
4/ Downstream of Susitna - Chulitna confluence (full mixing assumed)
5/ At Sunshine stream gaging station at Parks Highway Bridge

SOURCE: APA 1984e

420723
840817

TABLE E.3.2.85: MAXIMUM SIMULATED RIVER STAGES FOR CASE E-VI FLOW CONSTRAINTS, INFLOW TEMPERATURE-MATCHING, STAGE I FLOW, AND WINTER 1981-82 CLIMATE DATA

STAGE I				
Slough or Side Channel	River Mile	Threshold Elevation	Simulated Natural Conditions	Simulated Stage I Conditions
Whiskers	101.5	367	$\boxed{368}$	$\boxed{370}$
Gash Creek	112.0	453	$\boxed{455}$	$\boxed{457}$
6A	112.3	(Upland)	457	459
8	114.1	476	472	475
MSII West	115.5	482	$\boxed{484}$	$\boxed{487}$
MSII East	115.9	487	486	$\boxed{489}$
Curry	120.0	(Upland)	523	526
Moose	123.5	548	$\boxed{549}$	$\boxed{555}$
8A West	126.1	573	571	$\boxed{575}$
8A East	127.1	582	$\boxed{583}$	$\boxed{585}$
9	129.3	604	$\boxed{606}$	$\boxed{607}$
9 u/s	130.6	617	$\boxed{620}$	$\boxed{620}$
4th July	131.8	626	$\boxed{629}$	$\boxed{633}$
9A	133.7	651	$\boxed{651}$	$\boxed{656}$
10 u/s	134.3	657	$\boxed{657}$	$\boxed{664}$
11 d/s	135.3	667	$\boxed{670}$	$\boxed{675}$
11	136.5	687	683	$\boxed{688}$
17	139.3	(Upland)	---	715
20	140.5	730	---	729
21 (A6)	141.8	747	---	747
21	142.2	755	---	753
22	144.8	788	---	787
Ice Front Starting Date				12-10
Maximum Ice Front Extent (River Mile)				139
Melt-out Date				4-28

Notes:

1. $\boxed{}$ Indicates locations where maximum river stage equals or exceeds a known slough threshold elevation.

2. All river stages in feet.

Source: Exhibit E, Chapter 2

TABLE E.3.2.86: NATURAL AND ESTIMATED MEAN MONTHLY SUSPENDED SEDIMENT CONCENTRATIONS AND TURBIDITY VALUES EXPECTED TO EXIT WATANA RESERVOIR DURING STAGE I OPERATIONS

		STAGE I OPERATION	
Month	Observed Suspended Sediment Concentrations[1/]	Estimated Mean Suspended Sediment Concentrations[1/]	Estimated Mea Turbidity
	(mg/l)	(mg/l)	NTU[2/]
January	<1-8	65	130
February	N.A.	55	110
March	1-6	45	90
April	N.A.	30	60
May	65-1,110	35	70
June	151-1,860	85	170
July	100-2,790	130	260
August	158-1,040	110	220
September	23-812	90	180
October	7-140	100	200
November	N.A.	95	190
December	N.A.	85	170

1/ Data derived from Table E.2.4.23; from Exhibit E, Chapter 2 data

2/ Turbidity estimated by using factor of (2x) times TSS concentrations (See discussions in Exhibit E, Chapter 2).

TABLE E.3.2.88 MONTHLY MAXIMUM,MINIMUM AND MEAN FLOWS AT SUNSHINE (CFS)

STAGE I - WATANA (LOW) OPERATION

MONTH	NATURAL CONDITIONS			STAGE I FLOWS		
	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	20837	8176	13799	22367	11039	15942
NOV	8775	4020	6185	14272	7491	11438
DEC	6547	2675	4426	14730	7916	11705
JAN	5216	2228	3674	12066	6973	10267
FEB	4664	2095	3115	10992	6867	9386
MAR	3920	1972	2786	8548	5668	7344
APR	5528	2233	3585	7875	4905	6148
MAY	43121	10799	27674	36142	12001	20611
JUN	116152	40702	63268	81098	33618	48797
JUL	85600	45226	64143	71496	37340	54227
AUG	84940	25092	56148	82750	24281	52562
SEP	54110	14320	32867	54096	16243	33546
ANNUAL	28262	14431	23607	28439	15426	23597

TABLE E.3.2.89 MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT SUSITNA STATION (CFS)

STAGE I - WATANA (LOW) OPERATION

MONTH	NATURAL CONDITIONS			STAGE I FLOWS		
	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	58640	13476	32777	59759	16273	34847
NOV	31590	8251	15063	36073	13057	20345
DEC	14690	5753	9267	23150	10806	16563
JAN	10120	6365	8112	17556	11059	14707
FEB	9413	5614	7383	16058	11096	13654
MAR	8906	5271	6412	13917	9378	10972
APR	13029	4613	7684	15764	7259	10383
MAY	88470	28713	56770	79365	19442	49672
JUN	165900	73838	112256	141399	58483	97743
JUL	181400	92511	126590	162487	86221	116638
AUG	159600	80891	109084	155696	80080	105490
SEP	109700	37592	67721	107286	39515	68491
ANNUAL	63159	38030	46871	63066	38377	46868

TABLE E.3.2.89: JUVENILE CHINOOK REARING HABITAT INDEX VALUE FOR MEAN MONTHLY DISCHARGE AT THE SUNSHINE STATION[1/] UNDER THE NATURAL AND STAGE I OPERATING FLOW REGIMES

	AGGREGATE HABITAT INDEX VALUES[2/]			
	Natural Flows		Stage I Flows	
Month	Side Channels	Tributary Mouths	Side Channels	Tributary Mouths
June	0.028	0.140	0.045	0.064
July	0.027	0.142	0.037	0.108
August	0.035	0.120	0.038	0.095
September	0.040	0.055	0.04	0.055

1/ From Table E.3.2.88

2/ Estimated from Figures E.3.2.87 and E.3.2.88

TABLE E.3.2.90: SUSITNA HYDROELECTRIC PROJECT
TOPOGRAPHICAL FEATURES OF SELECTED
TRIBUTARIES OF THE PROPOSED
DEVIL CANYON IMPOUNDMENT[1/], 1982

Tributary	Susitna River Confluence (River Mile)	Total Length Affected (mi)	Stream Gradient (ft/mi)	Approximate Length in Drawdown Zone (mi)	Approximate Length Permanently Inundated (mi)
Cheechako Creek	152.4	1.7	321	0.4	1.3
Chinook Creek	157.0	1.3	308	0.4	0.9
Devil Creek	161.4	1.5	176	0.7	0.8
Fog Creek	176.7	1.3	72	1.3	0.0
Tsusena Creek	181.3	0.4	82	0.4	0.0

1/ Proposed Impoundment Elevation: 1455 Ft. MSL.

Source: ADF&G 1983b

TABLE E.3.2.91 MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT DEVIL CANYON (CFS)

STAGE II - WATANA (LOW) - DEVIL CANYON OPERATIONS

MONTH	NATURAL FLOWS			STAGE II FLOWS		
	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	7518	2867	5363	8638	4777	7167
NOV	3955	1146	2402	8009	2931	7686
DEC	2905	810	1703	8876	2973	8424
JAN	2212	687	1429	8241	5037	7931
FEB	1858	682	1216	8211	5055	7387
MAR	1779	664	1086	7478	4606	6245
APR	2405	697	1340	6858	3983	5831
MAY	19777	3428	12462	7348	4305	6106
JUN	47814	14710	26043	10956	6291	7582
JUL	32388	15651	23075	24991	6252	13542
AUG	35256	8484	20654	35114	7423	19164
SEP	19799	4796	12555	19799	6458	12583
ANNUAL	11254	5352	9159	11254	5613	9160

TABLE E.3.2.92: TOTAL CHINOOK REARING HABITAT AREA IN ALL REPRESENTATIVE GROUPS DURING SUMMER WEEKS UNDER STAGE II FLOW REGIME

Calendar Week	Stage II Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Stage II Flows: Total Habitat Area Exceeded 50% Percent of Time (sq ft)	Stage II Flows: Total Habitat Area Exceeded 10% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 50% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 10% Percent of Time (sq ft)
22	5147138	5743374	5908472	5887756	6131097	6843402
23	5794908	5929310	5929310	5476820	6222510	6893240
24	5755797	5929310	5929310	3494928	6151734	6780969
25	5751478	5929310	5929310	5218277	6187294	6840933
26	5794908	5929310	5929310	5958463	6372627	6892074
27	5794908	5929310	5929310	5960915	6245443	6836489
28	5794908	5929310	6634608	6963999	6108808	6790478
29	5794908	5929310	6569315	5954151	6240076	6873055
30	5794908	6002177	6750031	5971538	6137691	6847559
31	5794908	6085761	6784760	5517503	6294162	6815705
32	5794908	6006532	6780969	5954772	6171091	6823350
33	5048749	6044573	6376799	4956682	6063121	6376799
34	5060832	6091090	6219749	5561034	6096961	6376799
35	5678053	6186194	6474147	5517503	6138112	6292156
36	5704346	5998999	6316496	5685606	6000258	6316496
37	5690164	6008042	6228691	5690184	6008042	6228691
38	5292193	5960600	6259540	5292193	5960600	6259540
39	5180262	5839273	6216278	4987661	5809273	6216278

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.93: TOTAL CHINOOK REARING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER STAGE II FLOW REGIME

Calendar Week	Stage II Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
22	4244929	4543461	4729671	3853133	4125226	4543200
23	4482101	4727844	4727544	3426713	4124438	4449608
24	4493376	4727844	4727544	2335020	4071885	4488465
25	4485923	4727844	4727544	3284299	4076823	4581977
26	4488544	4727844	4727544	3828240	4113942	4220266
27	4161529	4727844	4727544	4025392	4119204	4230208
28	4069175	4727844	4727544	3976770	4125798	4258885
29	3963805	4726794	4727544	3853137	4091048	4245477
30	3966421	4589633	4727544	3966421	4137456	4240463
31	3923086	4143477	4727544	3449123	4101473	4181791
32	4039301	4158415	4727544	4039301	4138079	4230401
33	3190918	4173285	4685963	3140204	4171382	4496151
34	3197573	4176297	4634342	4040200	4176297	4629213
35	4037705	4348078	4725744	4037705	4332384	4712545
36	4047992	4430849	4734924	4096153	4398222	4734924
37	4165806	4528447	4728666	4151235	4528447	4721533
38	4172012	4450270	4718252	4145776	4450270	4718252
39	4244929	4504139	4720054	4116902	4504139	4720054

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.94: SUMMARY OF ACCESS CONDITIONS FOR CHUM SPAWNING SITES DURING STAGE II OPERATION BASED ON MEAN, MAXIMUM AND MINIMUM AVERAGE MONTHLY FLOWS

Site Name	River Mile[a] Designations	Passage Reach[b]	Natural Discharge						Stage II Discharge					
			Maximum		Mean		Minimum		Maximum		Mean		Minimum	
			AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP
Whisker's Creek Slough	101.4L	I	[c]		-	-	-	-	-	-	-	-	-	-
		II	-	-		-	-	-	-	-	-	-	-	-
Mainstem II	115.ØR	I	S[d]		S	S	S	S/D	U	S	S	S	S	U
		II	S	S	S	S	U	U	S	S	S	S	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IVL	-	-	-	-	-	-	-	-	-	-	-	-
		IVR	S	S	S	U	U	U	S	S	S	U	U	U
		VR	-	-	-	-	-	-	-	-	-	-	-	-
		VIR	-	-	-	-	-	-	-	-	-	-	-	-
		VIIR	-	-	-	-	-	-	-	-	-	-	-	-
		VIIIR	-	-	-	-	-	-	-	-	-	-	-	-
Slough 8A	126.ØR	I	S	S	S	S	S	U	S	S	S	S	S	U
		II	S	S	S	U	U	U	S	S	S	U	U	U
		III	S	S	S	U	U	U	S	S	S	U	U	U
		IVL	S	U	U	U	U	U	S	U	U	U	U	U
		IVR	-	-	-	-	-	-	-	-	-	-	-	-
		VR	-	-	-	-	-	-	-	-	-	-	-	-
		VIR	-	-	-	-	-	-	-	-	-	-	-	-
		VIIR	-	-	-	-	-	-	-	-	-	-	-	-
		VIIIR	-	-	-	-	-	-	-	-	-	-	-	-
		IXR	-	-	-	-	-	-	-	-	-	-	-	-
		XR	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.94: (Page 2 of 4)

Site Name	River Mile[a/] Designations	Passage Reach[b/]	Natural Discharge						Stage II Discharge					
			Maximum		Mean		Minimum		Maximum		Mean		Minimum	
			AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP
Slough 9	128.8R	I	S	S	S	S	U	U	S	S	S	S	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
Slough 9A	133.9R	I	S	S	S	S	U	U	S	S	S	S	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-
		VII	-	-	-	-	-	-	-	-	-	-	-	-
		IX	-	-	-	-	-	-	-	-	-	-	-	-
		X	-	-	-	-	-	-	-	-	-	-	-	-
		XI	-	-	-	-	-	-	-	-	-	-	-	-
Side Channel 10	133.8L	I	S	S	S	U	U	U	S	S	S	U	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.94: (Page 3 of 4)

Site Name	River Mile[a/] Designations	Passage Reach[b/]	Natural Discharge						Stage II Discharge					
			Maximum		Mean		Minimum		Maximum		Mean		Minimum	
			AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP
Slough 11	135.6R	I	S	S	S	U	U	U	S	S	S	U	U	U
		II	S	S	S	U	U	U	S	S	S	U	U	U
		III	S	U	U	U	U	U	S	U	U	U	U	U
		IV	U	U	U	U	U	U	U	U	U	U	U	U
		V	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-
		VII	-	-	-	-	-	-	-	-	-	-	-	-
Upper Side Channel 11	136.3R	I	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	-	-
Slough 19	139.7R	I	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
	139.9R	VI	S	S	S	S	U	U	S	S	S	S	U	U
		VII	S	S	S	U	U	U	S	S	S	U	U	U
		VIII	S	S	S	U	U	U	S	S	S	U	U	U
		IX	S	U	U	U	U	U	S	U	U	U	U	U

TABLE E.3.2.94: (Page 4 of 4)

Site Name	River Mile[a/] Designations	Passage Reach[b/]	Natural Discharge						Stage II Discharge					
			Maximum		Mean		Minimum		Maximum		Mean		Minimum	
			AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP
Slough 20	140.2R	I	S	S	S	S	U	U	S	S	S	S	S	S
		II	S	S	S	U	U	U	S	S/D	S/D	U	U	S/D
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-
Side Channel 21	141.4R	I	S	S	S	S	S	U	S	S	S	S	S	U
		II	S	S	S	S	U	U	S	S	S	S	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-
		VII	-	-	-	-	-	-	-	-	-	-	-	-
	141.6R	VIII	-	-	-	-	-	-	-	-	-	-	-	-
		IX	-	-	-	-	-	-	-	-	-	-	-	-
Slough 21	142.1R	I	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	-	-
		IIIL	-	-	-	-	-	-	-	-	-	-	-	-
		IIIR	-	-	-	-	-	-	-	-	-	-	-	-
Slough 22	144.4L	I	S	S	S	U	U	U	S	S	S	U	U	U
		II	S	U	S/D	U	U	U	S	U	U	U	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-

a/ Source: EWT&A and AEIDC 1985
b/ Source: ADF&G 19851, L=Left and R=Right, looking upstream
c/ Influence of backwater was not evaluated since breaching flow occurs at discharge lower than those required for providing backwater influence.
d/ U=Unsuccessful, S/D=Successful with Difficulty, and S=Successful

TABLE E.3.2.95: TOTAL CHUM SPAWNING HABITAT IN IFG AND DIHAB MODEL SITES DURING SUMMER MONTHS UNDER STAGE II FLOW REGIME

Calendar Week	Stage II Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
32	46690	73342	75531	72935	74117	76821
33	36575	73592	84506	35061	73755	78712
34	36774	73909	83557	45002	74129	84101
35	46690	75444	85363	44286	76030	85363
36	46690	74642	86202	47448	75257	86202
37	47027	76554	85219	47448	76554	85219
38	36322	74376	86928	36322	74376	86928
39	31919	62440	86438	26285	62440	86438

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.96: TOTAL CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER STAGE II FLOW REGIMES

Calendar Week	Stage II Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	 50%	 10%	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	 50%	 10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
32	784981	835011	883332	826654	849978	883525
33	345781	837107	859996	330883	832670	858434
34	347736	834605	854194	689191	836728	862500
35	784981	852626	868158	620955	852626	868158
36	784981	838007	866908	789790	840645	866908
37	787121	840943	864098	789790	840943	864098
38	729972	844361	867598	729972	844361	867598
39	698246	825264	865603	608728	825264	865603

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.97: TOTAL CHUM SPAWNING HABITAT AVAILABLE FOR INCUBATION OF EMBRYOS IN IFG AND DIHAB MODEL SITES UNDER STAGE II FLOW REGIME

Calendar Week	Stage II Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
40	34169	44783	80392	21116	44783	80392
41	36561	41813	49157	19923	38552	49157
42	38974	41503	45591	15404	21348	42731
43	40441	42502	44374	11066	20021	29479
44	41885	43572	45466	8127	16393	21148
45	43967	45240	46727	7586	13242	19511
46	44015	46768	47122	7112	12294	16391
47	46005	47016	47473	6230	11547	15172
48	46984	47383	47838	5552	10872	14053

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.98: TOTAL CHUM SPAWNING HABITAT IN REPRESENTATIVE GROUPS 2, 3, AND 4 AVAILABLE FOR INCUBATION OF EMBRYOS DURING EARLY WINTER WEEKS UNDER STAGE II FLOW REGIMES

Calendar Week	Stage II Flow Regime Modelled Habitat Area Exceeded Percent of Time			Natural Flow Regime Modelled Habitat Area Exceeded Percent of Time		
	90%	50%	10%	90%	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
40	714456	776940	855079	743236	790083	887478
41	731688	764420	797989	761361	790087	830175
42	749076	763112	780348	726475	794180	813151
43	758633	767324	775218	709737	801152	813434
44	764721	771836	779820	731494	776597	819621
45	773498	778866	785214	752897	775962	829240
46	773704	785478	787726	774723	791514	841854
47	782092	787049	789953	792830	804263	853051
48	786847	789381	792271	805815	816042	829623

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.99: SIMULATED STREAM TEMPERATURES
WEATHER PERIOD: SUMMER 1981
CASE E-VI FLOW CONSTRAINTS
STAGE II FLOW REGIME

RIVER	MAY					JUNE				JULY				
MILE	31	32	33	34	35	36	37	38	39	40	41	42	43	44
150	2.4	3.0	3.9	4.4	4.9	6.0	5.6	4.8	6.5	8.4	7.7	5.9	5.1	9.1
140	2.7	3.4	4.3	4.8	5.4	6.3	6.1	5.4	6.9	8.7	8.1	6.3	5.4	9.3
130	3.0	3.9	4.7	5.3	6.0	6.4	6.6	6.1	7.2	8.6	7.7	6.6	5.7	9.3
120	3.3	4.5	5.3	5.9	6.7	6.8	7.2	6.8	7.7	9.0	8.2	7.0	6.0	9.6
110	3.6	5.0	5.9	6.4	7.4	7.2	7.8	7.5	8.1	9.4	8.7	7.4	6.3	9.8
99	3.9	5.5	6.4	7.0	8.1	7.5	8.4	8.2	8.6	9.7	9.1	7.8	6.7	10.0
98	4.0	5.5	6.2	6.5	7.3	6.6	7.7	8.0	7.7	8.2	7.8	7.7	6.2	8.9
84	4.4	6.3	7.1	7.3	8.3	7.2	8.6	9.0	8.5	8.8	8.4	8.5	8.2	9.5

RIVER	AUGUST				SEPTEMBER							
MILE	45	46	47	48	49	50	51	52	1	2	3	4	5
150	9.9	9.5	8.7	9.0	9.7	9.7	9.6	9.0	8.3	7.8	7.3	6.7	5.9
140	10.0	9.5	8.8	9.2	9.7	9.7	9.6	8.8	7.9	7.5	7.0	6.4	5.3
130	10.0	9.4	8.8	9.2	9.7	9.5	9.4	8.3	7.3	7.0	6.5	5.9	4.6
120	10.2	9.5	9.0	9.4	9.8	9.5	9.3	8.0	6.9	6.7	6.2	5.5	4.0
110	10.4	9.5	9.1	9.6	9.9	9.5	9.3	7.8	6.6	6.5	5.9	5.3	3.4
99	10.6	9.6	9.3	9.8	10.0	9.5	9.3	7.5	6.2	6.1	5.6	4.9	2.7
98	9.2	8.2	8.3	8.6	8.2	7.9	7.3	5.3	4.5	4.6	4.3	3.6	1.9
84	9.6	8.3	8.6	9.1	8.4	7.9	7.2	4.7	4.0	4.1	3.8	3.1	1.1

TABLE E.3.2.100: SIMULATED STREAM TEMPERATURES
WEATHER PERIOD: SUMMER 1982
CASE E-VI FLOW CONSTRAINTS
STAGE II FLOW REGIME

RIVER	MAY						JUNE				JULY			
MILE	31	32	33	34	35	36	37	38	39	40	41	42	43	44
150	3.1	3.2	3.5	3.9	4.1	4.3	4.9	6.4	7.9	5.7	5.1	7.3	8.3	6.9
140	3.3	3.4	3.8	4.1	4.5	4.7	5.2	6.7	8.4	6.3	5.6	7.8	8.5	7.1
130	3.7	3.6	4.1	4.4	4.9	5.0	5.4	7.0	8.6	6.8	6.2	8.1	8.5	7.4
120	4.1	3.9	4.6	4.9	5.5	5.5	5.8	7.5	9.2	7.4	6.8	8.7	8.9	7.8
110	4.4	4.2	5.0	5.3	6.0	5.9	6.2	8.0	9.8	7.9	7.4	9.2	9.2	8.1
99	4.8	4.5	5.4	5.7	6.5	6.4	6.5	8.5	10.4	8.6	8.1	9.8	9.6	8.5
98	4.7	4.4	5.3	5.5	6.3	6.5	6.1	6.8	8.7	7.8	7.6	8.4	7.9	8.2
84	5.2	4.8	6.0	6.1	7.2	7.6	6.7	7.8	9.8	8.7	8.6	9.4	8.7	9.1

RIVER	AUGUST				SEPTEMBER			
MILE	45	46	47	48	49	50	51	52
150	8.2	8.8	9.7	9.1	9.8	9.5	9.9	9.9
140	8.5	9.0	9.9	9.2	9.8	9.5	9.8	9.7
130	8.7	9.1	10.0	9.3	9.6	9.3	9.6	9.3
120	9.1	9.4	10.3	9.5	9.7	9.4	9.6	9.2
110	9.5	9.7	10.6	9.7	9.8	9.4	9.6	9.1
99	9.9	10.0	10.9	9.9	9.8	9.5	9.5	8.9
98	8.6	8.4	9.0	7.8	8.0	7.5	6.8	6.5
84	9.4	9.1	9.6	8.4	8.1	7.5	6.7	6.0

TABLE E.3.2.101: SUSITNA HYDROELECTRIC PROJECT
MAXIMUM SIMULATED RIVER STAGES
FLOW CASE E-VI, INFLOW-MATCHING
STAGE II FLOW REGIME

Slough or Side Channel	River Mile	Threshold Elevation	Simulated Natural Conditions	Simulated Stage II Conditions
			1981-1982 Winter	1981-1982 Winter
Whiskers	101.5	367	$\boxed{368}$	$\boxed{370}$
Gash Creek	112.0	453	$\boxed{455}$	$\boxed{459}$
6A	112.3	(Upland)	457	461
8	114.1	476	472	$\boxed{476}$
MSII West	115.5	482	$\boxed{484}$	$\boxed{487}$
MSII East	115.9	487	486	$\boxed{490}$
Curry	120.0	(Upland)	523	521
Moose	123.5	548	$\boxed{549}$	$\boxed{551}$
8A West	126.1	573	571	$\boxed{573}$
8A East	127.1	582	$\boxed{583}$	$\boxed{584}$
9	129.3	604	$\boxed{606}$	$\boxed{605}$
9 u/s	130.6	617	$\boxed{620}$	$\boxed{619}$
4th July	131.8	626	$\boxed{629}$	$\boxed{630}$
9A	133.7	651	$\boxed{651}$	649
10 u/s	134.3	657	$\boxed{657}$	655
11 d/s	135.3	667	$\boxed{670}$	$\boxed{667}$
11	136.5	687	683	682
17	139.3	(Upland)	-	714
20	140.5	730	-	728
21 (A6)	141.8	747	-	746
21	142.2	755	-	752
22	144.8	788	-	785
LRX-3 Ice Front Starting Date				12-29
Maximum Ice Front Extent (River Mile)				133
Melt-out Date				3-26

NOTES:

1. $\boxed{\quad}$ Indicates locations where maximum river stage equals or exceeds a known slough threshold elevation.

2. All river stages in feet.

Source: Exhibit E Chapter 2

TABLE E.3.2.102: NATURAL AND ESTIMATED MEAN MONTHLY SUSPENDED SEDIMENT CONCENTRATIONS AND TURBIDITY VALUES EXPECTED TO EXIT DEVIL CANYON RESERVOIR DURING STAGE II OPERATION

Month	Suspended Sediment Concentrations[1/]	Stage II Operation: Estimated Mean Suspended Sediment Concentrations[1/]	Stage II Operation: Estimated Mean Turbidity
	(mg/l)	(mg/l)	NTU[2/]
January	<1-8	60	120
February	N.A.	45	90
March	1-6	40	80
April	N.A.	30	60
May	65-1,110	30	60
June	151-1,860	55	110
July	100-2,790	110	220
August	158-1,040	110	220
September	23-812	90	180
October	7-140	80	160
November	N.A.	80	160
December	N.A.	75	150

N.A. = Not Available

1/ Data derived Table E.2.4.49 (in Exhibit E, Chapter 2)

2/ Turbidity estimated by using factor of (2x) times TSS concentrations (see discussions in Exhibit E, Chapter 2).

TABLE E.3.2.103 MONTHLY MAXIMUM,MINIMUM AND MEAN FLOWS AT SUNSHINE (CFS)

STAGE II - WATANA (LOW) - DEVIL CANYON OPERATIONS

MONTH	NATURAL DISCHARGE			STAGE II DISCHARGE		
	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	20837	8176	13799	21708	11320	15636
NOV	8775	4020	6185	13641	5805	11533
DEC	6547	2675	4426	12518	5025	11156
JAN	5216	2228	3674	11312	6897	10173
FEB	4664	2095	3115	10968	6806	9285
MAR	3920	1972	2786	9593	6278	7946
APR	5528	2233	3585	10018	6161	8082
MAY	43121	10799	27674	37836	12811	21380
JUN	116152	40702	63268	78540	33014	44676
JUL	85600	45226	64143	74011	37295	54654
AUG	84940	25092	56148	83050	24031	54607
SEP	54110	14320	32867	54110	15983	32876
ANNUAL	28262	14431	23607	28396	15886	23609

TABLE E.3.2.104 MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT SUSITNA STATION (CFS)

STAGE II - WATANA (LOW) - DEVIL CANYON OPERATIONS

MONTH	NATURAL DISCHARGE			STAGE II DISCHARGE		
	MAX	MIN	MEAN	MAX	MIN	MEAN
OCT	58640	13476	32777	59665	16543	34541
NOV	31590	8251	15063	35269	11370	20441
DEC	14690	5753	9267	21099	7915	16014
JAN	10120	6365	8112	16574	10983	14614
FEB	9413	5614	7383	15998	11035	13553
MAR	8906	5271	6412	14990	9992	11574
APR	13029	4613	7684	18011	8862	12317
MAY	88470	28713	56770	80071	19949	50440
JUN	165900	73838	112256	136429	53169	93622
JUL	181400	92511	126590	168263	82662	117066
AUG	159600	80891	109084	157254	79830	107536
SEP	109700	37592	67721	109195	39255	67820
ANNUAL	63159	38030	46871	63155	38030	46879

TABLE E.3.2.105: FEATURES OF SELECTED TRIBUTARIES WITHIN THE STAGE III WATANA IMPOUNDMENT 1/

Tributary	Susitna River Confluence (River Mile)	Additional Length Affected (mi)	Total Length Affected (mi)	Stream Gradient (ft/mi)	Approximate Length in Drawdown Zone (mi)	Approximate Length Permanently Inundated (mi)
Deadman Creek	186.7	0.7	2.7	253	.5	2.2
Watana Creek	194.1	1.0	8.5 2/	60 2/	0.0	8.5
East Fork	N/A	1.2	1.2 3/	113 3/	1.1	0.1
West Fork	N/A	2.1	2.1 3/	67 3/	1.8	0.3
Kosina Creek	206.8	1.7	4.5	118	1.0	3.5
Jay Creek	208.5	1.4	3.5	143	.8	2.7
Goose Creek	231.3	1.2	1.2	114	1.1	0.1
Oshetna River	233.4	2.2	2.2	41	2.2	0.0

1/ Stage III Watana Water Surface Elevation: 2,185 ft. MSL
2/ Watana Creek below forks
3/ Watana Creek above fork

Source: Adapted from ADF&G 1983b

TABLE E.3.2.106: Monthly Maximum, Minimum and Mean Flows at Gold Creek (CFS)
Stage III - Watana (High) - Devil Canyon Operations

Month	Natural Flows			With-Project Conditions Early Stage III Flows			Late Stage III Flows		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
October	8,212	3,124	5,825	9,488	5,032	7,720	11,090	5,032	8,609
November	4,192	1,215	2,578	8,724	5,235	8,244	11,466	3,000	9,530
December	3,264	866	1,828	9,401	8,074	9,011	12,857	5,466	10,987
January	2,452	724	1,524	8,471	7,456	8,256	11,752	6,547	10,268
February	2,028	723	1,309	8,284	7,358	8,112	11,611	6,459	10,139
March	1,900	713	1,173	7,462	6,575	7,280	10,533	5,772	9,076
April	2,650	745	1,441	7,187	5,610	6,623	9,874	4,923	8,064
May	21,890	3,745	13,483	10,524	6,080	7,643	12,857	5,912	9,027
June	50,580	15,500	27,795	10,394	7,867	9,223	12,388	7,907	10,355
July	34,400	16,100	24,390	26,016	8,000	13,156	11,748	8,000	9,414
August	37,870	8,879	21,911	36,698	8,000	18,489	22,316	8,000	10,710
September	21,240	5,093	13,493	20,605	6,767	13,406	18,391	6,767	10,761
ANNUAL	11,961	5,596	9,781	11,961	6,942	9,781	11,961	6,333	9,742

TABLE E.3.2.107: TOTAL CHINOOK REARING HABITAT AREA
IN ALL REPRESENTATIVE GROUPS
DURING SUMMER WEEKS UNDER
EARLY STAGE III FLOW REGIME

Calendar Week	Early Stage III Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Early Stage III Flows: Total Habitat Area Exceeded 50% Percent of Time (sq ft)	Early Stage III Flows: Total Habitat Area Exceeded 10% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 50% Percent of Time (sq ft)	Natural Flows: Total Habitat Area Exceeded 10% Percent of Time (sq ft)
22	5346615	5805357	5928598	5887756	6131097	6843402
23	5738188	5929310	5929310	5476820	6222510	6893240
24	5711664	5929310	5929310	3494928	6151734	6780969
25	5729148	5929310	5929310	5218277	6187294	6840933
26	5782783	5929310	5929310	5958463	6372627	6892074
27	5865743	5929310	5929310	5960915	6245443	6836489
28	5794908	5929310	6089966	6963999	6108808	6790478
29	5794908	5929310	6506449	5954151	6240076	6873055
30	5767194	5929310	6750031	5971538	6137691	6847559
31	5794908	5985561	6784760	5517503	6294162	6815705
32	5794908	6006532	6595469	5954772	6171091	6823350
33	5794908	5996771	6376799	4956682	6063121	6376799
34	5542401	6006819	6216433	5561034	6096961	6376799
35	5725102	6078320	6291106	5517503	6138112	6292156
36	5704346	6000258	6307107	5685606	6000258	6316496
37	5378032	6008042	6228691	5690184	6008042	6228691
38	5147138	5960600	6259540	5292193	5960600	6259540
39	5147138	5799111	6216278	4987661	5809273	6216278

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.108: TOTAL CHINOOK REARING HABITAT AREA
IN ALL REPRESENTATIVE GROUPS
DURING SUMMER WEEKS UNDER
LATE STAGE III FLOW REGIME

Calendar Week	Late Stage III Flows: Total Habitat Area Exceeded 90% Percent of Time	Late Stage III Flows: 50%	Late Stage III Flows: 10%	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time	Natural Flows: 50%	Natural Flows: 10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
22	5586825	5735399	6194400	5887756	6131097	6843402
23	5666345	5807735	5929310	5476820	6222510	6893240
24	5673545	5808222	6190181	3494928	6151734	6780969
25	5671184	5847999	6152700	5218277	6187294	6840933
26	5663766	5794908	5929310	5958463	6372627	6892074
27	5716871	5909072	5929310	5960915	6245443	6836489
28	5726084	5902044	5929310	6963999	6108808	6790478
29	5694015	5929310	5929310	5954151	6240076	6873055
30	5704532	5926367	5929310	5971538	6137691	6847559
31	5664157	5893721	5929310	5517503	6294162	6815705
32	5693549	5842494	5929310	5954772	6171091	6823350
33	5710287	5929310	6146531	4956682	6063121	6376799
34	5757441	5929310	6126918	5561034	6096961	6376799
35	5739023	5929310	6197795	5517503	6138112	6292156
36	5681436	5794908	6216433	5685606	6000258	6316496
37	5378032	5735891	6206042	5690184	6008042	6228691
38	5147138	5754687	6163950	5292193	5960600	6259540
39	5147138	5796548	5983301	4987661	5809273	6216278

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.109: TOTAL CHINOOK REARING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER EARLY STAGE III FLOW REGIMES

Calendar Week	Early Stage III Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Early Stage III Flows: 50% (sq ft)	Early Stage III Flows: 10% (sq ft)	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Natural Flows: 50% (sq ft)	Natural Flows: 10% (sq ft)
22	4338476	4600147	4730723	3853133	4125226	4543200
23	4438344	4727844	4727844	3426713	4124438	4449608
24	4413518	4727844	4727844	2335020	4071885	4488465
25	4451764	4727844	4727844	3284299	4076823	4581977
26	4629940	4727844	4727844	3828240	4113942	4220266
27	4725744	4727844	4727844	4025392	4119204	4230208
28	4145386	4727844	4727844	3976770	4125798	4258885
29	4018774	4727844	4727844	3853137	4091048	4245477
30	4018592	4725744	4727844	3966421	4137456	4240463
31	4002079	4171971	4727844	3449123	4101473	4181791
32	4040695	4179058	4727844	4039301	4138079	4230401
33	4040399	4186821	4727844	3140204	4171382	4496151
34	3462838	4252662	4727844	4040200	4176297	4629213
35	3879665	4433162	4727844	4037705	4332384	4712545
36	4037663	4430849	4734924	4096153	4398222	4734924
37	4165806	4448220	4721533	4151235	4528447	4721533
38	4172012	4357829	4718252	4145776	4450270	4718252
39	4244929	4492490	4720054	4116902	4504139	4720054

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.110: TOTAL CHINOOK REARING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER LATE STAGE III FLOW REGIMES

Calendar Week	Late Stage III Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Late Stage III Flows: 50% (sq ft)	Late Stage III Flows: 10% (sq ft)	Natural Flows: Total Habitat Area Exceeded 90% Percent of Time (sq ft)	Natural Flows: 50% (sq ft)	Natural Flows: 10% (sq ft)
22	4321512	4427439	4705611	3853133	4125226	4543200
23	4331791	4518613	4729067	3426713	4124438	4449608
24	4347859	4603977	4727844	2335020	4071885	4488465
25	4335317	4655812	4727844	3284299	4076823	4581977
26	4320770	4464864	4727844	3828240	4113942	4220266
27	4432822	4725744	4727844	4025392	4119204	4230208
28	4446286	4725744	4727844	3976770	4125798	4258885
29	4399419	4727844	4727844	3853137	4091048	4245477
30	4380656	4727316	4727844	3966421	4137456	4240463
31	4326096	4712075	4727844	3449123	4101473	4181791
32	4398738	4711701	4727844	4039301	4138079	4230401
33	4120335	4691978	4727844	3140204	4171382	4496151
34	4081098	4675669	4727844	4040200	4176297	4629213
35	4168675	4675177	4727844	4037705	4332384	4712545
36	4145789	4623713	4727844	4096153	4398222	4734924
37	4287101	4421124	4657908	4151235	4528447	4721533
38	4244929	4463560	4731473	4145776	4450270	4718252
39	4244929	4561480	4728717	4116902	4504139	4720054

Calendar Week 22 = Week Beginning May 27

TABLE E.3.2.111: SUMMARY OF ACCESS CONDITIONS FOR CHUM SPAWNING SITES DURING STAGE II OPERATION BASED ON MEAN, MAXIMUM AND MINIMUM AVERAGE MONTHLY FLOWS

Site Name	River Mile[a] Designations	Passage Reach[b]	Natural Flows						Early Stage III Flows						Late Stage III Flows					
			Maximum		Mean		Minimum		Maximum		Mean		Minimum		Maximum		Mean		Minimum	
			AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP	AUG	SEP
Whisker's Creek Slough	101.41	I	[c]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mainstem II	115.ØR	I	S[d]	S	S	S	S/D	U	S	S	S	S	S	U	U	S	S	S	S	U
		II	S	S	S	S	U	U	S	S	S	S	S	U	U	S	S	U	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IVL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IVR	S	S	S	U	U	U	S	S	U	U	U	U	U	S	U	U	U	U
		VR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIIIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slough 8A	126.ØR	I	S	S	S	S	S	U	S	S	S	S	S	U	S	S	S	S	S	U
		II	S	S	S	U	U	U	S	S	S	U	U	U	S	S	U	U	U	U
		III	S	S	S	U	U	U	S	S	S/D	U	U	U	S	S/D	U	U	U	U
		IVL	S	U	U	U	U	U	S	U	U	U	U	U	U	U	U	U	U	U
		IVR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIIIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IXR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		XR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.111: (Page 2 of 4)

Site Name	River Mile[a/] Designations	Passage Reach[b/]	Natural Flows						Early Stage III Flows						Late Stage III Flows					
			Max		Mean		Min		Max		Mean		Min		Max		Mean		Min	
			Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep
Slough 9	128.8R	I	S	S	S	S	U	U	S	S	S	S	U	U	S	S	U	U	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slough 9A	133.9R	I	S	S	S	S	U	U	S	S	S	S	U	U	S	S	U	U	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VIII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		XI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Side Channel 10	133.8L	I	S	S	S	S	U	U	S	S	S	U	U	U	S	S/D	U	U	U	U
		II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

TABLE E.3.2.111: (Page 3 of 4)

Site Name	River Mile[a/] Designations	Passage Reach[b/]	Natural Flows						Early Stage III Flows						Late Stage III Flows					
			Max		Mean		Min		Max		Mean		Min		Max		Mean		Min	
			Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep
Slough 11	135.6R	I	S	S	S	U	U	U	S	S	S	U	U	U	S	S	U	U	U	U
		II	S	S	S	U	U	U	S	S	S/D	U	U	U	S	S/D	U	U	U	U
		III	S	U	U	U	U	U	S	U	U	U	U	U	U	U	U	U	U	U
		IV	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U	U
		V	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		VI	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		VII	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Upper Side Channel 11	136.3R	I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		II	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Slough 19	139.7R	I	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		II	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		IV	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		V	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	139.9R	VI	S	S	S	S	U	U	S	S	S	S	U	U	S	S	U	U	U	U
		VII	S	S	S	U	U	U	S	S	S	U	U	U	S	S	U	U	U	U
		VIII	S	S	S	U	U	U	S	S	S/D	U	U	U	S	S/D	U	U	U	U
		IX	S	U	U	U	U	U	S	U	U	U	U	U	U	U	U	U	U	U
Slough 20	140.2R	I	S	S	S	S	U	U	S	S	S	S	U	U	S	S	U	U	U	U
		II	S	S	S	U	U	U	S	S/D	U	U	U	U	S	U	U	U	U	U
		III	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		IV	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		V	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		VI	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

TABLE E.3.2.111: (Page 4 of 4)

Site Name	River Mile[a] Designations	Passage Reach[b]	Natural Flows						Early Stage III Flows						Late Stage III Flows					
			Max		Mean		Min		Max		Mean		Min		Max		Mean		Min	
			Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep	Aug	Sep
Side Channel 21	141.4R	I	S	S	S	S	S	U	S	S	S	S	S	U	S	S	S	S	S	U
		II	S	S	S	S	U	U	S	S	S	S	U	U	S	S	S	S	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IV	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		V	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VI	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		VII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	141.6R	VIII	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IX	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slough 21	142.1R	I	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		II	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IIIL	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		IIIR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Slough 22	144.4L	I	S	S	S	U	U	U	S	S	S	U	U	U	S	S	U	U	U	U
		II	S	U	S/D	U	U	U	S	U	U	U	U	U	S/D	U	U	U	U	U
		III	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

a/ Source: EWT&A and AEIDC 1985

b/ Source: ADF&G 19851, L=Left and R=Right looking upstream

c/ Influence of backwater was not evaluated since breaching/flow occurs at discharge lower than those required for providing backwater influence.

d/ U=Unsuccessful conditions
S/D=Successful with difficulty
S=Successful conditions

TABLE E.3.2.112: TOTAL CHUM SPAWNING HABITAT IN IFG AND DIHAB MODEL SITES DURING SUMMER MONTHS UNDER STAGE III FLOW REGIME

Calendar Week	Early Stage III Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%	Late Stage III Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time	50%	10%
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
32	46690	73195	75531	47387	48725	67764	72935	74117	76821
33	46690	73302	83706	46690	49403	73881	35061	73755	78712
34	44695	73369	83557	46690	48963	73269	45002	74129	84101
35	46690	75444	85363	46690	50633	74183	44286	76030	85363
36	46690	74642	85831	46690	54405	83557	47448	75257	86202
37	40102	76554	85219	40102	59032	84199	47448	76554	85219
38	30653	74376	86928	30653	59047	86787	36322	74376	86928
39	30653	55189	86150	30653	53196	84911	26285	62440	86438

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.113: TOTAL CHUM SPAWNING HABITAT AREA IN REPRESENTATIVE GROUPS 2, 3, AND 4 DURING SUMMER WEEKS UNDER STAGE III FLOW REGIMES

Calendar Week	Early Stage III Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)	Late Stage III Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded 90% Percent of Time (sq ft)	50% (sq ft)	10% (sq ft)
32	784981	832073	883256	789403	796449	845897	826654	849978	883525
33	784981	829384	863293	784981	798869	853837	330883	832670	858434
34	470522	833106	854194	784981	797299	847750	689191	836728	862500
35	676094	843238	867223	784981	803249	851937	620955	852626	868158
36	784981	840645	866908	784981	816694	866252	789790	840645	866908
37	757205	834550	864098	757205	825269	864435	789790	840943	864098
38	689123	844361	867598	689123	827055	867598	729972	844361	867598
39	689123	819486	865277	689123	812382	865277	608728	825264	865603

Calendar Week 32 = Week Beginning August 5

TABLE E.3.2.114: TOTAL CHUM SPAWNING HABITAT AVAILABLE FOR INCUBATION OF EMBRYOS IN IFG AND DIHAB MODEL SITES UNDER STAGE III FLOW REGIME

Calendar Week	Early Stage III Flow Regime Modelled Habitat Area Exceeded Percent of Time 90% (sq ft)	50% (sq ft)	10% (sq ft)	Late Stage III Flow Regime Modelled Habitat Area Exceeded Percent of Time 90% (sq ft)	50% (sq ft)	10% (sq ft)	Natural Flow Regime Modelled Habitat Area Exceeded Percent of Time 90%	50%	10%
40	30653	44783	80392	30653	49998	57390	21116	44783	80392
41	30653	43183	49157	30653	49470	66367	19923	38552	49157
42	25428	43379	46716	21554	48306	64789	15404	21348	42731
43	42049	44413	46587	18965	49023	66165	11066	20021	29479
44	43406	45358	46879	14224	51492	57035	8127	16393	21148
45	45404	46736	47170	16455	55403	63008	7586	13242	19511
46	46833	47134	47512	46704	61729	71412	7112	12294	16391
47	47280	47543	47891	47222	71218	86277	6230	11547	15172
48	47708	47949	48556	47714	79618	87196	5552	10872	14053

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.115: TOTAL CHUM SPAWNING HABITAT
IN REPRESENTATIVE GROUPS 2, 3, AND 4
AVAILABLE FOR INCUBATION OF EMBRYOS
DURING EARLY WINTER WEEKS UNDER
STAGE III FLOW REGIMES

Calendar Week	Early Stage III Flow Regime Modelled Habitat Area Exceeded			Late Stage III Flow Regime Modelled Habitat Area Exceeded			Natural Flow Regime Modelled Habitat Area Exceeded		
	90%	50%	10%	90%	50%	10%	90%	50%	10%
	Percent of Time			Percent of Time			Percent of Time		
	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)	(sq ft)
40	689123	776940	855079	689123	800986	827328	743236	790083	887478
41	689123	770193	797989	689123	799108	843478	761361	790087	830175
42	592951	771022	785145	521634	793526	840746	726475	794180	813151
43	765413	775380	784545	481271	797514	843128	709737	801152	813434
44	771135	779363	786182	360953	806313	826064	731494	776597	819621
45	779559	785275	788026	417575	820249	837661	752897	775962	829240
46	785889	787798	790199	785068	835446	852213	774723	791514	841854
47	788729	790399	792607	788357	851878	869312	792830	804263	853051
48	791446	792973	795849	791484	865771	867986	805815	816042	829623

Calendar Week 40 = Week Beginning October 1

TABLE E.3.2.116: SUSITNA HYDROELECTRIC PROJECT
SIMULATED STREAM TEMPERATURES
STAGE III
WEATHER PERIOD: SUMMER 1981
CASE E-VI FLOW REQUIREMENTS
STAGED CONSTRUCTION
50 FT DRAWDOWN AT DEVIL CANYON
2 LEVELS OF PORTS

RIVER		MAY					JUNE					JULY		
MILE	31	32	33	34	35	36	37	38	39	40	41	42	43	44
150 1/	2.7	3.2	4.0	4.5	5.2	6.2	7.3	8.5	8.2	7.3	7.0	8.5	9.8	10.4
140	2.9	3.5	4.3	4.8	5.6	6.4	7.6	8.8	8.5	7.6	7.4	8.8	10.0	10.6
130	3.1	3.9	4.7	5.2	6.1	6.6	7.9	9.1	8.5	7.8	7.4	8.6	9.7	10.1
120	3.4	4.4	5.2	5.7	6.7	7.0	8.5	9.7	8.9	8.2	7.8	9.0	10.1	10.5
110	3.6	4.8	5.7	6.2	7.3	7.3	9.0	10.2	9.3	8.6	8.2	9.3	10.5	10.8
99 2/	3.9	5.3	6.1	6.7	7.8	7.6	9.5	10.7	9.6	9.0	8.6	9.7	10.8	11.1
98 3/	4.0	5.4	6.1	6.4	7.3	6.7	8.0	8.7	8.0	8.0	7.8	8.1	8.6	8.6
84 4/	4.4	6.2	7.0	7.2	8.3	7.2	8.8	9.5	8.7	8.7	8.4	8.8	9.2	9.3

RIVER		AUGUST			SEPTEMBER							
MILE	45	46	47	48	49	50	51	52	1	2	3	4	5
150 1/	9.9	5.3	5.0	6.6	7.3	7.3	7.6	8.1	7.5	7.0	6.6	6.1	5.4
140	10.1	5.6	5.2	6.8	7.4	7.4	7.6	7.9	7.3	6.9	6.4	5.9	5.0
130	9.8	5.7	5.4	7.0	7.5	7.4	7.6	7.5	6.9	6.6	6.1	5.5	4.5
120	10.1	5.9	5.7	7.3	7.7	7.5	7.6	7.3	6.6	6.4	5.9	5.2	3.9
110	10.4	6.1	5.9	7.6	7.9	7.6	7.7	7.1	6.4	6.2	5.7	5.0	3.4
99 2/	10.7	6.4	6.1	7.9	8.1	7.7	7.7	6.8	7.1	6.0	5.5	4.7	2.9
98 3/	8.5	6.7	6.4	7.5	7.2	6.9	6.4	4.9	4.7	4.8	4.4	3.7	2.1
84 4/	9.1	7.1	7.1	8.3	7.6	7.1	6.6	4.4	4.2	4.3	4.0	3.2	1.3

1/ Downstream of Devil Canyon Dam Site
2/ Upstream of Chulitna - Susitna confluence
3/ Downstream of Chulitna - Susitna confluence
4/ At Sunshine Stream gaging station

TABLE E.3.2.117: SUSITNA HYDROELECTRIC PROJECT
SIMULATED STREAM TEMPERATURES
STAGE III
WEATHER PERIOD: SUMMER 1982
CASE E-VI FLOW REQUIREMENTS
STAGED CONSTRUCTION
50 FT DRAWDOWN AT DEVIL CANYON
2 LEVELS OF PORTS

RIVER	MAY					JUNE					JULY			
MILE	31	32	33	34	35	36	37	38	39	40	41	42	43	44
150 1/	3.6	3.8	4.0	4.3	4.6	4.9	5.4	6.1	6.6	7.3	8.6	9.6	9.8	9.9
140	3.8	3.9	4.2	4.5	4.9	5.1	5.6	6.4	7.1	7.8	8.9	9.9	10.0	10.2
130	4.1	4.1	4.5	4.8	5.2	5.4	5.8	6.7	7.5	8.0	9.0	9.9	9.6	10.0
120	4.4	4.3	4.8	5.1	5.7	5.8	6.1	7.2	8.2	8.6	9.5	10.4	9.9	10.5
110	4.7	4.5	5.2	5.4	6.1	6.2	6.4	7.7	8.7	9.1	9.9	10.8	10.3	10.9
99 2/	5.0	4.7	5.5	5.8	6.5	6.5	6.8	8.2	9.4	9.6	10.3	11.3	10.6	11.4
98 3/	4.9	4.5	5.4	5.5	6.3	6.6	6.2	6.8	8.5	8.1	8.3	8.8	8.0	8.7
84 4/	5.3	4.9	6.0	6.1	7.2	7.7	6.8	7.8	9.7	8.9	9.0	9.7	8.8	9.6

RIVER	AUGUST				SEPTEMBER		
MILE	45	46	47	48	49	50	51	52
150 1/	9.9	9.7	9.9	8.5	7.3	7.6	7.8	8.0
140	10.2	9.9	10.1	8.7	7.5	7.6	7.7	7.8
130	10.2	9.9	10.1	8.7	7.5	7.4	7.2	7.4
120	10.7	10.2	10.5	9.1	7.7	7.6	7.3	7.3
110	11.1	10.6	10.9	9.3	7.8	7.7	7.3	7.2
99 2/	11.6	10.9	11.2	9.6	8.1	7.8	7.4	7.1
98 3/	8.8	8.4	8.8	7.3	6.8	6.2	5.1	5.3
84 4/	9.5	9.1	9.5	8.1	7.3	6.5	5.5	5.1

1/ Downstream of Devil Canyon Dam Site
2/ Upstream of Chulitna - Susitna confluence
3/ Downstream of Chulitna - Susitna confluence
4/ At Sunshine Stream gaging station

TABLE E.3.2.118: MAXIMUM SIMULATED RIVER STAGES FOR CASE E-VI FLOW CONSTRAINTS, INFLOW TEMPERATURE-MATCHING, AND WINTER 1981-82 CLIMATE DATA

Slough or Side Channel	River Mile	Threshold Elevation	Simulated Natural Conditions	Simulated Stage III Conditions
Whiskers	101.5	367	$\boxed{368}$	$\boxed{370}$
Gash Creek	112.0	453	$\boxed{455}$	$\boxed{457}$
6A	112.3	(Upland)	457	459
8	114.1	476	472	$\boxed{474}$
MSII West	115.5	482	$\boxed{484}$	$\boxed{485}$
MSII East	115.9	487	486	$\boxed{487}$
Curry	120.0	(Upland)	523	518
Moose	123.5	548	$\boxed{549}$	$\boxed{545}$
8A West	126.1	573	$\boxed{571}$	$\boxed{569}$
8A East	127.1	582	$\boxed{583}$	$\boxed{581}$
9	129.3	604	$\boxed{606}$	$\boxed{603}$
9 u/s	130.6	617	$\boxed{620}$	$\boxed{617}$
4th July	131.8	626	$\boxed{629}$	$\boxed{628}$
9A	133.7	651	$\boxed{651}$	650
10 u/s	134.3	657	$\boxed{657}$	656
11 d/s	135.3	667	$\boxed{670}$	$\boxed{668}$
11	136.5	687	683	684
17	139.3	(Upland)	---	715
20	140.5	730	---	729
21 (A6)	141.8	747	---	747
21	142.2	755	---	753
22	144.8	788	---	787
LRX-3 Ice Front Starting Date			1-2	
Maximum Ice Front Extent (River Mile)			114	
Melt-out Date			3-5	

NOTES:

1. $\boxed{}$ Indicates locations where maximum river stage equals or exceeds a known slough threshold elevation.
2. All river stages in feet.

Source: Exhibit E, Chapter 2.

TABLE E.3.2.119: NATURAL AND ESTIMATED MEAN MONTHLY SUSPENDED SEDIMENT CONCENTRATIONS AND TURBIDITY VALUES EXPECTED TO EXIT DEVIL CANYON RESERVOIR DURING STAGE III OPERATION

Month	Observed Suspended Sediment Concentrations[1/]	Stage III Operation: Estimated Mean Suspended Sediment Concentrations[1/]	Stage III Operation: Estimated Mean Turbidity
	(mg/l)	(mg/l)	NTU[2/]
January	<1-8	55	110
February	N.A.	50	100
March	1-6	25	50
April	N.A.	25	50
May	65-1,110	15	30
June	151-1,860	35	70
July	100-2,790	75	150
August	158-1,040	75	150
September	23-812	55	110
October	6-140	50	100
November	N.A.	70	140
December	N.A.	70	140

N.A. = Not Available

1/ Data derived Table E.2.4.73 (in Exhibit E, Chapter 2)

2/ Turbidity estimated by using factor of (2x) times TSS concentrations (see discussions in Exhibit E, Chapter 2).

TABLE E.3.2.120: MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT SUNSHINE (CFS)
STAGE III - WATANA (HIGH) - DEVIL CANYON OPERATIONS

Month	Natural Conditions			Early Stage III Flows			Late Stage III Flows		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
October	20,837	8,176	13,799	21,881	11,129	15,759	22,402	9,604	16,648
November	8,775	4,020	6,185	13,944	8,040	11,882	16,124	5,805	13,168
December	6,547	2,675	4,426	12,710	10,069	11,595	16,167	7,560	13,572
January	5,216	2,228	3,674	11,336	9,249	10,388	14,289	8,340	12,400
February	4,664	2,095	3,115	10,836	9,051	9,908	13,575	8,151	11,935
March	3,920	1,972	2,786	9,375	8,194	8,892	12,437	7,391	10,688
April	5,528	2,233	3,585	9,969	7,736	8,662	12,457	7,048	10,104
May	43,121	10,799	27,674	37,862	13,481	21,874	40,342	13,000	23,258
June	116,152	40,702	63,268	77,405	33,066	44,695	77,926	33,055	45,827
July	85,600	45,226	64,143	73,890	37,295	52,891	65,761	37,295	49,148
August	84,940	25,092	56,148	82,999	24,031	52,775	68,817	24,031	44,996
September	54,110	14,320	32,867	54,110	15,983	32,722	47,235	15,983	30,077
ANNUAL	28,262	14,431	23,607	28,396	16,473	23,605	28,396	17,052	23,566

TABLE E.3.2.121: MONTHLY MAXIMUM, MINIMUM AND MEAN FLOWS AT SUSITNA STATION (CFS)
STAGE III - WATANA (HIGH) - DEVIL CANYON OPERATIONS

Month	Natural Conditions			Early Stage III Flows			Late Stage III Flows		
	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean
October	58,640	13,476	32,777	59,829	16,807	34,664	60,590	18,428	35,553
November	31,590	8,251	15,063	35,538	13,605	20,789	37,990	11,370	22,075
December	14,690	5,753	9,267	21,261	12,959	16,453	24,723	10,351	18,430
January	10,120	6,365	8,112	16,688	13,217	14,828	19,885	12,426	16,840
February	9,413	5,614	7,383	15,877	12,785	14,176	19,204	13,280	16,203
March	8,906	5,271	6,412	14,756	11,526	12,520	17,847	11,105	14,316
April	13,029	4,613	7,684	17,672	10,113	12,897	20,021	10,960	14,338
May	88,470	28,713	56,770	80,229	20,902	50,935	81,866	22,479	52,318
June	165,900	73,838	112,256	136,737	52,305	93,641	138,236	54,878	94,773
July	181,400	92,511	126,590	167,898	82,662	115,302	156,910	82,662	111,560
August	159,600	80,891	109,084	157,203	79,830	105,704	143,603	73,221	97,925
September	109,700	37,592	67,721	109,195	39,255	67,667	100,258	36,183	65,022
ANNUAL	63,159	38,030	46,871	63,155	38,038	46,875	63,011	38,778	46,836

TABLE E.3.2.122: JUVENILE CHINOOK REARING HABITAT INDEX VALUES FOR MEAN MONTHLY DISCHARGE AT THE SUNSHINE STATION[1/] UNDER THE NATURAL AND STAGE III OPERATING FLOW REGIMES

AGGREGATE HABITAT INDEX VALUES[2/]

Month	Natural Flows		Early Stage III Flows		Late Stage III Flows	
	Side Channels	Tributary Mouths	Side Channels	Tributary Mouths	Side Channels	Tributary Mouths
June	0.028	0.140	0.050	0.055	0.050	0.055
July	0.027	0.142	0.036	0.110	0.040	0.070
August	0.035	0.120	0.036	0.110	0.05	0.055
September	0.040	0.055	0.040	0.055	0.035	0.051

1/ From Table E.3.2.117

2/ Estimated form Figures E.3.2.87 and E.3.2.88

TABLE E.3.2.123: IMPACT ISSUES AND PROPOSED MITIGATION FEATURES FOR ANTICIPATED FILLING AND OPERATIONAL IMPACTS TO AQUATIC HABITATS, SUSITNA HYDROELECTRIC PROJECT

IMPACT ISSUE	OCCURRENCE				MITIGATION FEATURE			
	Watana Development (Both Stages)		Devil Canyon Development		Watana Development (Both Stages)		Devil Canyon Development	
	Filling	Operation	Filling	Operation	Filling	Operation	Filling	Operation
Passage of Adult Salmon	X	X	X	X	- Minimum flow requirement	- Minimum flow requirement	- Minimum flow requirement	- Minimum flow requirement
Impacts to Slough Habitat	X	X	X	X	- Minimum flow requirement - Slough modification	- Minimum flow requirement - Slough modification	- Minimum flow requirement	- Minimum flow requirement - Slough modification
Loss of Side-Channel and Mainstem Salmon Spawning Areas	X	X		X	- Modification of side channels	- Modification of side channels		- Modification of side channels
Altered Thermal Regime		X		X		- Multiple level outlet		- Multiple level outlet
Gas Superaturation	X	X		X	- Fixed cone valves	Fixed cone valves		- Fixed cone valves
Inundation of Tributary Habitat	X		X		- Improved access to fishing area - Habitat improvement		- Improved access to fishing area - Habitat improvement	
Out-migration of Junvenile Anadromous Fish	X	X		X	- Minimum flow requirement	- Minimum flow requirement		- Minimum flow requirement

TABLE E.3.2.124: ESTIMATED COST FOR WATER QUALITY AND FISHERIES MONITORING (IN 1985 DOLLARS) DURING CONSTRUCTION (1986 to 2012)

Year	Management	Field Labor	Field Equipment	Travel	Total (x1000)
1986 1/	120,000	150,000	7,500	10,000	287.5
1987 1/	120,000	150,000	7,500	12,500	290
1988 1/	90,000	75,000	--	5,000	170
1989 1/	96,000	75,000	--	5,000	170
1990 1/	180,000	255,000	30,000	26,000	480
1991 1/	240,000	340,000	20,000	15,000	615
1992 1/	240,000	340,000	20,000	15,000	615
1993 1/	180,000	255,000	5,000	10,000	450
1994 1/	120,000	170,000	10,000	5,000	305
1995 2/	360,000	680,000	10,000	10,000	1,060
1996 2/	360,000	510,000	10,000	10,000	890
1997 2/	360,000	510,000	10,000	10,000	890
1999 2/	240,000	410,000	10,000	5,000	665
2000 2/	120,000	170,000	5,000	2,500	297.5
2001 2/	120,000	170,000	5,000	2,500	297.5
2002 2/	120,000	170,000	5,000	2,500	297.5
2003 2/	120,000	170,000	5,000	2,500	297.5
2004 2/	120,000	170,000	5,000	2,500	297.5
2005 2/	120,000	170,000	5,000	2,500	297.5
2006 3/	120,000	170,000	5,000	2,500	297.5
2007 3/	120,000	170,000	5,000	2,500	297.5
2008 3/	120,000	170,000	5,000	2,500	297.5
2009 3/	120,000	170,000	5,000	2,500	296.5
2010 3/	120,000	170,000	5,000	2,500	297.5
2011 3/	120,000	170,000	5,000	2,500	297.5
2012 3/	120,000	130,000	5,000	2,500	257.5
				TOTAL	$11,605.0
				AVERAGE ANNUAL	429.8

1/ Includes Stage I only
2/ Includes Stages I and II
3/ Includes Stage III

TABLE E.3.2.125: ALASKA DEPARTMENT OF FISH AND GAME STANDARDS FOR BLASTING NEAR AN ANADROMOUS FISH STREAM MEASURED IN FEET1/

	Explosive Charge Weight in Pounds							
Substrate	1	2	5	10	25	100	500	1,000
Rock	50	80	120	170	270	530	1,180	1,670
Frozen Material	50	70	110	160	250	500	1,120	1,580
Stiff Clay, Gravel, Ice	40	60	100	140	220	440	990	1,400
Clayey Silt, Dense Sand	40	50	80	120	180	370	820	1,160
Medium to Dense Sand	30	50	70	100	160	320	720	1,020
Medium Organic Clay	20	30	50	70	100	210	460	660
Soft Organic Clay	20	30	40	60	100	190	440	620

1/ Required distances for charge weights not set forth in this table must be computed by linear intropolation between the charge weights bracketing the desired charge if the charge weight is between one and 1000 pounds; example: for 15 pounds of explosive in rock substrate - required distance = 170 feet + $\frac{15\text{ lbs}-10\text{ lbs}}{25\text{ lbs}-10\text{ lbs}}$ (270 feet-170 feet) = 203 feet; for charge weights greater than 1,000 pounds, the required distance may be determined by linear extropolation.

Source: Edfelt 1981

TABLE E.3.2.126: PROPOSED FISHERIES MITIGATIONS WITH ESTIMATED CAPITAL AND ANNUAL OPERATING AND MAINTENANCE COSTS

Mitigation Feature		Capital Costs Total		Annual Operating and Maintenance Costs
Downstream Mitigation[1]				
Protective Slough Berms		347,000		---
Restructured Slough Mouth		52,000		---
Lowered and Restructured Slough Profile		224,000		---

Wing Deflectors		288,000		---
Bank Stabilization		25,000		---
Rock Weirs		98,000		---
Log Barriers		54,000		---
	Total	$1,088,000	Total	$30,000
Impoundment Mitigation[2]				
Public Access Acquisition		650,000		N/A
Habitat Improvement		290,000		20,000
	Total	940,000	Total	20,000
Dam Structures[3]				
Multiple Level Intakes		18,400,000		N/A
Cone Valves - Watana (6 valves)		47,100,000		N/A
Cone Valves - Devil Canyon (7 valves)		14,600,000		N/A
	Total	$80,100,000		
	Total for Fisheries Mitigation	$82,128,000	Annual O & M	$50,000

1/ Costing details are in WCC 1984a and Table E.3.2.128
2/ Costs are based on primary mitigation options
3/ Costing details are in Exhibit D

TABLE E.3.2.127: ARCTIC GRAYLING POPULATION ESTIMATES IN SELECTED TRIBUTARIES OF THE WATANA IMPOUNDMENT ZONE

Tributary	River Mile	Estimated Grayling per Mile1/	Estimated Tributary Miles Inundated2/			Estimated Number of Grayling in Inundated Reach		
			Stage 1	Stage 3	Total	Stage 1	Stage 3	Total
Deadman Creek	186.7	1,835 3/	2.0	0.7	2.7	3,670	1,285	4,955
Watana Creek	194.1	324	7.5	4.3	11.8	2,430	1,393	3,823
Kosina Creek	206.8	1,232	2.8	1.7	4.5	3,450	2,094	5,544
Jay Creek	208.5	455	2.1	1.4	3.5	955	637	1,592
Goose Creek	231.3	791	0.0	1.2	1.2	0	949	949
Oshetna River	233.4	1,103	0.0	2.2	2.2	0	2,427	2,427
Total			14.4	11.5	25.9	10,505	8,785	19,290

1/ Modified from ADF&G 1983b Beyer-9.

2/ Assumes reservoir levels at probable maximum flood stage: Stage 1 Watana = el. 2020. Stage 3 Watana = el. 2,200.5.

3/ Estimated grayling per mile in Deadman Creek was calculated by ADF&G (1983b) for the reach of stream blow the falls (0.3 mi). Extrapolation of grayling per mile to total length of stream inundated is likely an overestimation of grayling population size.

TABLE E.3.2.128: ARCTIC GRAYLING POPULATION ESTIMATES IN SELECTED TRIBUTARIES OF THE DEVIL CANYON IMPOUNDMENT ZONE

Tributary	River Mile	Estimated Tributary Miles Inundated[1/]	Estimated Number of Grayling in Inundated Reach
Fog Creek	176.7	1.3	176
Tsusena Creek	181.3	0.4	1,000
Total		1.7	1,176

1/ Assumes reservoir level at probable maximum flood stage = el. 1,466.

Source: ADF&G 1983b.

TABLE E.3.2.129: ANNUAL OPERATING COSTS OF LONG-TERM MONITORING PROGRAM IN 1985 DOLLARS 1/

Task	Costs
Management and Analysis	$ 200,000
Adult and Smolt 2/ Enumeration	500,000
Slough Modification	90,000
Resident Fish	50,000
Water Quality	50,000
Contractual Services	75,000
Materials	50,000
Repair and Maintenance of Equipment	30,000
Administration and Support Costs	175,000
Average Annual Fisheries Monitoring Costs	$ 1,220,000
Total Project Cost	$49,250,000

1/ Costs are based on the estimated level of effort required to perform the monitoring studies. These costs are exclusive of those for construction related monitoring.

2/ Assumes fishwheels at Sunshine and Curry and a smolt trap at Curry.

3/ Assumes that Annual Cost will drop to $750,000 after 25 years due to increased efficiency and lack of impact on certain species.

TABLE E.3.2.130: SUSITNA HYDROELECTRIC PROJECT SCHEDULE FOR LONG-TERM AQUATIC MONITORING PLAN[1]

Study Element	Prior Data Avail.	1985 W S S F	1986 W S S F	1988 W S S F	1989 W S S F	1990 W S S F	Stage I Watana Complete	Stage II Devil Canyon Complete	Stage III Watana Complete	Complete Project + 5 years
Water Quality										
1. Dissolved Gas Supersaturation	yes	-----					-----	-----	-----------	------->
2. Temperature/Ice Turbidity/Sediment	yes yes	--------				------	----------	----------	----------	--------
3. Mercury/Heavy Metals	no					-----	-----	-----		-----
4. Dissolved Oxygen, pH, Organic Nitrogen, and Phosphorus	yes	--------					-----	-----		-----
Water Quantity	yes	--------	--------	--------	--------	--------	----------	----------	----------	------->
Fish Resources	yes	---	---	---	---	---	-----	-----	----------	------->
Structural Habitat Modifications		(If incorporated as part of mitigation)					-----	-----	----------	------->
Fluvial Geomorphology	yes						-----	-----	----------	------->
Special Monitoring Studies		(Performed on an as-needed basis)								
Project Schedule (milestones)										
License Granted					*	*				
Stage One										
Watana Main Access Begins						*				

W S S F - Winter, Spring, Summer, Fall

[1] Based on the project schedule presented in this license application amendment

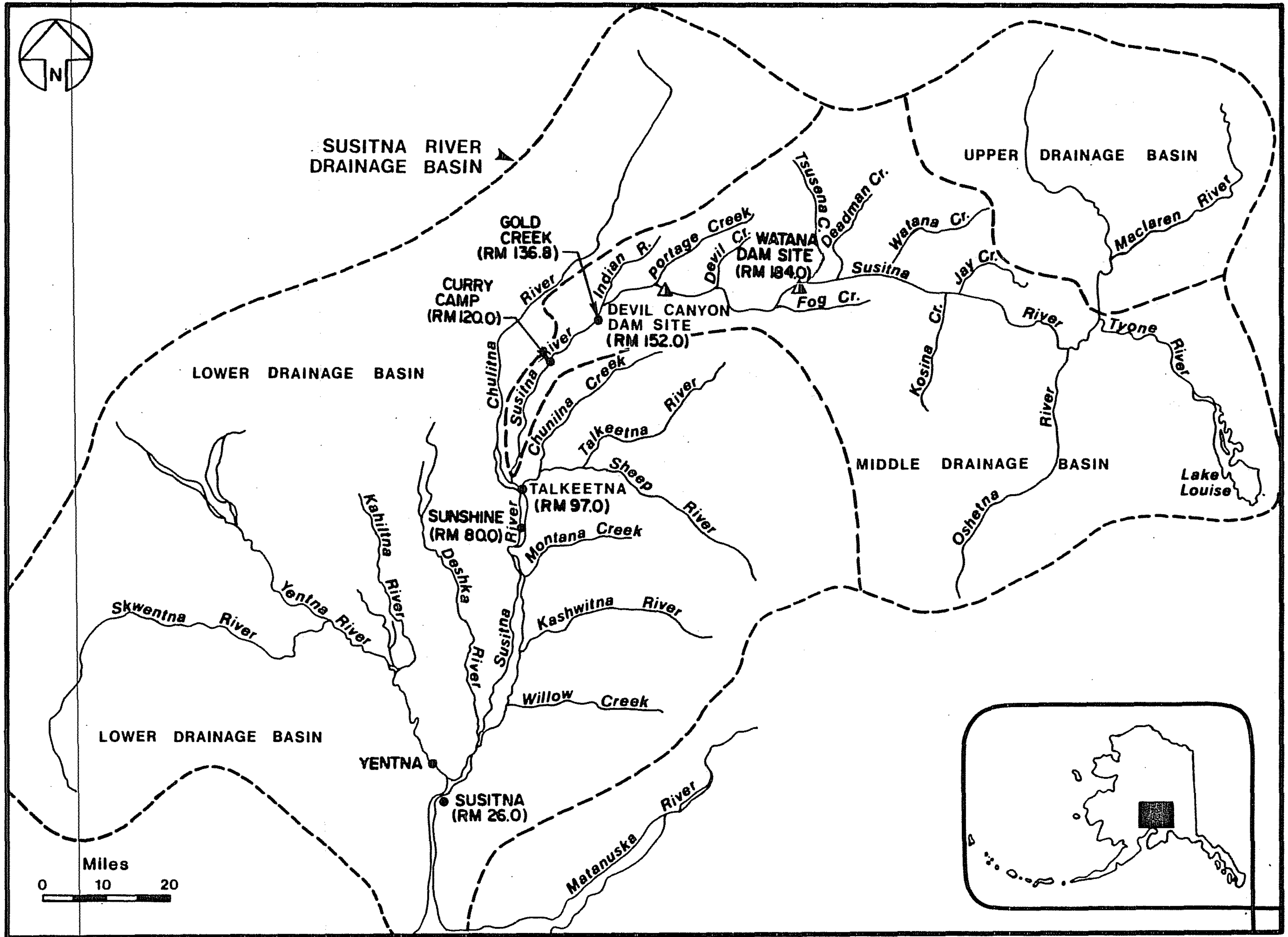
TABLE E.3.2.131: SUMMARY OF ESTIMATED COSTS FOR HABITAT MODIFICATION MEASURES IN SELECTED SLOUGHS AND SIDE CHANNELS.

	Slough 8A		Slough 9		Slough 9A		Slough 11		USC 11		Slough 21		Side Channel 21		Total	
	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M	Capital Costs	O&M
Slough Mouth Excavation	26,000		26,000												52,000	
Wing Deflector	24,000						24,000						240,000		288,000	
Passage Reach Excavations	10,000		7,000												17,000	
Protective Berm	61,000		59,000		42,000		24,000		161,000						347,000	
Log Barriers			30,000				24,000								54,000	
Bank Stabilization							25,000								25,000	
Rock Weir			37,000				61,000								98,000	
Total Slough Excavations					76,000		26,000		26,000		34,000		45,000		207,000	
Total	121,000	4,000	159,000	4,000	118,000	4,000	184,000	4,000	187,000	4,000	34,000	5,000	285,000	5,000	1,088,000	30,000

TABLE E.3.2.132: SCHEDULE FOR IMPLEMENTING AQUATIC MITIGATION PROGRAM

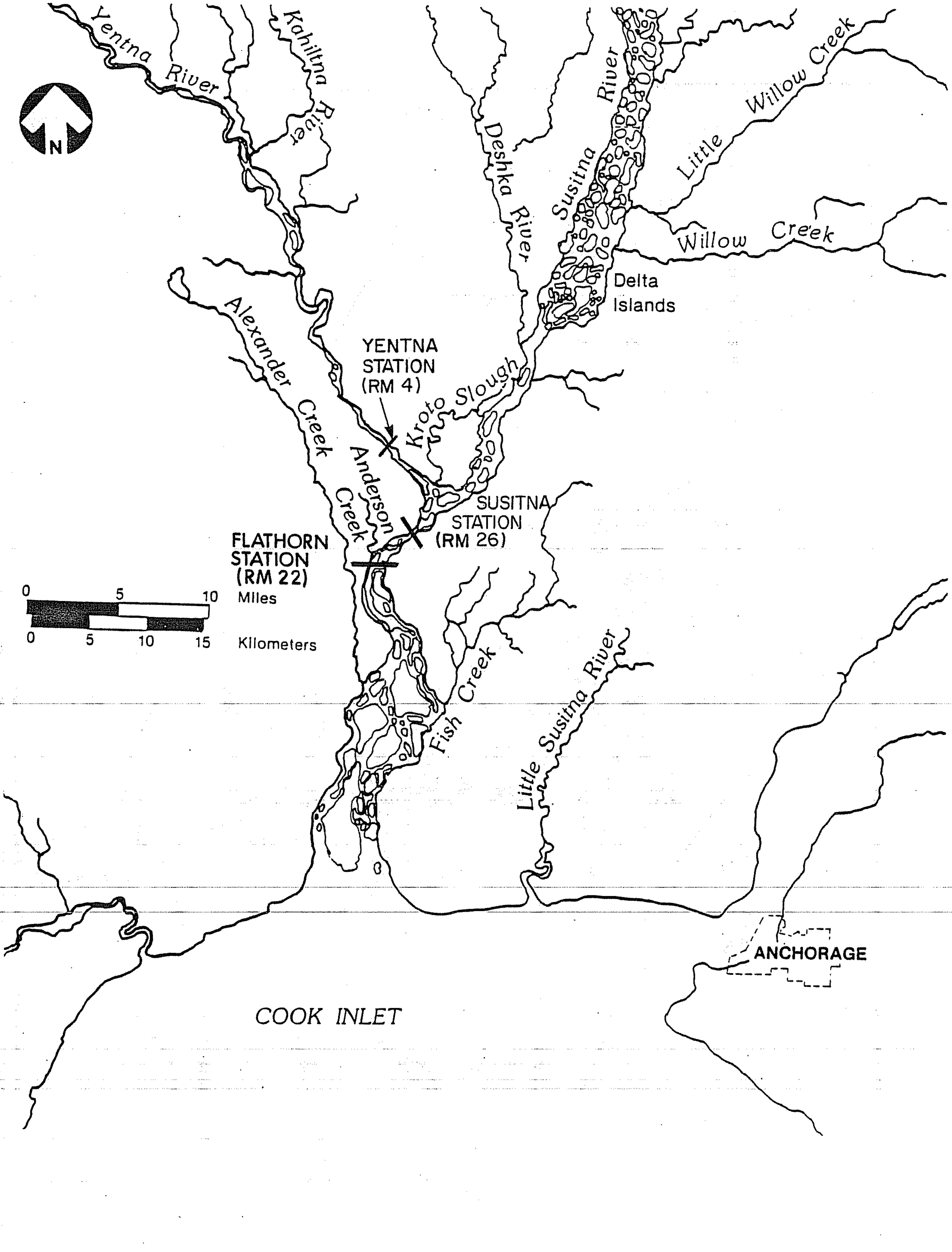
Mitigation Measure	Project Phase for Implementation	Year of Implementation	
		Final Planning	Construction
<u>Construction Mitigation</u>			
Preconstruction Design and Planning	Final Design	1986	---
Construction Monitoring	Watana Stage I Construction	1986	1989
<u>Operational Mitigation</u>			
Downstream Mitigation			
Protective Slough Berms	Watana Stage I Construction	1986	1989
Slough Mouth Excavation	Watana Stage I Construction	1986	1989
Lowered and Restructured Sloughs	Watana Stage I Construction	1986	1989
Impoundment Mitigation			
Public Access Acquisition	Final Design	1986	---
Habitat Improvement	Final Design	1986	1989
Multiple Level Intakes	Watana Stage I Filling	1986	1996
	Devil Canyon Filling	1991	1995
Cone Valves	Watana Stage I Filling	1986	1996
	Devil Canyon Filling	1991	1995
Operational Monitoring	Watana Stage I Filling	1986	1996

FIGURES



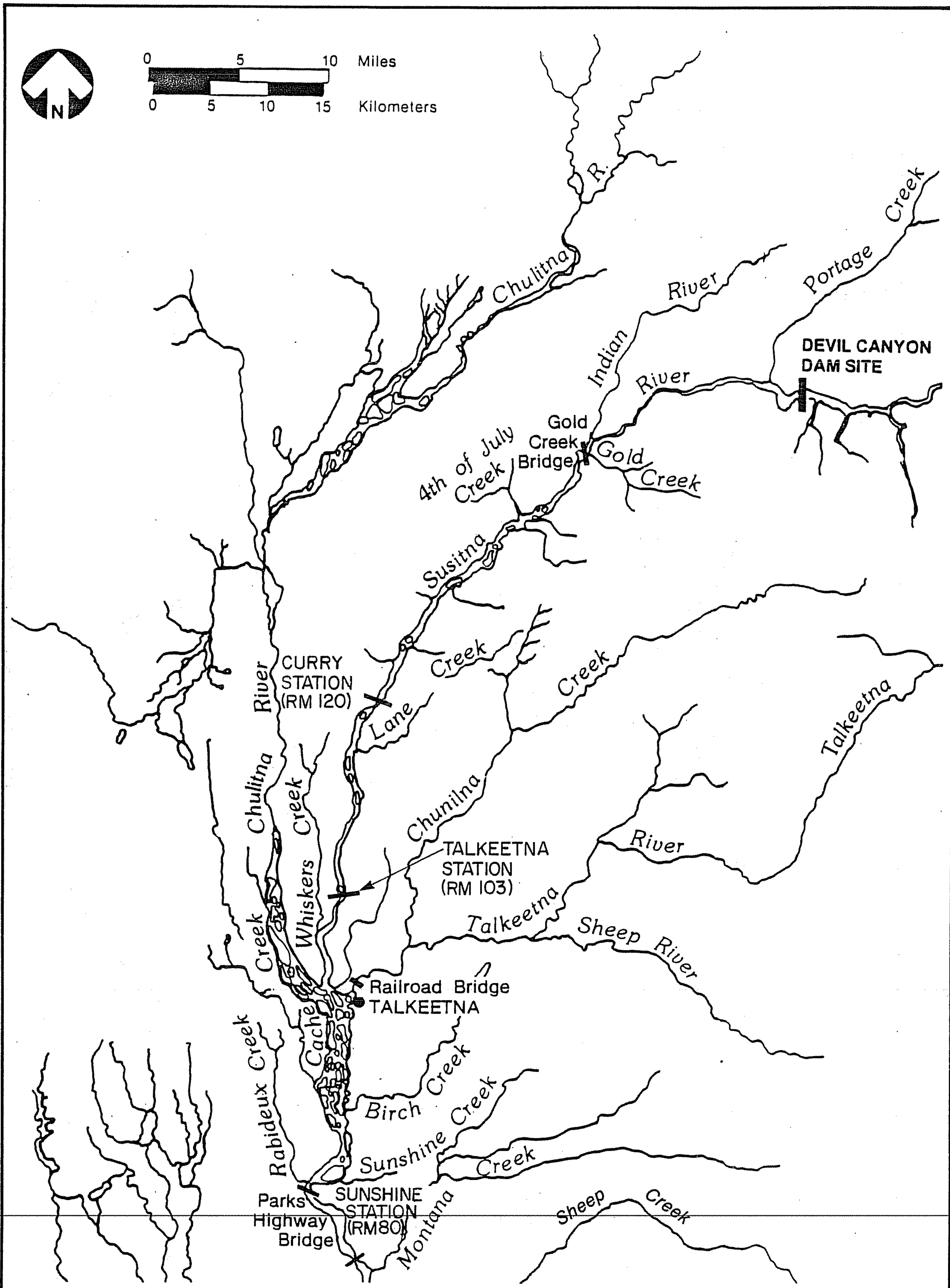
UPPER, MIDDLE, AND LOWER DRAINAGE OF THE SUSITNA PROJECT AREA.

FIGURE E.3.2.1



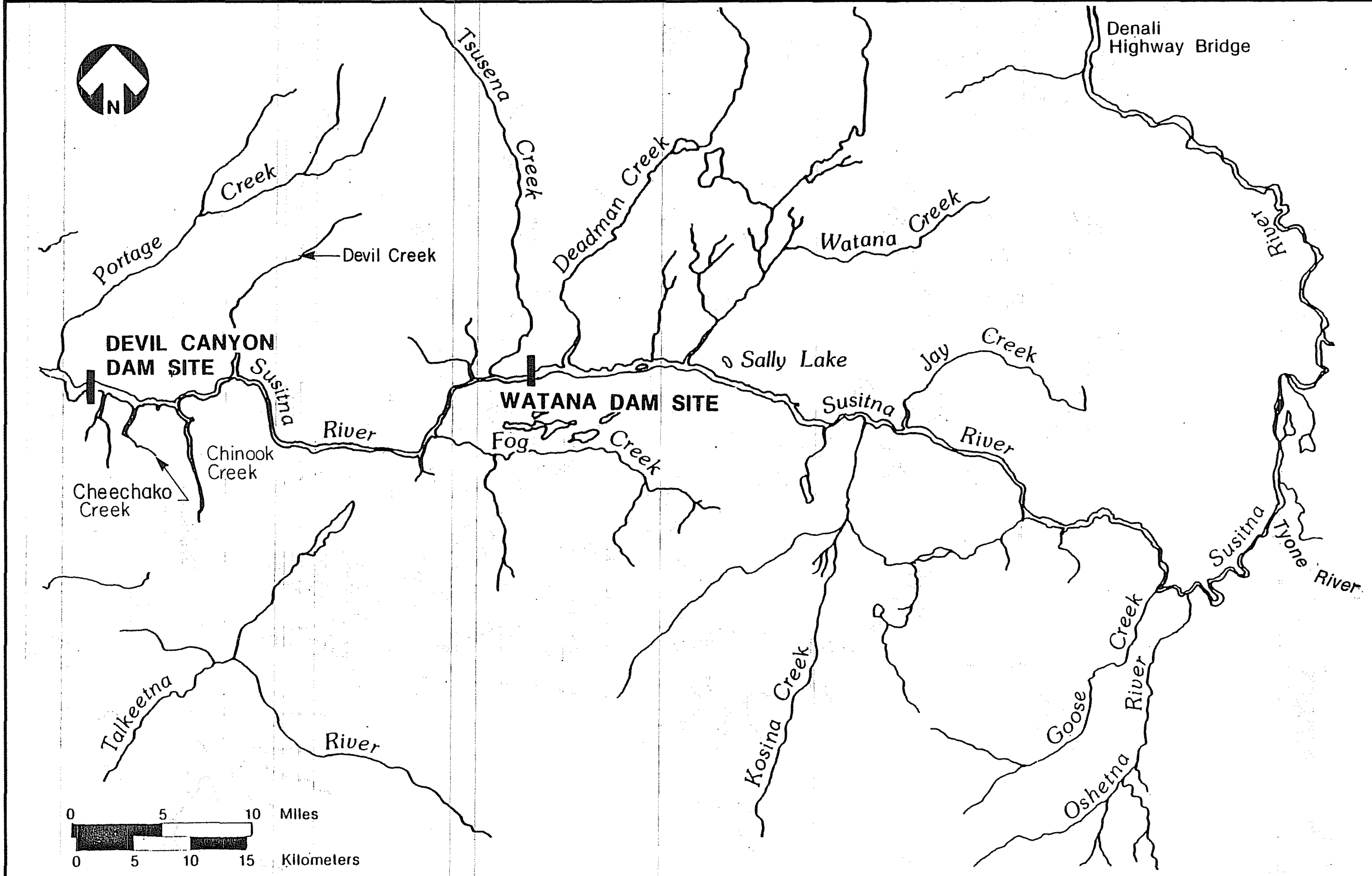
SUSITNA RIVER AND MAJOR TRIBUTARIES FROM MOUTH TO LITTLE WILLOW CREEK

FIGURE E.3.2.2



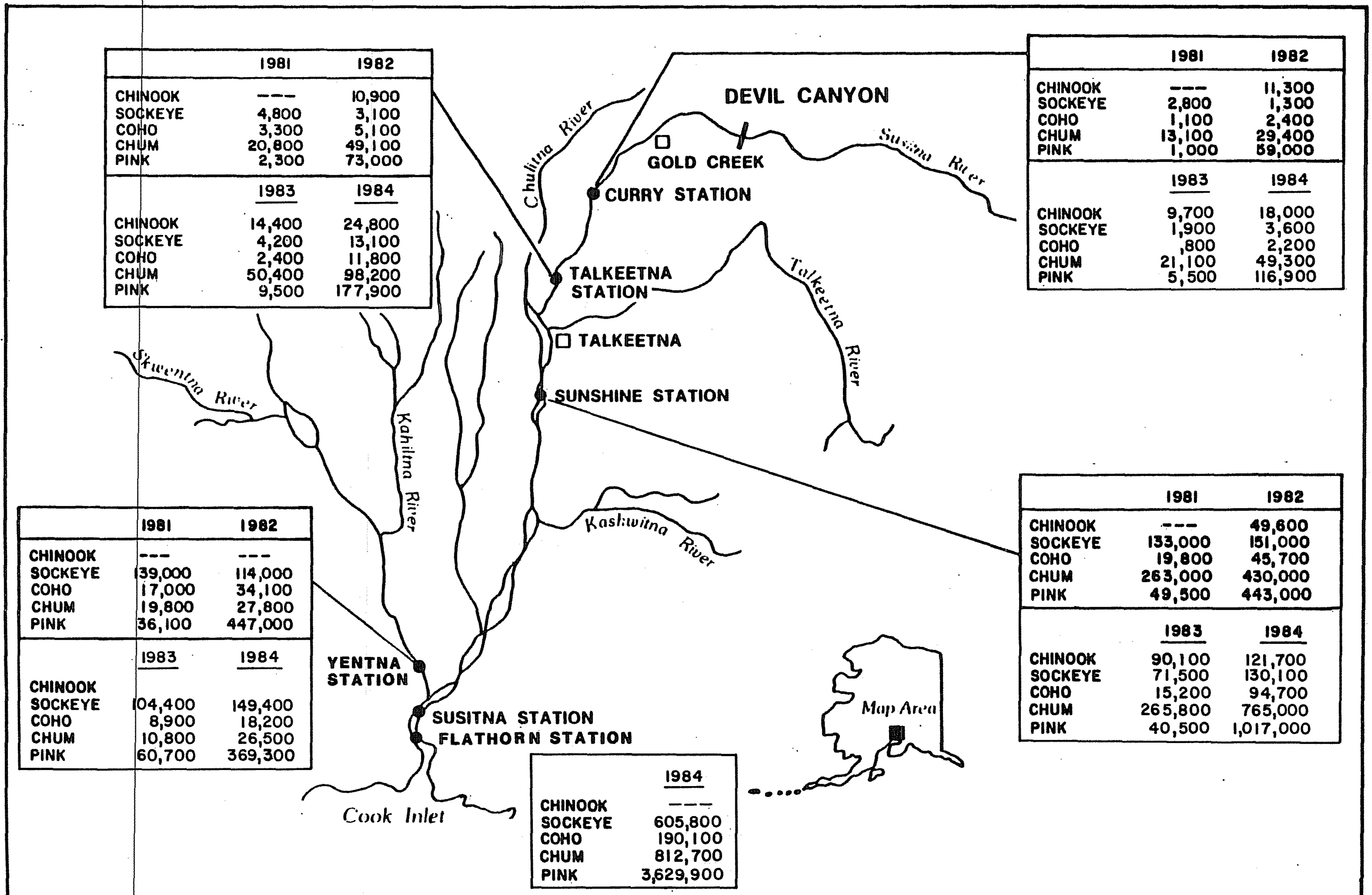
SUSITNA RIVER AND MAJOR TRIBUTARIES FROM
MONTANA CREEK TO DEVIL CANYON

FIGURE E.3.2.3



SUSITNA RIVER AND MAJOR TRIBUTARIES
FROM DEVIL CANYON TO DENALI HIGHWAY

FIGURE E.3.2.4



Talkeetna Station

	1981	1982
CHINOOK	---	10,900
SOCKEYE	4,800	3,100
COHO	3,300	5,100
CHUM	20,800	49,100
PINK	2,300	73,000
	1983	**1984**
CHINOOK	14,400	24,800
SOCKEYE	4,200	13,100
COHO	2,400	11,800
CHUM	50,400	98,200
PINK	9,500	177,900

Curry Station

	1981	1982
CHINOOK	---	11,300
SOCKEYE	2,800	1,300
COHO	1,100	2,400
CHUM	13,100	29,400
PINK	1,000	59,000
	1983	**1984**
CHINOOK	9,700	18,000
SOCKEYE	1,900	3,600
COHO	,800	2,200
CHUM	21,100	49,300
PINK	5,500	116,900

Sunshine Station

	1981	1982
CHINOOK	---	49,600
SOCKEYE	133,000	151,000
COHO	19,800	45,700
CHUM	263,000	430,000
PINK	49,500	443,000
	1983	**1984**
CHINOOK	90,100	121,700
SOCKEYE	71,500	130,100
COHO	15,200	94,700
CHUM	265,800	765,000
PINK	40,500	1,017,000

Yentna Station

	1981	1982
CHINOOK	---	---
SOCKEYE	139,000	114,000
COHO	17,000	34,100
CHUM	19,800	27,800
PINK	36,100	447,000
	1983	**1984**
CHINOOK		
SOCKEYE	104,400	149,400
COHO	8,900	18,200
CHUM	10,800	26,500
PINK	60,700	369,300

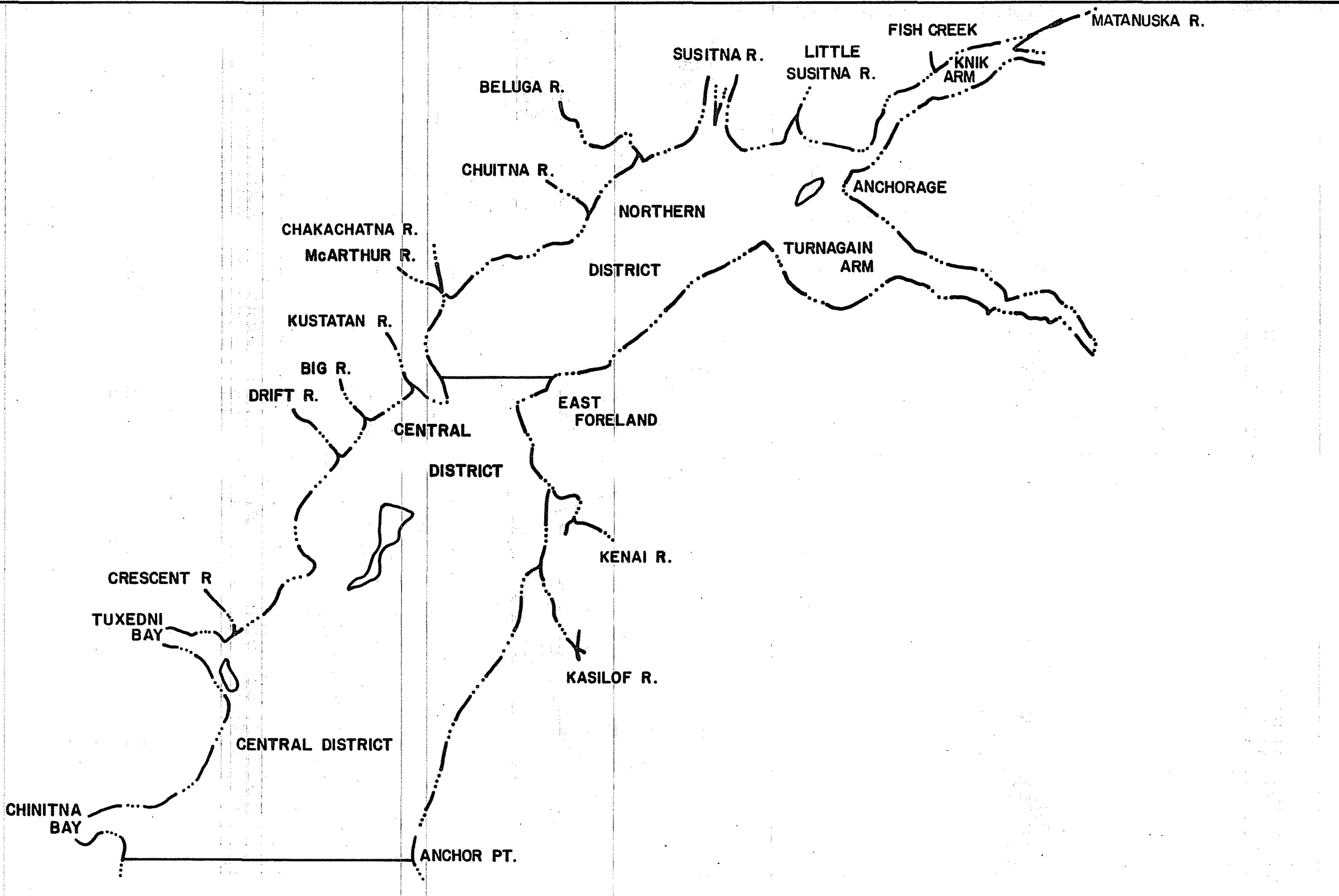
Flathorn Station

	1984
CHINOOK	---
SOCKEYE	605,800
COHO	190,100
CHUM	812,700
PINK	3,629,900

SOURCE: ADF&G 1985b

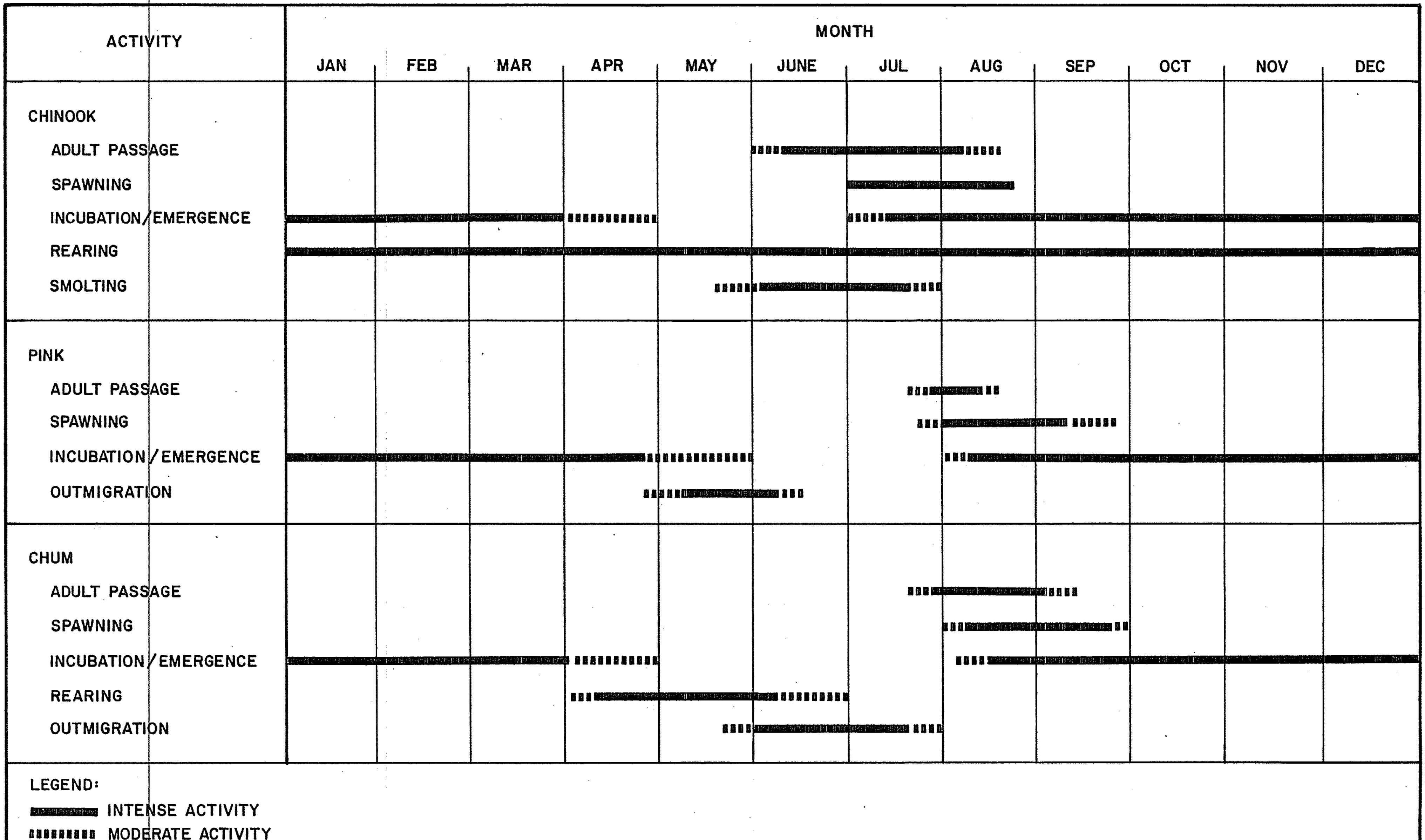
POPULATION ESTIMATES OF ADULT SALMON IN SUSITNA RIVER

FIGURE E.3.2.5



UPPER COOK INLET COMMERCIAL SALMON MANAGEMENT AREA

FIGURE E.3.2.6

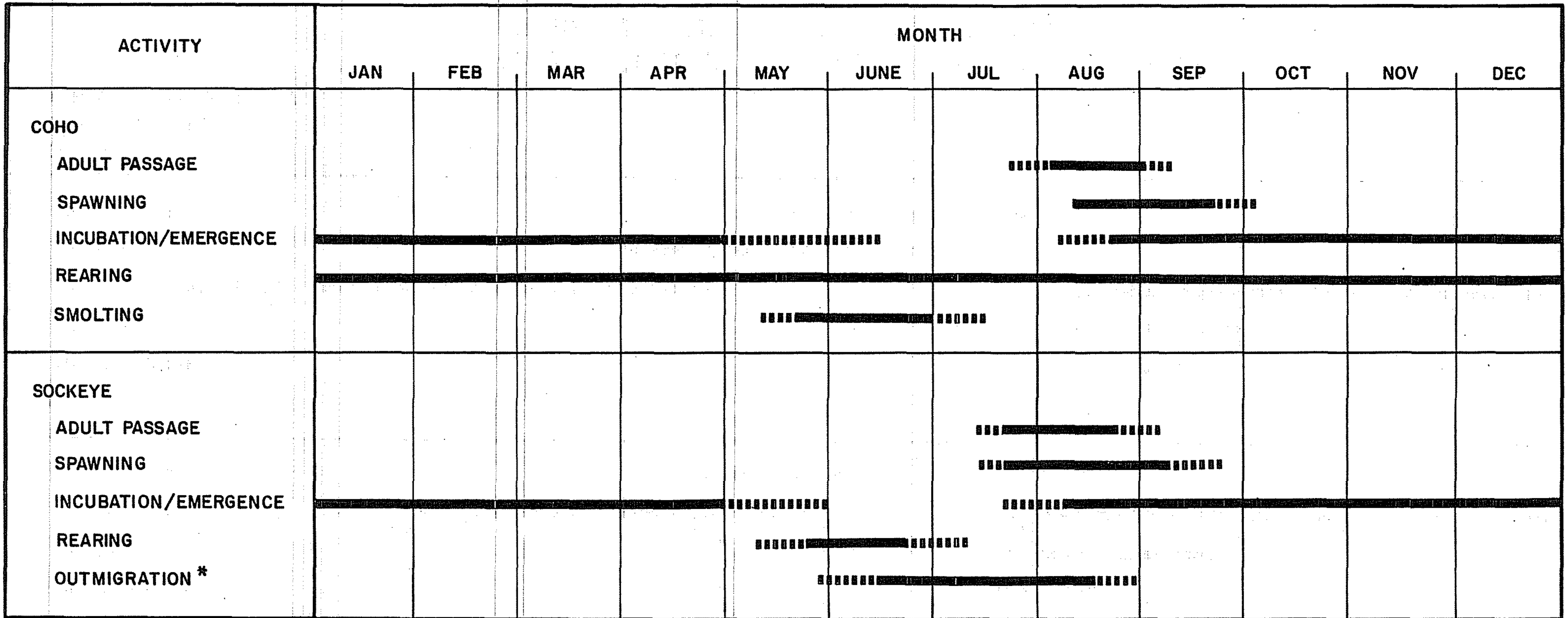


TIMING OF LIFE STAGES OF SALMON IN THE SUSITNA RIVER FROM TALKEETNA TO DEVIL CANYON

SHEET 1 OF 2

SOURCE: ADF&G 1981a, 1981d, 1983a, 1983m, 1984c, 1984h, 1985b, 1985c; MORROW 1980

FIGURE E.3.2.7

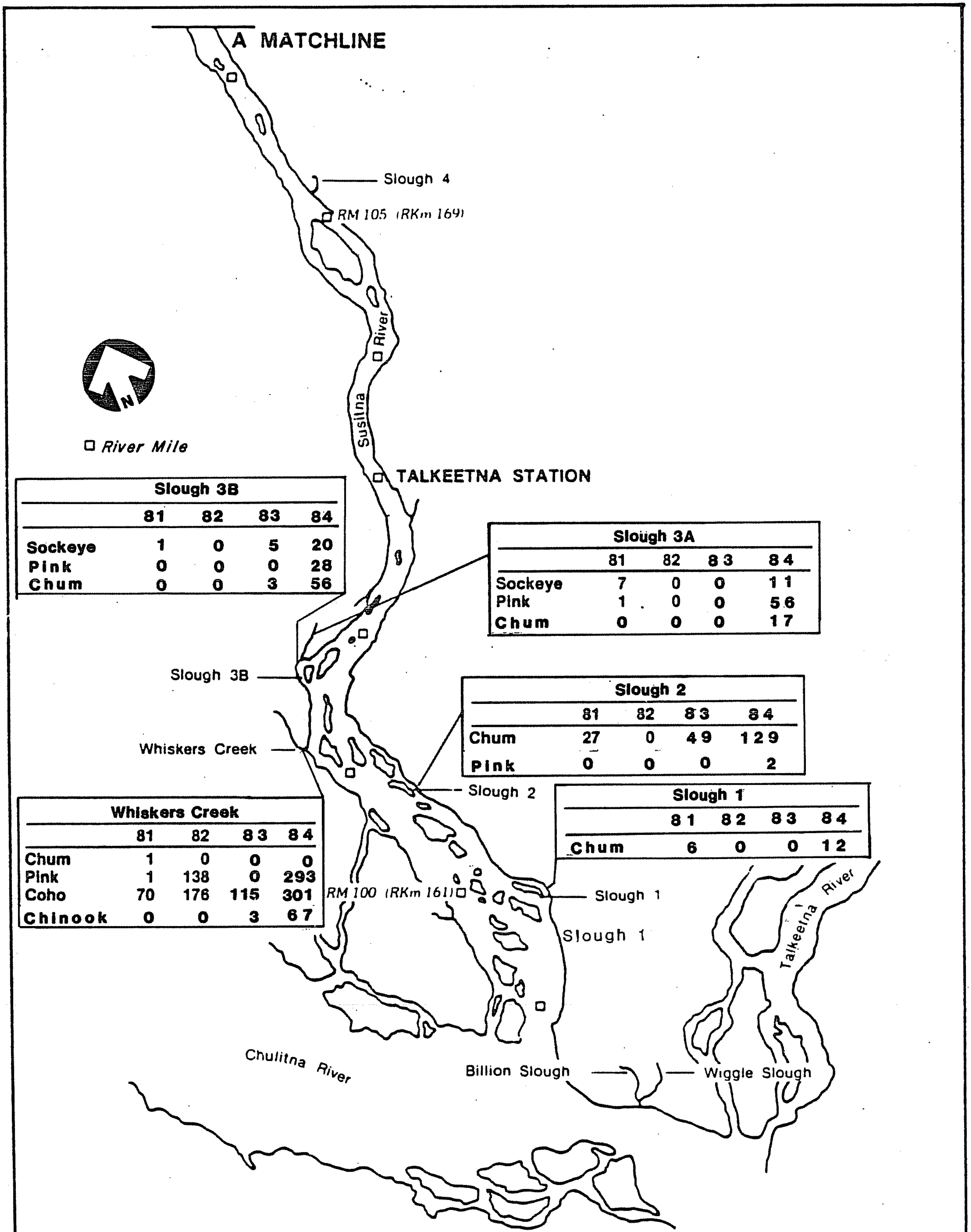


* JUVENILE SOCKEYE APPEAR TO BE ABSENT FROM THIS REACH

LEGEND:
INTENSE ACTIVITY
MODERATE ACTIVITY

TIMING OF LIFE STAGES OF SALMON IN THE SUSITNA RIVER
FROM TALKEETNA TO DEVIL CANYON
SHEET 2 OF 2

FIGURE E.3.2.7



Slough 3B

	81	82	83	84
Sockeye	1	0	5	20
Pink	0	0	0	28
Chum	0	0	3	56

Slough 3A

	81	82	83	84
Sockeye	7	0	0	11
Pink	1	0	0	56
Chum	0	0	0	17

Slough 2

	81	82	83	84
Chum	27	0	49	129
Pink	0	0	0	2

Whiskers Creek

	81	82	83	84
Chum	1	0	0	0
Pink	1	138	0	293
Coho	70	176	115	301
Chinook	0	0	3	67

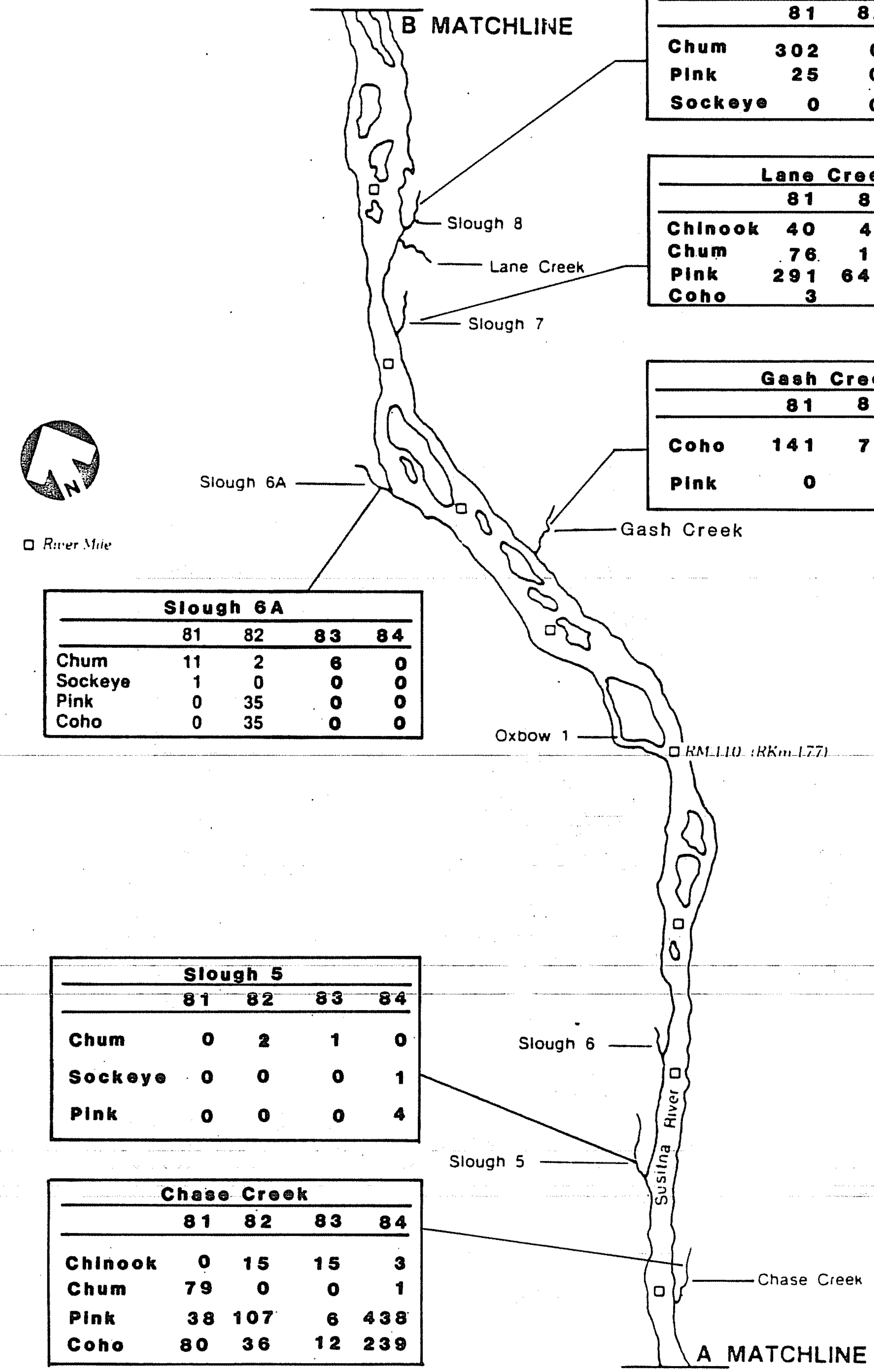
Slough 1

	81	82	83	84
Chum	6	0	0	12

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE: ADF & G 1981a, 1983a, 1984h, 1985b

FIGURE E.3.2.8



Slough 8

	81	82	83	84
Chum	302	0	0	65
Pink	25	0	0	1
Sockeye	0	0	0	2

Lane Creek

	81	82	83	84
Chinook	40	47	12	22
Chum	76	11	6	31
Pink	291	640	287	1184
Coho	3	5	2	24

Gash Creek

	81	82	83	84
Coho	141	74	0	234
Pink	0	0	19	6

Slough 6A

	81	82	83	84
Chum	11	2	6	0
Sockeye	1	0	0	0
Pink	0	35	0	0
Coho	0	35	0	0

Slough 5

	81	82	83	84
Chum	0	2	1	0
Sockeye	0	0	0	1
Pink	0	0	0	4

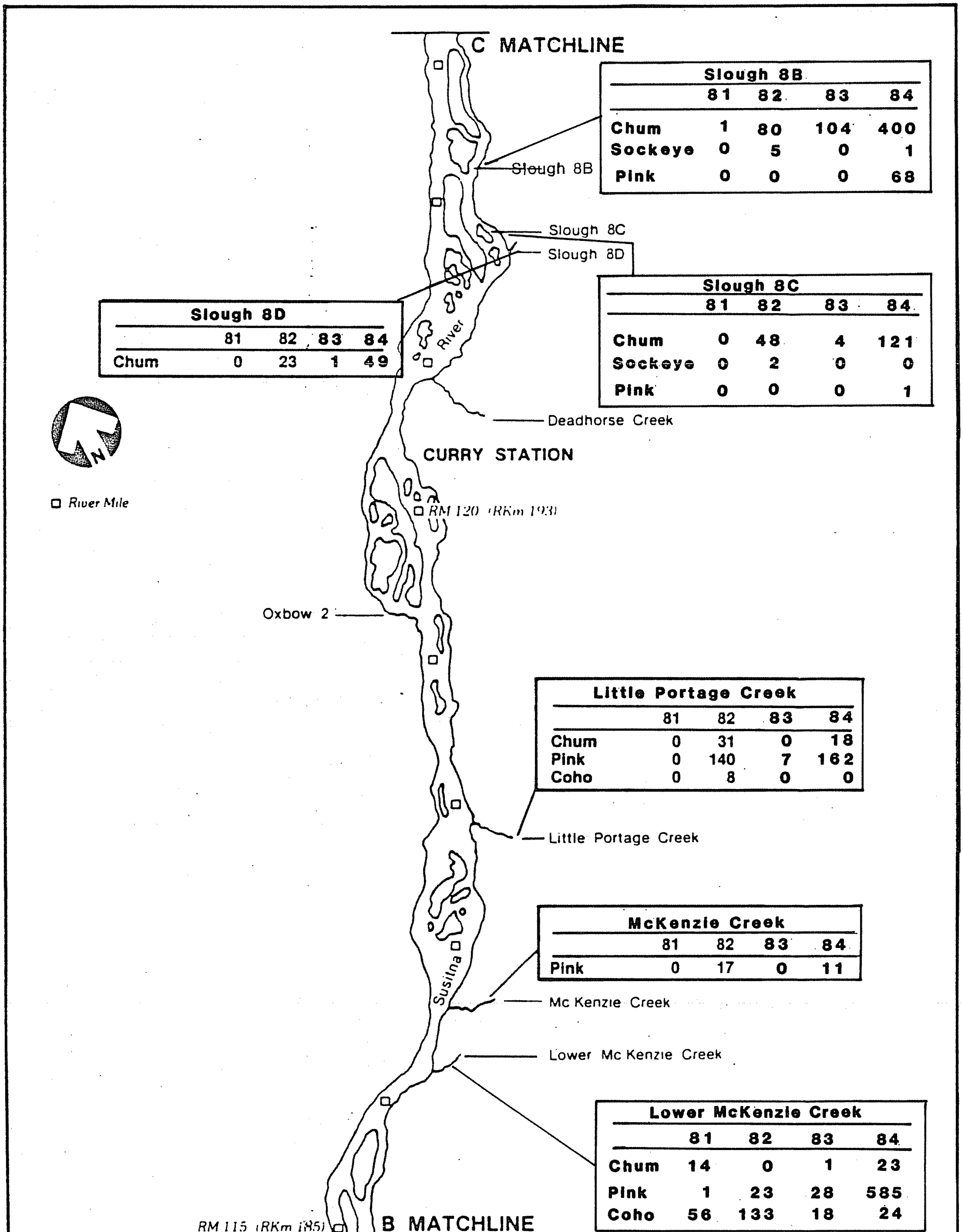
Chase Creek

	81	82	83	84
Chinook	0	15	15	3
Chum	79	0	0	1
Pink	38	107	6	438
Coho	80	36	12	239

SOURCE: ADF&G 1981a, 1983a, 1984h, 1985b

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

FIGURE E.3.2.9



Slough 8B

	81	82	83	84
Chum	1	80	104	400
Sockeye	0	5	0	1
Pink	0	0	0	68

Slough 8C

	81	82	83	84
Chum	0	48	4	121
Sockeye	0	2	0	0
Pink	0	0	0	1

Slough 8D

	81	82	83	84
Chum	0	23	1	49

Little Portage Creek

	81	82	83	84
Chum	0	31	0	18
Pink	0	140	7	162
Coho	0	8	0	0

McKenzie Creek

	81	82	83	84
Pink	0	17	0	11

Lower McKenzie Creek

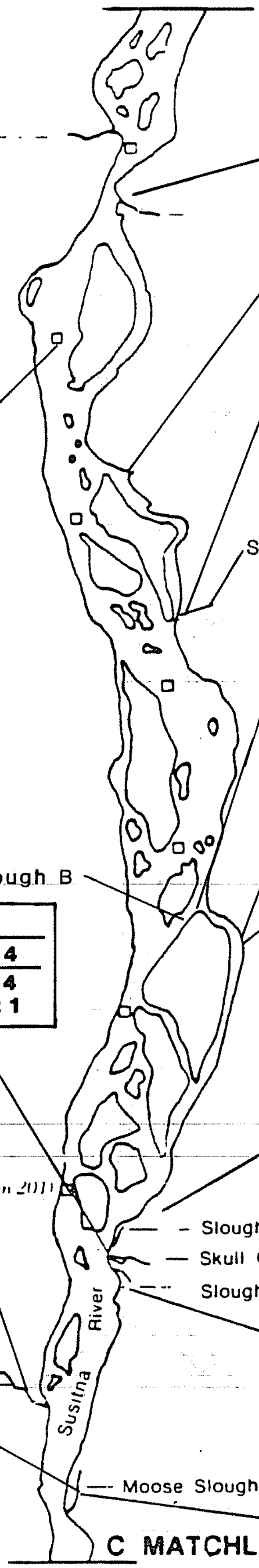
	81	82	83	84
Chum	14	0	1	23
Pink	1	23	28	585
Coho	56	133	18	24

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE: ADF&G 1981a, 1983a, 1984h, 1985b

FIGURE E.3.2.10

D MATCHLINE



Sherman Creek

	81	82	83	84
Chinook	0	3	0	0
Chum	9	0	0	6
Pink	6	24	0	48

4th of July Creek

	81	82	83	84
Chinook	—	56	6	92
Chum	90	191	148	193
Pink	29	702	78	1842
Coho	1	4	3	8

Slough 9B

	81	82	83	84
Chum	90	5	0	73
Sockeye	81	1	0	7

Slough 9

	81	82	83	84
Chum	260	300	169	350
Sockeye	10	5	2	6
Pink	0	12	0	1

Slough B

	81	82	83	84
Chum	0	0	7	108
Sockeye	0	0	2	9

Slough 8 A

	81	82	83	84
Chum	620	336	37	917
Sockeye	177	68	66	128
Pink	0	28	0	134
Coho	0	4	0	0

Skull Creek

	81	82	83	84
Chum	10	1	0	4
Pink	8	12	1	121

Slough A

	81	82	83	84
Chum	34	0	2	2
Pink	2	0	0	0

5th of July Creek

	81	82	83	84
Chinook	0	3	0	17
Chum	0	1	6	2
Pink	2	113	9	411

Slough A'

	81	82	83	84
Chum	140	0	77	111
Pink	0	0	0	24

Moose Slough

	81	82	83	84
Chinook	0	1	0	0
Chum	167	23	68	76
Sockeye	0	8	22	8
Pink	0	8	0	25

C MATCHLINE

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE : ADF&G 1981a, 1983a, 1984h, 1985b

FIGURE E.3.2.11

Slough 20	81	82	83	84
Chum	14	30	63	280
Sockeye	2	0	0	0
Pink	0	64	0	85

Slough 19	81	82	83	84
Chum	3	0	3	45
Sockeye	23	0	5	11
Pink	0	1	0	0

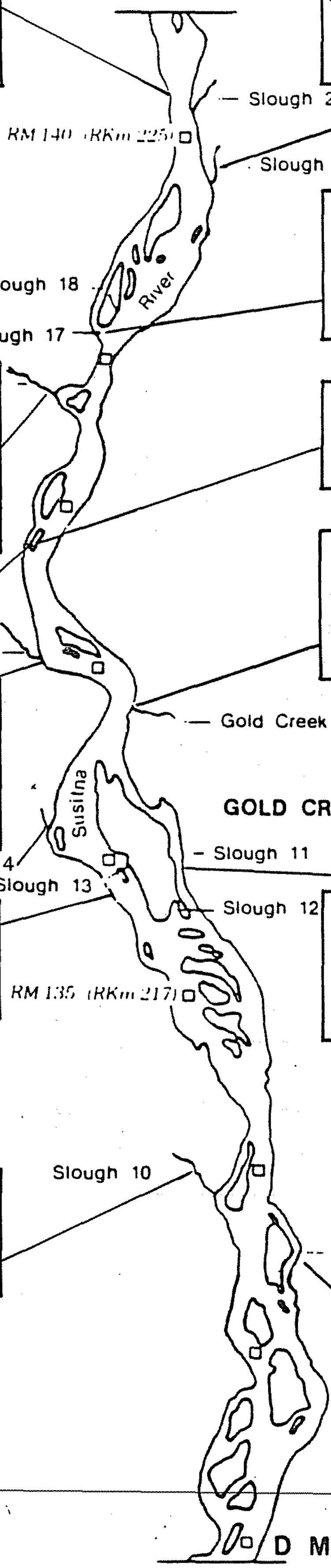
Slough 17	81	82	83	84
Chum	38	21	90	66
Sockeye	6	0	6	16
Pink	0	0	0	1

Indian River	81	82	83	84
Chinook	422	1053	1193	1456
Chum	40	1346	722	2247
Pink	2	738	886	9066
Coho	85	101	53	465
Sockeye	0	0	1	1

Slough 16	81	82	83	84
Chum	3	0	0	15

Gold Creek	81	82	83	84
Chinook	-	21	23	23
Pink	0	11	7	82
Coho	0	1	0	0

Slough 15	81	82	83	84
Chum	1	1	2	100
Pink	1	132	0	500
Coho	0	14		0
Sockeye	0	0	0	1



Slough 13	81	82	83	84
Chum	4	0	4	22

Slough 11	81	82	83	84
Chum	411	459	238	1586
Sockeye	893	456	248	564
Pink	0	131	0	121

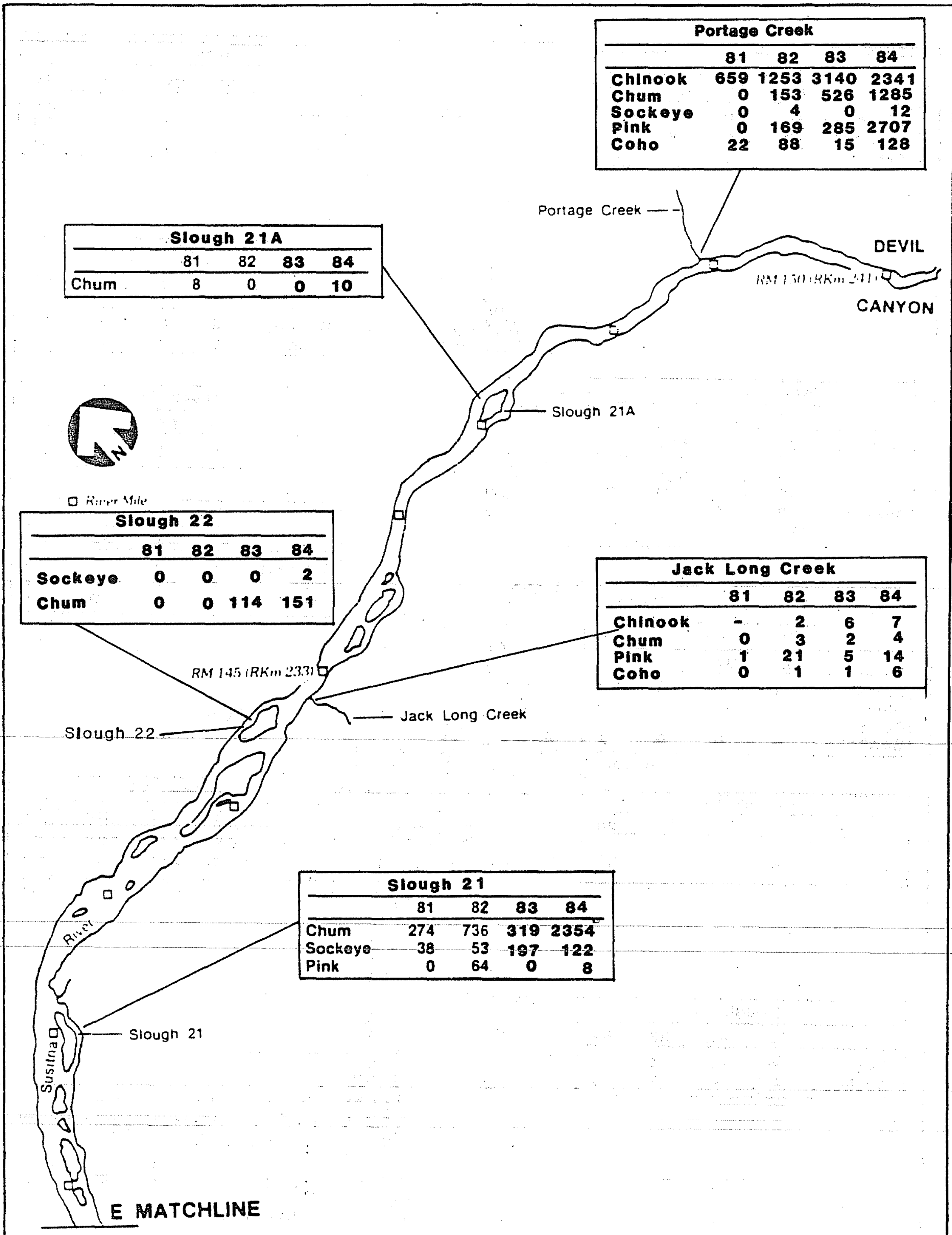
Slough 10	81	82	83	84
Chum	0	2	1	36
Sockeye	-	-	1	0

Slough 9A	81	82	83	84
Chum	182	118	105	303
Sockeye	2	1	1	0

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE: ADF & G 1981a, 1983a, 1984h, 1985b

FIGURE E.3.2.12



Portage Creek

	81	82	83	84
Chinook	659	1253	3140	2341
Chum	0	153	526	1285
Sockeye	0	4	0	12
Pink	0	169	285	2707
Coho	22	88	15	128

Slough 21A

	81	82	83	84
Chum	8	0	0	10

Slough 22

	81	82	83	84
Sockeye	0	0	0	2
Chum	0	0	114	151

Jack Long Creek

	81	82	83	84
Chinook	-	2	6	7
Chum	0	3	2	4
Pink	1	21	5	14
Coho	0	1	1	6

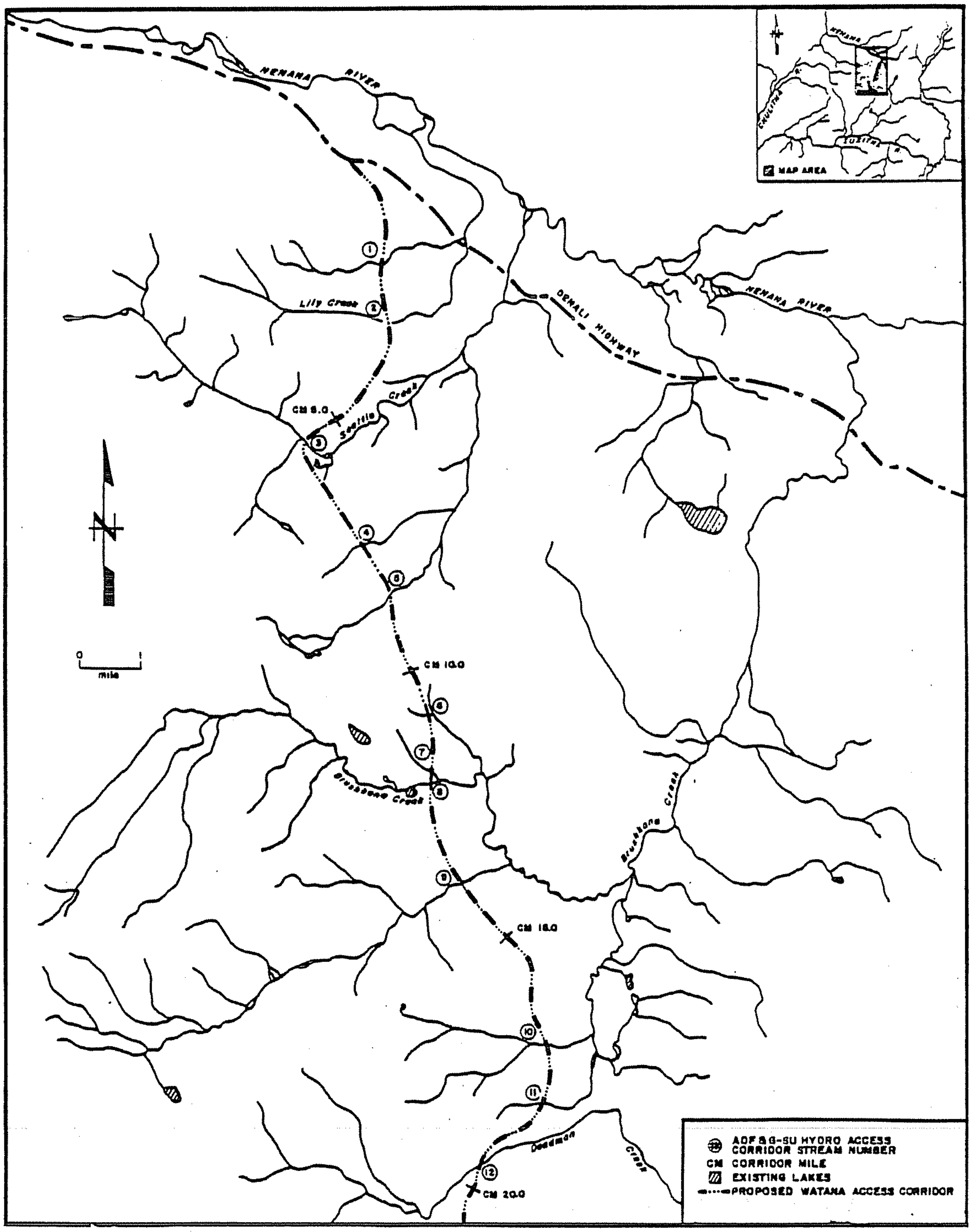
Slough 21

	81	82	83	84
Chum	274	736	319	2354
Sockeye	38	53	197	122
Pink	0	64	0	8

SLOUGH AND TRIBUTARY INDEX AREA
PEAK SPAWNING COUNTS

SOURCE: ADF & G 1981a, 1983a, 1984h, 1985b

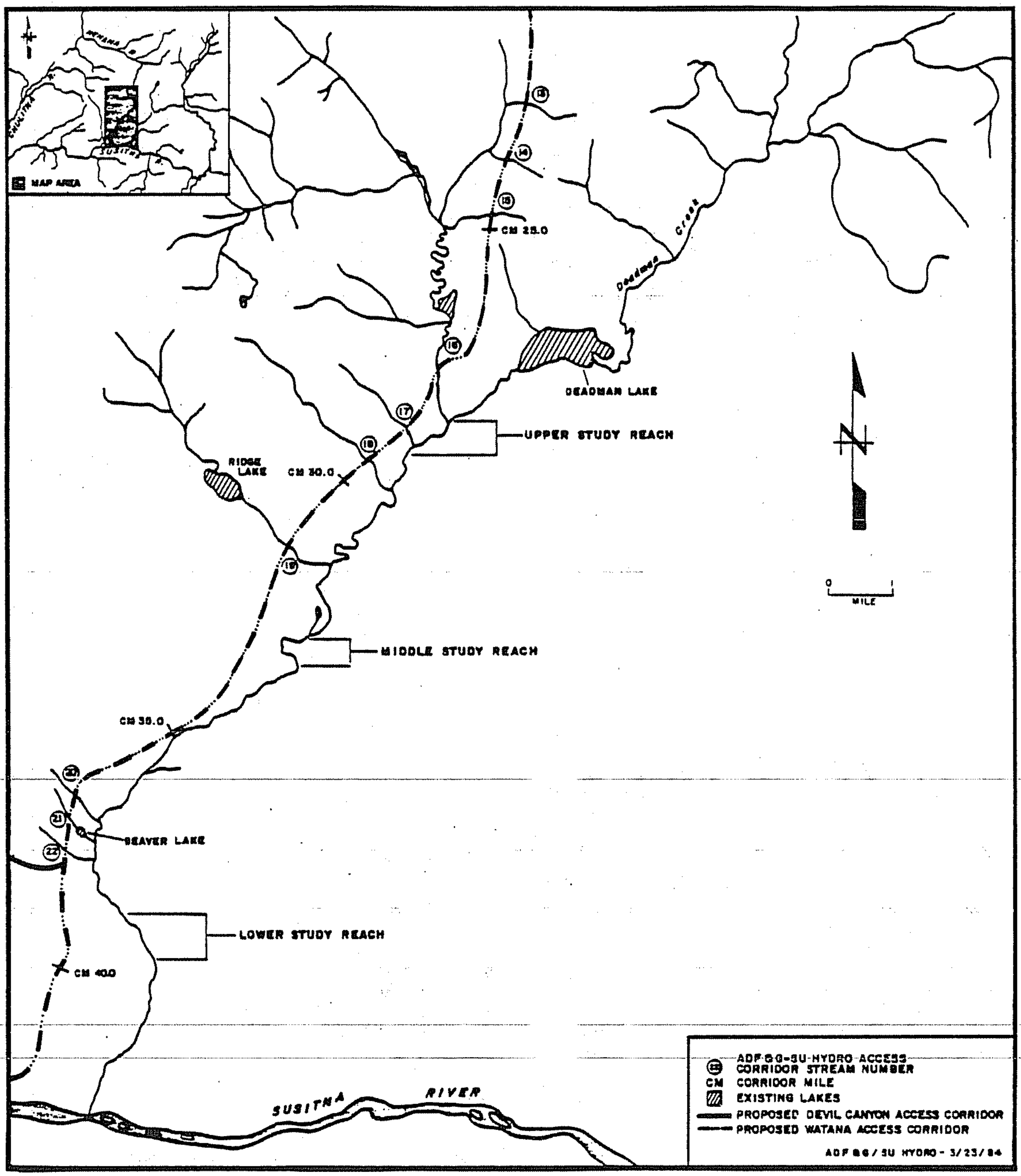
FIGURE E.3.2.13



Stream crossing sites along the northern portion of the proposed Watana Access corridor.

SOURCE: ADF & G 1984a

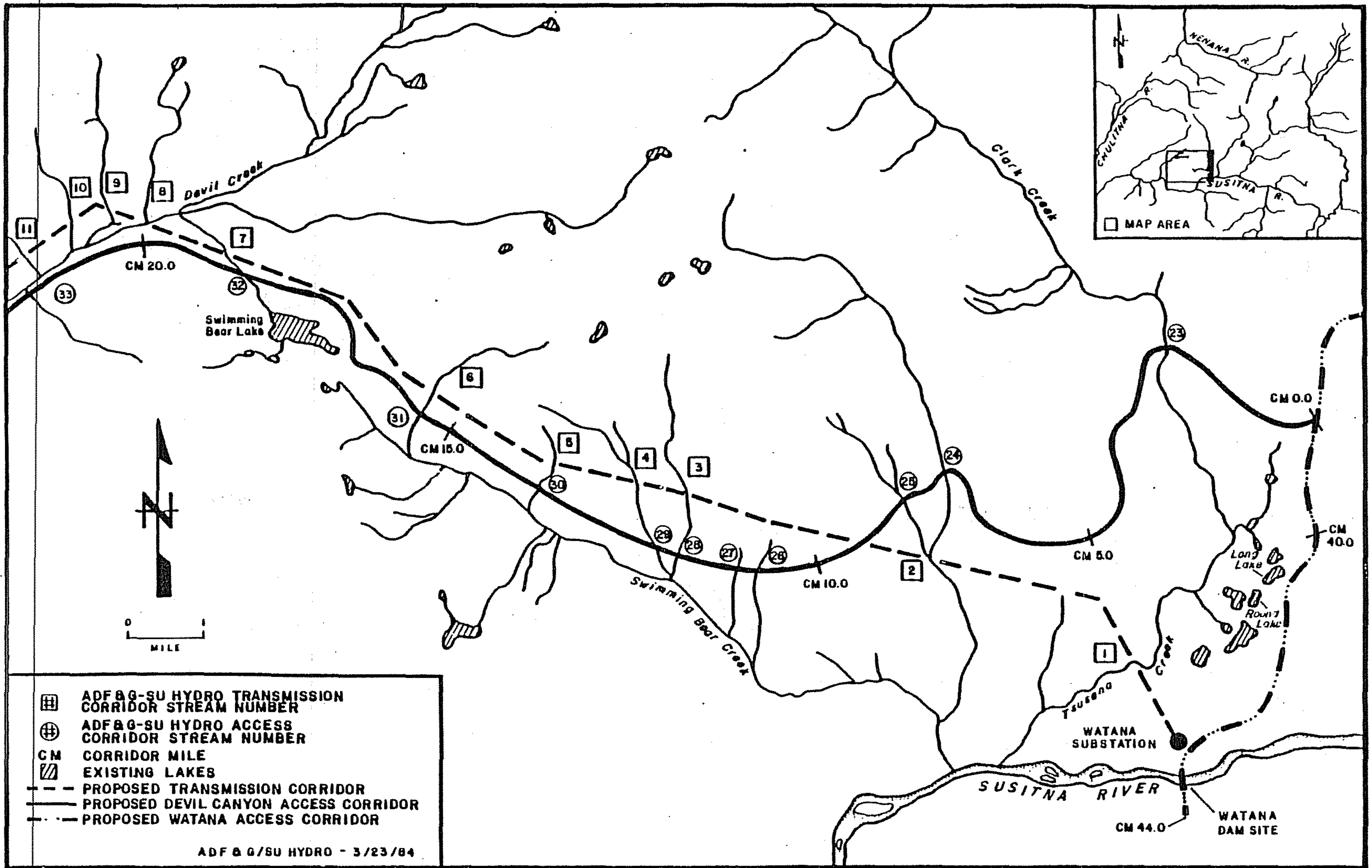
FIGURE E.3.2.14



Stream crossing sites along the southern portion of the proposed Watana access corridor, including three study reaches of Deadman Creek.

SOURCE: ADF&G 1984a

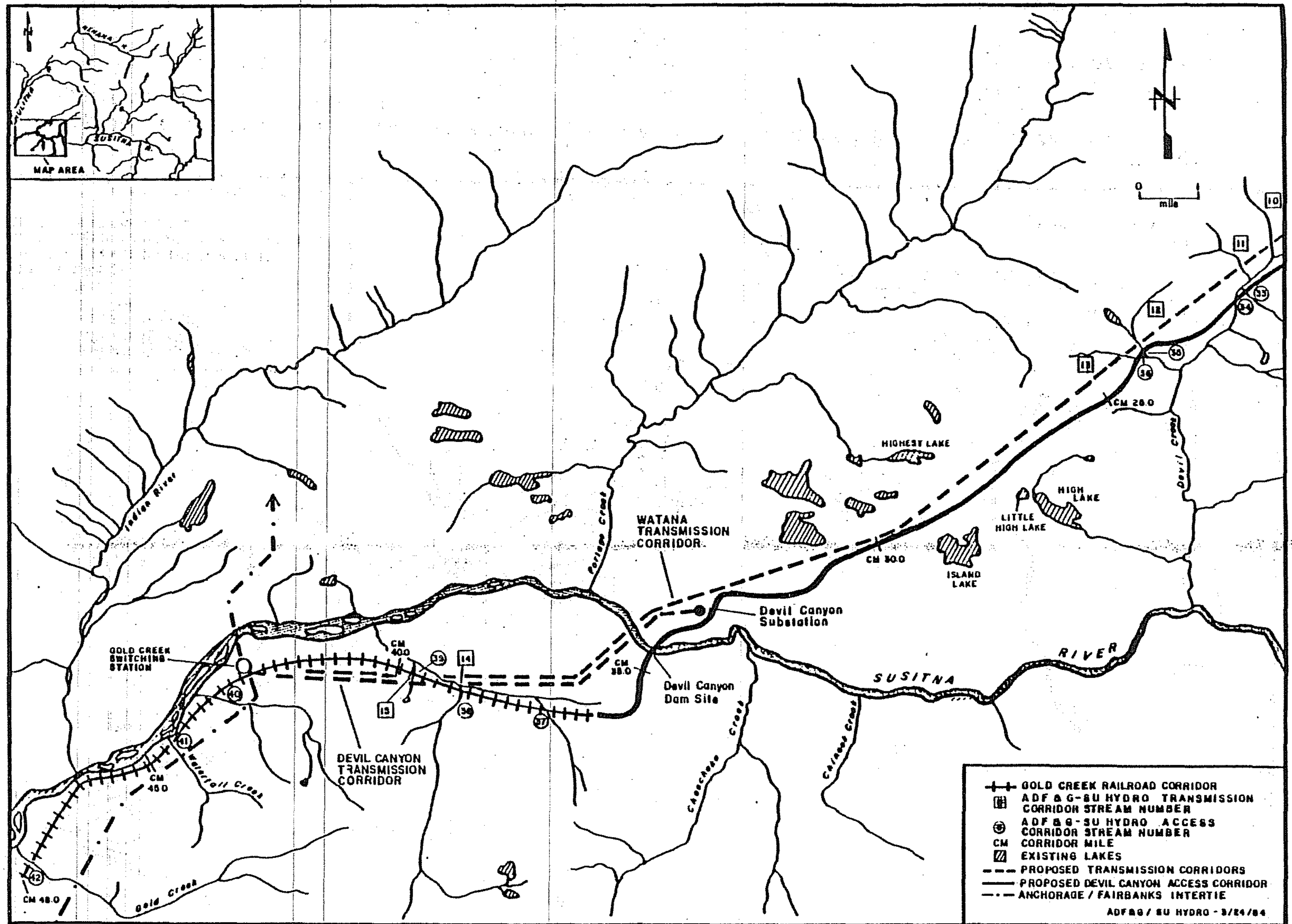
FIGURE E.3.2.15



Stream crossing sites along the eastern portion of the proposed Devil Canyon access and transmission corridors.

SOURCE: ADF&G 1984a

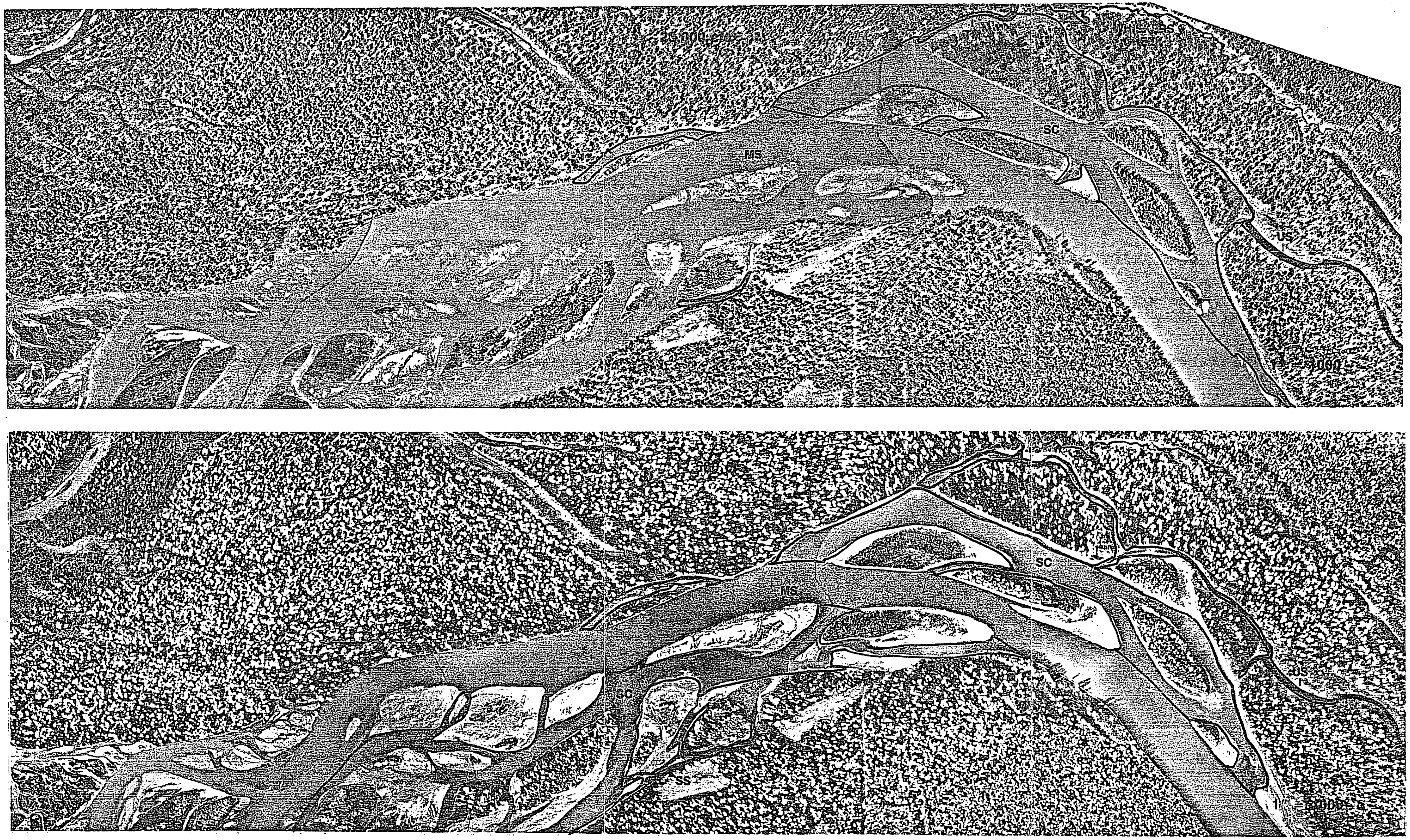
FIGURE E.3.2.16



Stream crossing sites along the western portion of the proposed Devil Canyon access and transmission corridors, and the proposed Gold Creek rail access corridor.

SOURCE: ADF & G 1984a

FIGURE E.3.2.17



LEGEND:

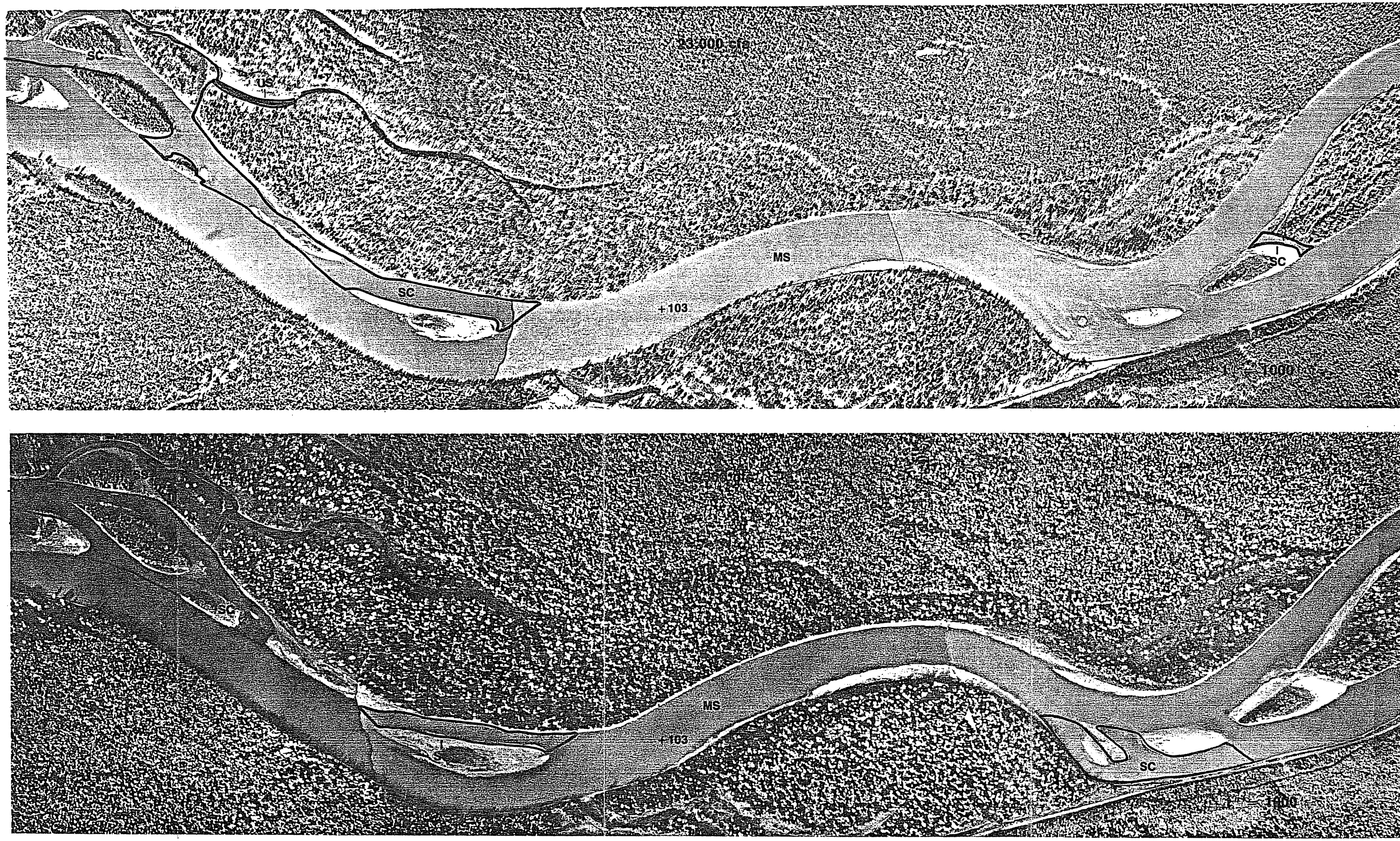
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

FIGURE E.3.2.18

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 101 TO 102



LEGEND:

+ = RIVER MILE

MS = MAINSTEM

SC = SIDE CHANNEL

SS = SIDE SLOUGH

US = UPLAND SLOUGH

TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

FIGURE E.3.2.19

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 102 TO 104

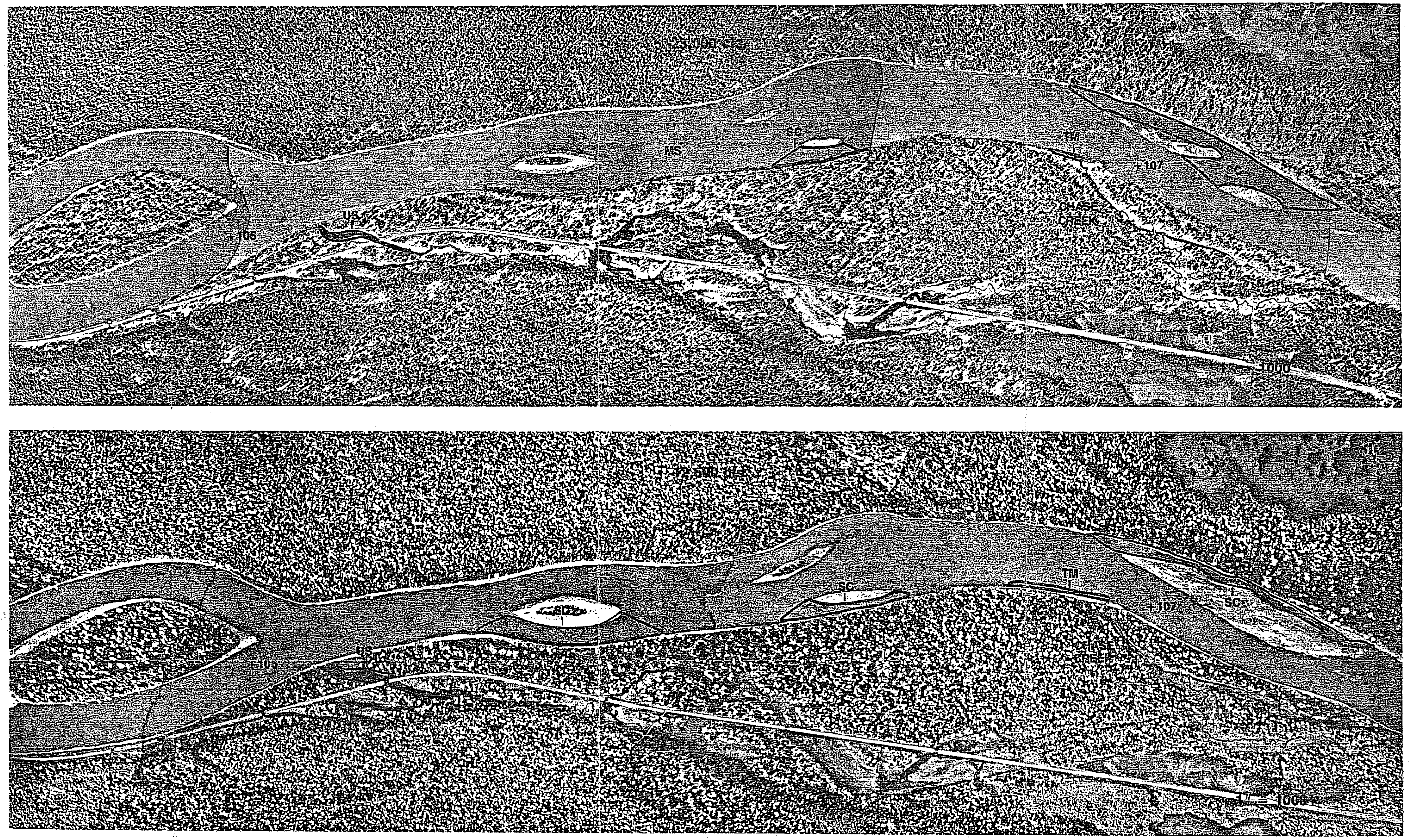


FIGURE E.3.2.20

LEGEND:

+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 105 TO 107

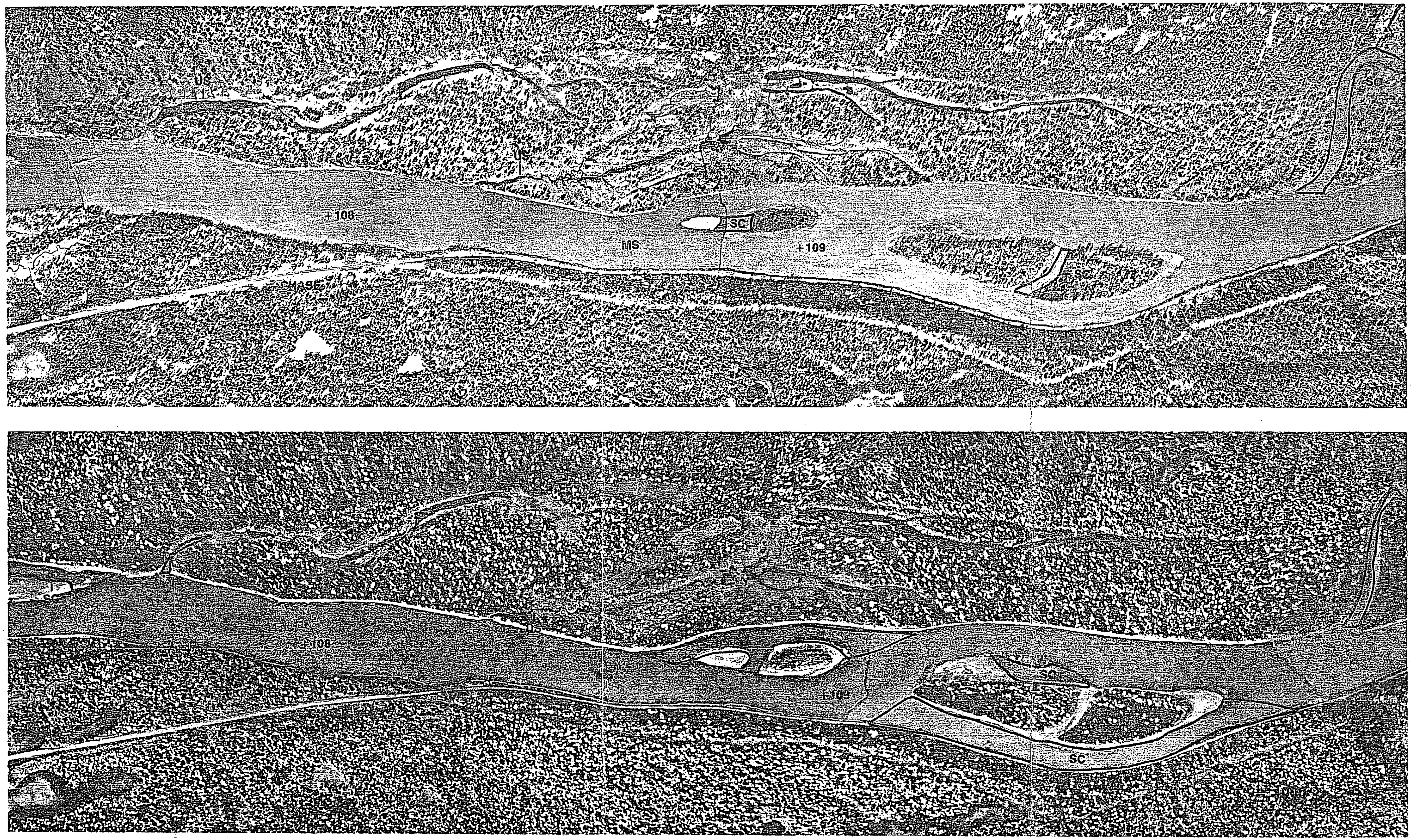


FIGURE E.3.2.21

LEGEND:

+ = RIVER MILE

MS = MAINSTEM

SC = SIDE CHANNEL

SS = SIDE SLOUGH

US = UPLAND SLOUGH

TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 108 TO 110

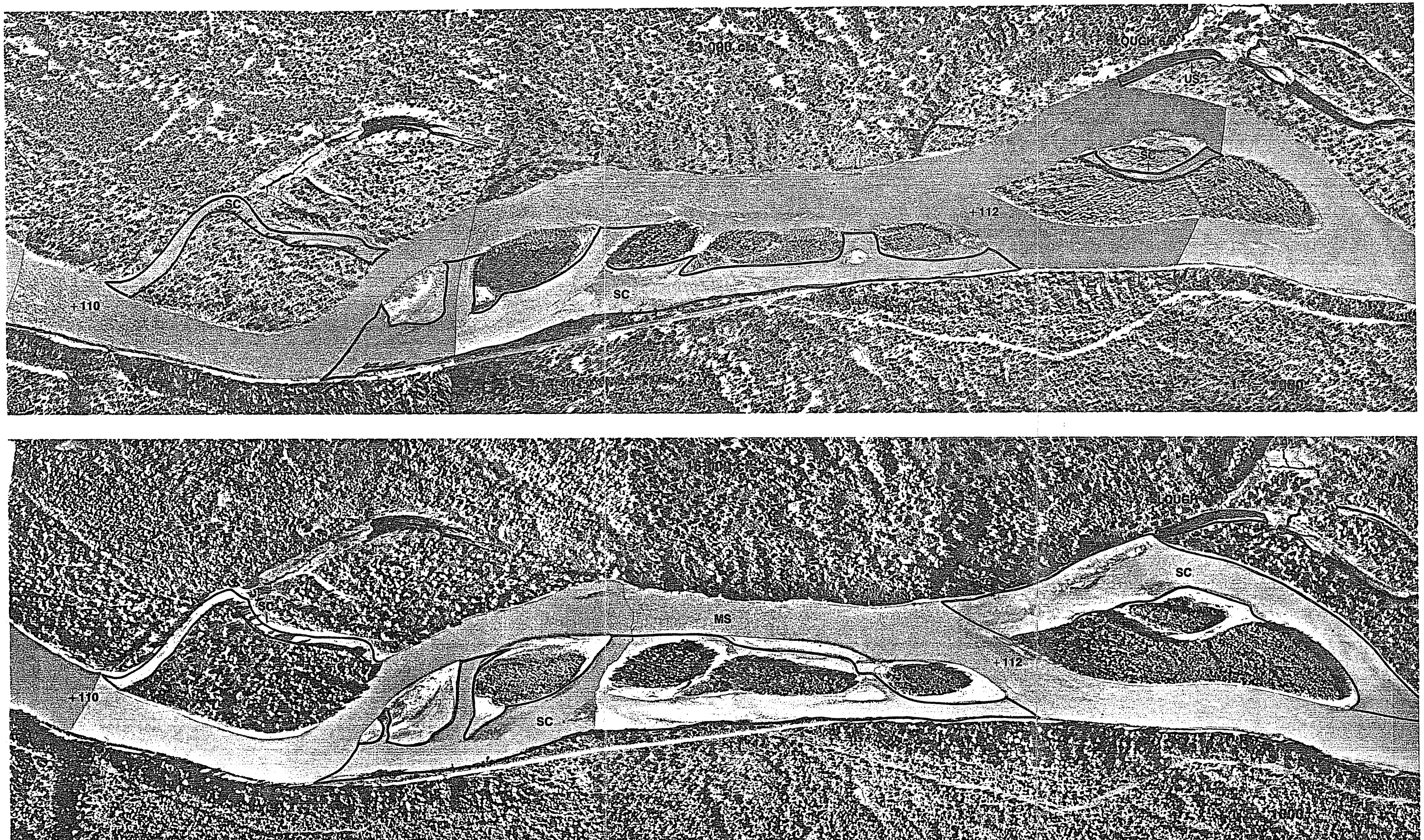


FIGURE E.3.2.22

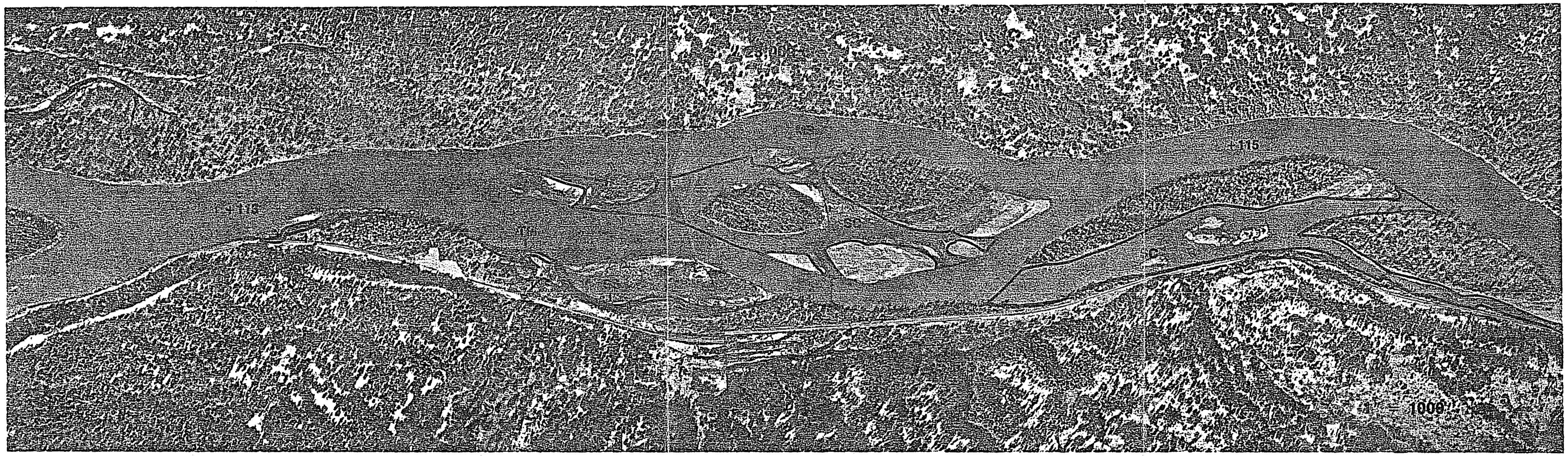
LEGEND:

+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 110 TO 112



LEGEND:

+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

FIGURE E.3.2.23

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 113 TO 115

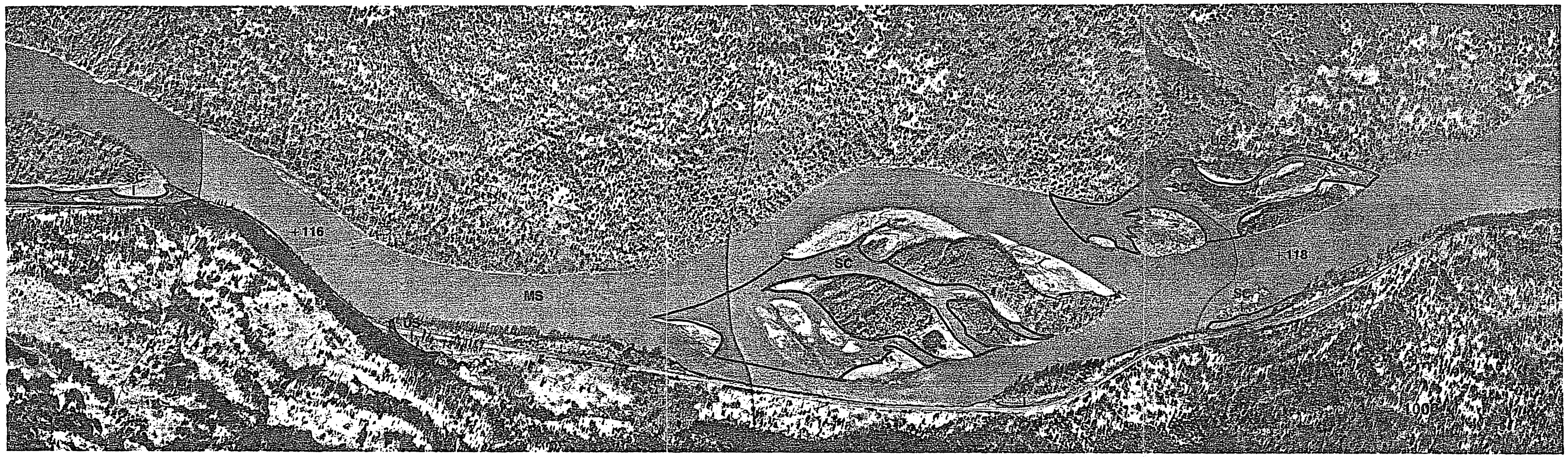


FIGURE E.3.2.24

LEGEND:

+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

SOURCE: EWT&A 1984

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 116 TO 118

LEGEND:

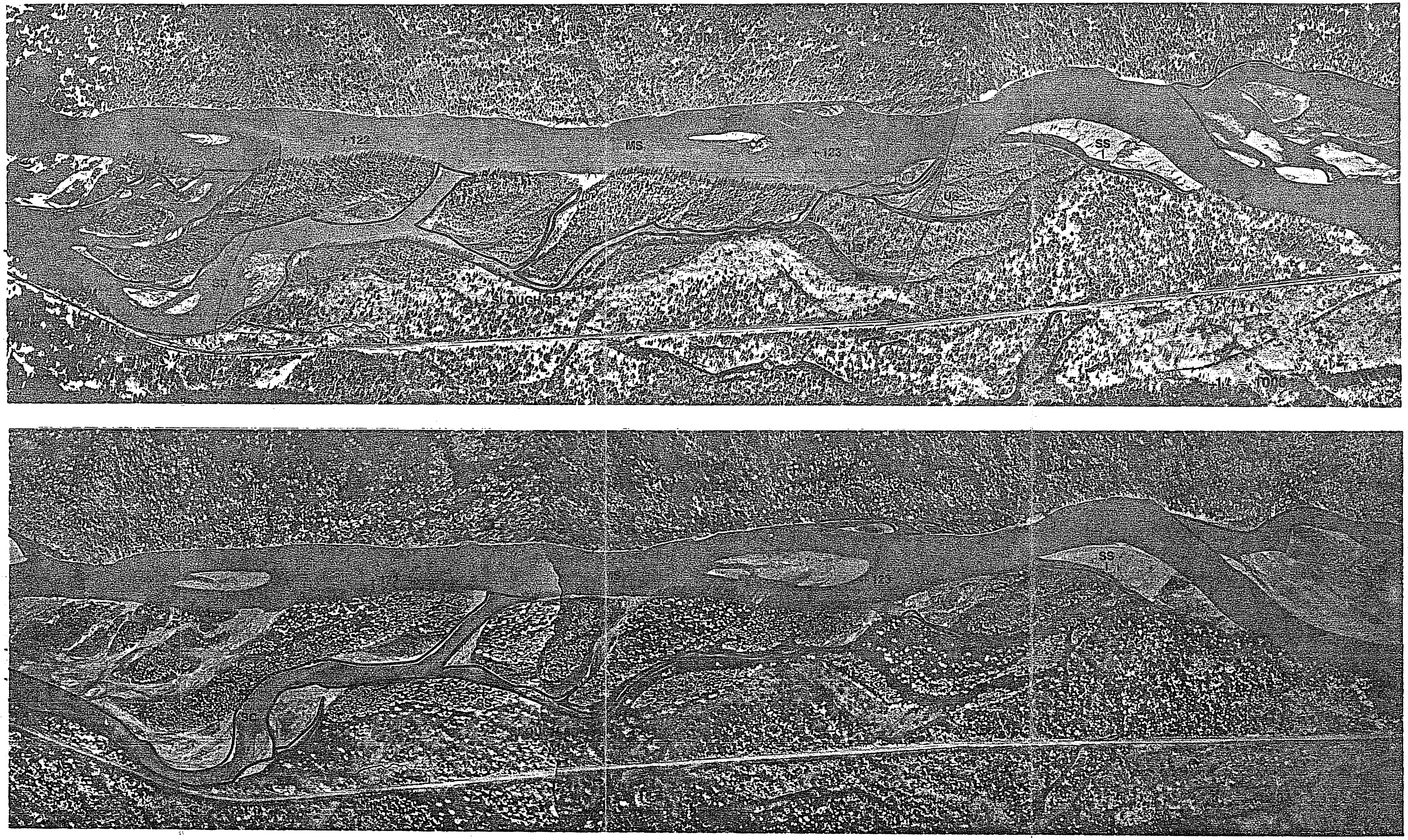
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.25

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 119 TO 121



LEGEND:

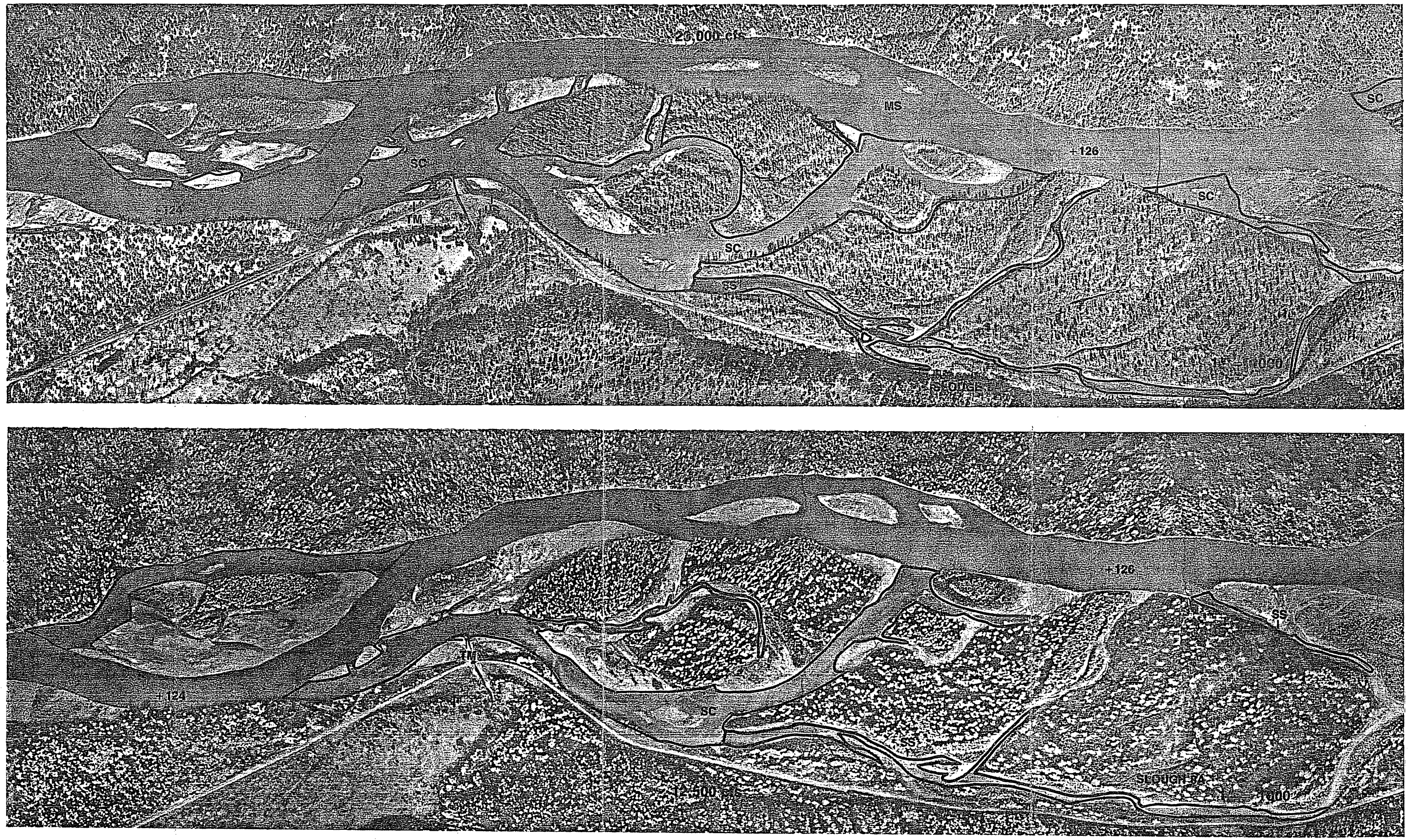
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.26

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 122 TO 124



LEGEND:

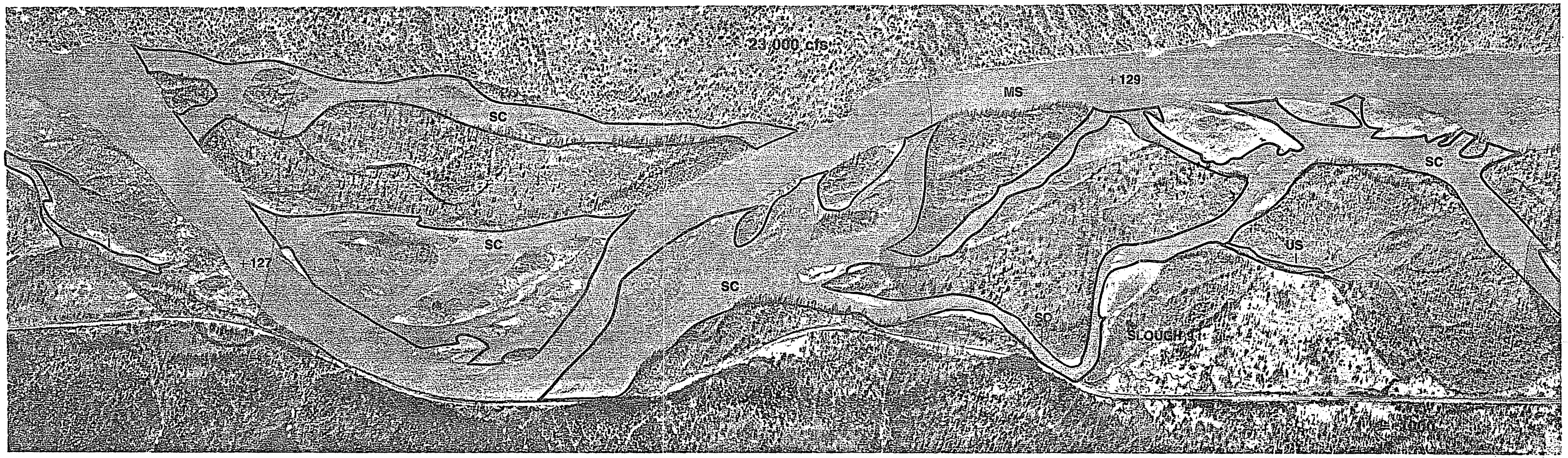
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.27

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 124 TO 126

SOURCE: EWT&A 1984



LEGEND:

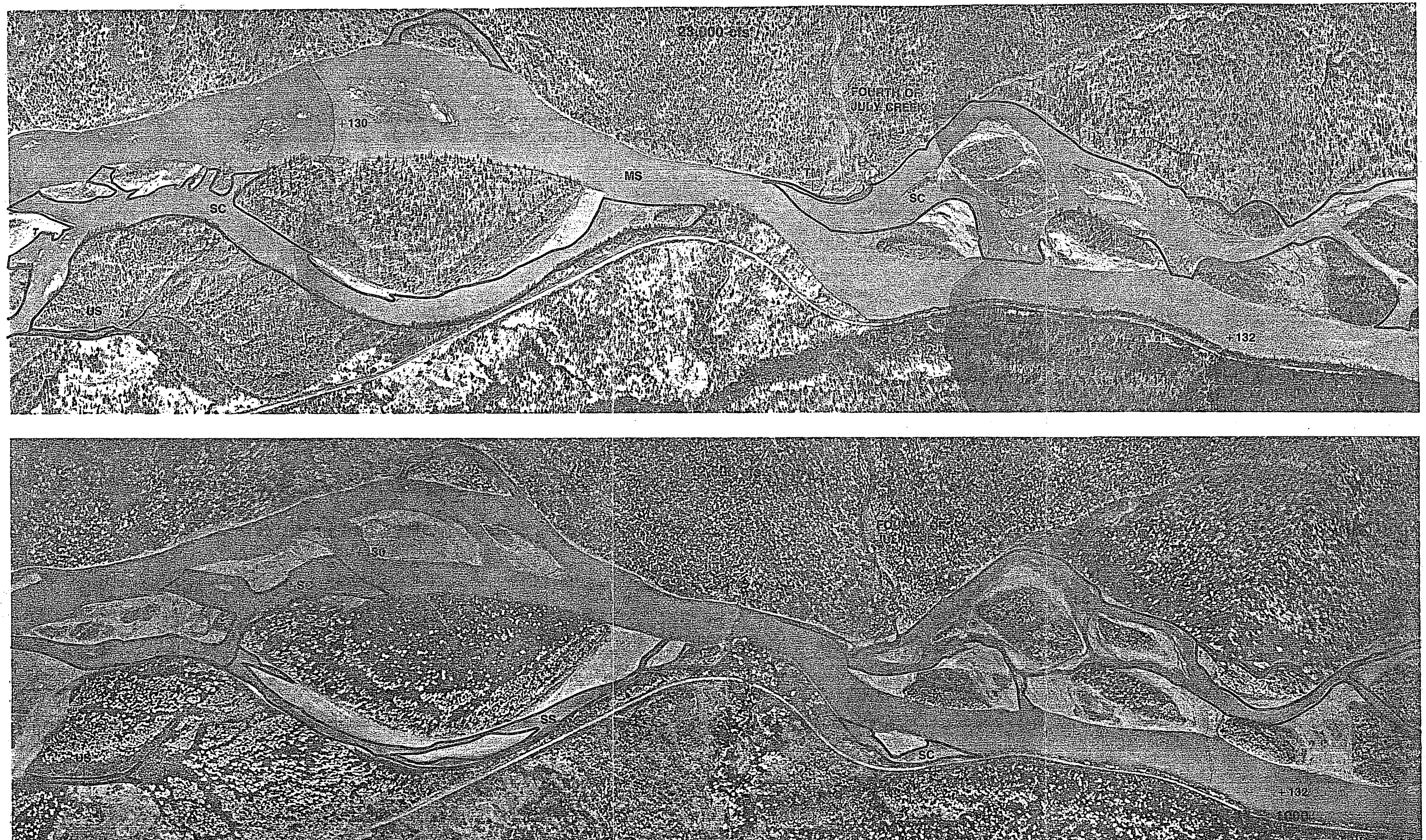
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.28

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 127 TO 129

SOURCE: EWT&A 1984



LEGEND:

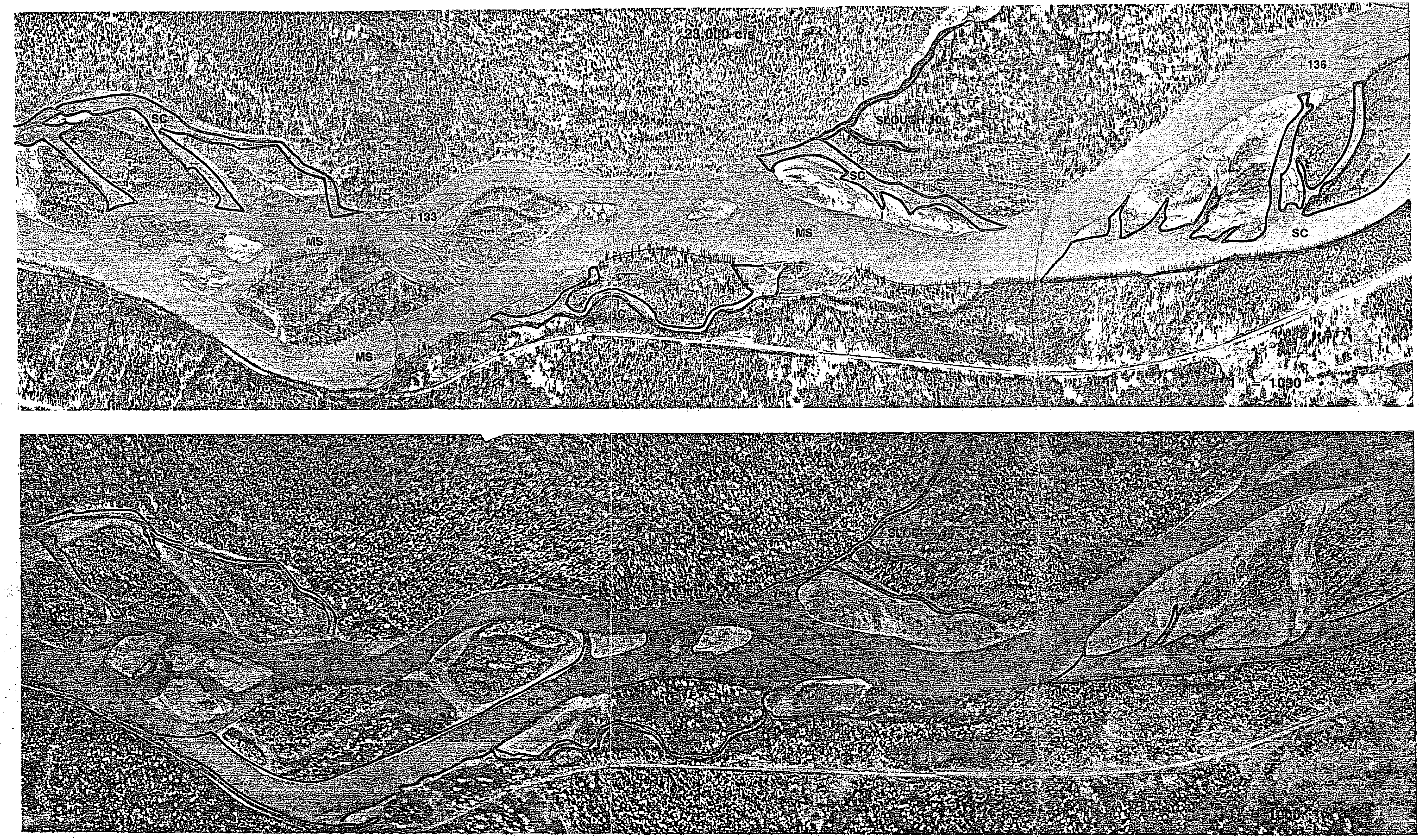
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.29

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 130 TO 132



LEGEND:

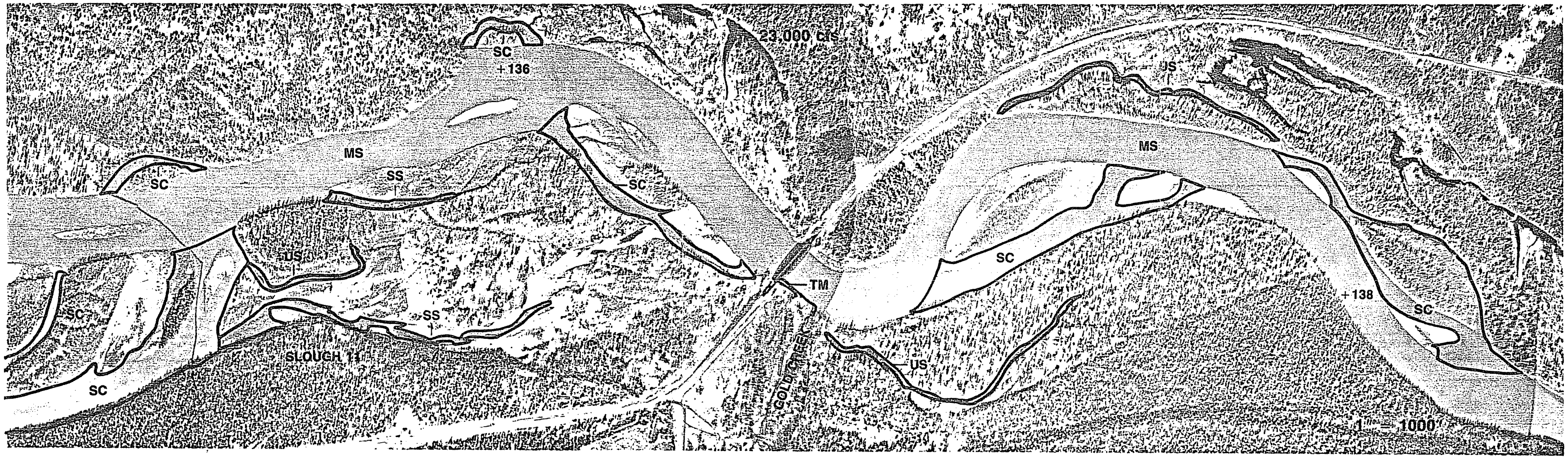
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

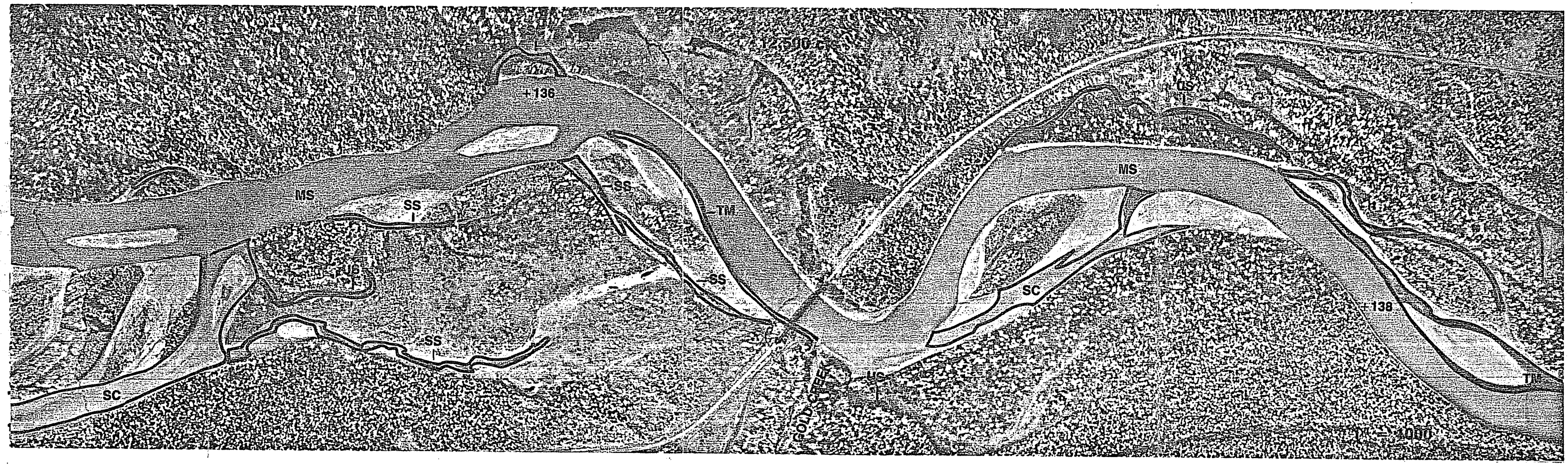
SOURCE: EWT&A 1984

FIGURE E.3.2.30

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 133 TO 136





LEGEND:

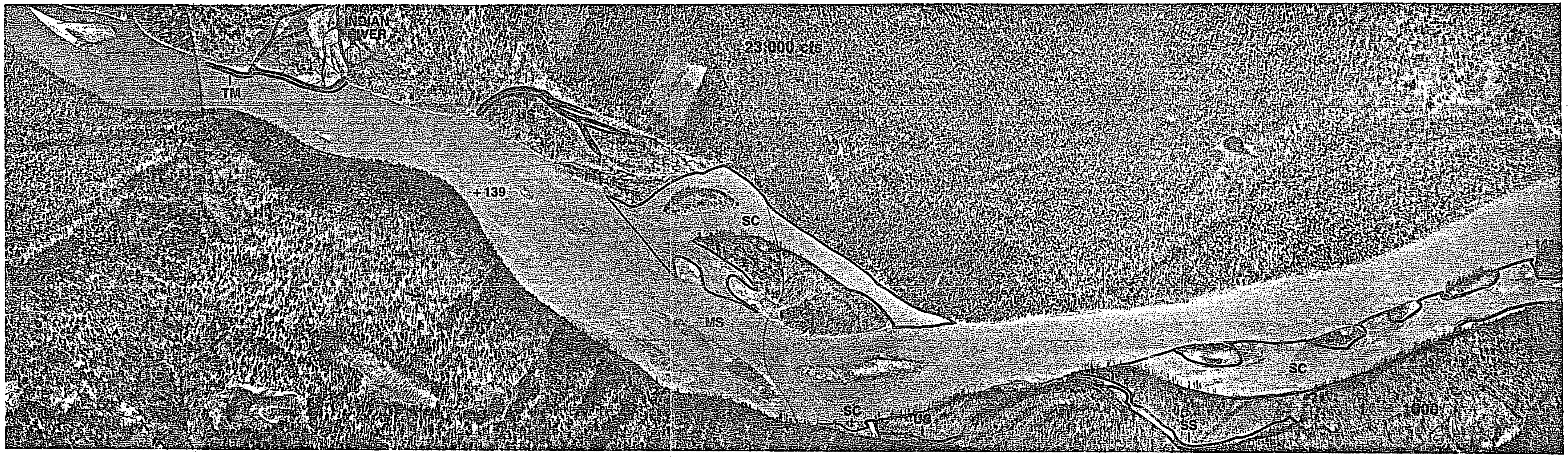
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

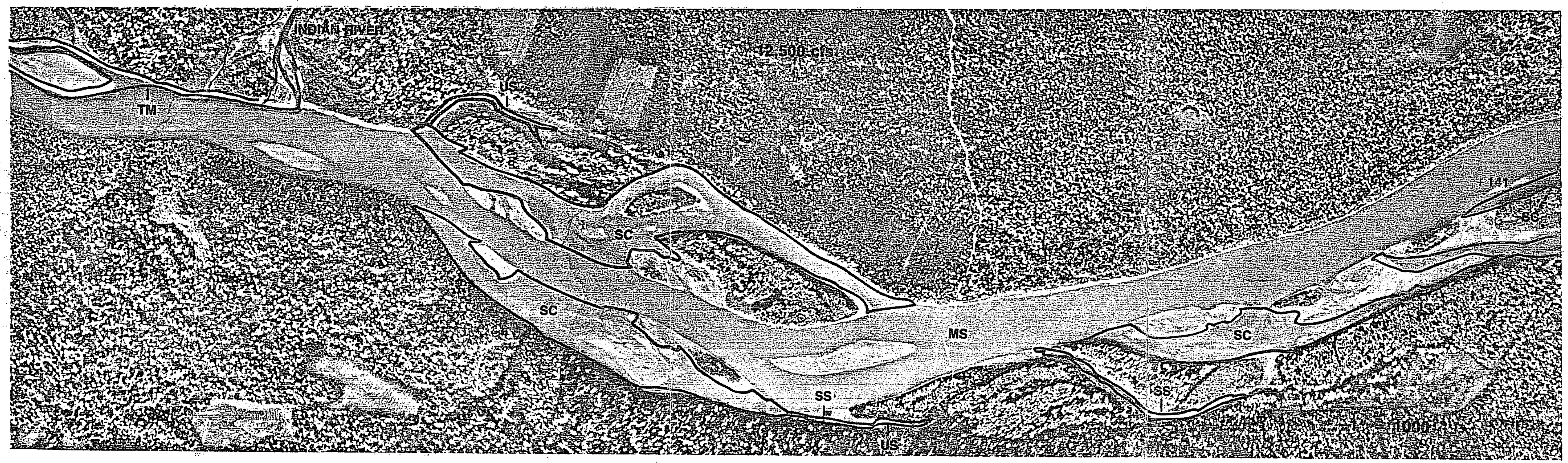
FIGURE E.3.2.31

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

RIVER MILE 136 TO 138

SOURCE: EWT&A 1984





LEGEND:

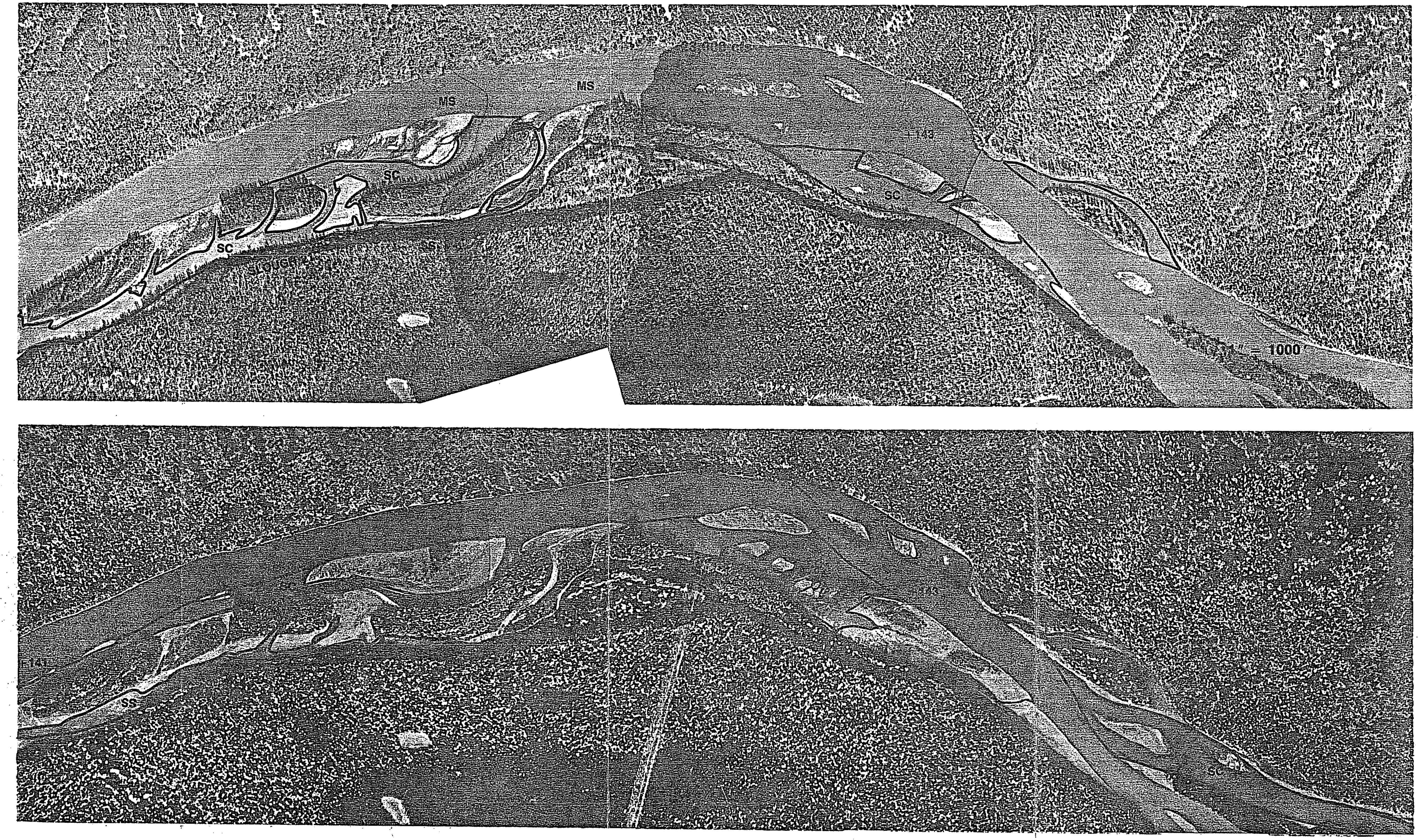
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.32

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 139 TO 141



LEGEND:

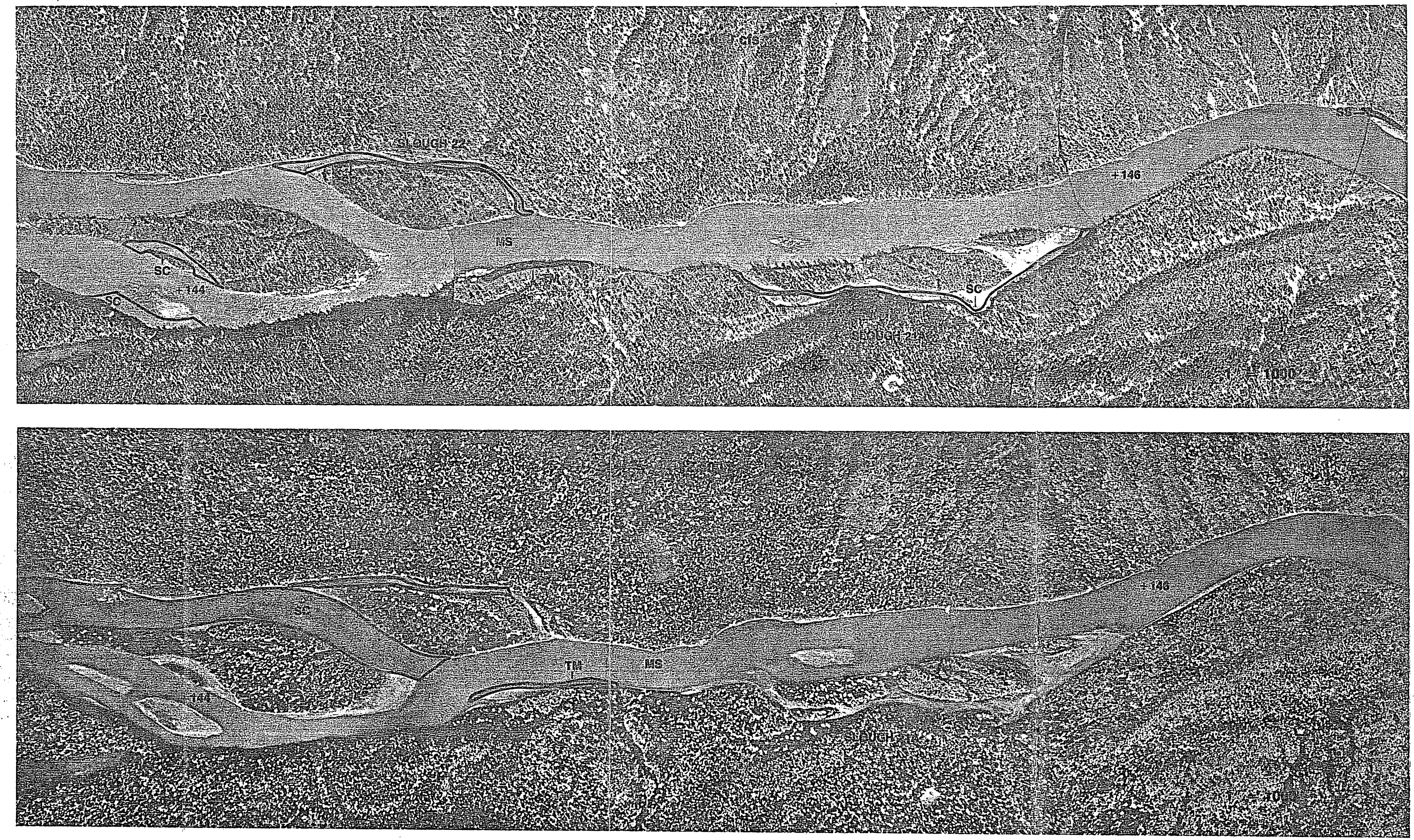
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.33

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 142 TO 144



LEGEND:

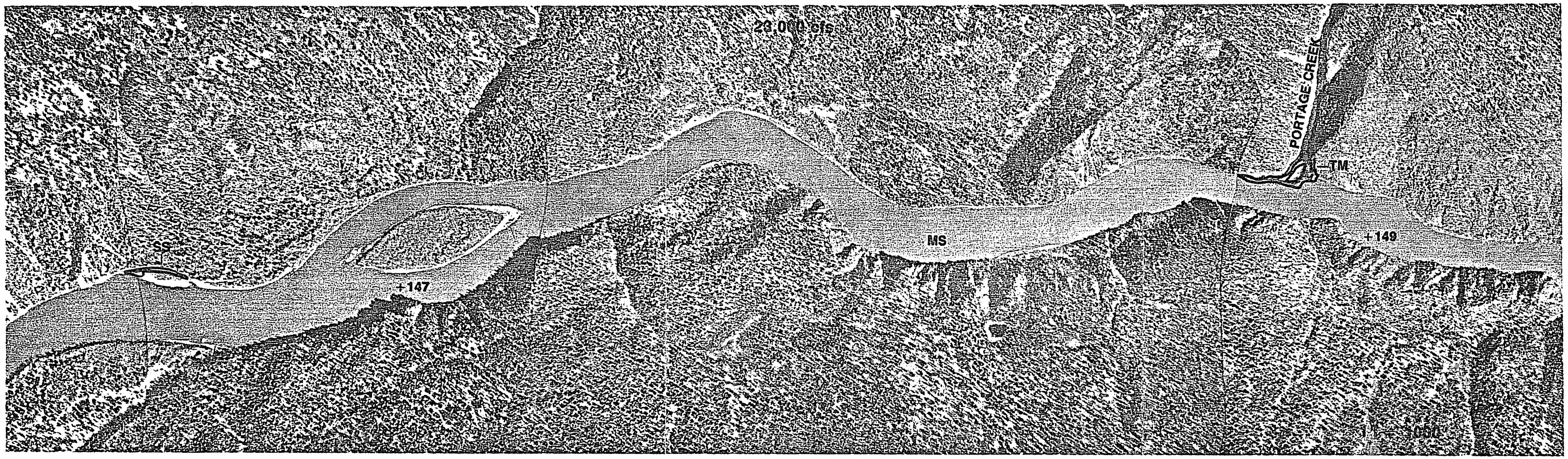
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

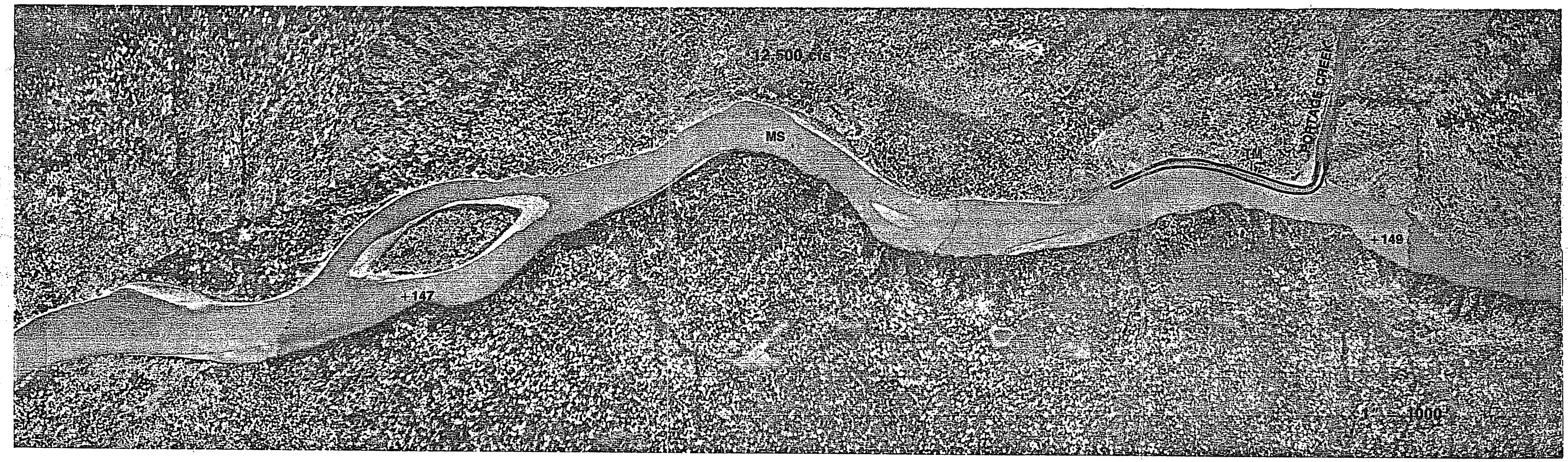
FIGURE E.3.2.34

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

RIVER MILE 144 TO 146





LEGEND:

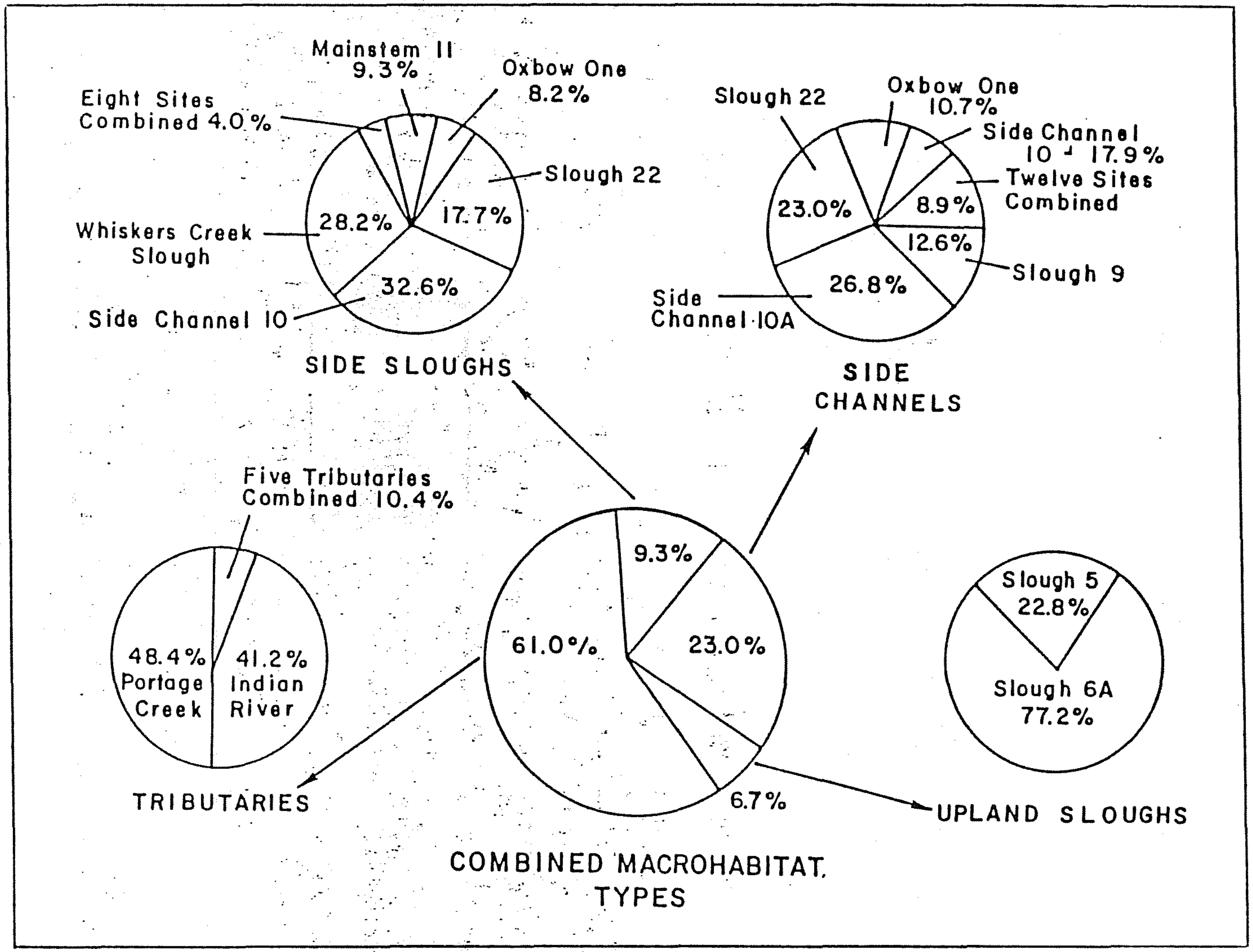
+ = RIVER MILE
MS = MAINSTEM
SC = SIDE CHANNEL
SS = SIDE SLOUGH
US = UPLAND SLOUGH
TM = TRIBUTARY MOUTH

FIGURE E.3.2.35

DELINEATION OF HABITAT AREAS IN THE MIDDLE SUSITNA RIVER
AT 23,000 CFS (TOP) AND 12,500 CFS (BOTTOM)

SOURCE: EWT&A 1984

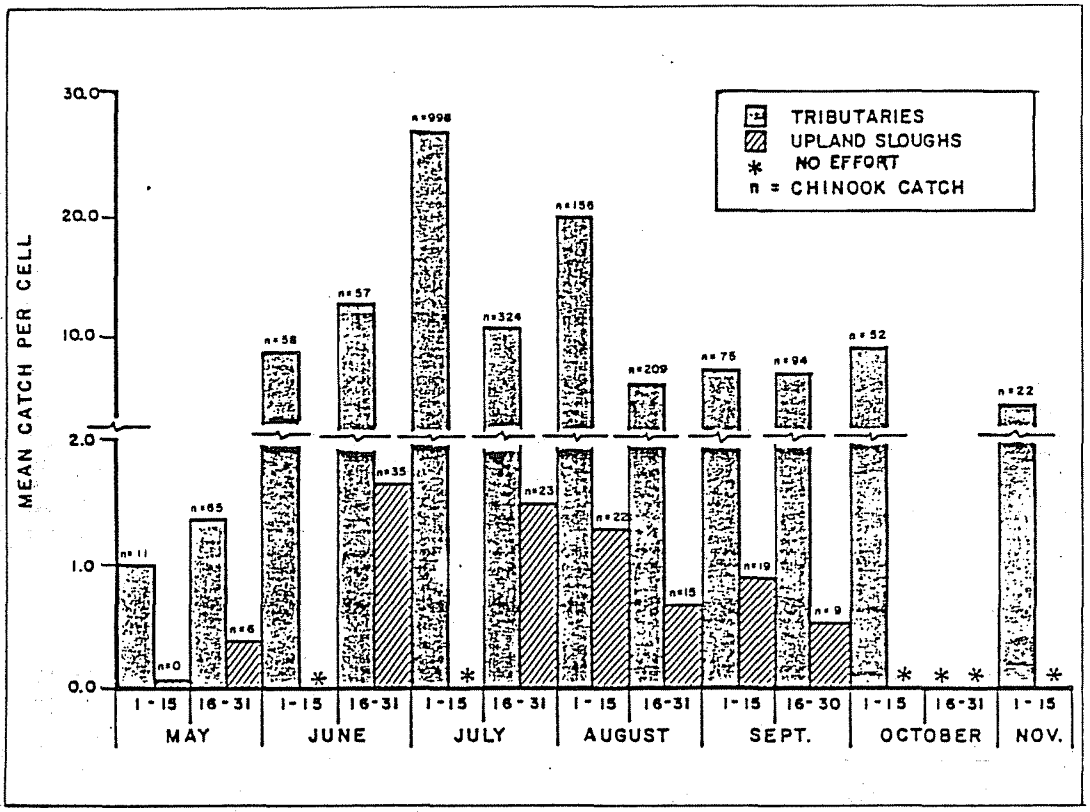
RIVER MILE 147 TO 149



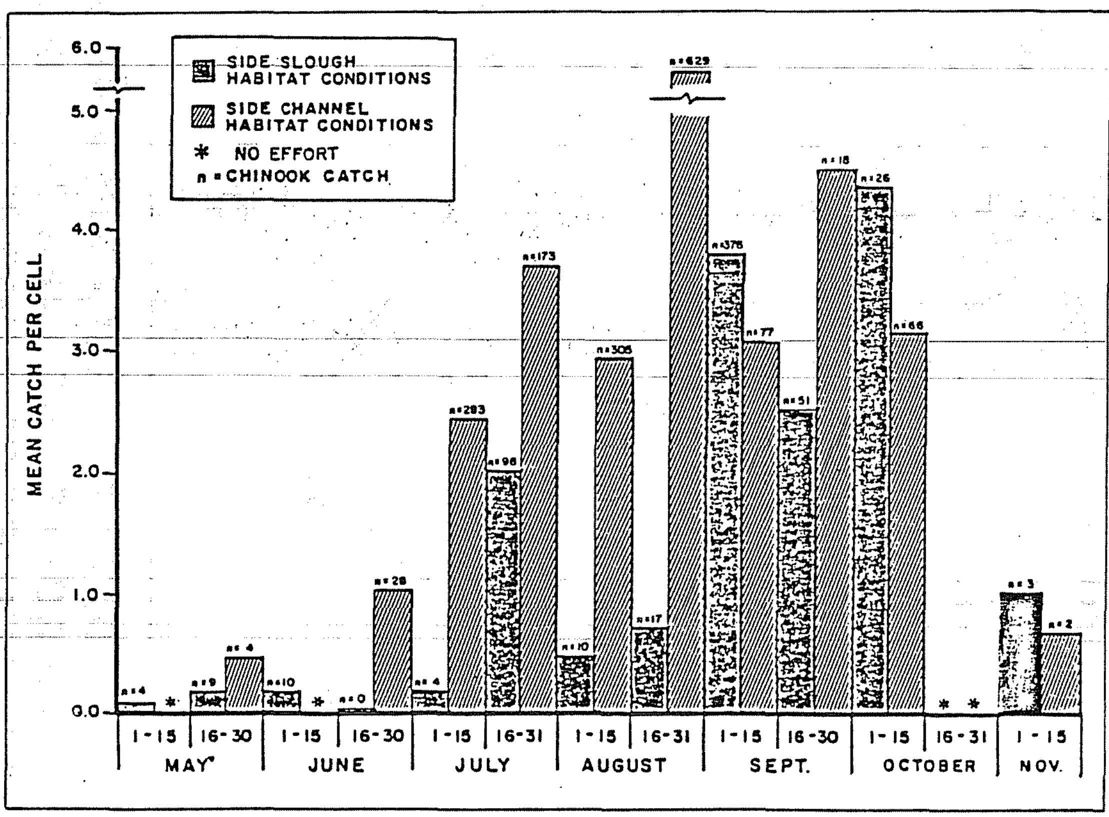
DENSITY DISTRIBUTION AND JUVENILE CHINOOK SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH NOVEMBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL.

SOURCE: ADF&G 1984c

FIGURE E.3.2.36



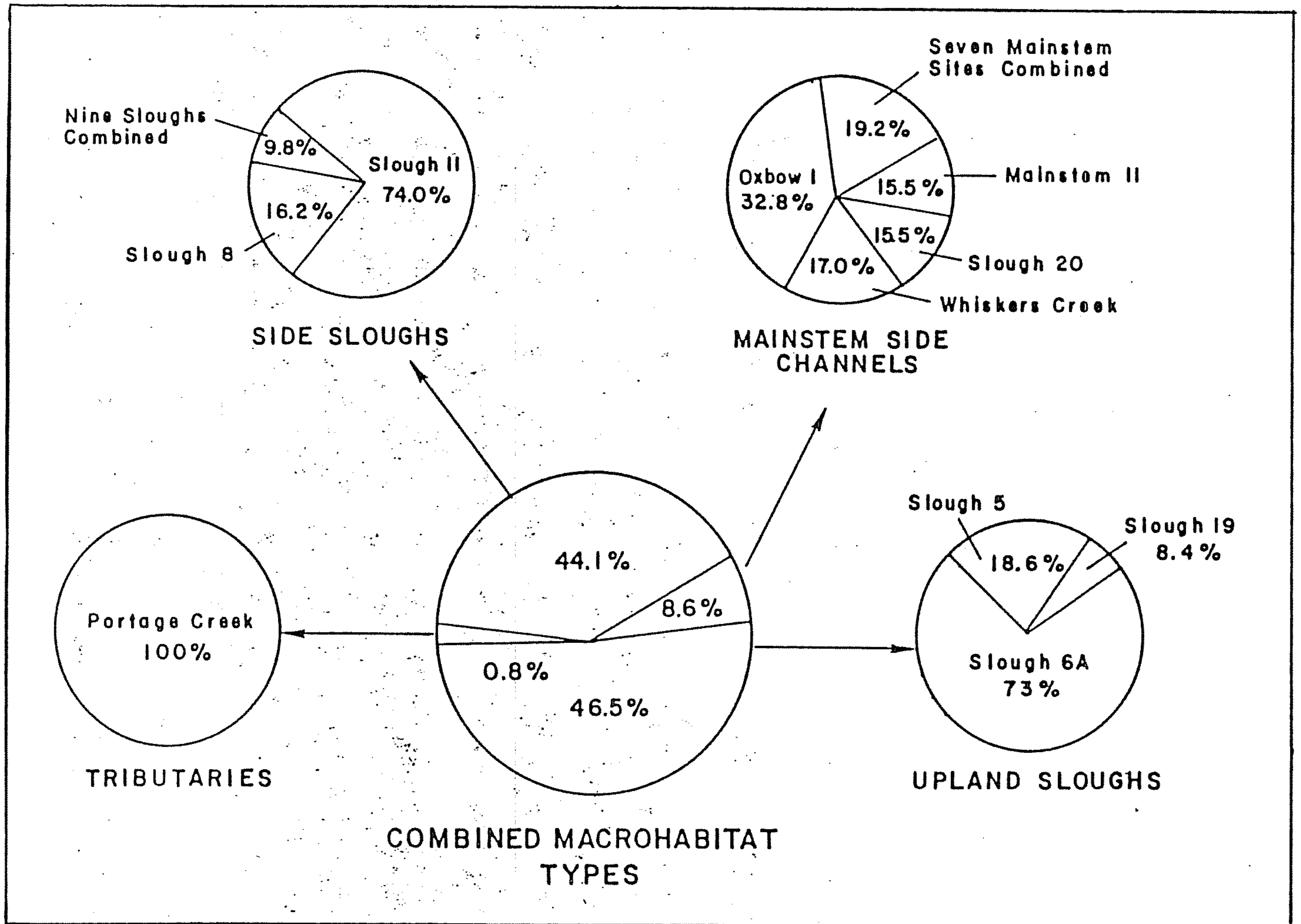
JUVENILE CHINOOK SALMON MEAN CATCH PER CELL AT TRIBUTARIES AND UPLAND SLOUGHS BY SAMPLING PERIOD, MAY THROUGH NOVEMBER 1983



JUVENILE CHINOOK SALMON MEAN CATCH PER CELL AT SIDE SLOUGHS AND SIDE CHANNELS BY SAMPLING PERIOD, MAY THROUGH NOVEMBER 1983

SOURCE: ADF&G 1984c

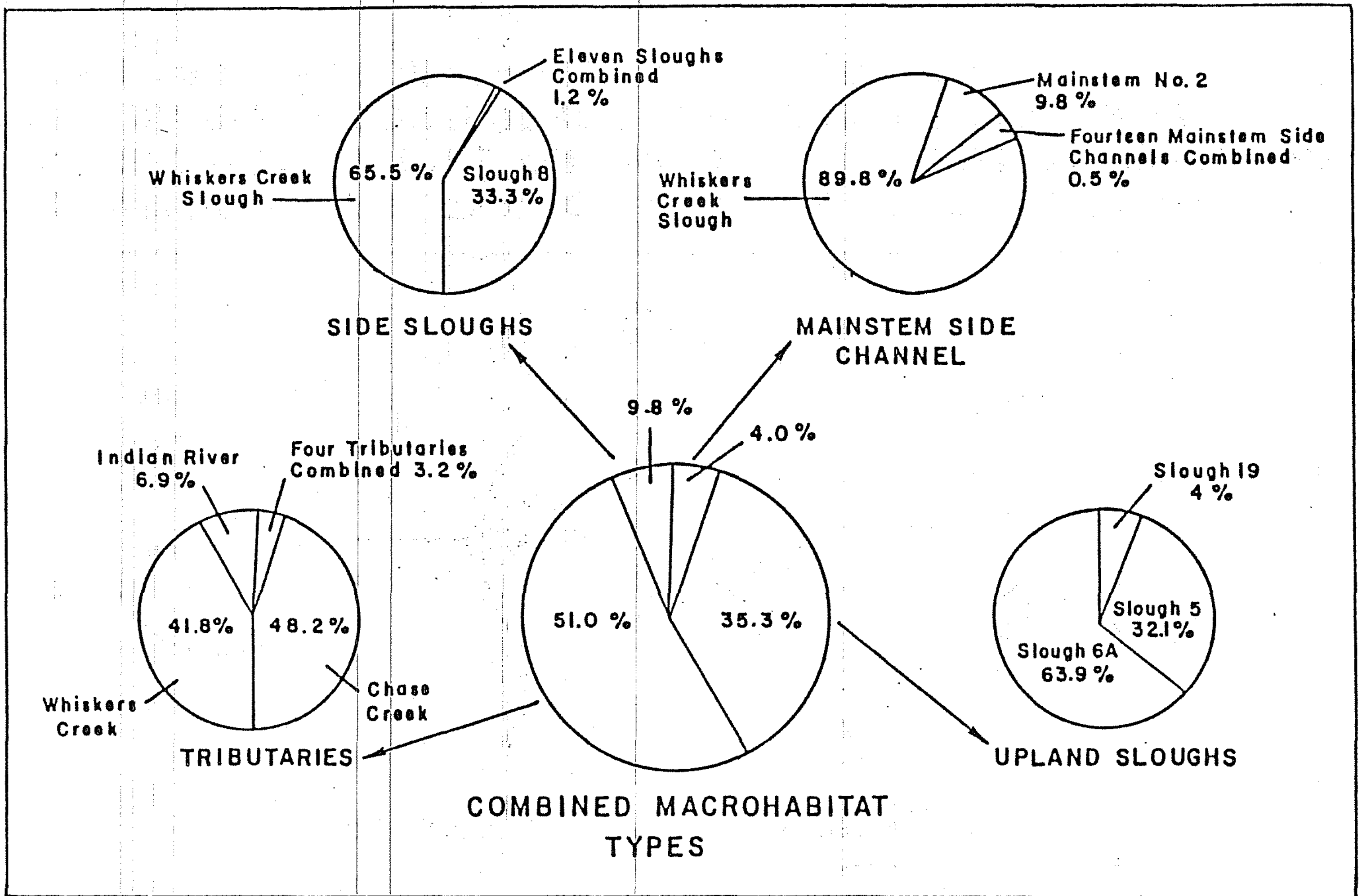
FIGURE E.3.2.37



DENSITY DISTRIBUTION OF JUVENILE SOCKEYE SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH OCTOBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL.

SOURCE: ADF & G 1984c

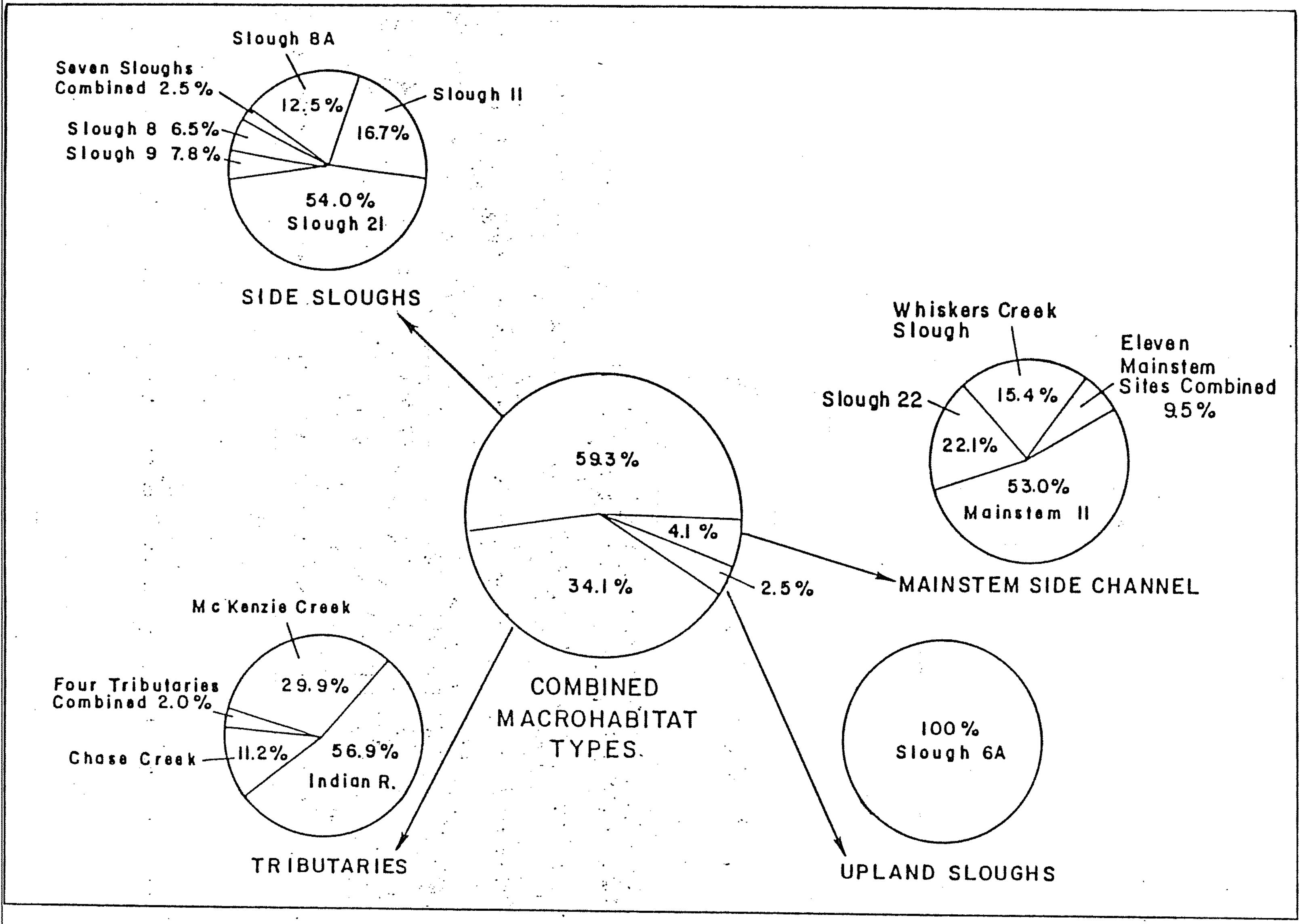
FIGURE E.3.2.38



DENSITY DISTRIBUTION OF JUVENILE COHO SALMON BY MACROHABITAT TYPE ON THE SUSITNA BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON, MAY THROUGH NOVEMBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL.

SOURCE: ADF&G 1984c

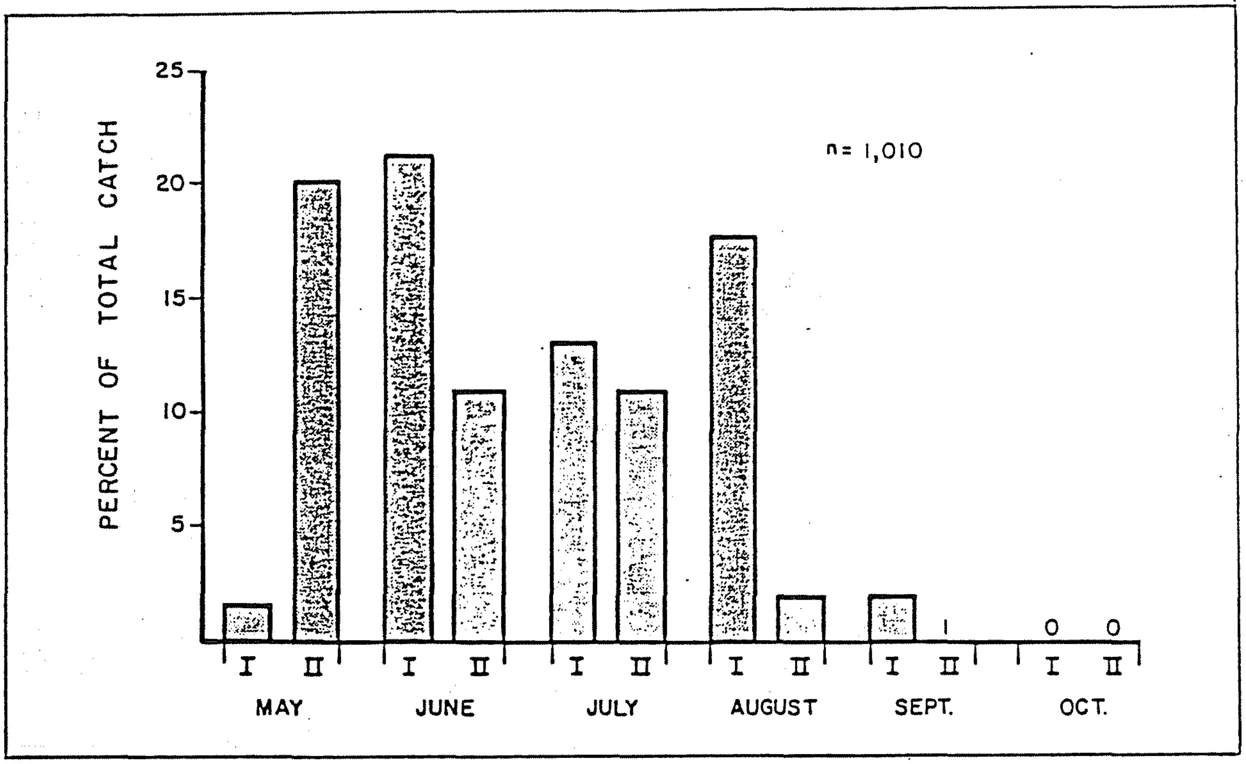
FIGURE: E.3.2.39



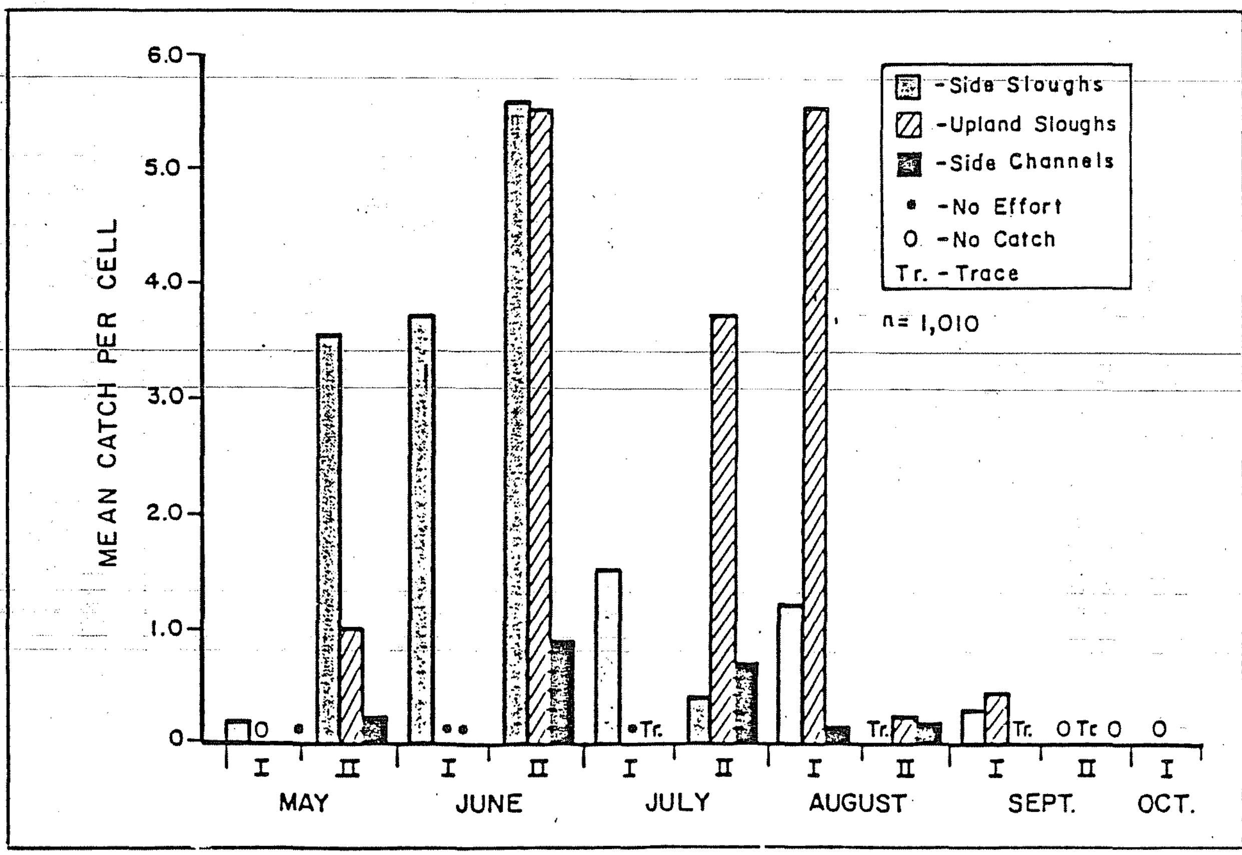
DENSITY DISTRIBUTION OF JUVENILE CHUM SALMON BY MACROHABITAT TYPE ON THE SUSITNA RIVER BETWEEN THE CHULITNA RIVER CONFLUENCE AND DEVIL CANYON , MAY THROUGH OCTOBER 1983. PERCENTAGES ARE BASED ON MEAN CATCH PER CELL.

SOURCE: ADF&G 1984c

FIGURE E.3.2.40



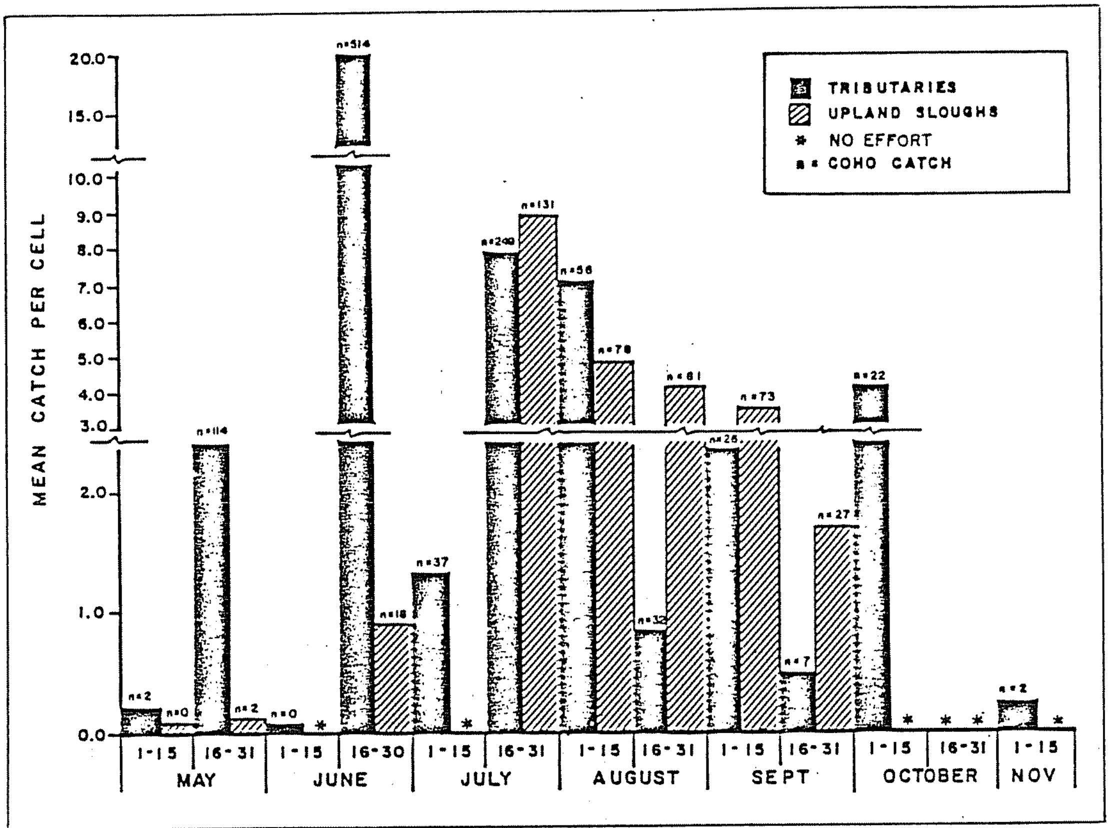
PERCENTAGES OF THE TOTAL JUVENILE SOCKEYE SALMON CATCH BY SAMPLING PERIOD, MAY THROUGH OCTOBER 1983



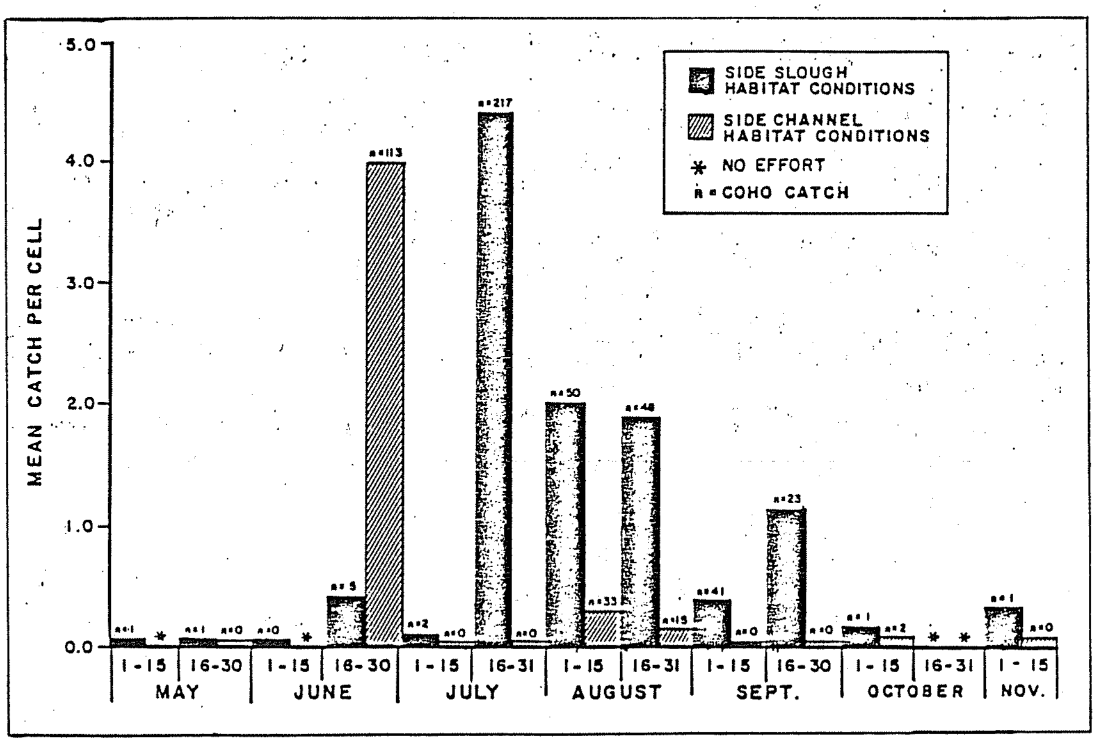
JUVENILE SOCKEYE SALMON MEAN CATCH PER CELL AT THREE MACROHABITATS BY SAMPLING PERIOD MAY THROUGH OCTOBER 1983

SOURCE: ADF&G 1984c

FIGURE E.3.2.41



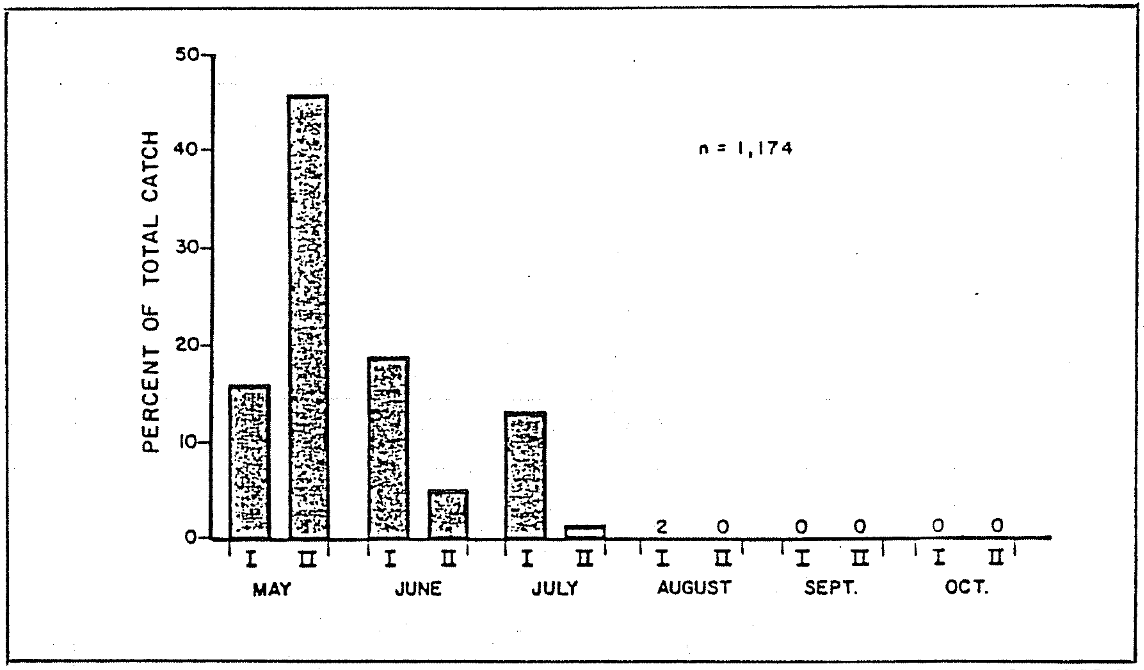
JUVENILE COHO SALMON MEAN CATCH PER CELL AT TRIBUTARIES AND UPLAND SLOUGHS BY SAMPLING PERIOD, MAY THROUGH NOVEMBER 1983.



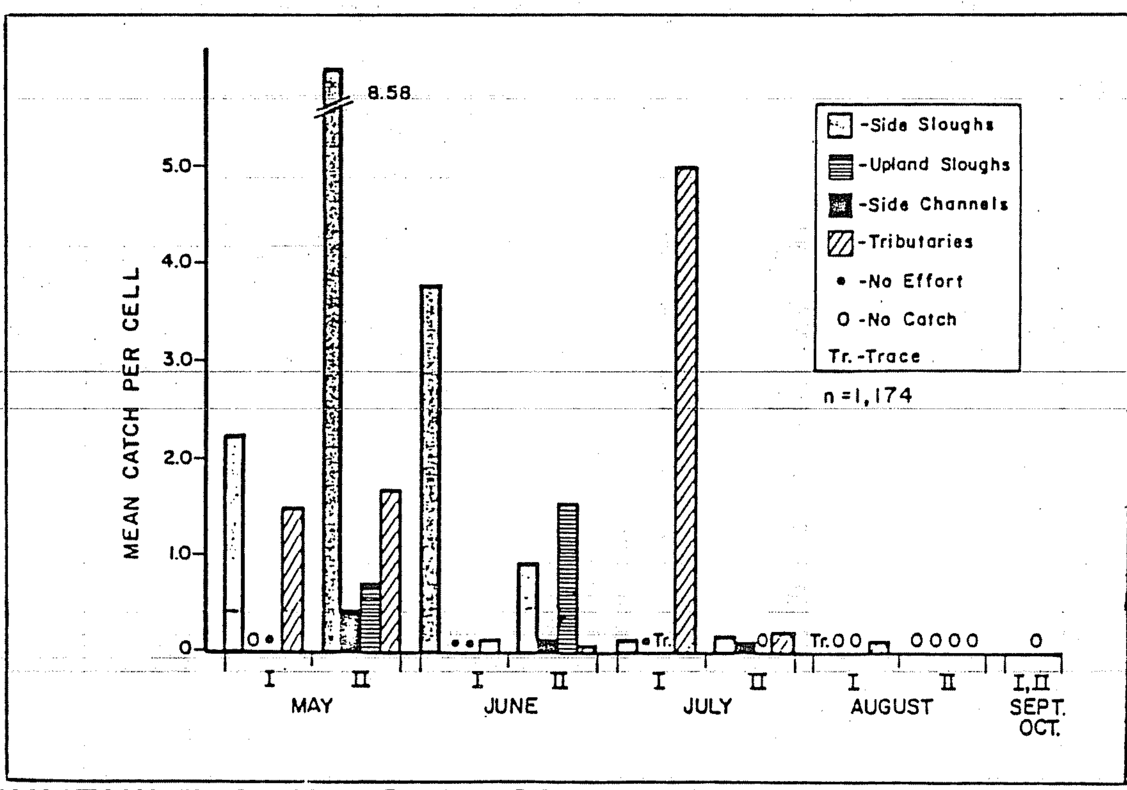
JUVENILE COHO SALMON MEAN CATCH PER CELL AT SIDE SLOUGHS AND SIDE CHANNELS BY SAMPLING PERIOD, MAY THROUGH NOVEMBER 1983

SOURCE: ADF&G 1984c

FIGURE E.3.2.4 2



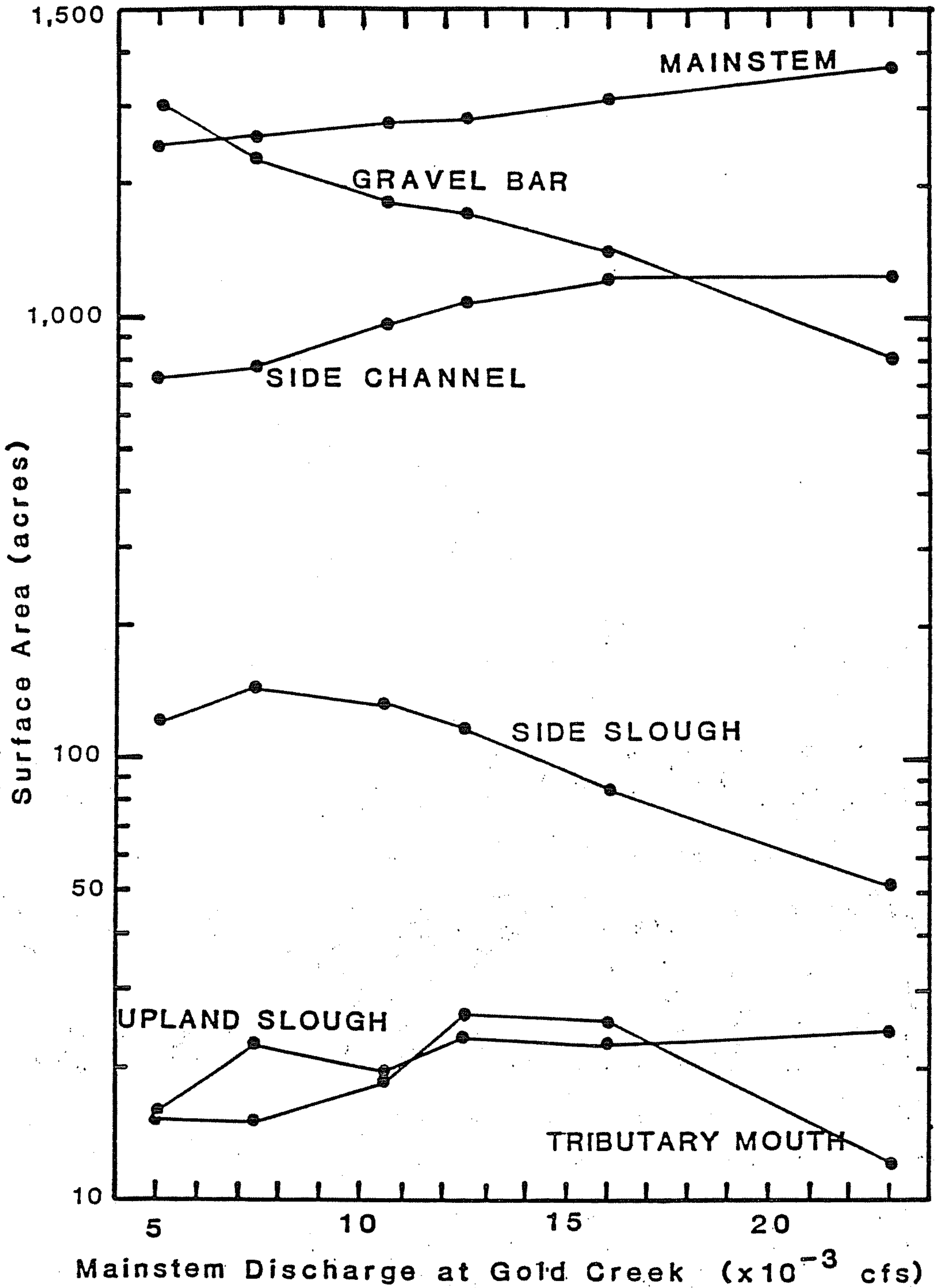
PERCENTAGES OF THE TOTAL JUVENILE CHUM SALMON CATCH BY SAMPLING PERIOD, MAY THROUGH OCTOBER 1983.



JUVENILE CHUM SALMON MEAN CATCH PER CELL AT THE FOUR MACROHABITATS BY SAMPLING PERIOD, MAY THROUGH OCTOBER 1983.

SOURCE: ADF&G 1984c

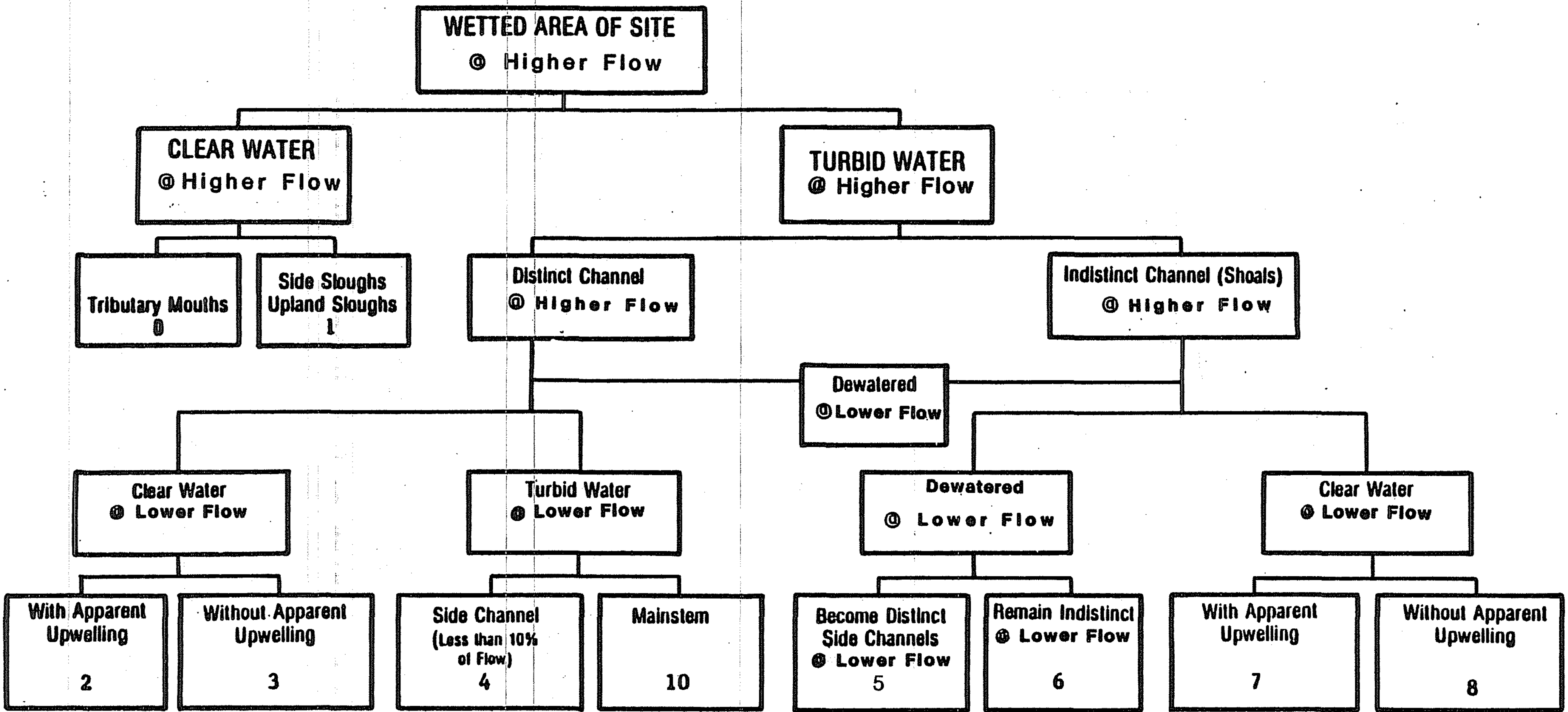
FIGURE E.3.2.43



SURFACE AREA RESPONSES TO MAINSTEM DISCHARGE IN THE TALKEETNA-TO-DEVIL CANYON REACH OF THE SUSITNA RIVER (RM 101 TO 149).

SOURCE: EWT&A 1985b

FIGURE E.3.2.44



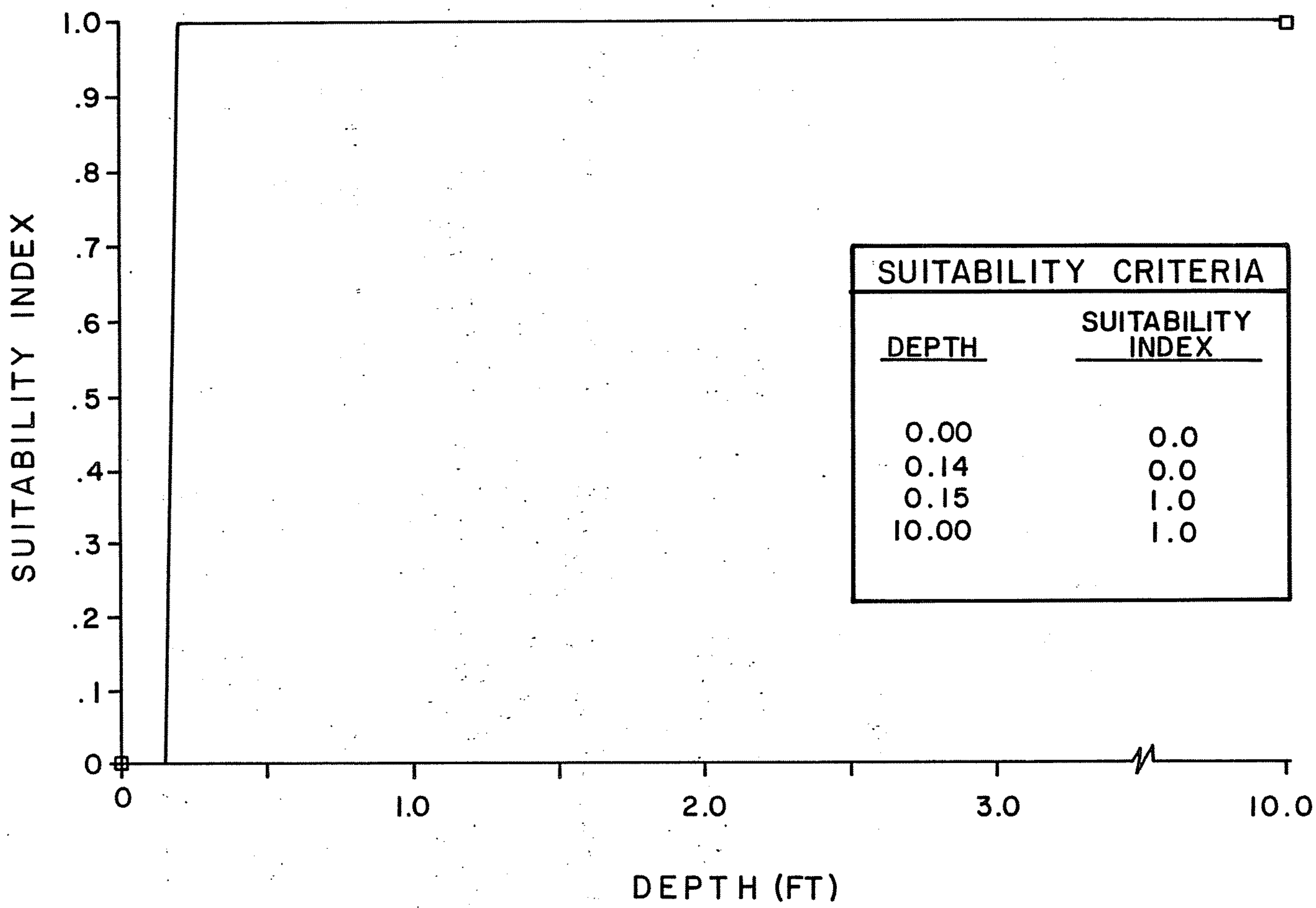
FLOW CHART FOR CLASSIFYING THE TRANSFORMATION OF AQUATIC HABITAT TYPES BETWEEN TWO FLOWS (CATEGORIES 0-10).

SOURCE: ADAPTED FROM EWT&A AND WCC 1985;
EWT&A AND AEIDC 1985

FIGURE E.3.2.45

JUVENILE CHINOOK

SUITABILITY CRITERIA CURVE DEPTH

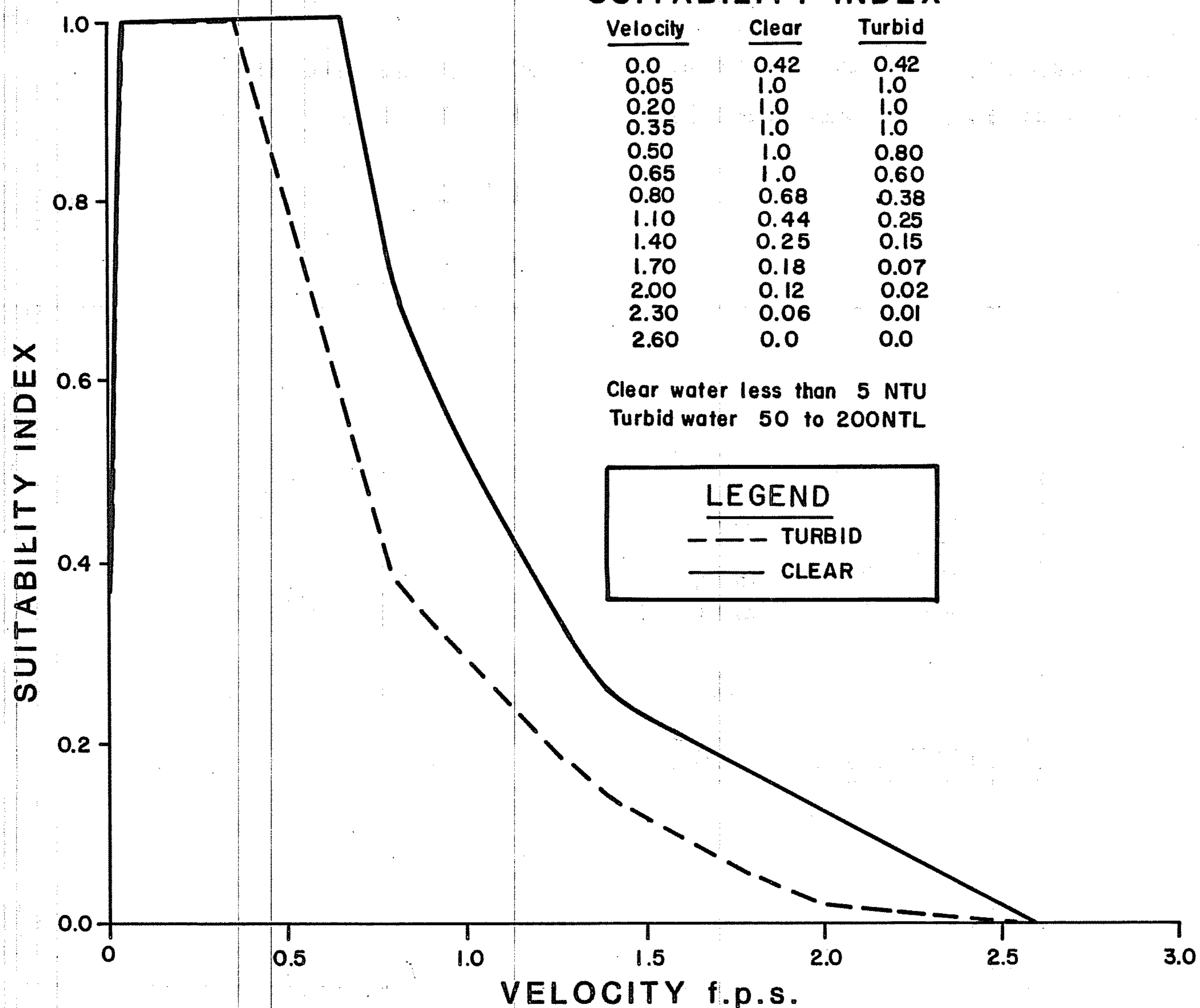


SUITABILITY CRITERIA	
DEPTH	SUITABILITY INDEX
0.00	0.0
0.14	0.0
0.15	1.0
10.00	1.0

JUVENILE CHINOOK SALMON SUITABILITY CRITERIA FOR DEPTH APPLICABLE TO CLEAR AND TURBID WATER HABITATS

SOURCE: ADF&G 1984c

FIGURE E.3.2.46



SUITABILITY INDEX

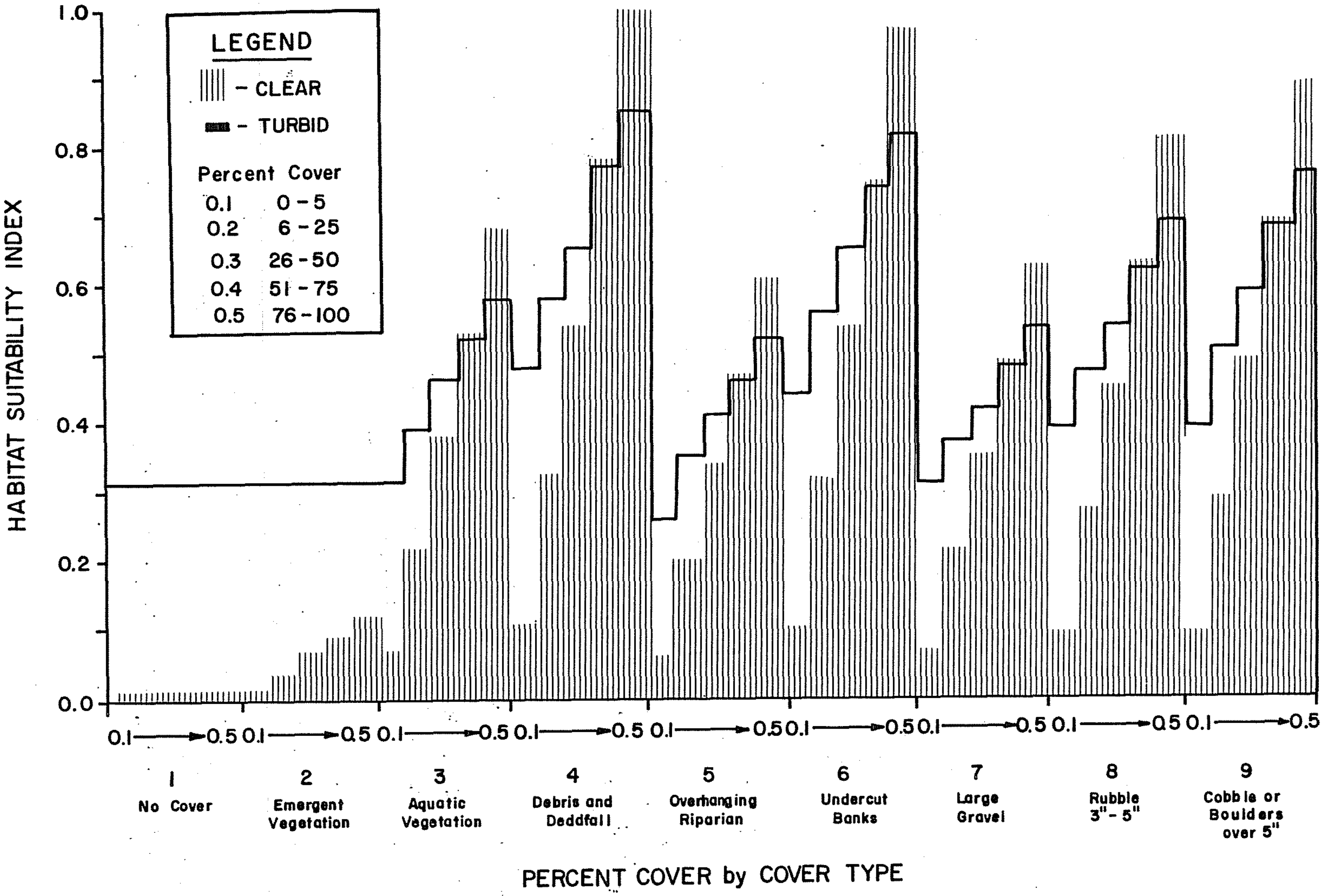
Velocity	Clear	Turbid
0.0	0.42	0.42
0.05	1.0	1.0
0.20	1.0	1.0
0.35	1.0	1.0
0.50	1.0	0.80
0.65	1.0	0.60
0.80	0.68	0.38
1.10	0.44	0.25
1.40	0.25	0.15
1.70	0.18	0.07
2.00	0.12	0.02
2.30	0.06	0.01
2.60	0.0	0.0

Clear water less than 5 NTU
Turbid water 50 to 200NTL

JUVENILE CHINOOK SALMON SUITABILITY CRITERIA FOR VELOCITY APPLICABLE TO CLEAR AND TURBID WATER HABITATS.

FIGURE E.3.2.47

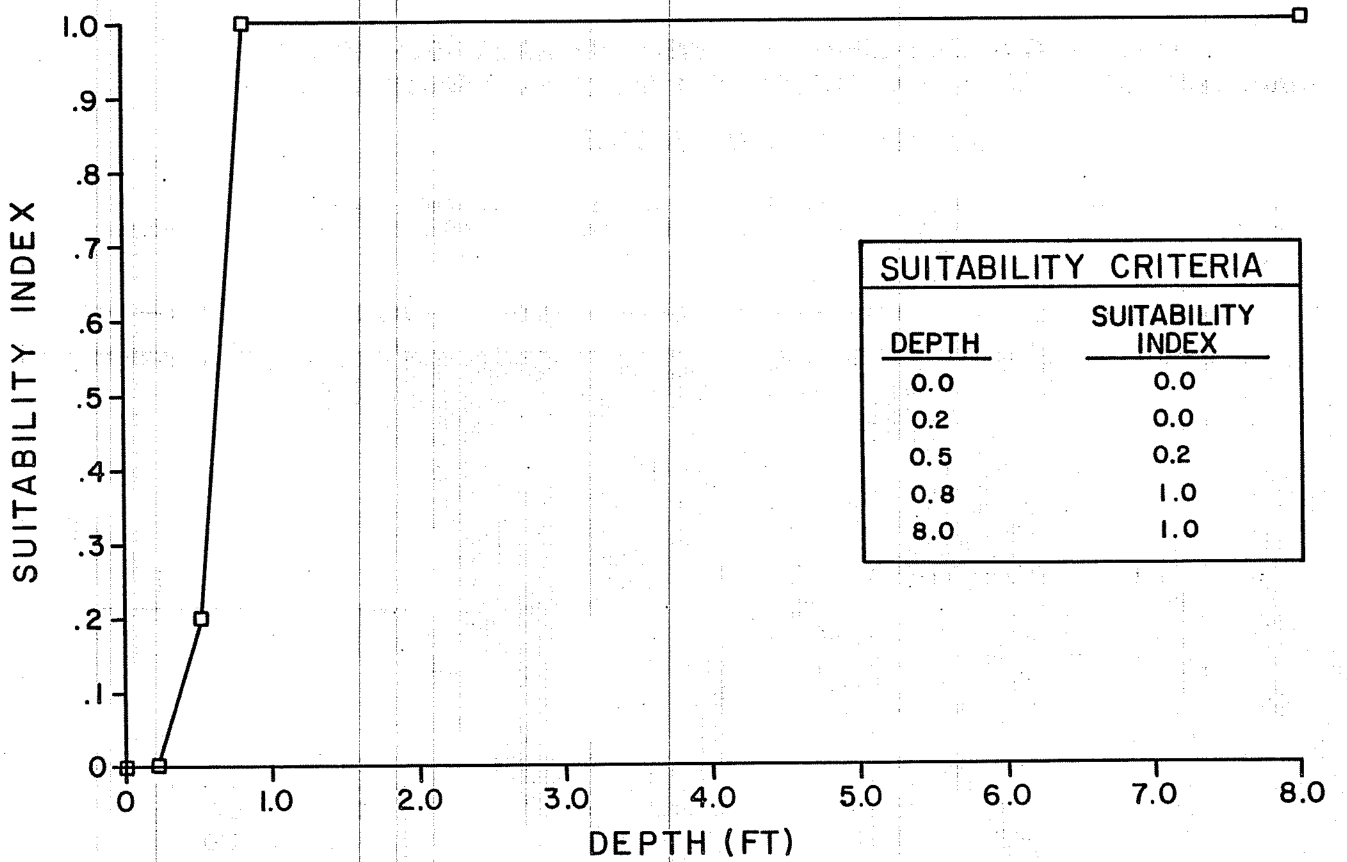
SOURCE: ADF&G 1984c; EWT&A and WCC 1985



COVER SUITABILITY CRITERIA RECOMMENDED FOR USE IN MODELING JUVENILE CHINOOK HABITAT UNDER CLEAR AND TURBID WATER CONDITION.

FIGURE E.3.2.48

SOURCE: EWT&A and WCC 1985; EWT&A and AEIDC 1985

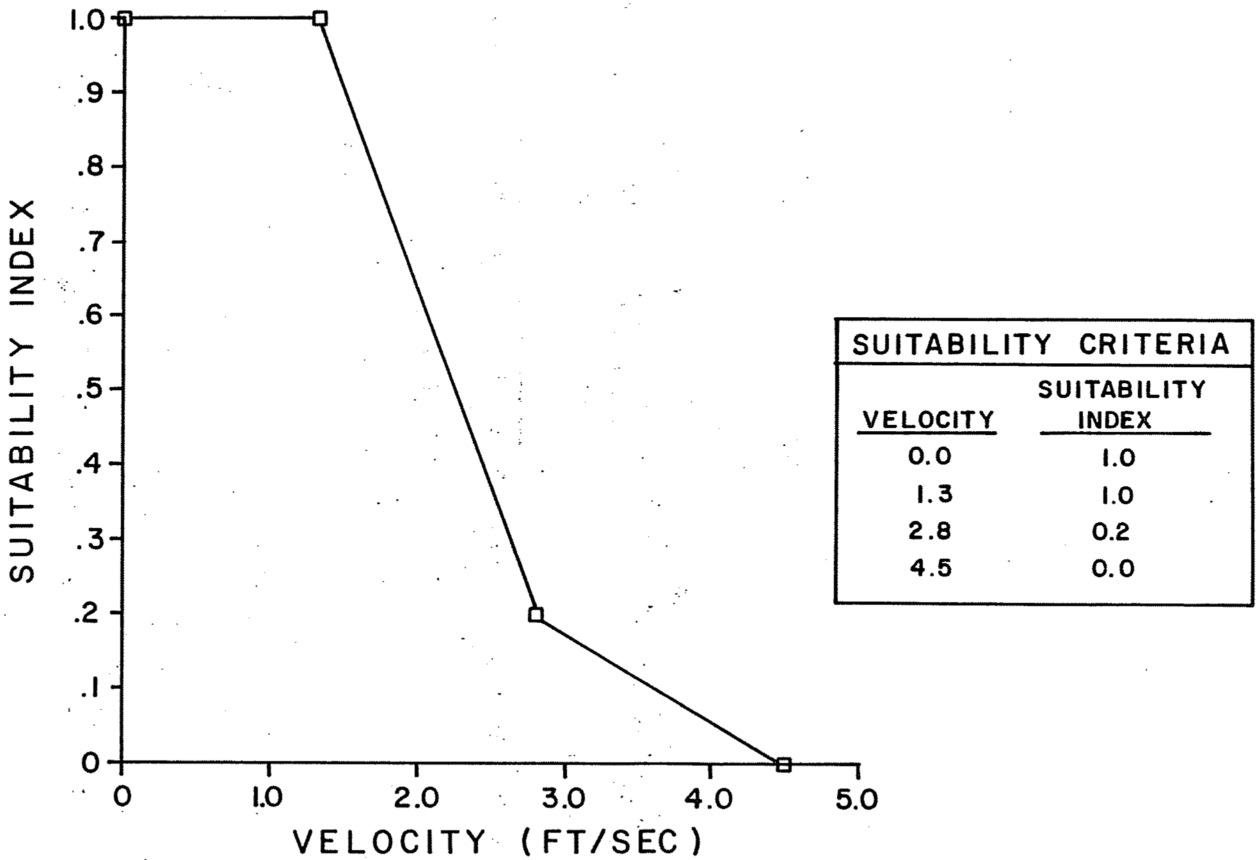


DEPTH	SUITABILITY INDEX
0.0	0.0
0.2	0.0
0.5	0.2
0.8	1.0
8.0	1.0

DEPTH SUITABILITY CURVE FOR CHUM SALMON SPAWNING.

FIGURE E. 3.2.49

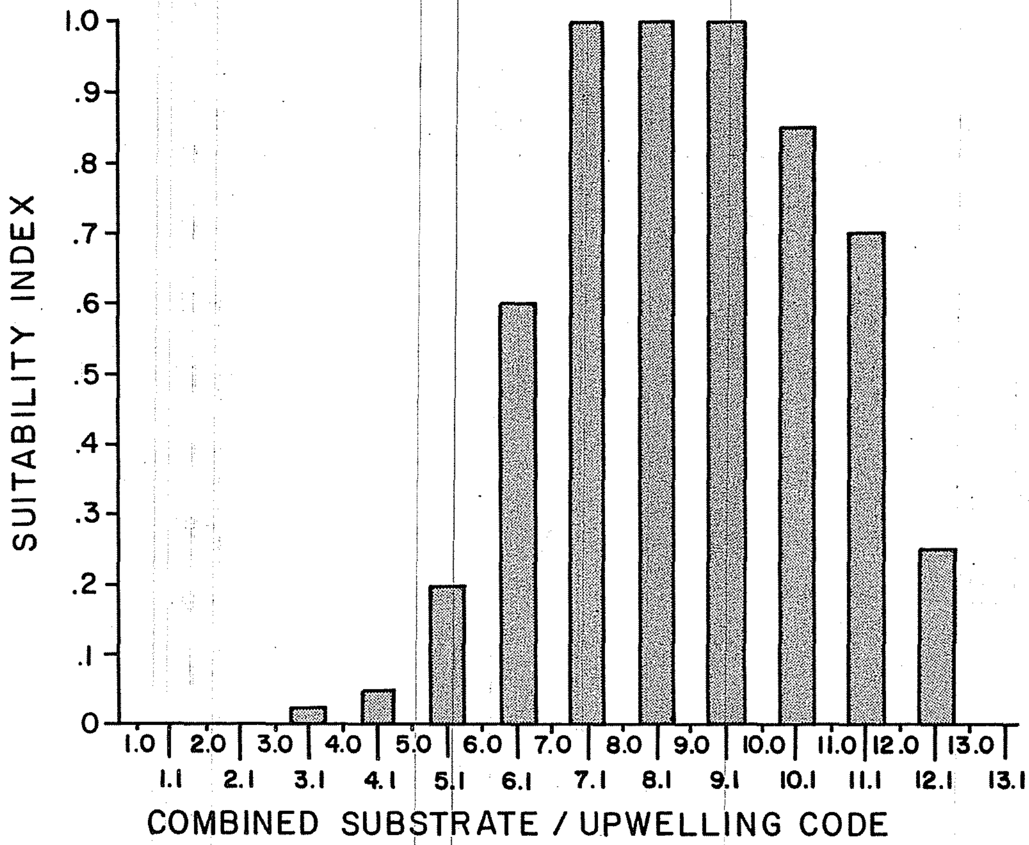
SOURCE: ADF&G 1984b



VELOCITY SUITABILITY CURVE FOR CHUM SALMON SPAWNING.

SOURCE ADF&G 1984b

FIGURE E.3.2.50



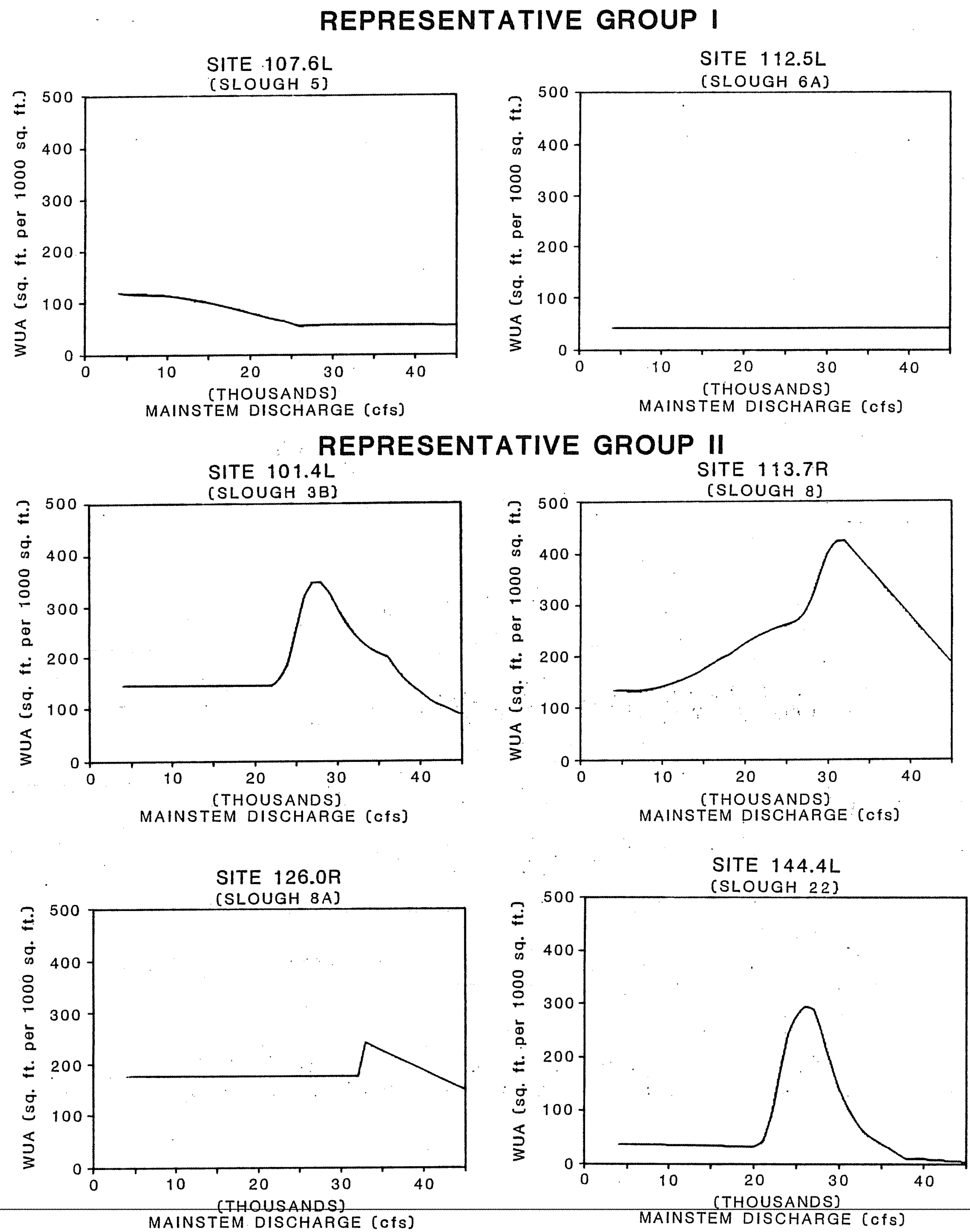
SUITABILITY CRITERIA

CODE	SUITABILITY INDEX
1.0	0.00
1.1	0.00
2.0	0.00
2.1	0.00
3.0	0.00
3.1	0.025
4.0	0.00
4.1	0.05
5.0	0.00
5.1	0.20
6.0	0.00
6.1	0.60
7.0	0.00
7.1	1.00
8.0	0.00
8.1	1.00
9.0	0.00
9.1	1.00
10.0	0.00
10.1	0.85
11.0	0.00
11.1	0.70
12.0	0.00
12.1	0.25
13.0	0.00
13.1	0.00

COMBINED SUBSTRATE/UPWELLING SUITABILITY CURVE FOR CHUM SALMON SPAWNING.

SOURCE: ADF&G 1984b

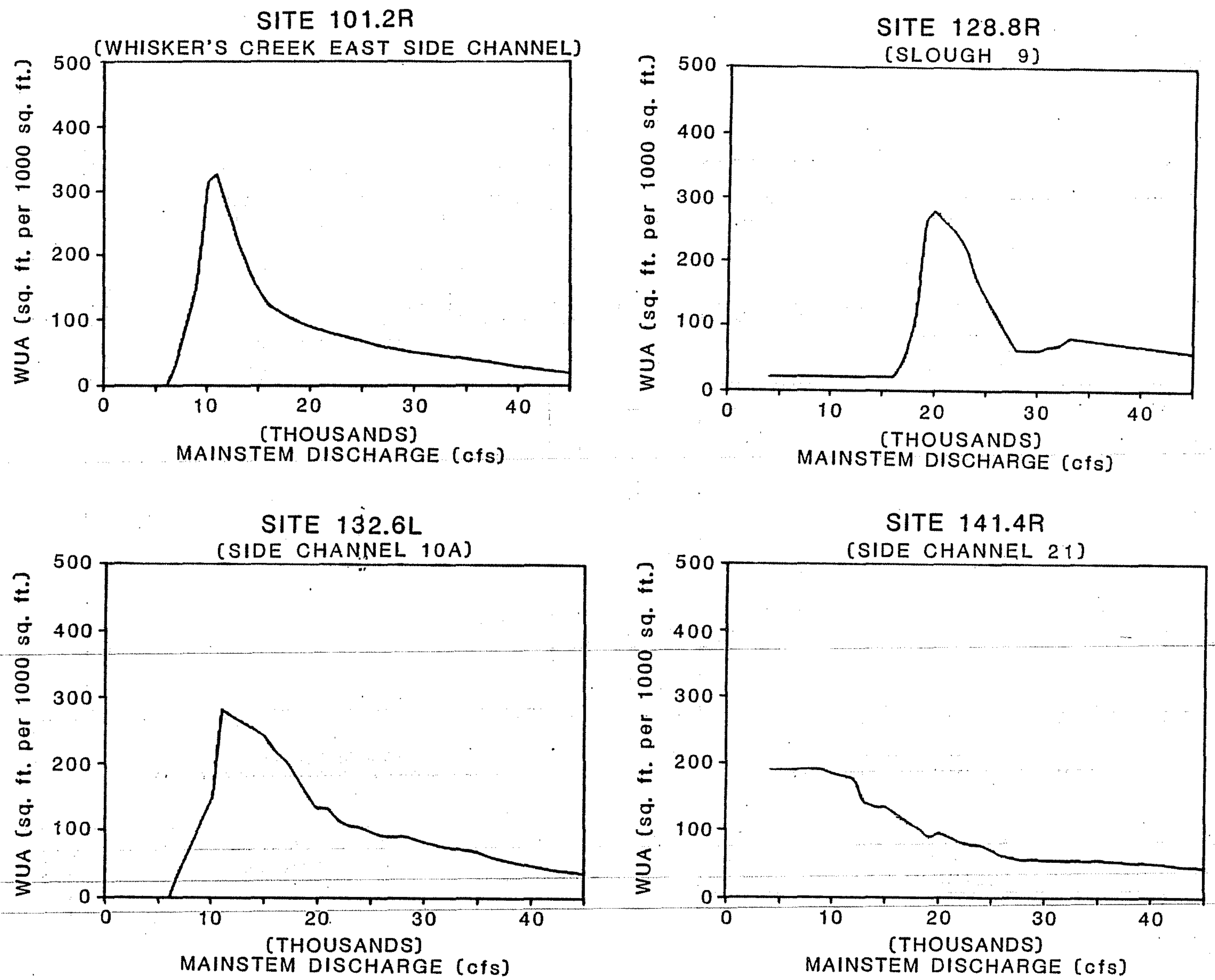
FIGURE E.3.2.51



JUVENILE CHINOOK HABITAT QUALITY RESPONSES TO MAINSTEM DISCHARGE FOR MODELLED SITES IN THE MIDDLE SUSITNA RIVER

FIGURE E.3.2.52

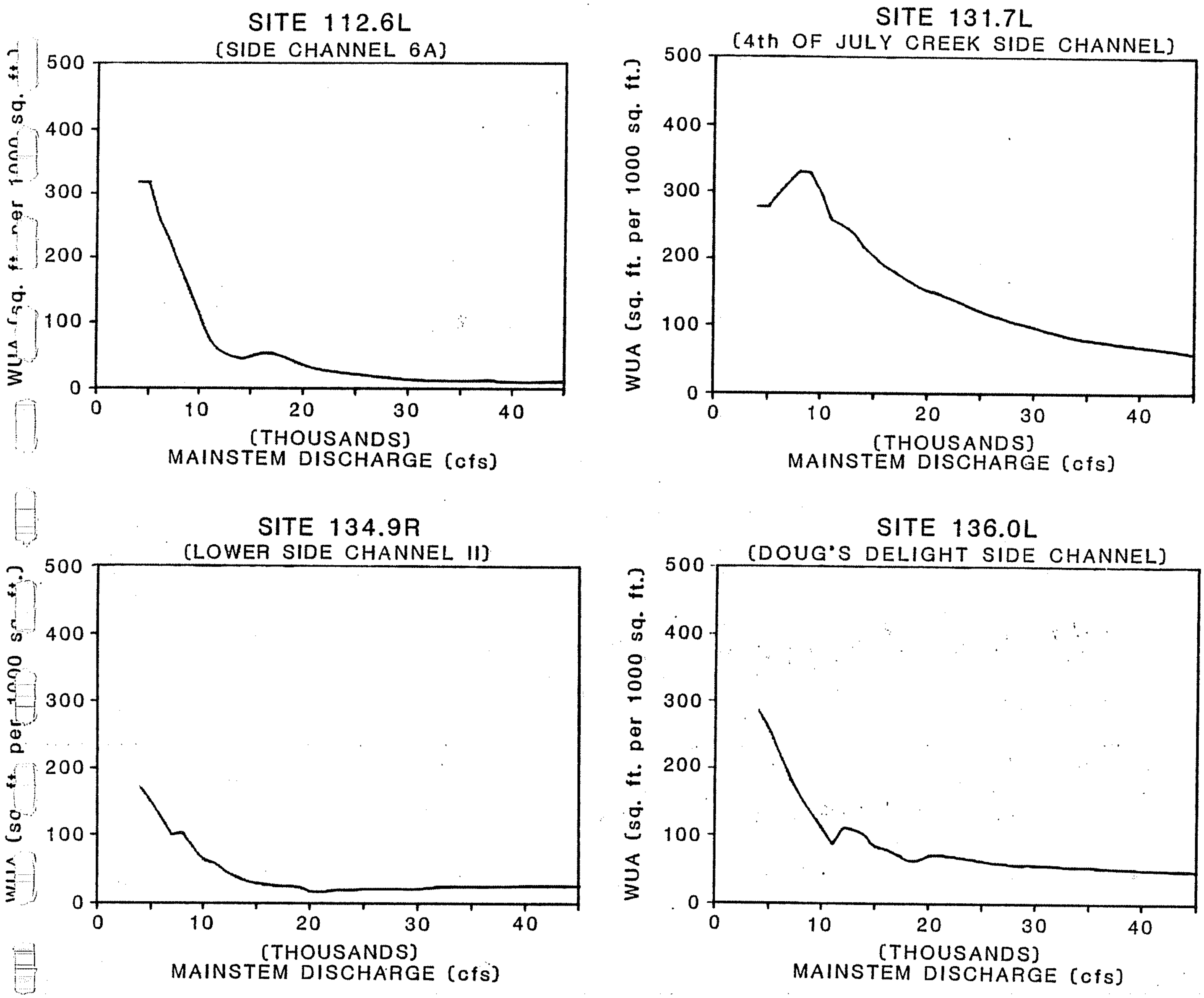
REPRESENTATIVE GROUP III



JUVENILE CHINOOK HABITAT QUALITY RESPONSES TO MAINSTEM DISCHARGE FOR MODELLED SITES IN THE MIDDLE SUSITNA RIVER

FIGURE E.3.2.52

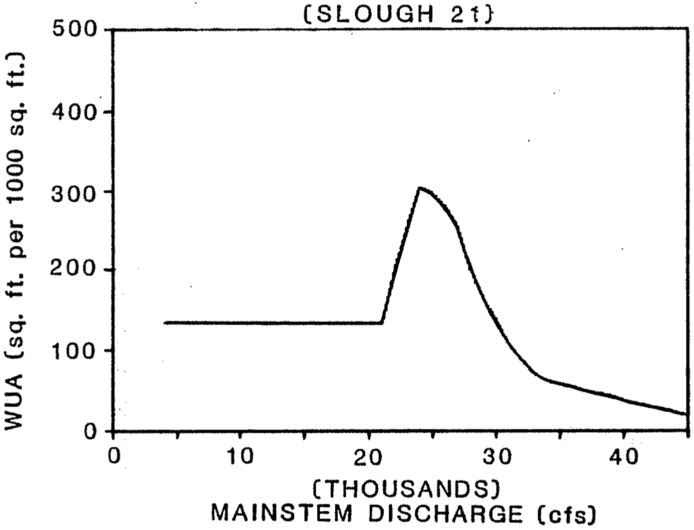
REPRESENTATIVE GROUP IV



JUVENILE CHINOOK HABITAT QUALITY RESPONSES TO MAINSTEM DISCHARGE FOR MODELLED SITES IN THE MIDDLE SUSITNA RIVER

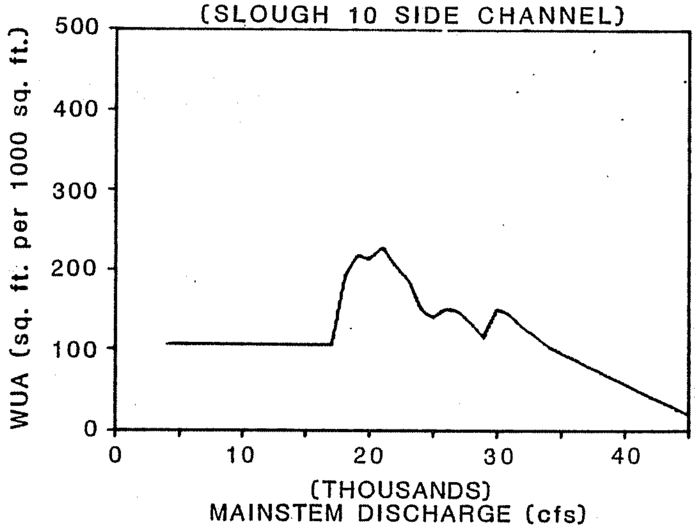
REPRESENTATIVE GROUP V

SITE 141.6R
(SLOUGH 21)



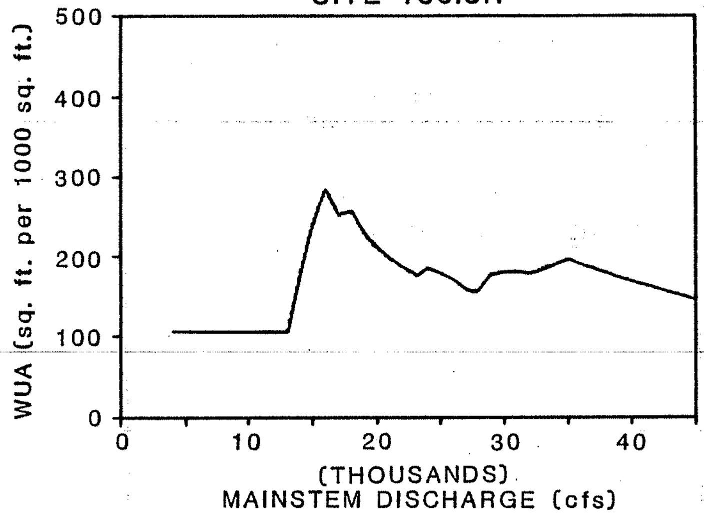
REPRESENTATIVE GROUP VI

SITE 133.8L
(SLOUGH 10 SIDE CHANNEL)



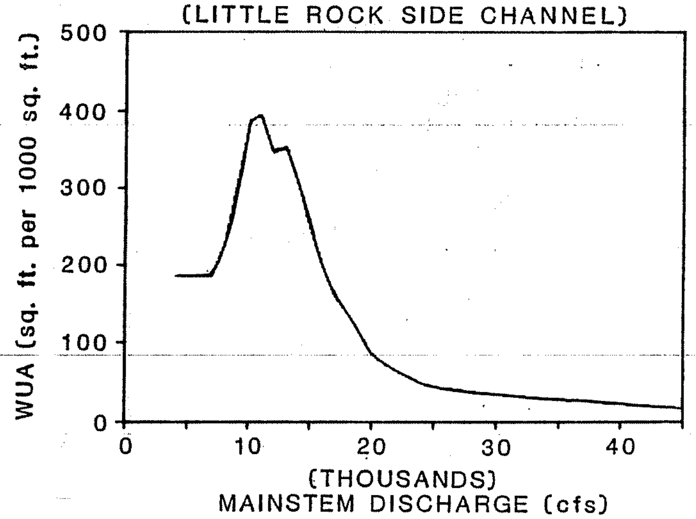
REPRESENTATIVE GROUP VI

SITE 136.3R



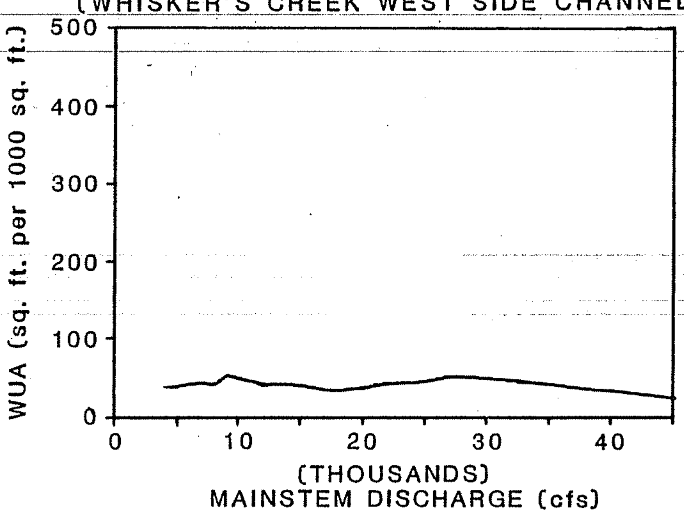
REPRESENTATIVE GROUP VII

SITE 119.2R
(LITTLE ROCK SIDE CHANNEL)

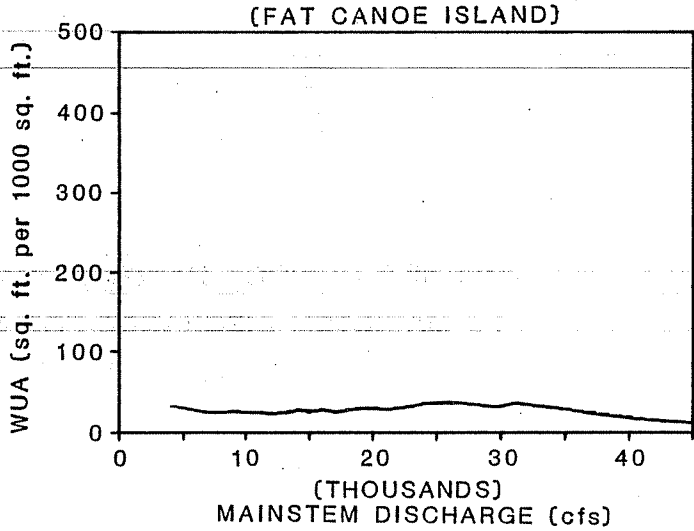


REPRESENTATIVE GROUP IX

SITE 101.5L
(WHISKER'S CREEK WEST SIDE CHANNEL)



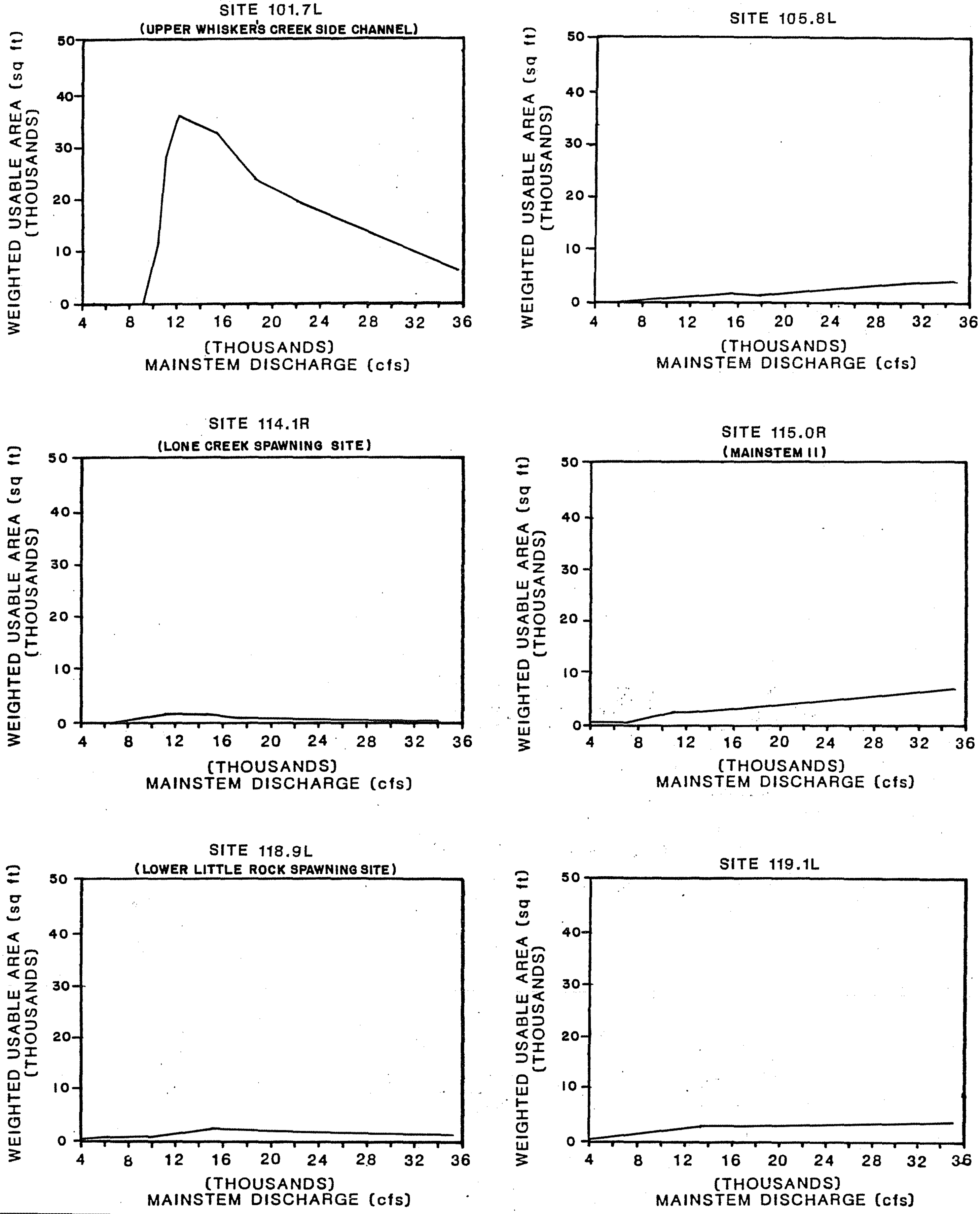
SITE 147.1L
(FAT CANOE ISLAND)



JUVENILE CHINOOK HABITAT QUALITY RESPONSES
TO MAINSTEM DISCHARGE FOR MODELLED SITES
IN THE MIDDLE SUSITNA RIVER

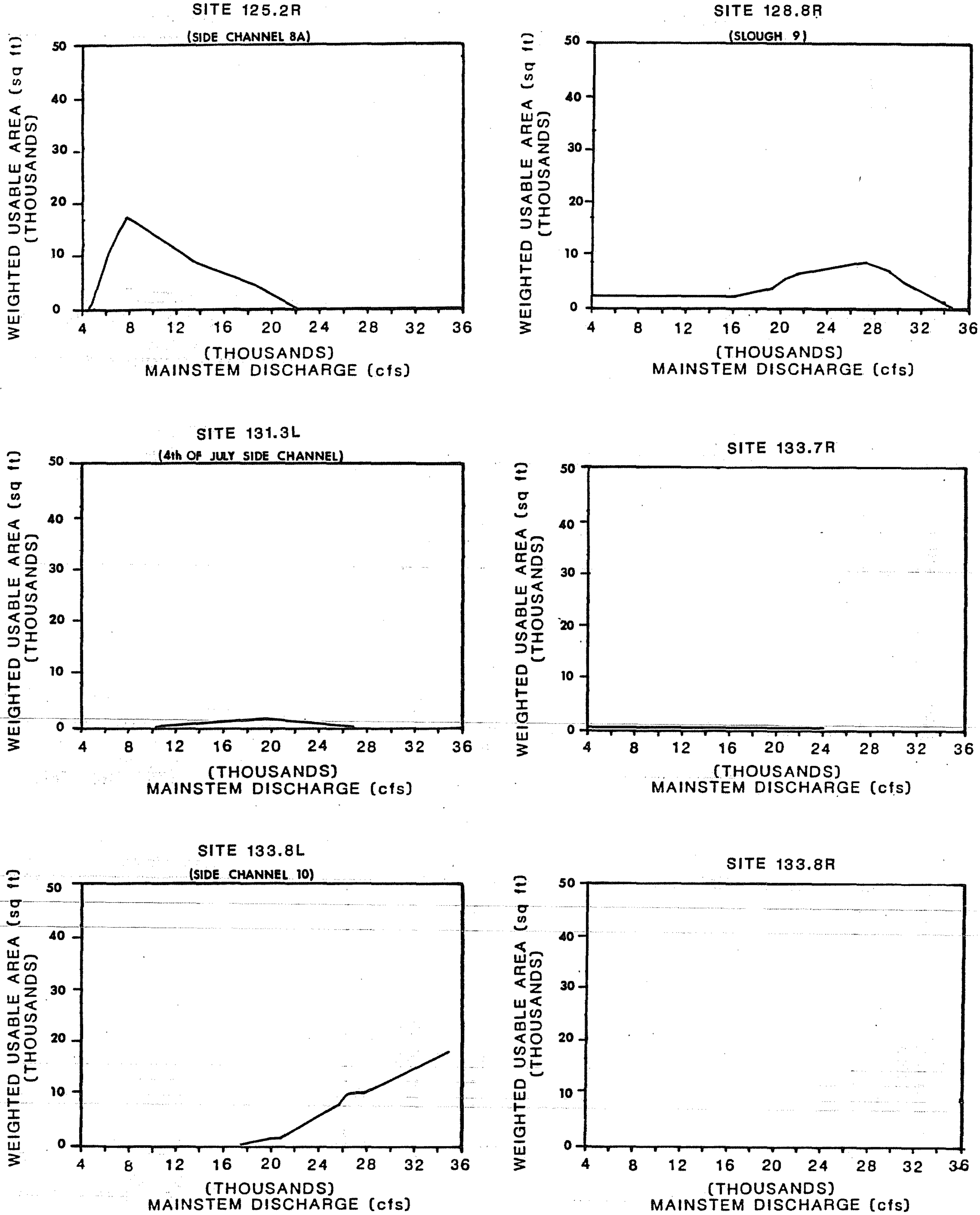
PAGE 4 OF 4

FIGURE E.3.2.52



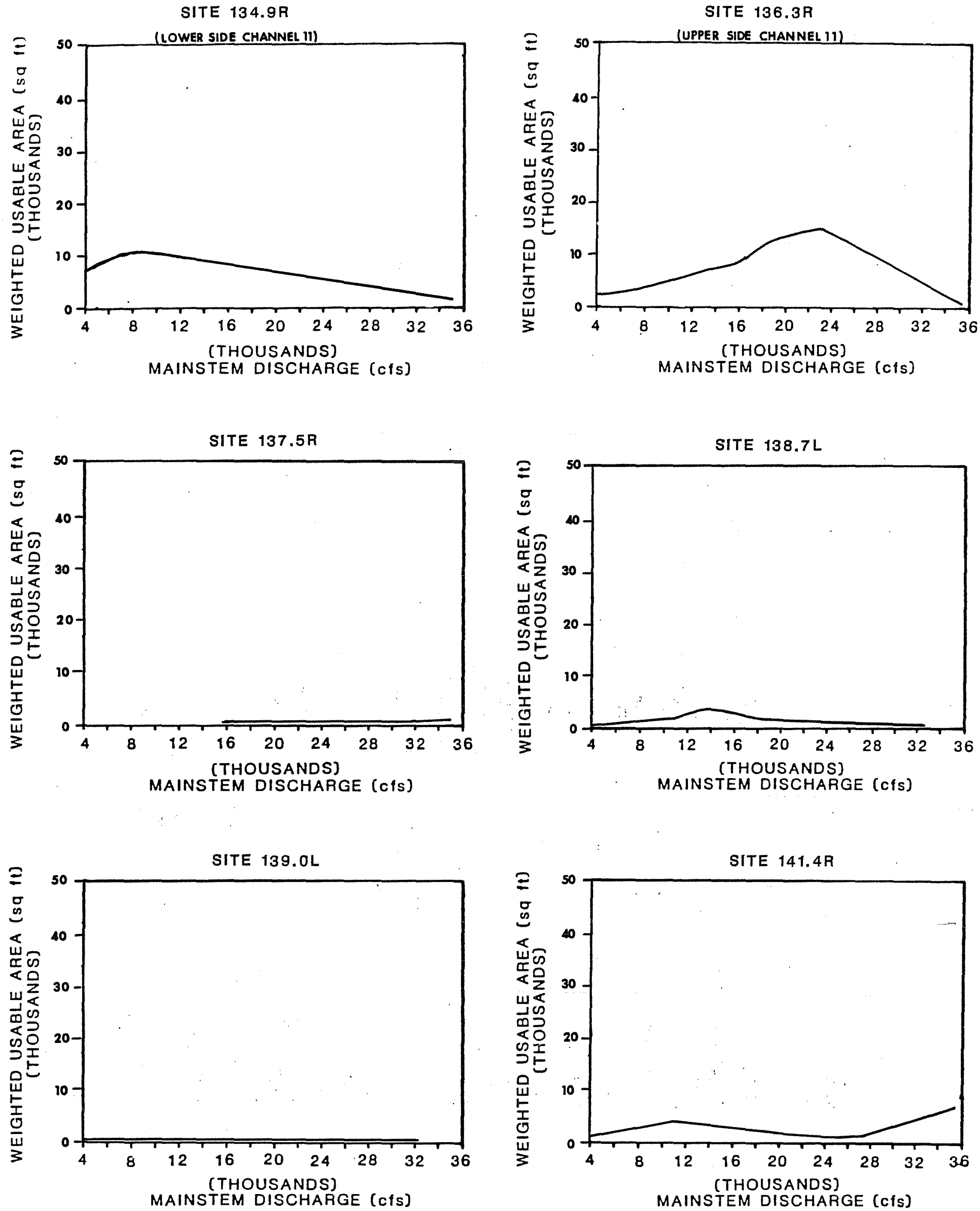
TOTAL HABITAT AREA RESPONSE CURVES IN CHUM SPAWNING SITES USING IFG AND DIHAB MODELS

FIGURE E.3.2.53



TOTAL HABITAT AREA RESPONSE CURVES
IN CHUM SPAWNING SITES USING
IFG AND DIHAB MODELS

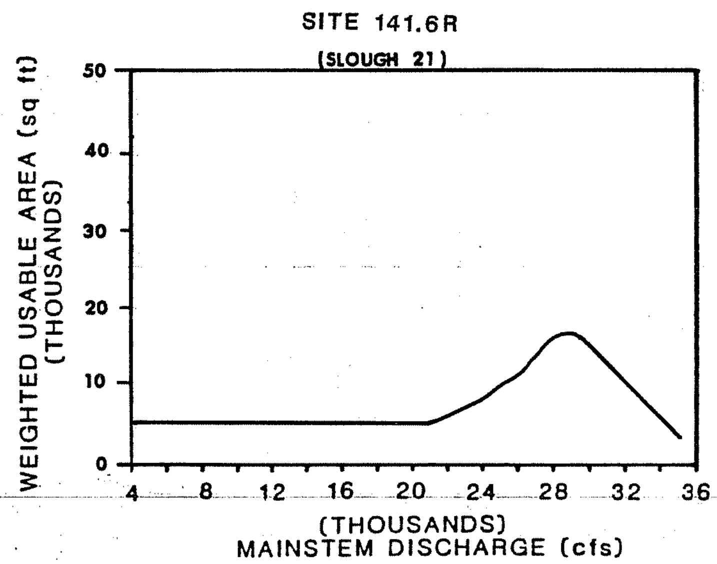
FIGURE E.3.2.53



TOTAL HABITAT AREA RESPONSE CURVES IN CHUM SPAWNING SITES USING IFG AND DIHAB MODELS

FIGURE E.3.2.53

PAGE 3 OF 4

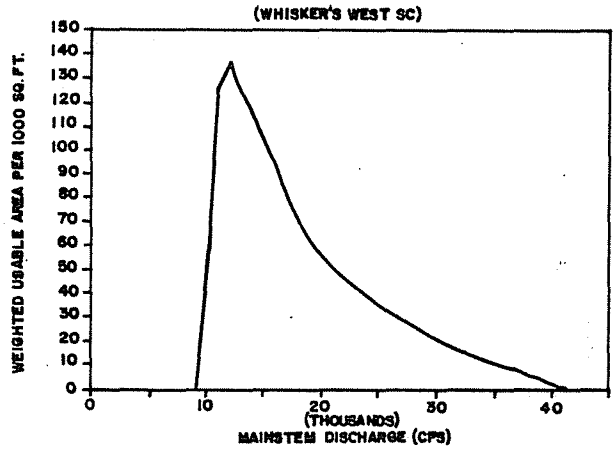


TOTAL HABITAT AREA RESPONSE CURVES
IN CHUM SPAWNING SITES USING
IFG AND DIHAB MODELS

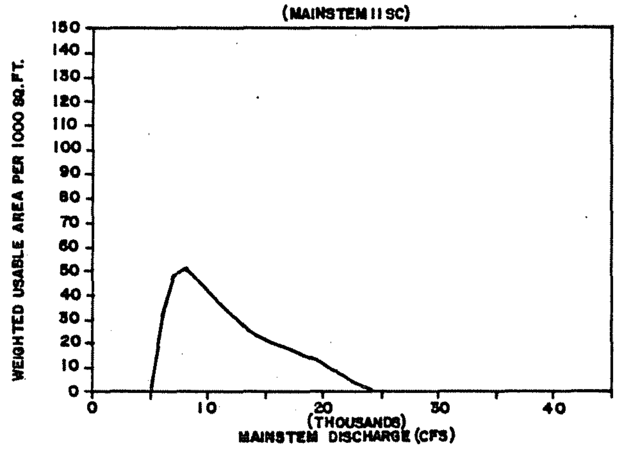
FIGURE E.3.2.53

OURCE: ADF&G 1984b EWT&A 1985c

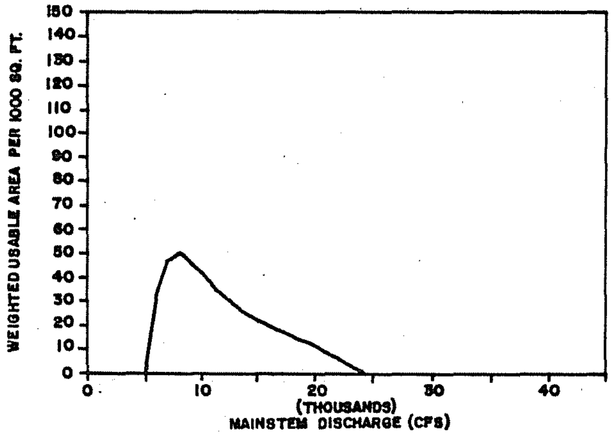
SITE 101.7L
(WHISKER'S WEST SC)



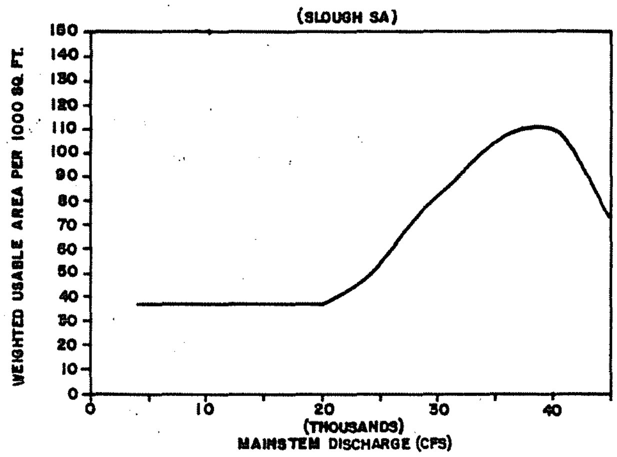
SITE 115.0R
(MAINSTEM II SC)



SITE 125.2R

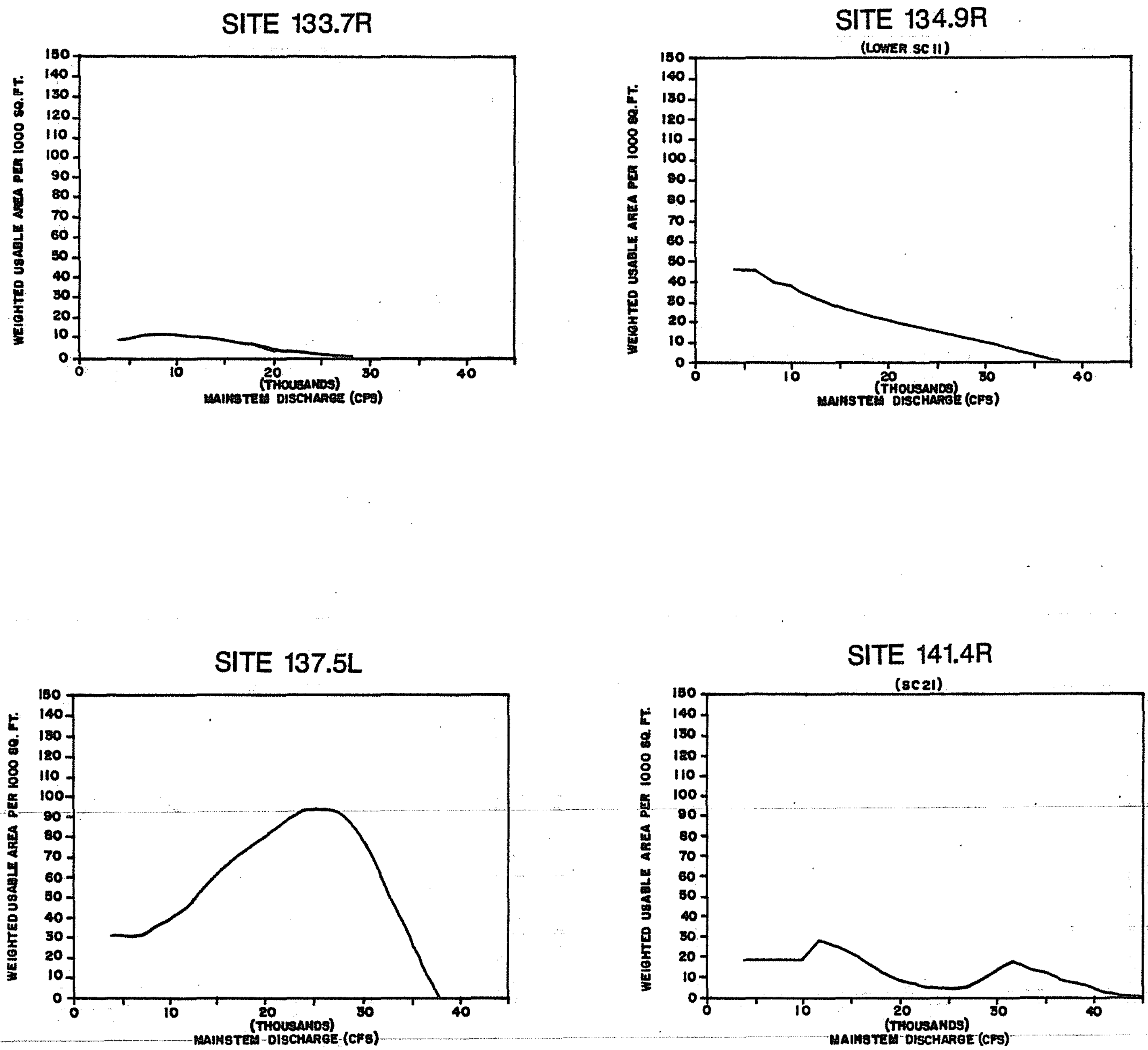


SITE 126.0R
(SLOUGH 8A)



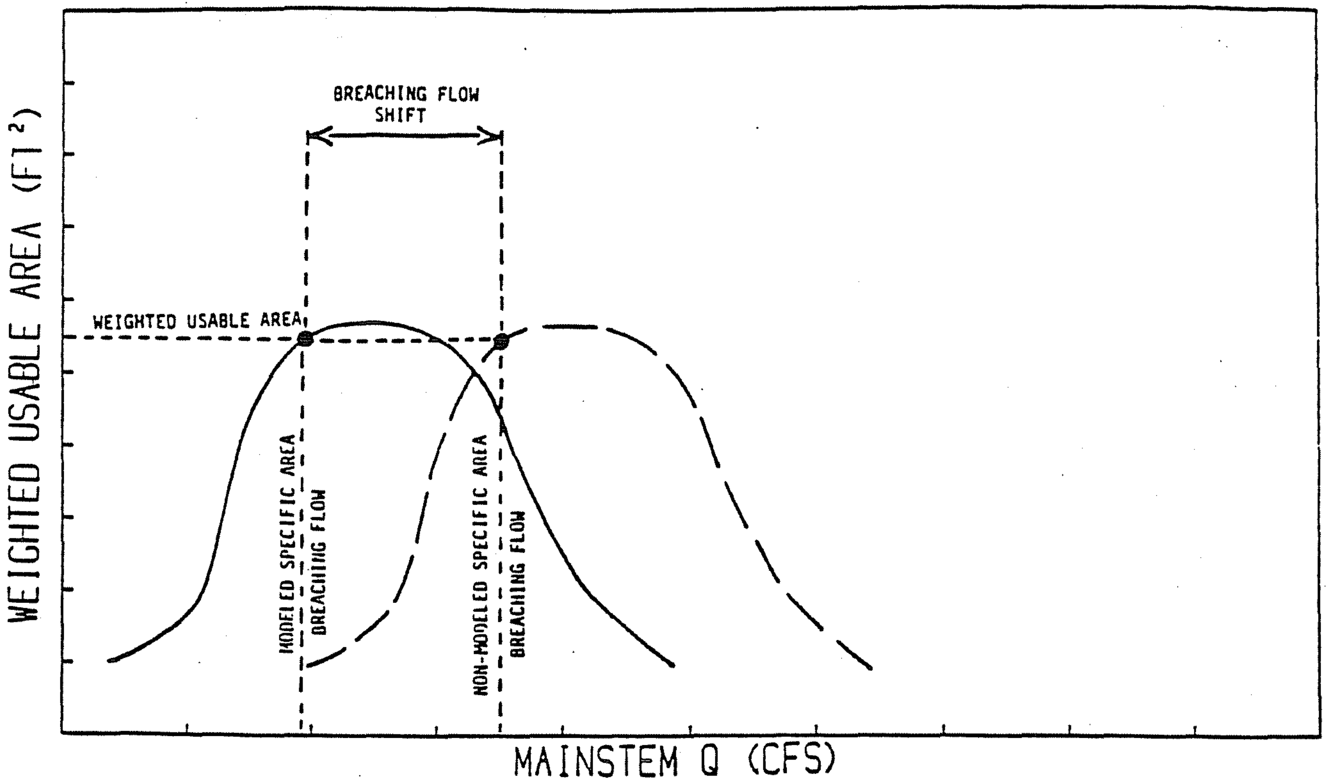
HABITAT QUALITY (WUA/1000 SQ. FT.) RESPONSE OF CHUM SPAWNING AREAS (MODELLED SITES)

FIGURE E.3.2.54

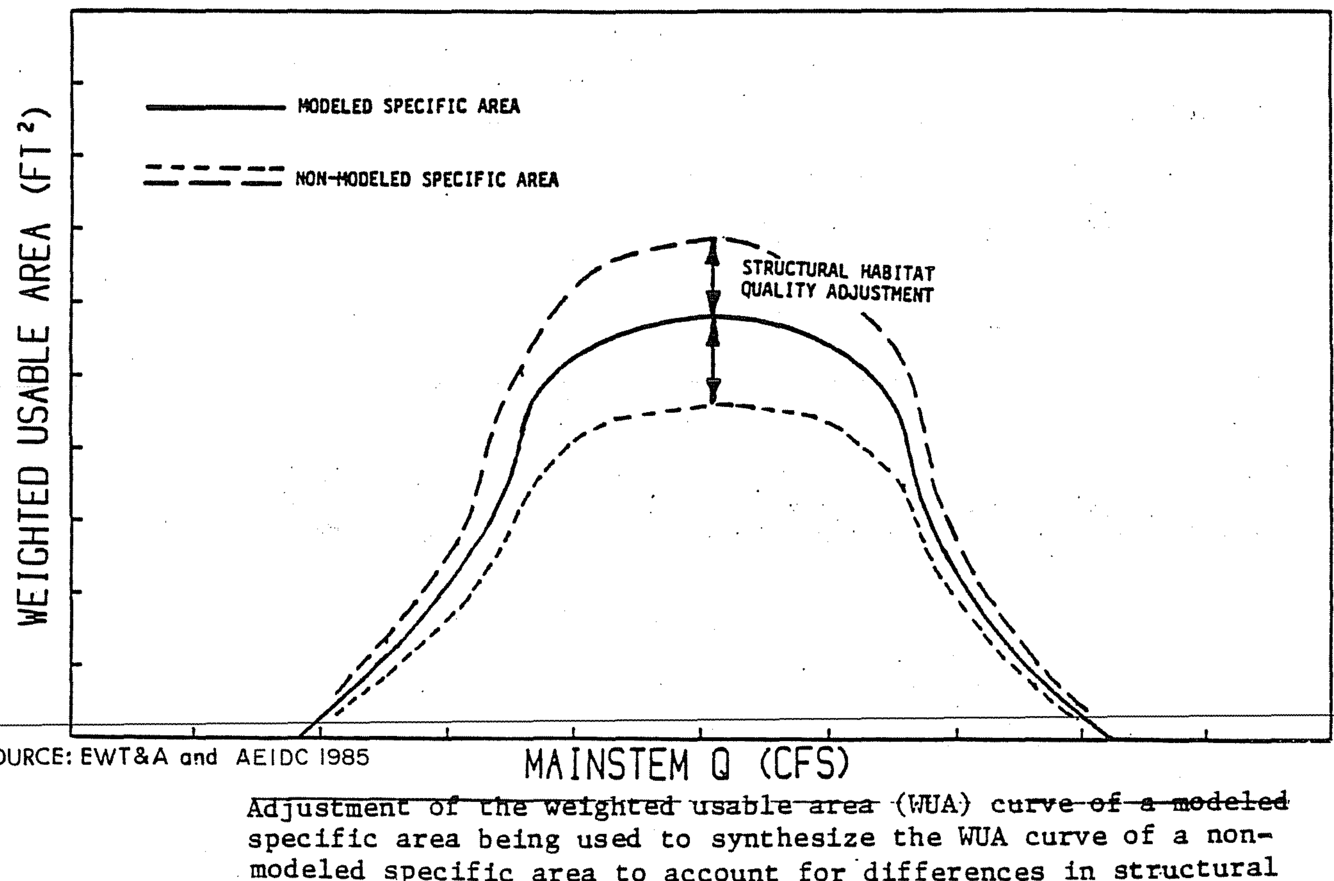


HABITAT QUALITY (WUA/1000 SQ. FT.) RESPONSE OF CHUM SPAWNING AREAS (MODELLED SITES)

FIGURE E.3.2.54



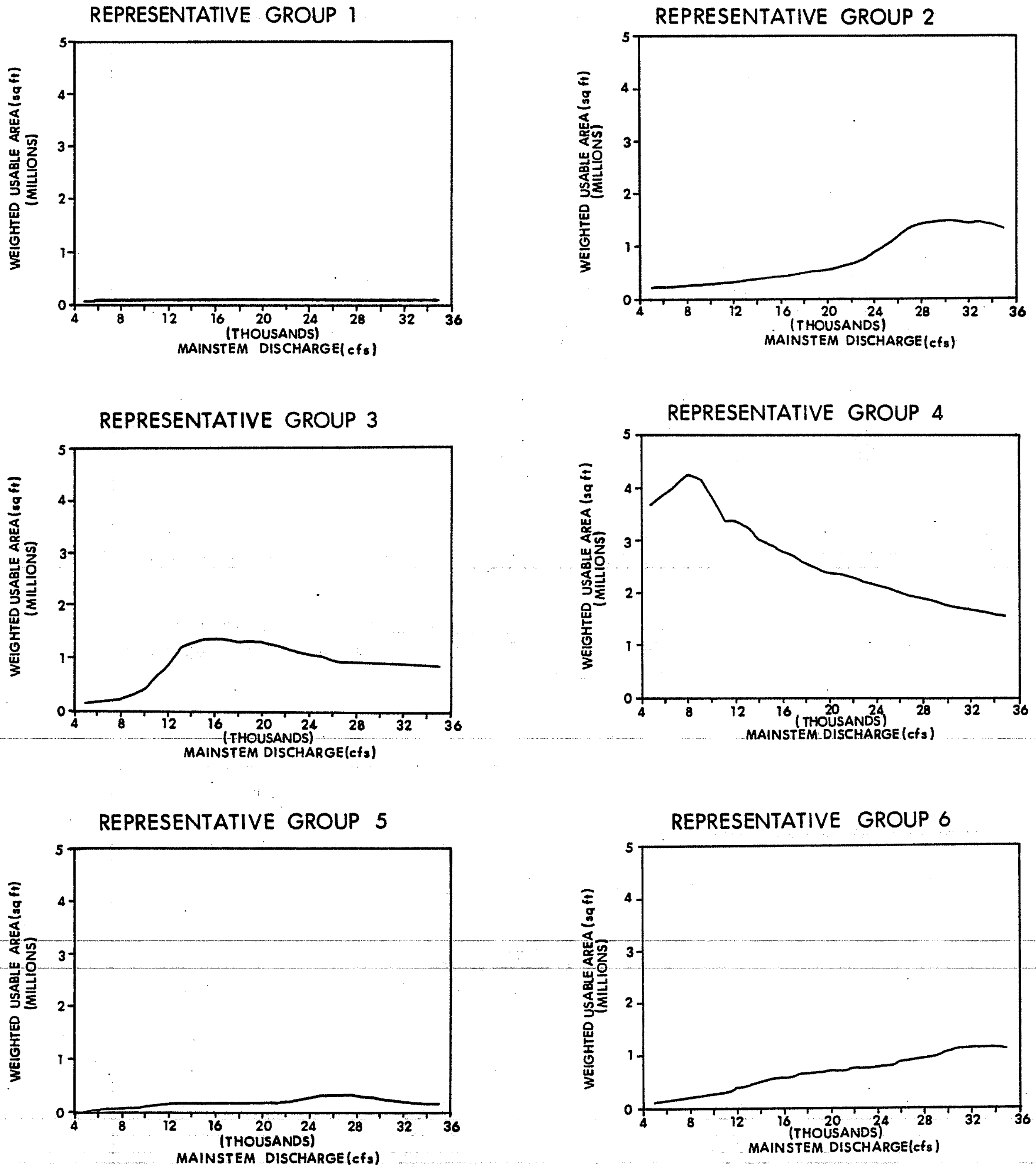
Lateral shift of weighted usable area (WUA) curve of a modeled specific area to synthesize the WUA curve of a nonmodeled specific area that has a different breaching flow.



SOURCE: EWT&A and AEIDC 1985

Adjustment of the weighted usable area (WUA) curve of a modeled specific area being used to synthesize the WUA curve of a non-modeled specific area to account for differences in structural habitat quality between the two specific areas.

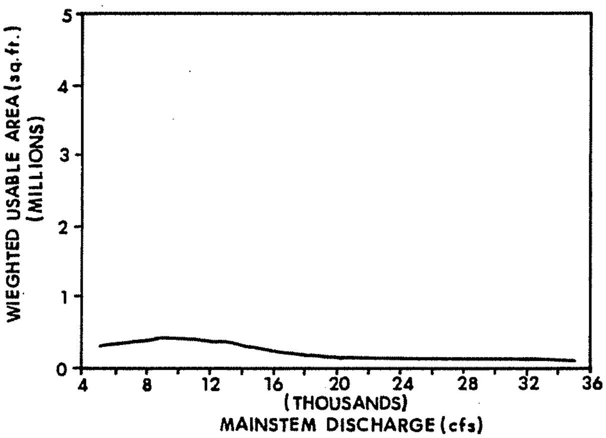
FIGURE E.3.2.55



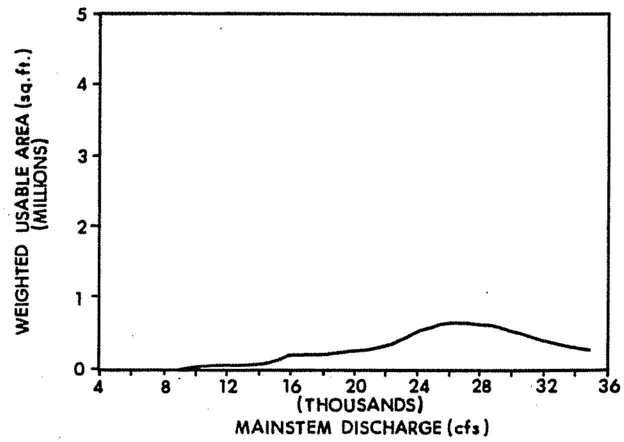
CUMULATIVE JUVENILE CHINOOK HABITAT AREA RESPONSE TO MAINSTEM DISCHARGE IN EACH REPRESENTATIVE GROUP.

FIGURE E.3.2.56

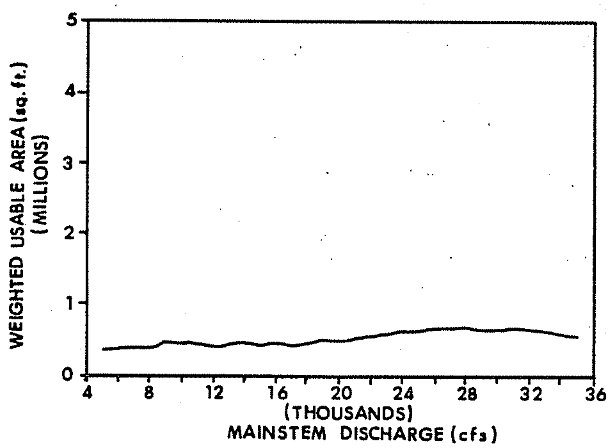
REPRESENTATIVE GROUP 7



REPRESENTATIVE GROUP 8



REPRESENTATIVE GROUP 9



CUMULATIVE JUVENILE CHINOOK HABITAT AREA RESPONSE TO MAINSTEM DISCHARGE IN EACH REPRESENTATIVE GROUP.

FIGURE E.3.2.56

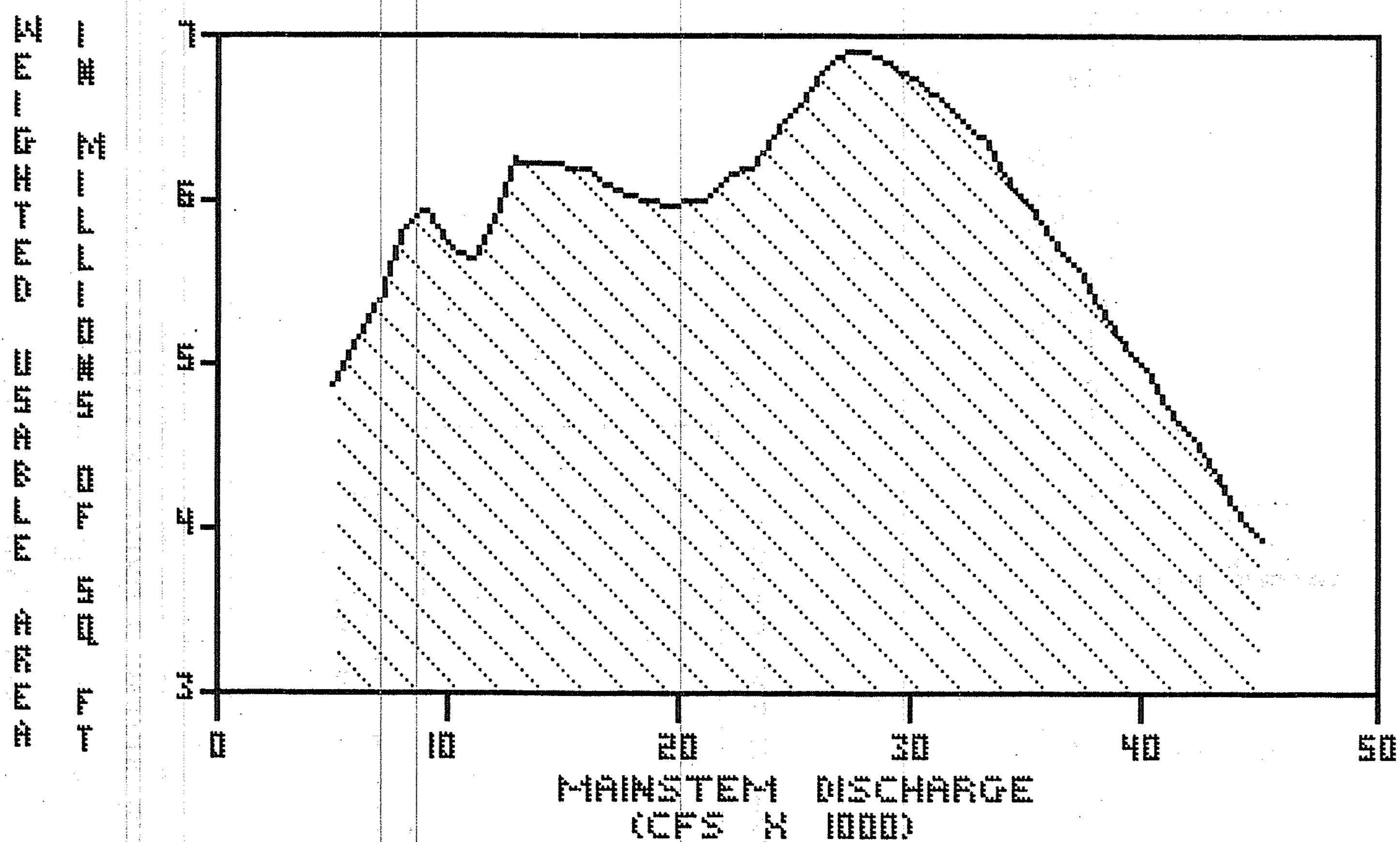


Figure E.3.2.57:
Response of Rearing Habitat to Flow
In All Representative Groups Combined

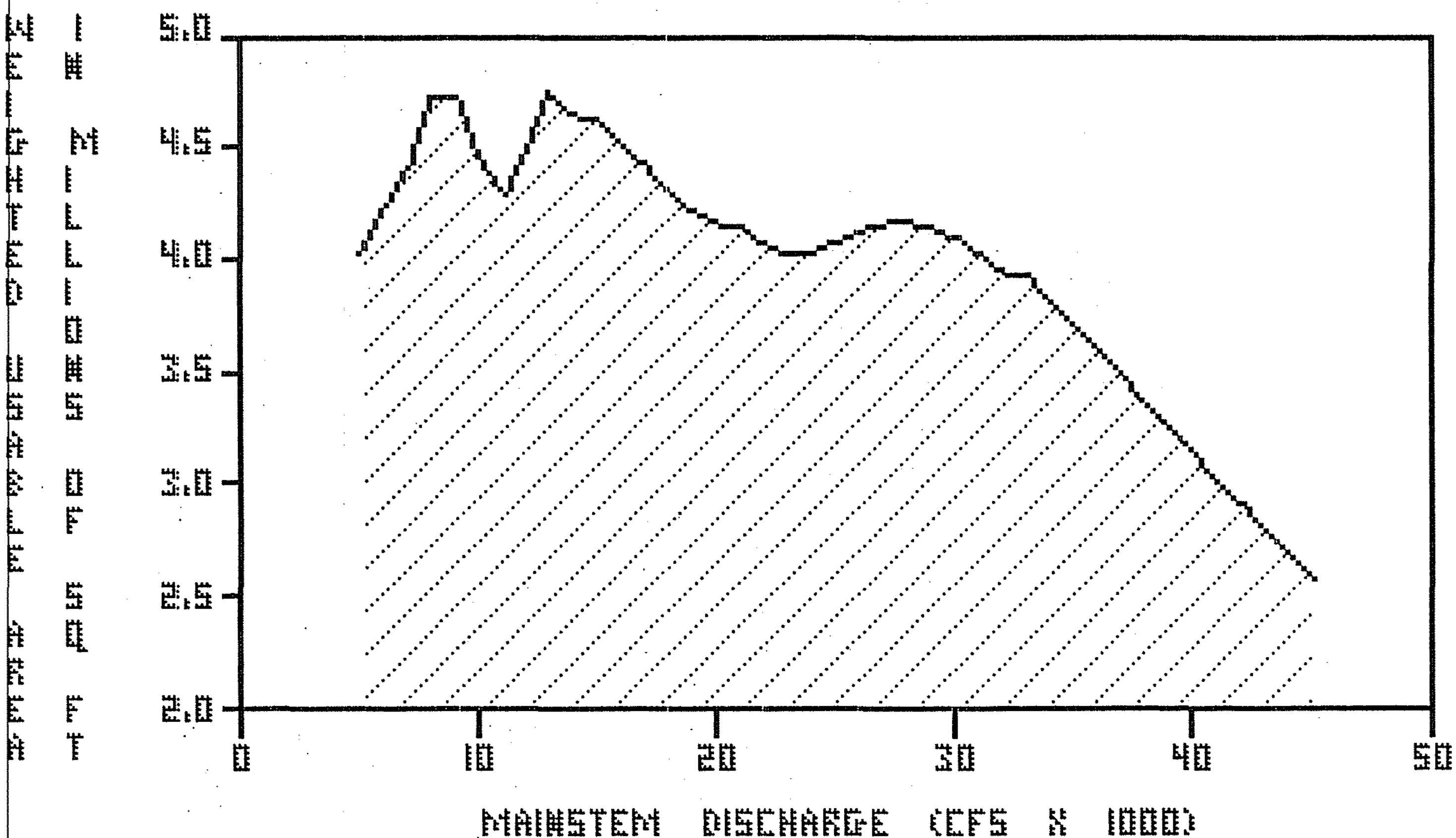
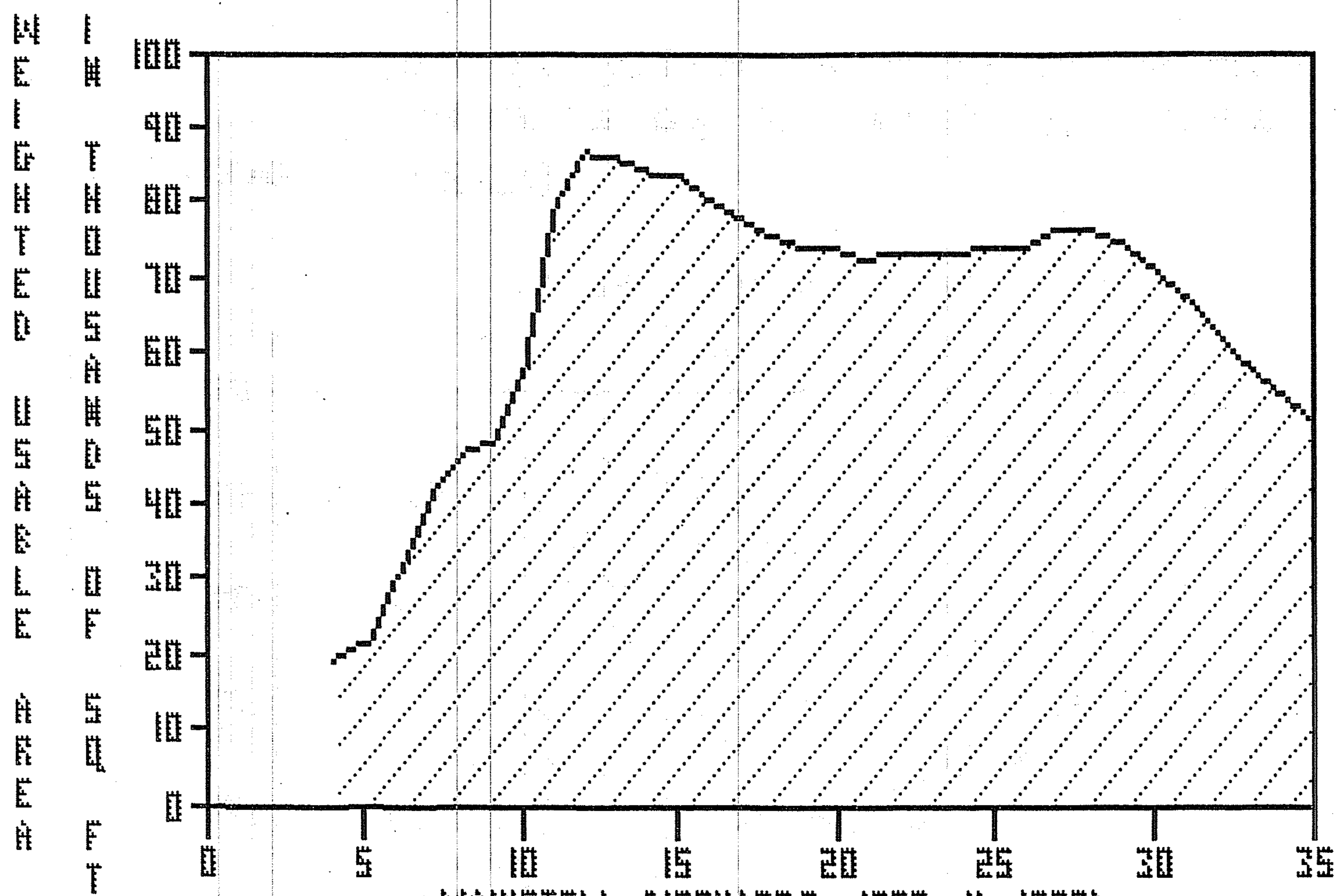
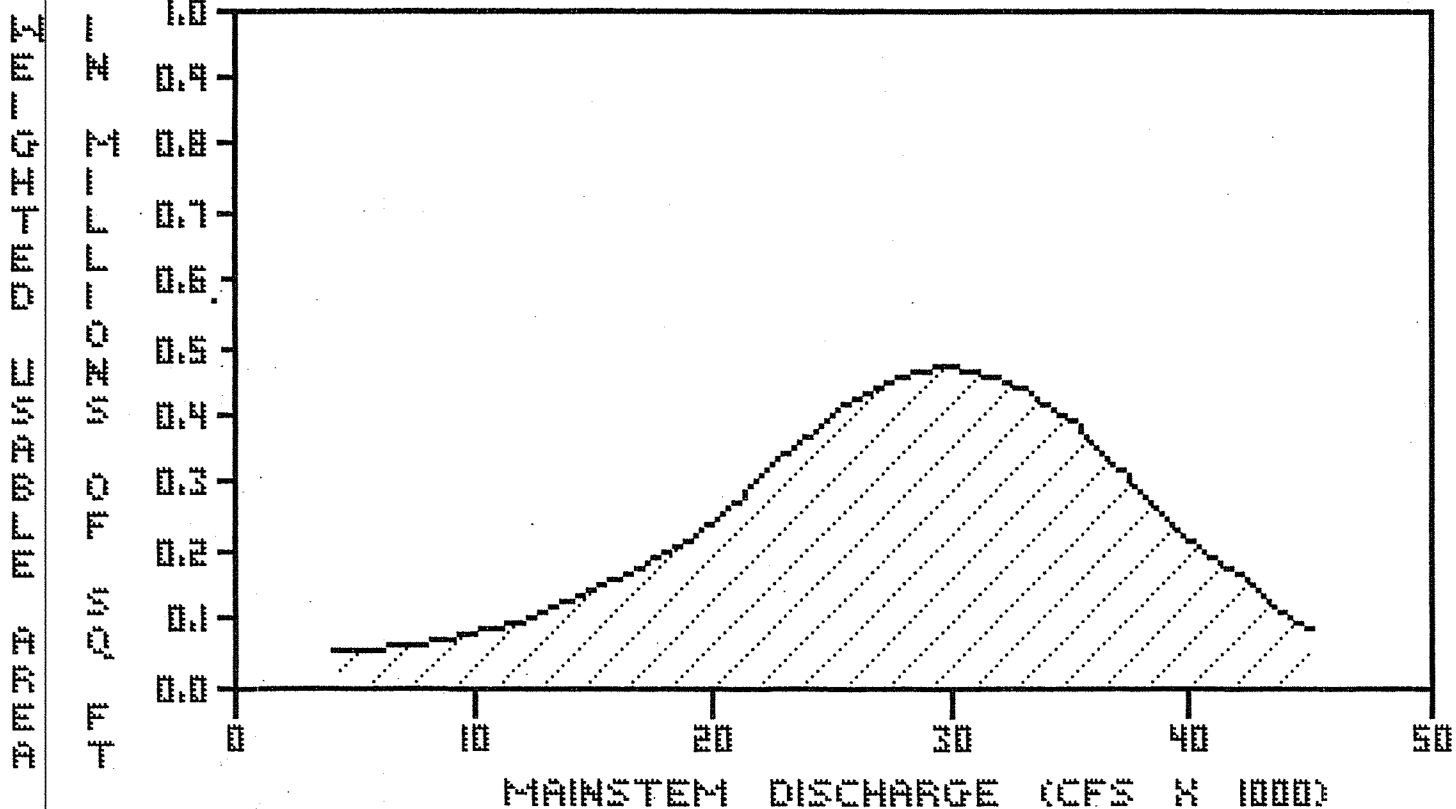


Figure E.3.2.58:
Response of Rearing Habitat Area to Flow in Representative Groups 2, 3, 4



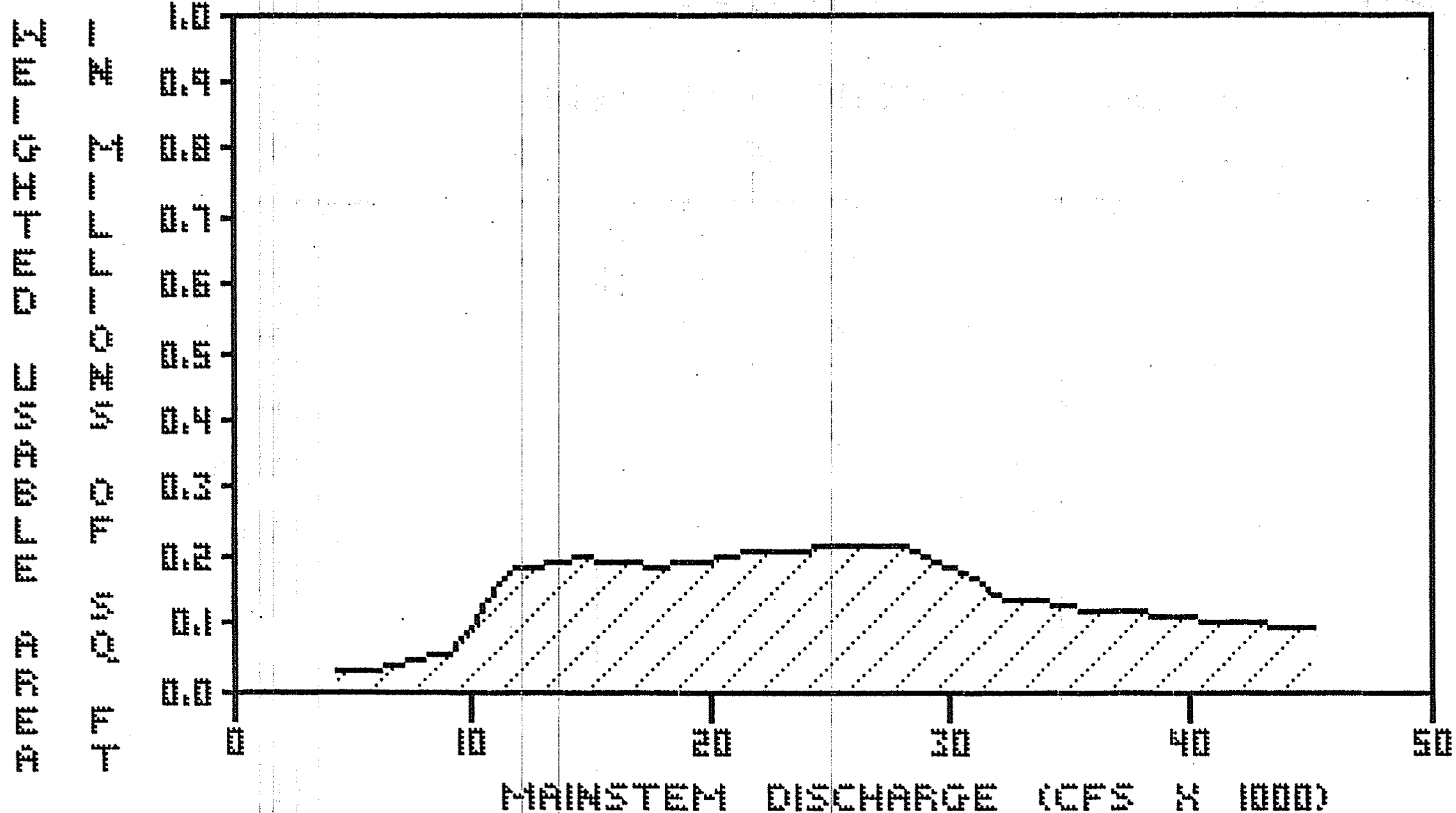
Response of Chum Spawning Area to Flow in IFG and DIHAB Model Sites

Figure E.3.2.59



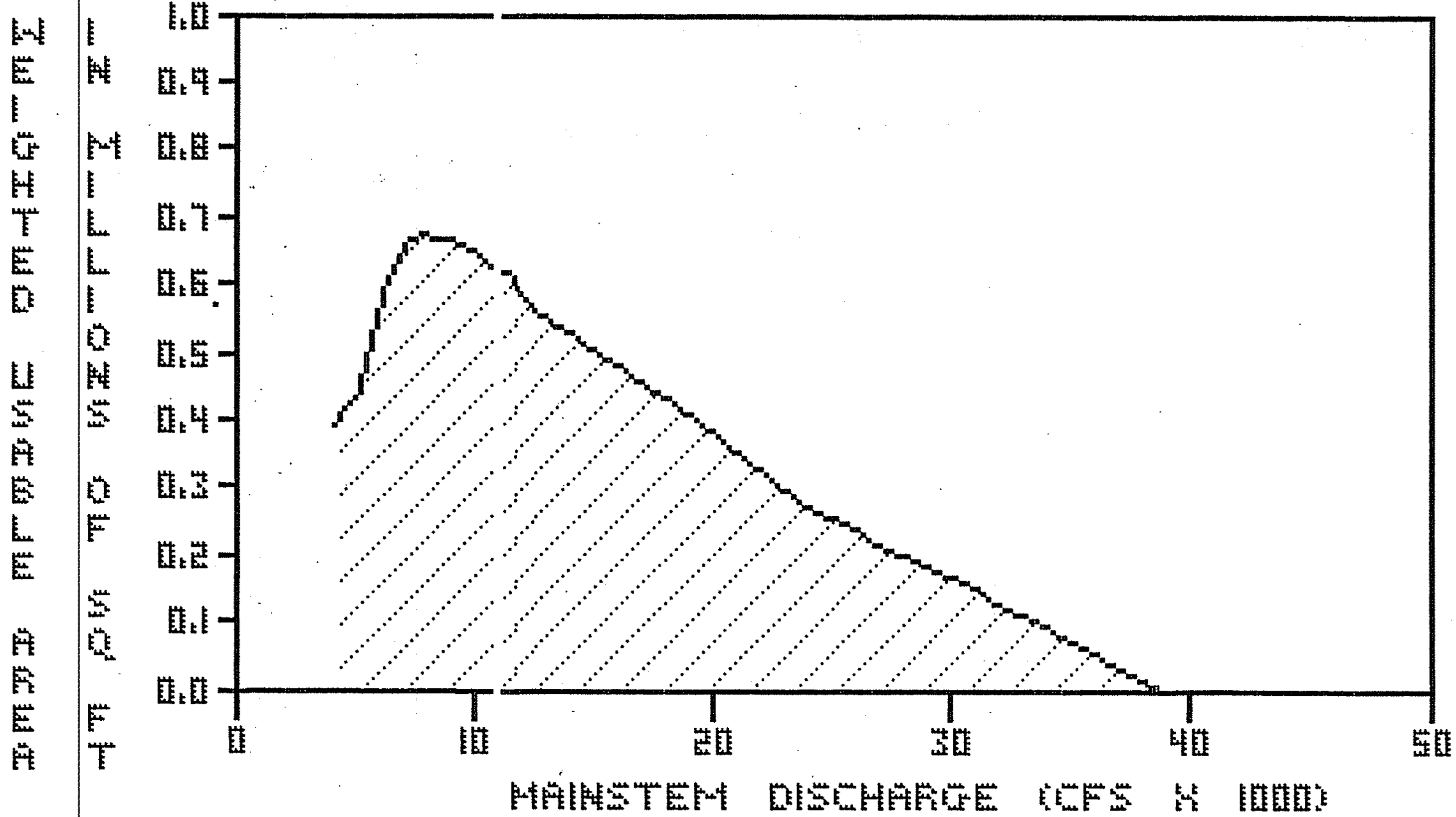
Response of Chum Spawning
Area to Flow in
Representative Group 2

Figure E.3.2.60



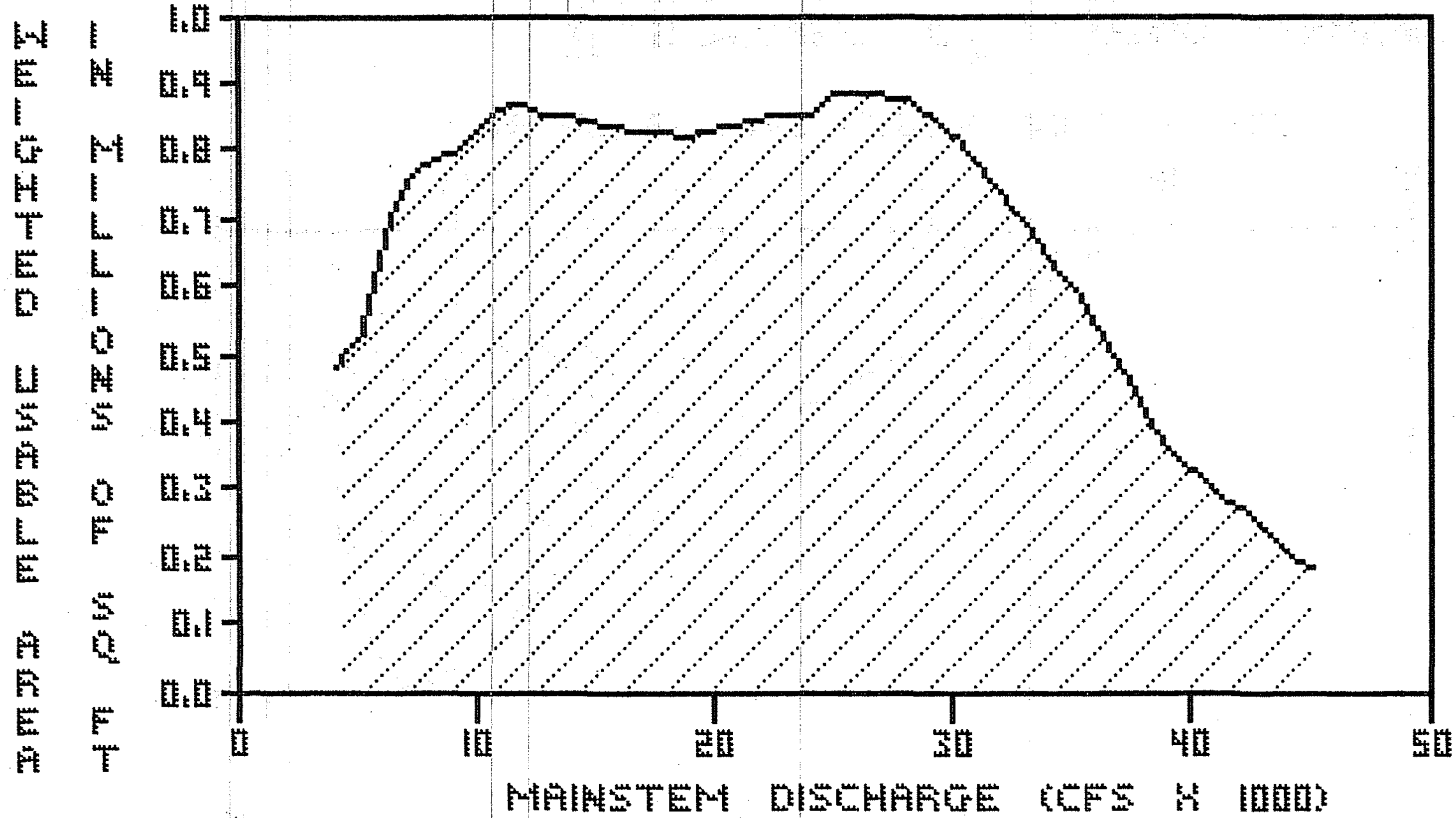
Response of Chum Spawning
Area to Flow in
Representative Group 3

Figure E.3.2.61



Response of Chum Spawning Area to Flow in Representative Group 4

Figure E.3.2.62



Response of Chum Spawning Area to Flow in Representative Groups 2,3,4

Figure E.3.2.63

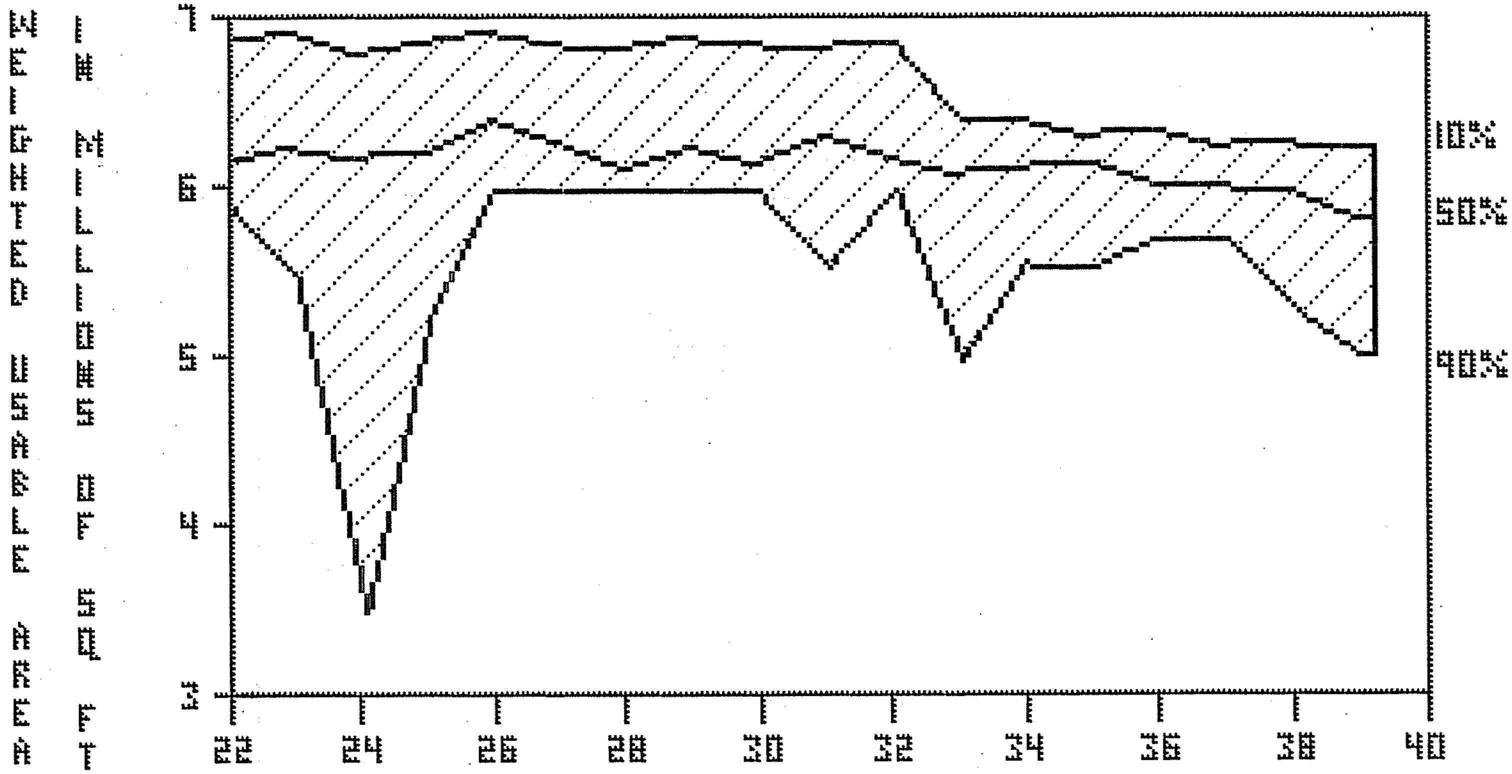


Figure E.3.2.64: Chinook Rearing Habitat Area Under Natural Flow Regime In All Representative Groups

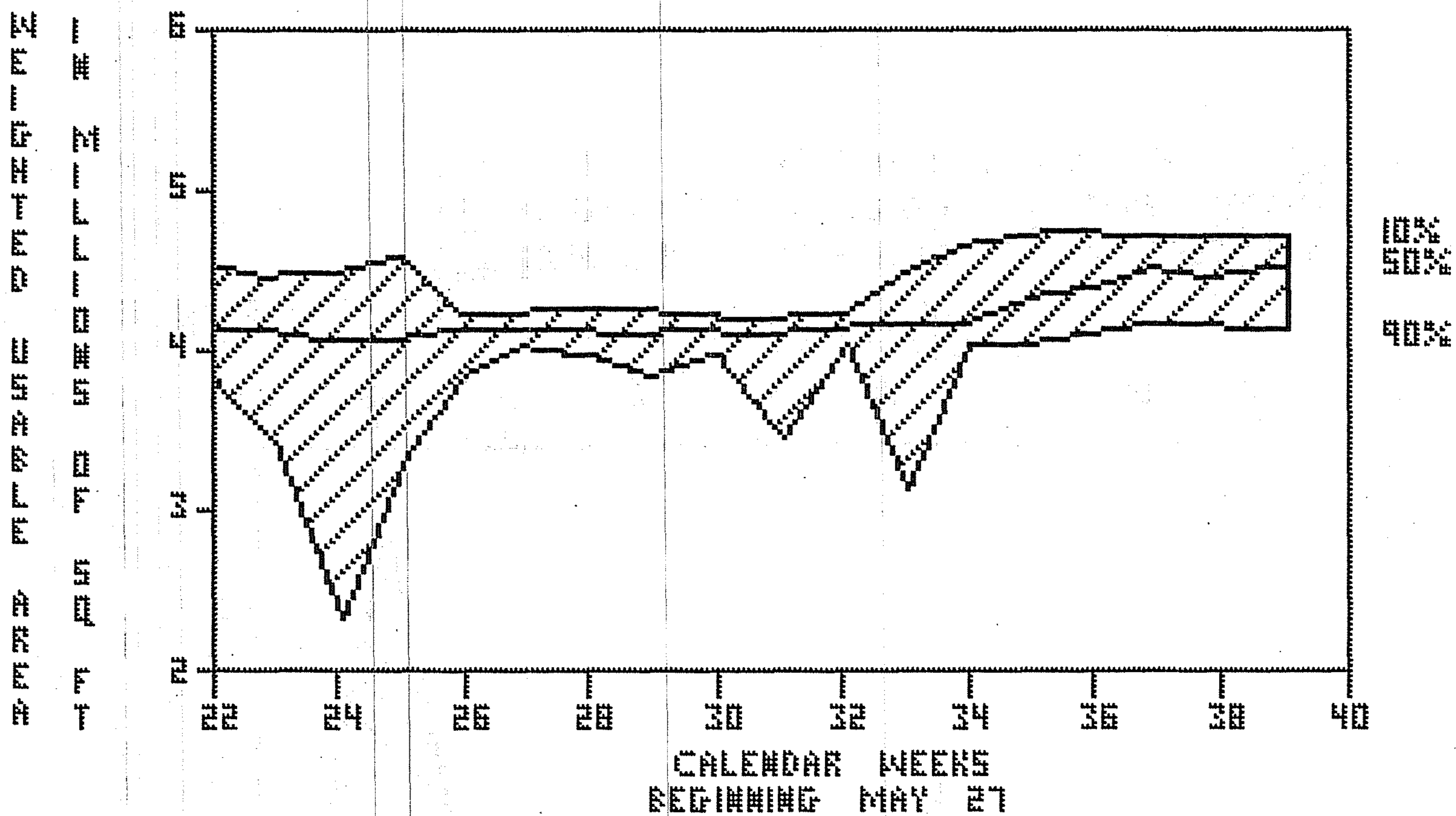


Figure E.3.2.65: Chinook Rearing Habitat Area Under Natural Flow Regime In Representative Groups 2,3,4

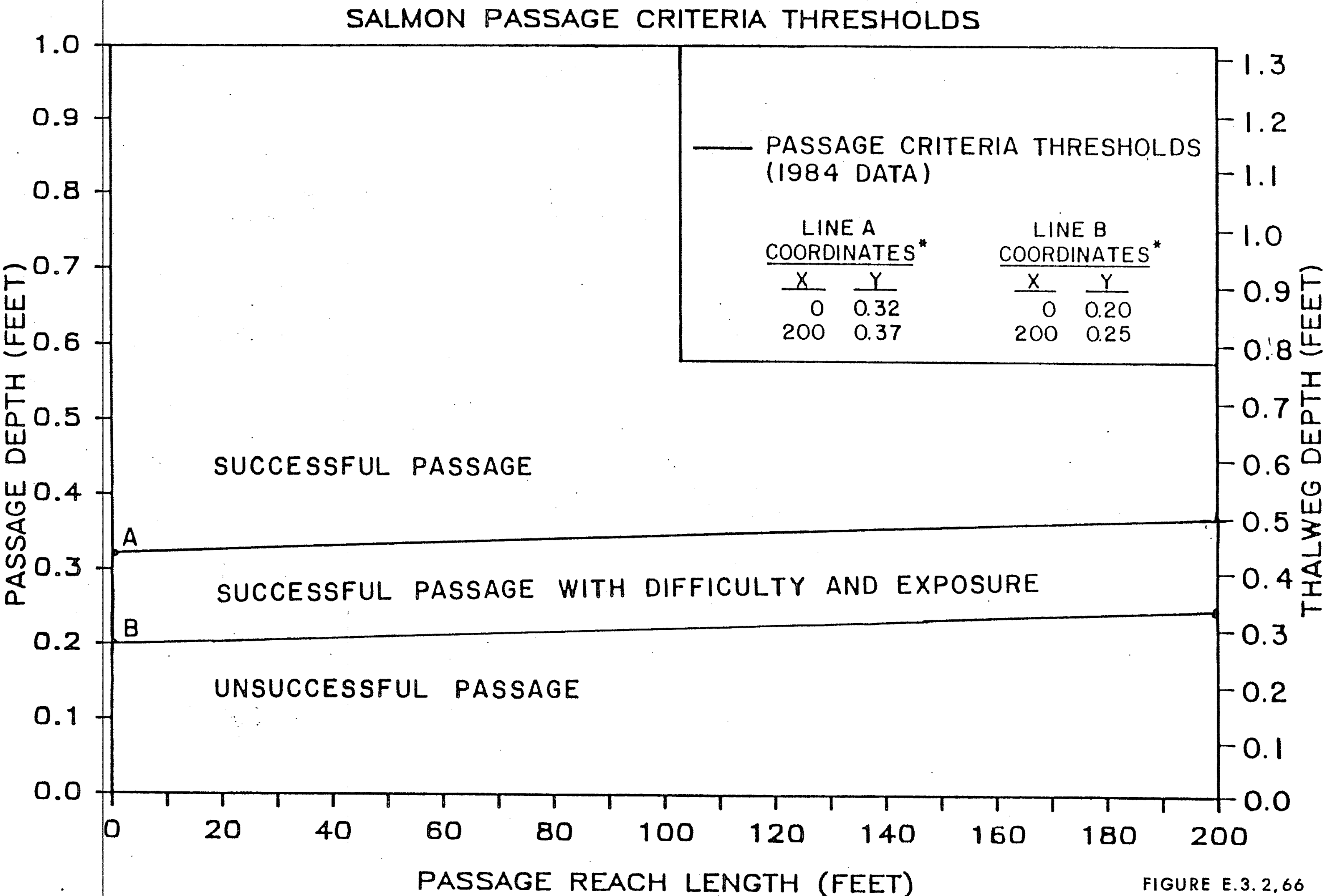
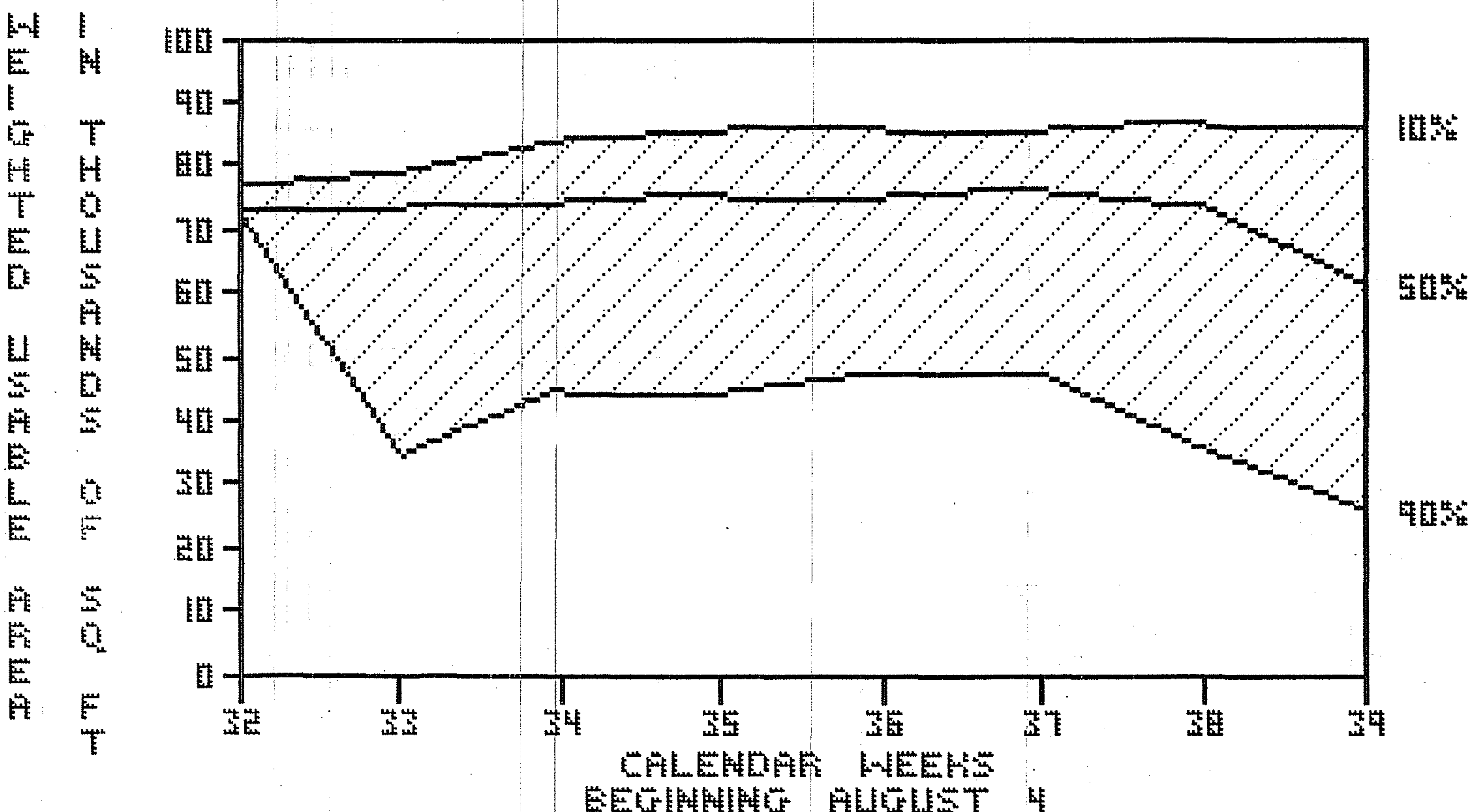
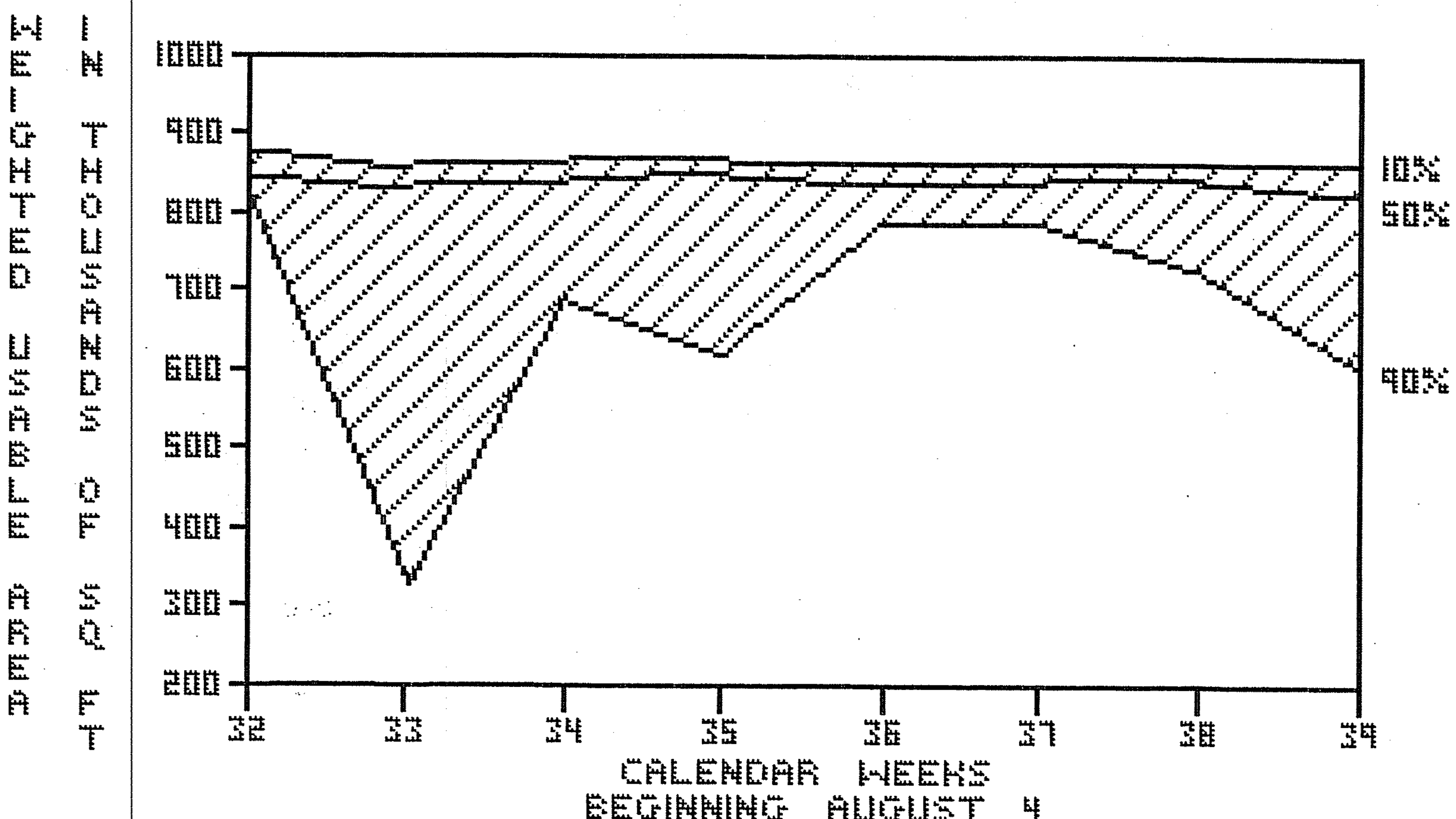


FIGURE E.3.2.66

SOURCE: ADAPTED FROM ADF&G 1985I

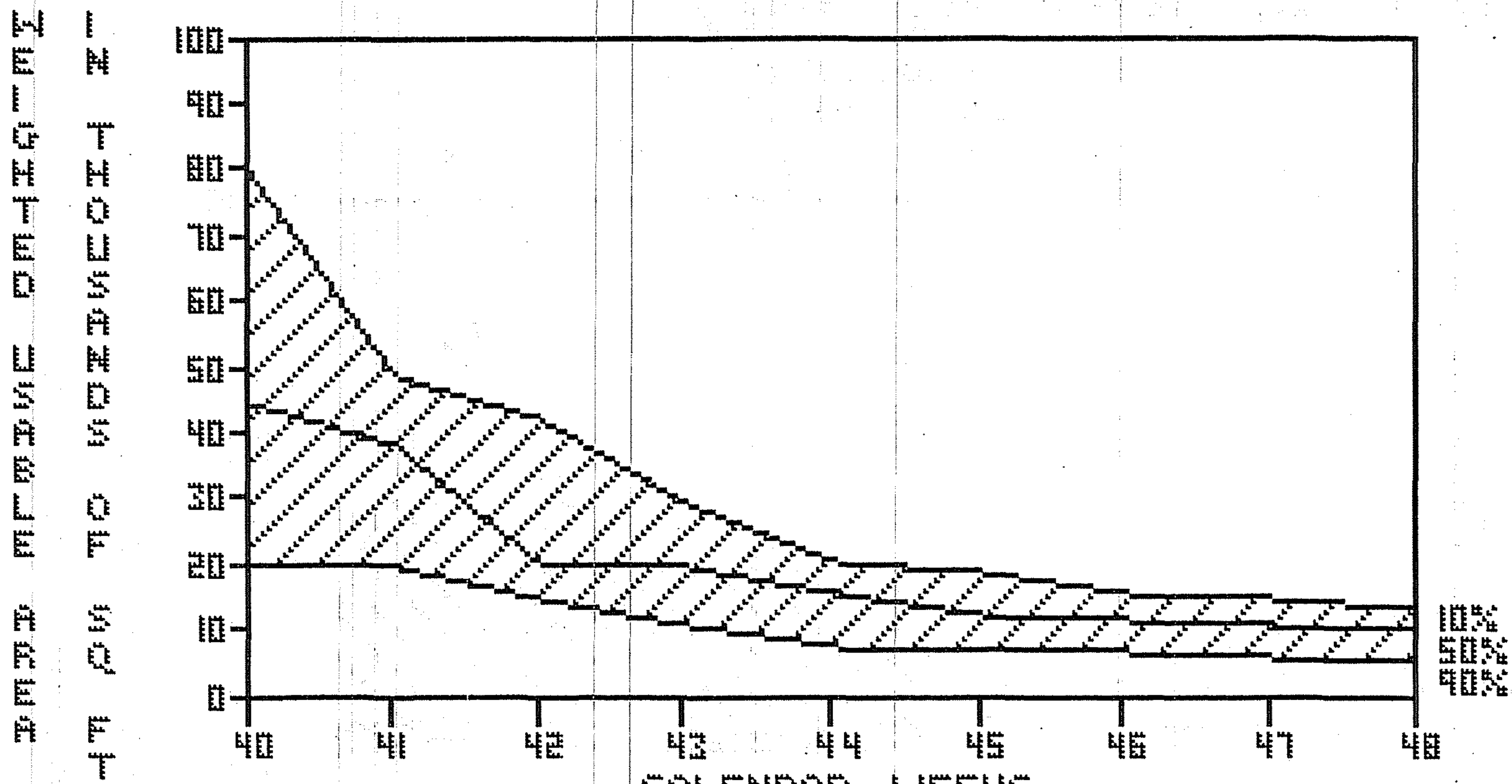


Chum Spawning Area in
IFG and DIHAB Model Sites
Under Natural Flow Regime
Figure E.3.2.67



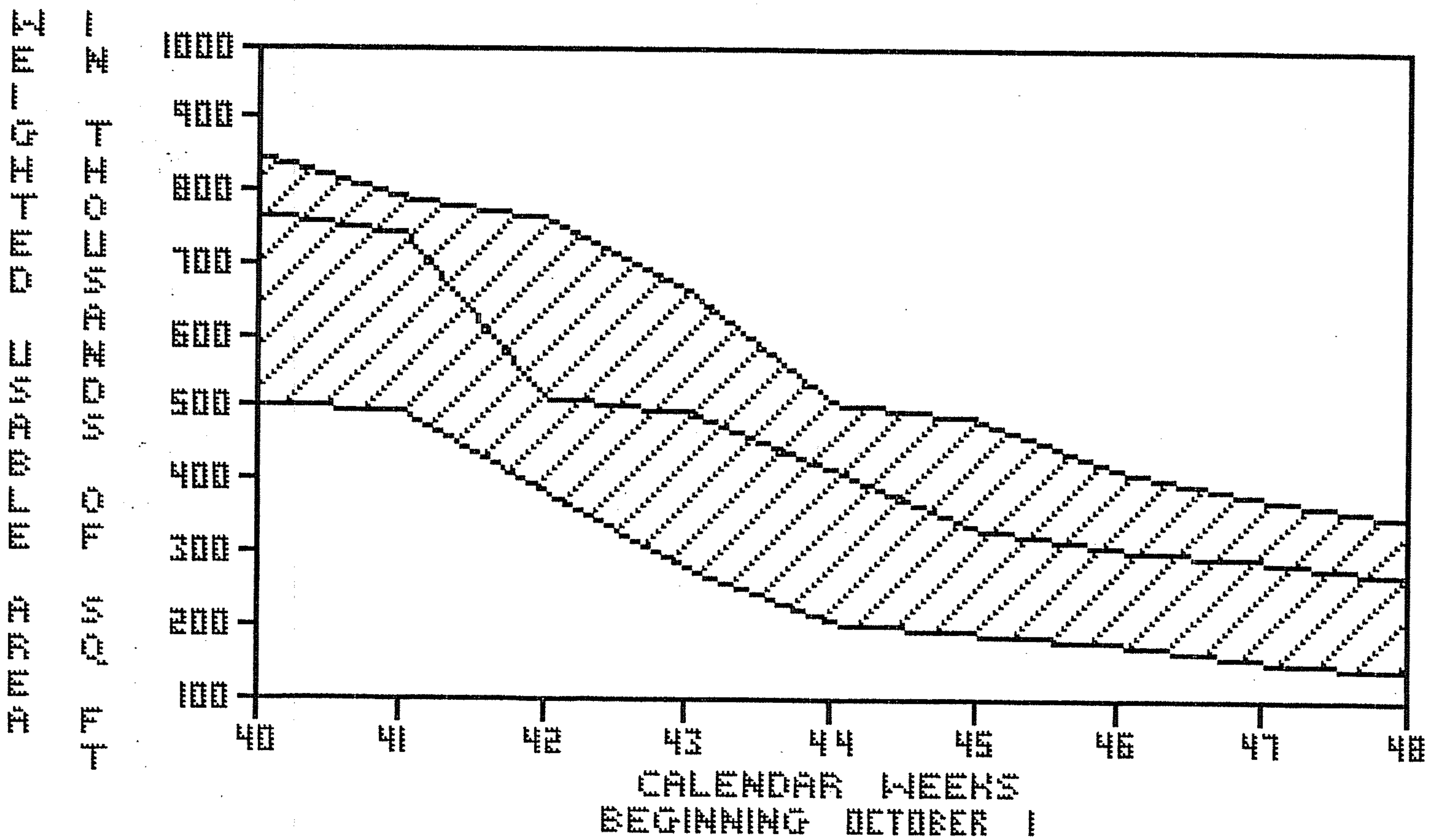
Chum Spawning Area in
Representative Groups 2,3,4
Under Natural Flows

Figure E.3.2.68



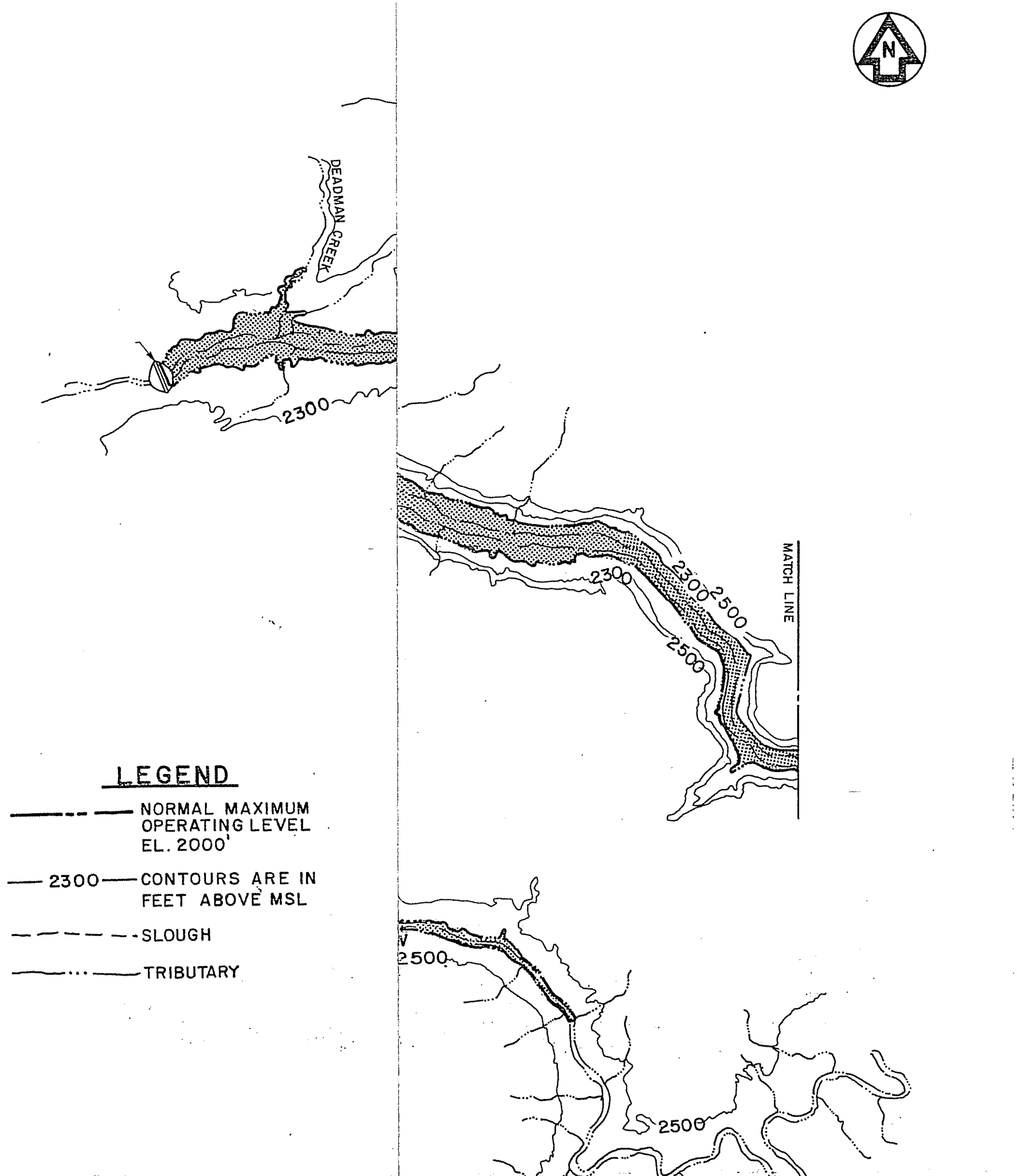
Chum Incubation Area in IFG and DIHAB Model Sites Under Natural Flows

Figure E.3.2.69



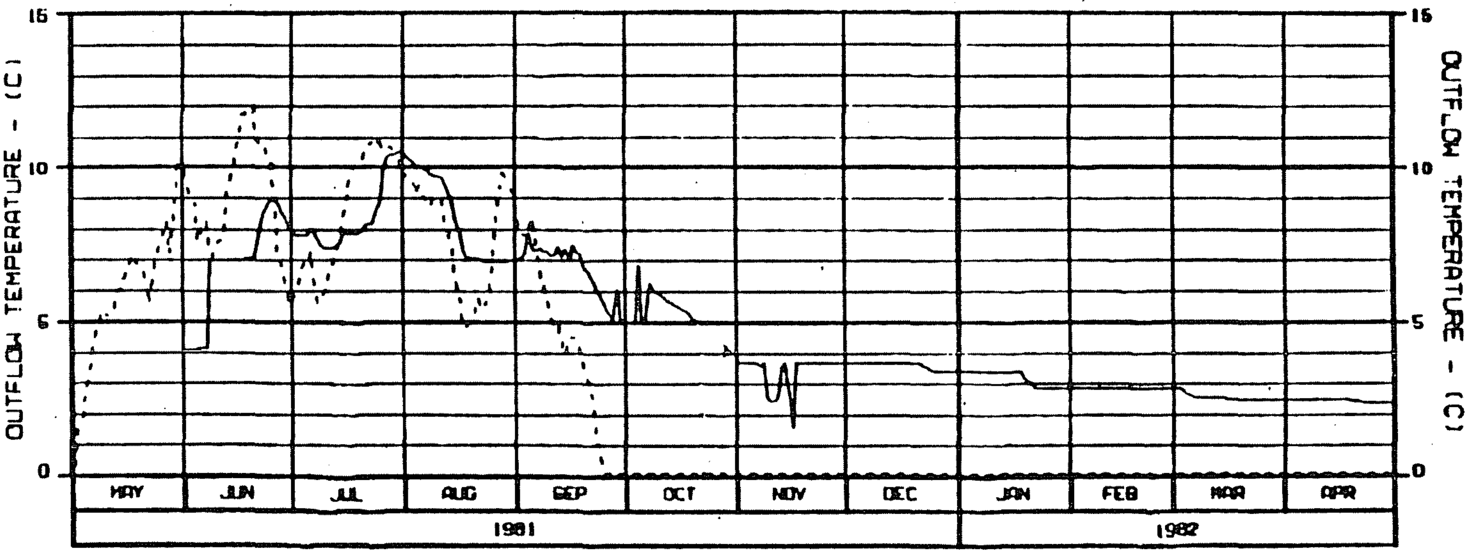
Chum Incubation Area in
Representative Groups 2,3,4
Under Natural Flows

Figure E.3.2.70

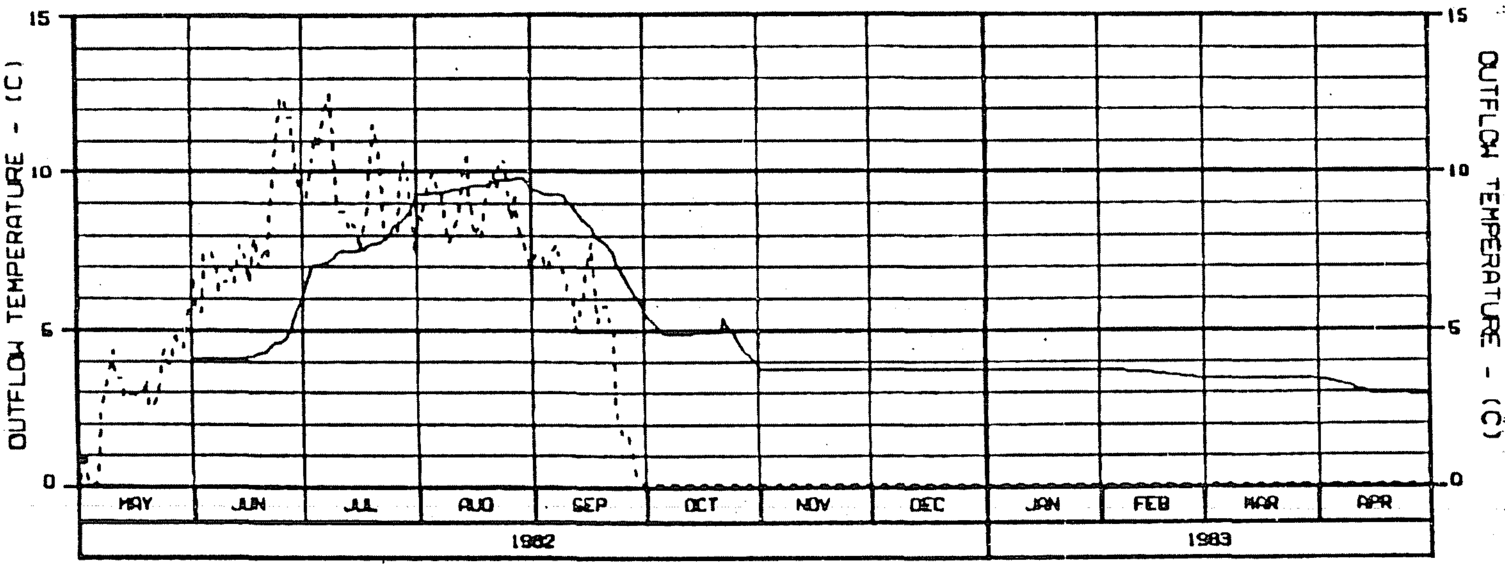


WATER BODIES

FIGURE E.3.2.71



LEGEND: CASE: ■■■■■ WA81FILA - WATANA FILLING OPERATION ■■■■■
FIRST YEAR FILLING USING 1981 CLIMATE DATA
———— PREDICTED OUTFLOW TEMPERATURE
- - - - - - - INFLOW TEMPERATURE

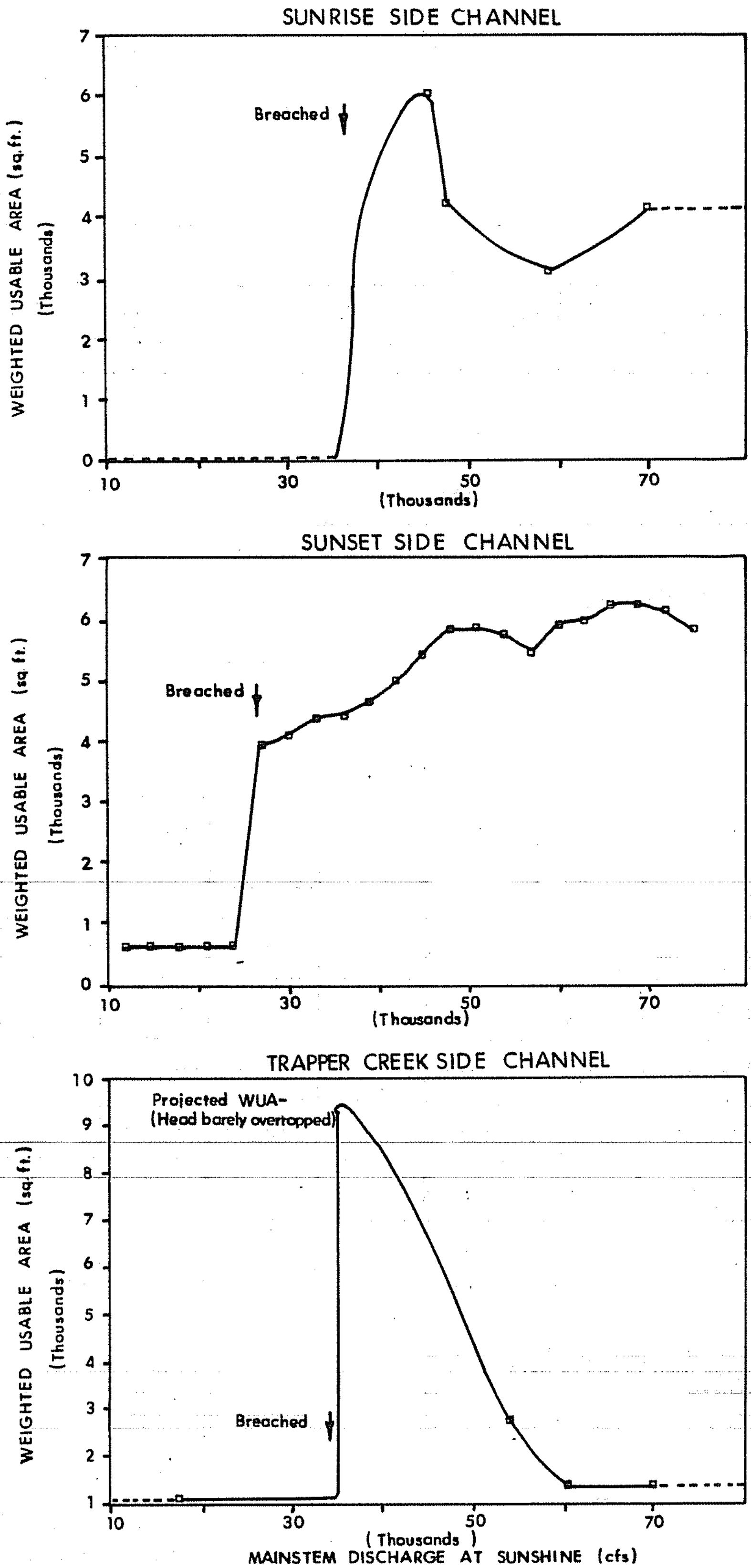


LEGEND: CASE: ■■■■■ WA81FILF - WATANA FILLING OPERATION ■■■■■
FIRST YEAR FILLING USING 1982 CLIMATE DATA
———— PREDICTED OUTFLOW TEMPERATURE
- - - - - - - INFLOW TEMPERATURE

WATANA RESERVOIR
OUTFLOW TEMPERATURE
DURING INITIAL FILLING

FIGURE E.3.2.72

SOURCE: APA 1984e



SOURCE: ADF&G 1985 RPT. 7

JUVENILE CHINOOK WEIGHTED USABLE AREA IN REPRESENTATIVE SITES LOCATED IN THE LOWER RIVER

FIGURE E.3.2.73
(PAGE 1 OF 6)

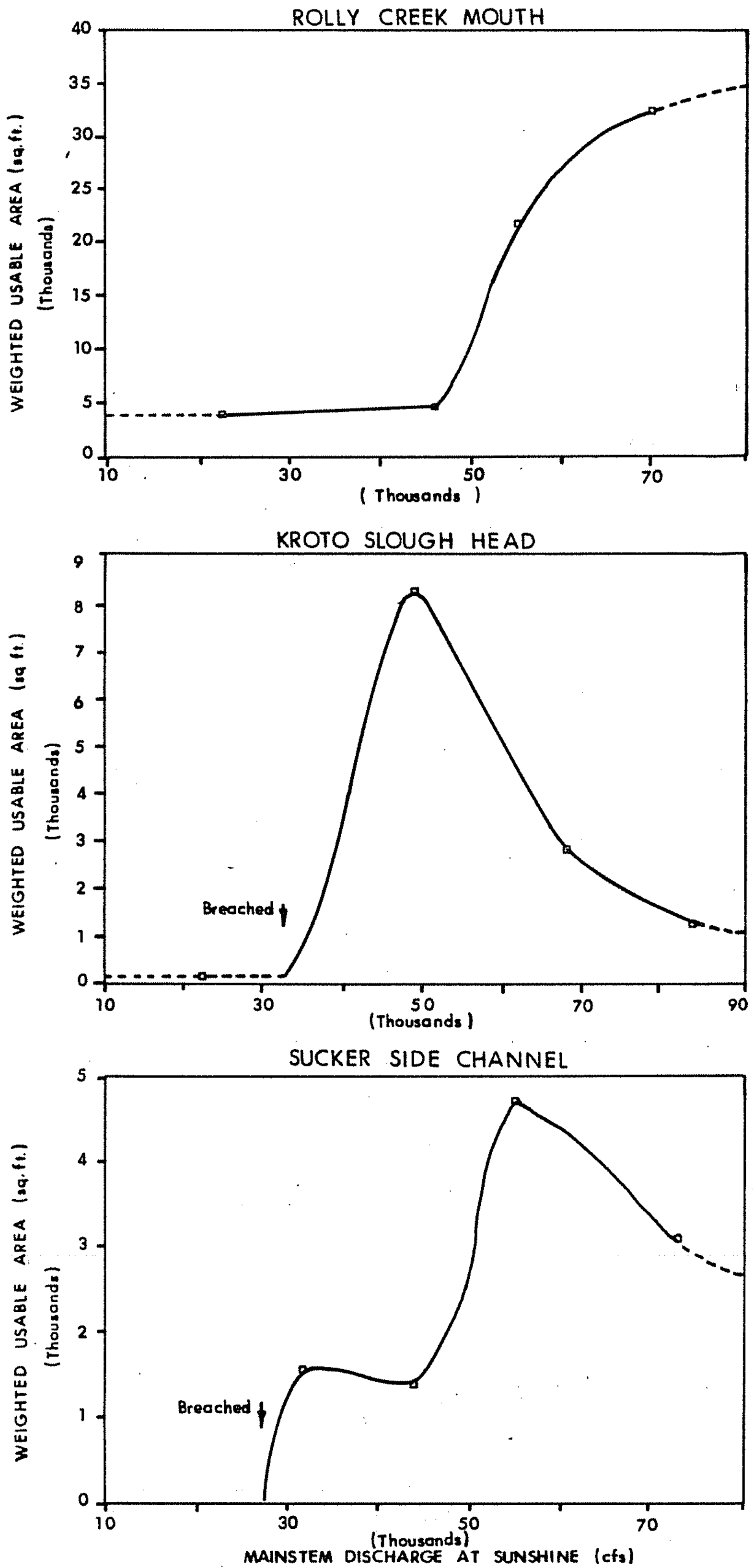


FIGURE E.3.2.73
(PAGE 2 OF 6)

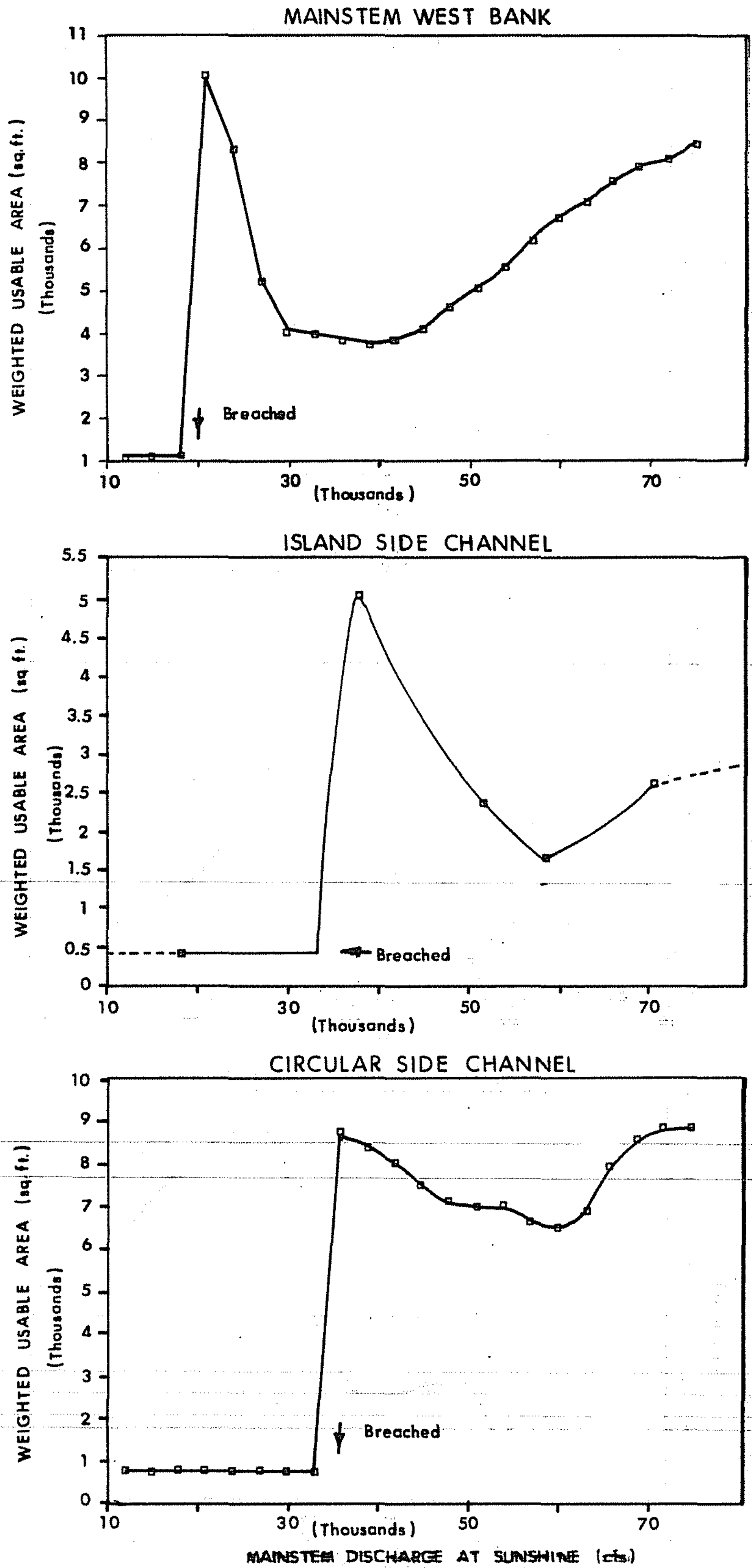


FIGURE E.3.2.73
(PAGE 3 OF 6)

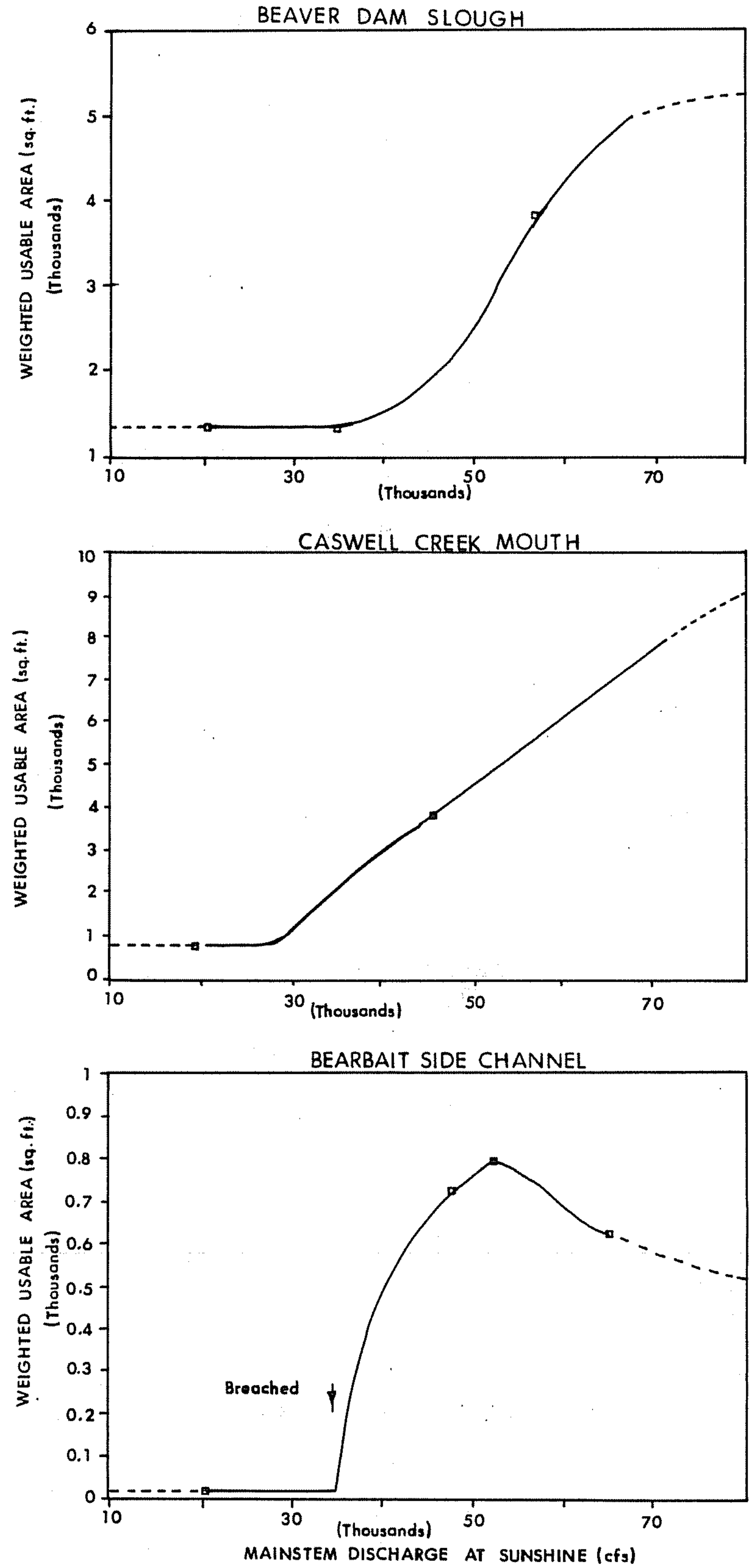
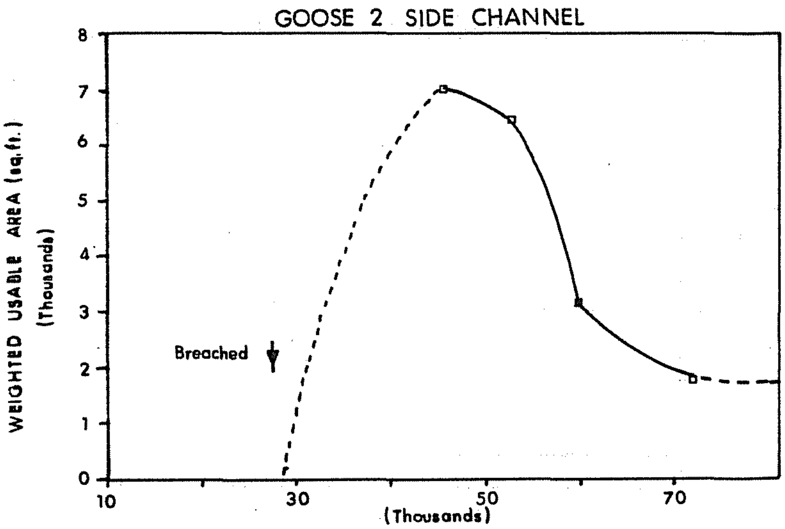
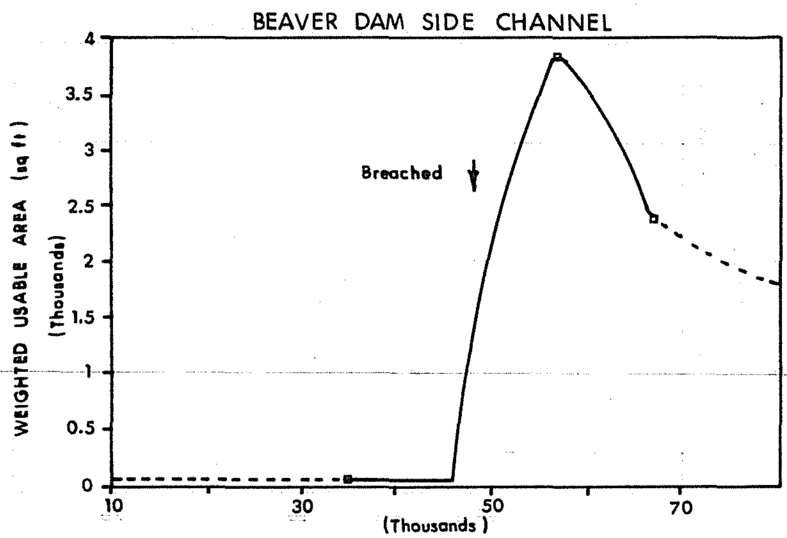


FIGURE E.3.2.73
(PAGE 4 OF 6)





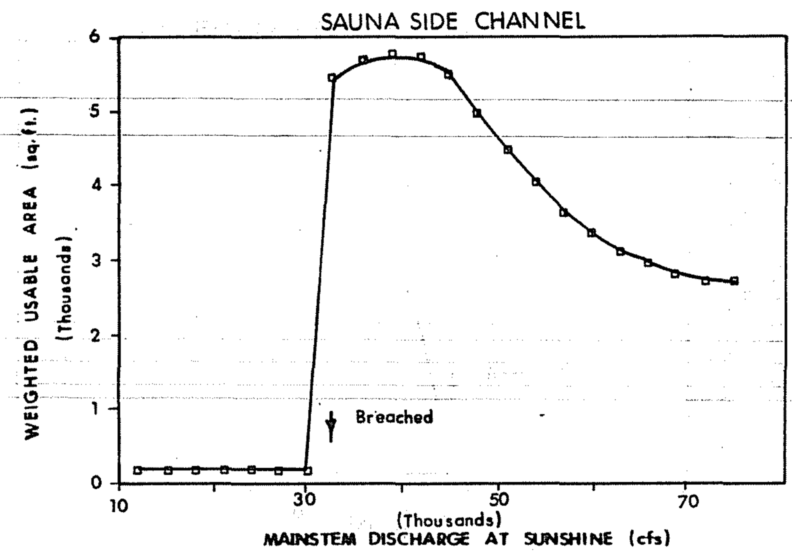


FIGURE E.3.2.73
(PAGE 5 OF 6)

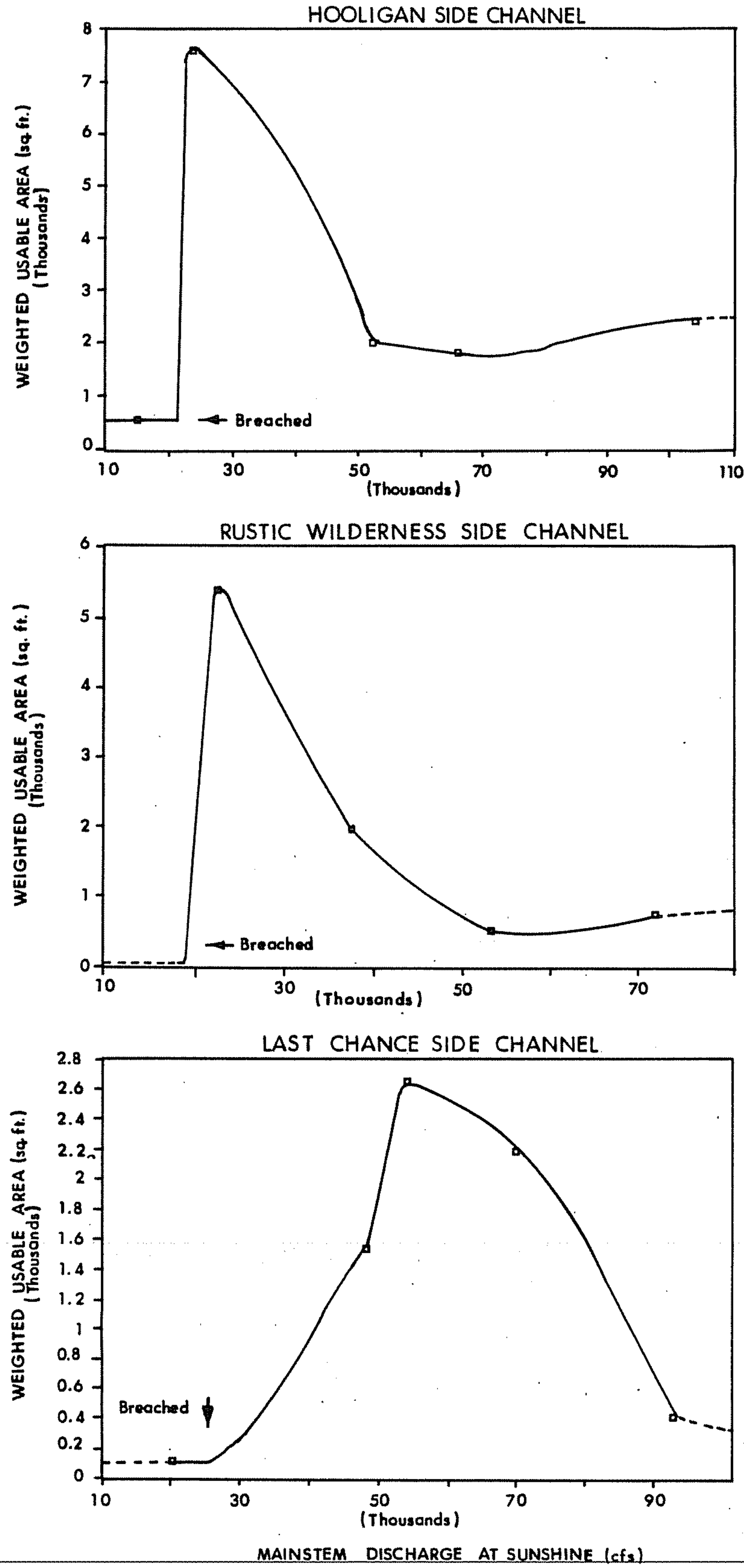
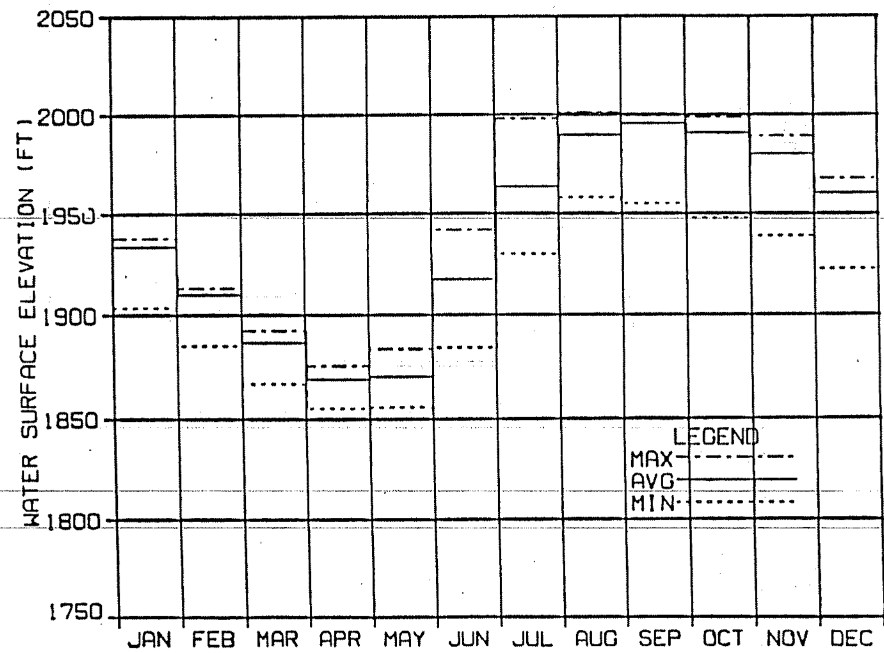


FIGURE E.3.2.73
(PAGE 6 OF 6)

WATANA WATER SURFACE ELEVATION
MONTHLY SUMMARY

STAGE I

WATANA 2000 FT. NO DEVIL CANYON



SOURCE: APA 1985h

FIGURE E.3.2.74

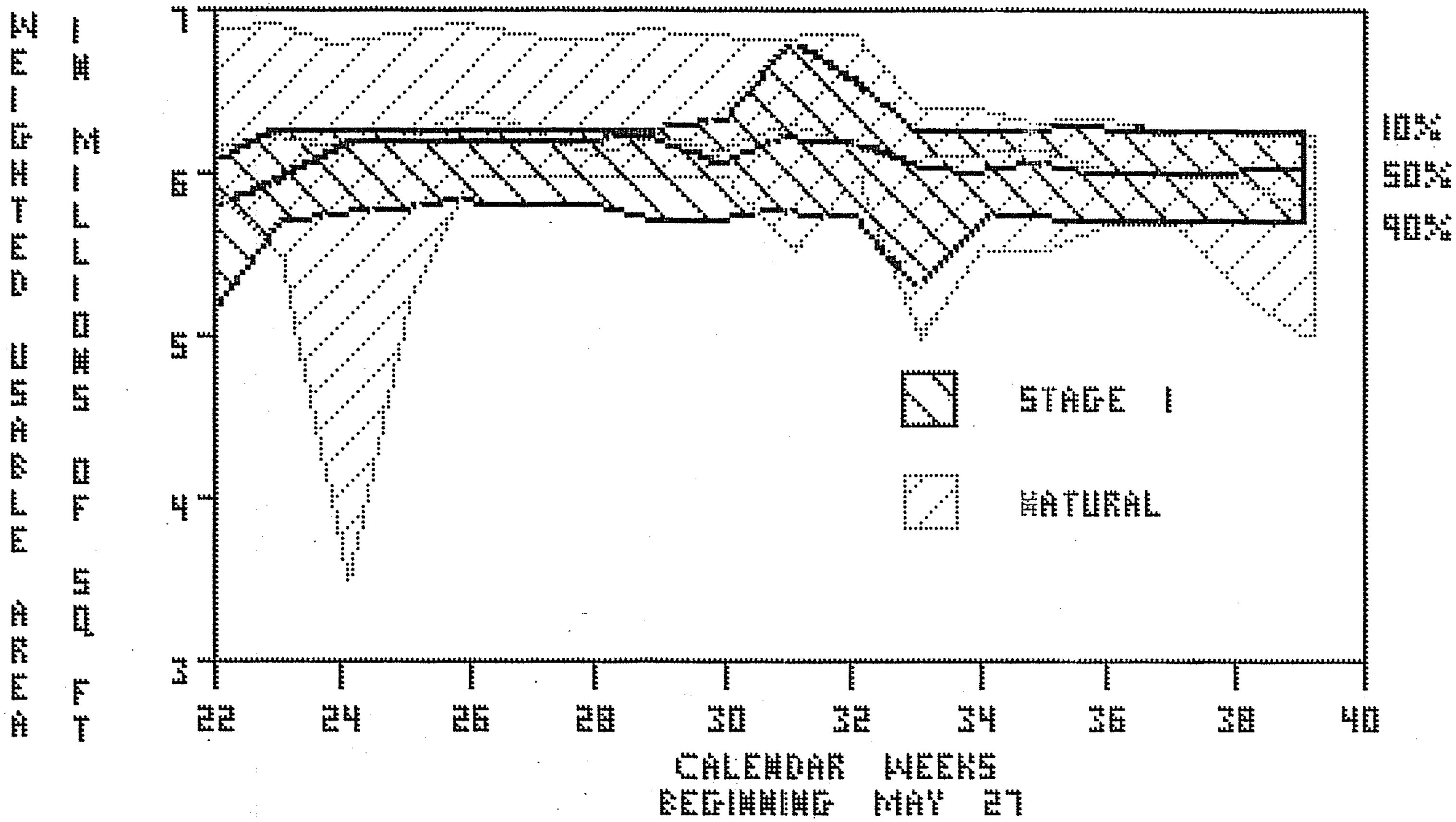


Figure E.3.2.75 :
Chinook Rearing Habitat Area
Under Stage I Flow Regime
In All Representative Groups

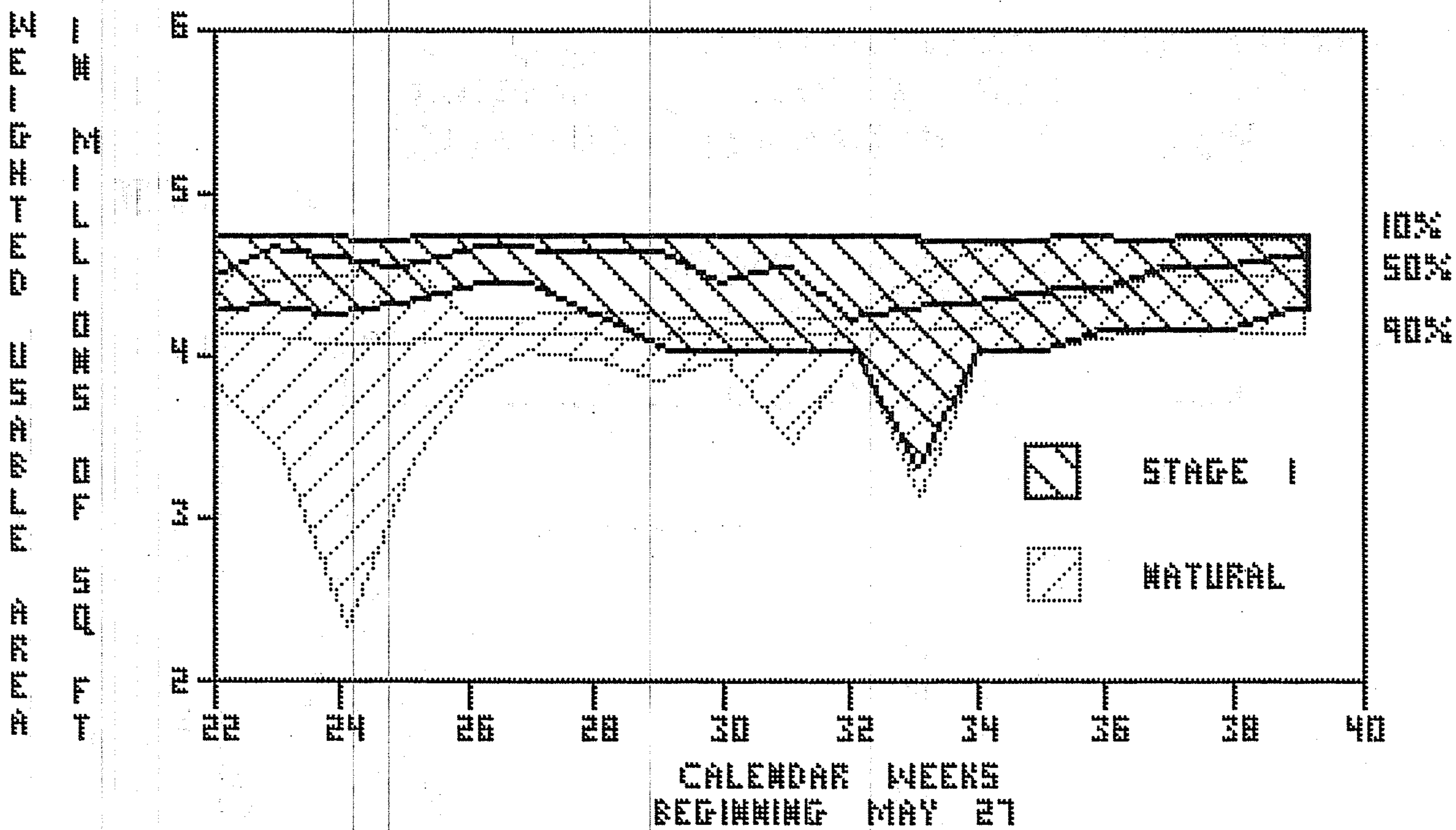
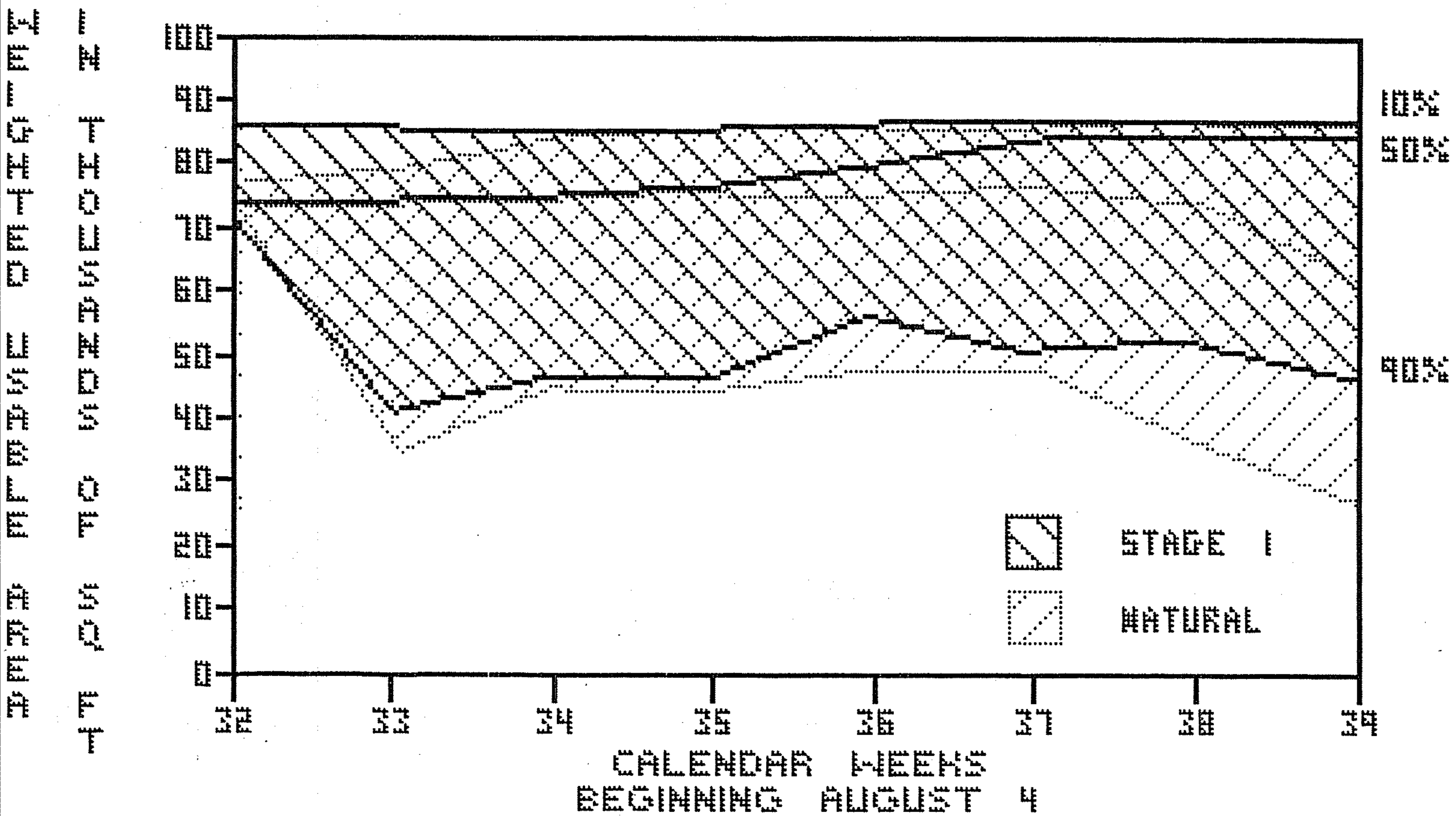
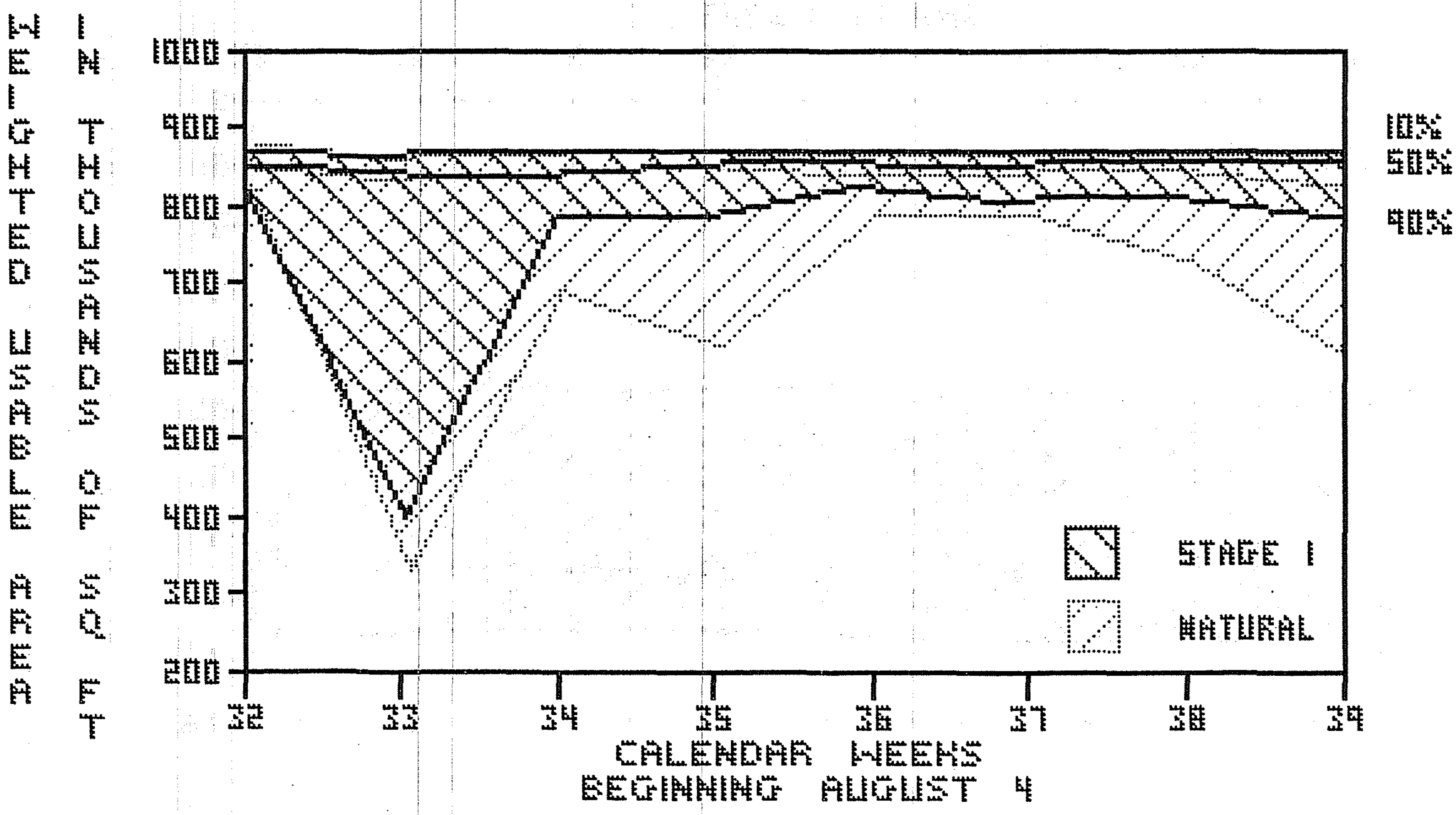


Figure E.3.2.76: Chinook Rearing Habitat Area Under Stage I Flow Regime In Representative Groups 2,3,4



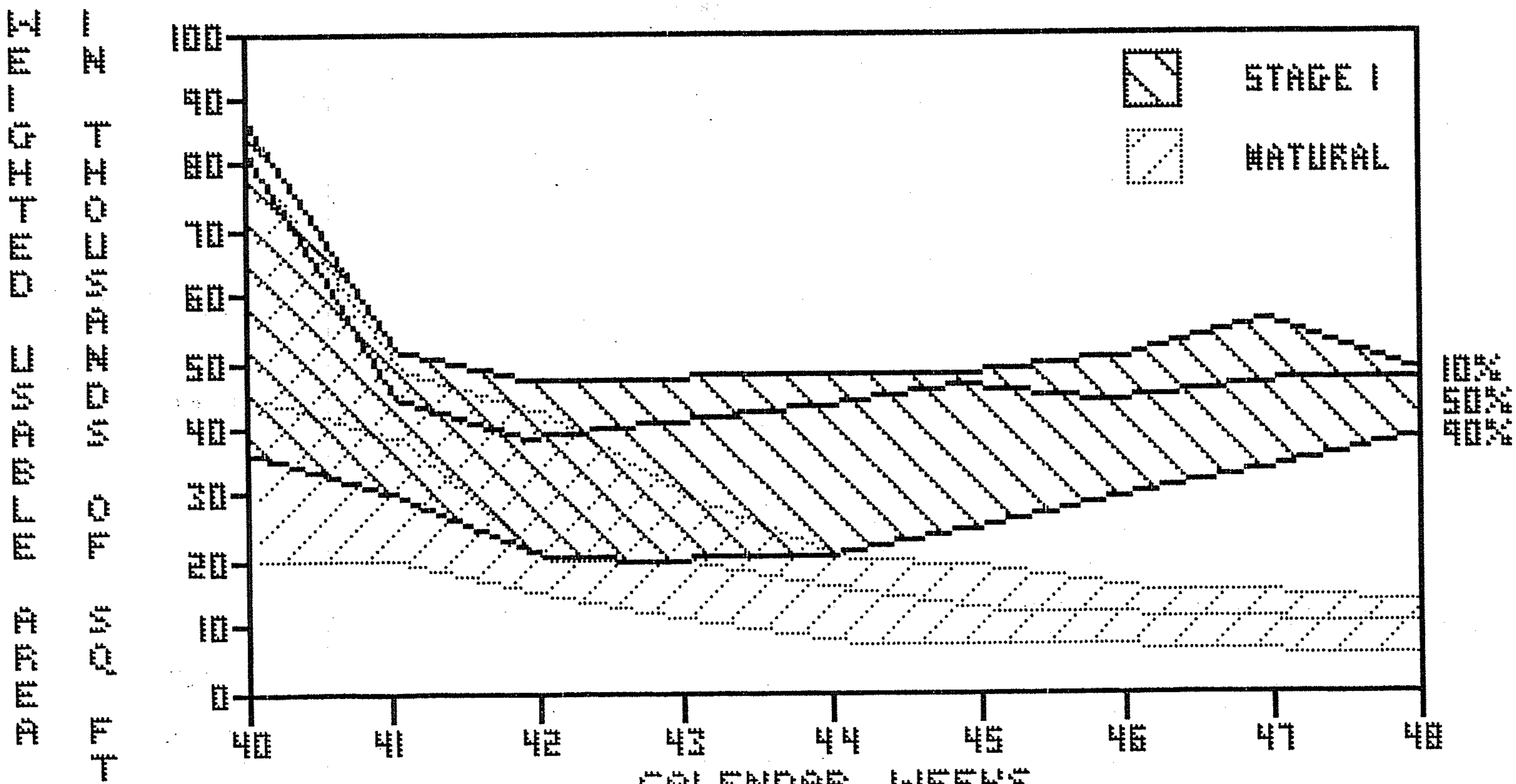
Chum Spawning Area in
IFG and DIHAB Model Sites
Under Stage I Flows

Figure E.3.2.77



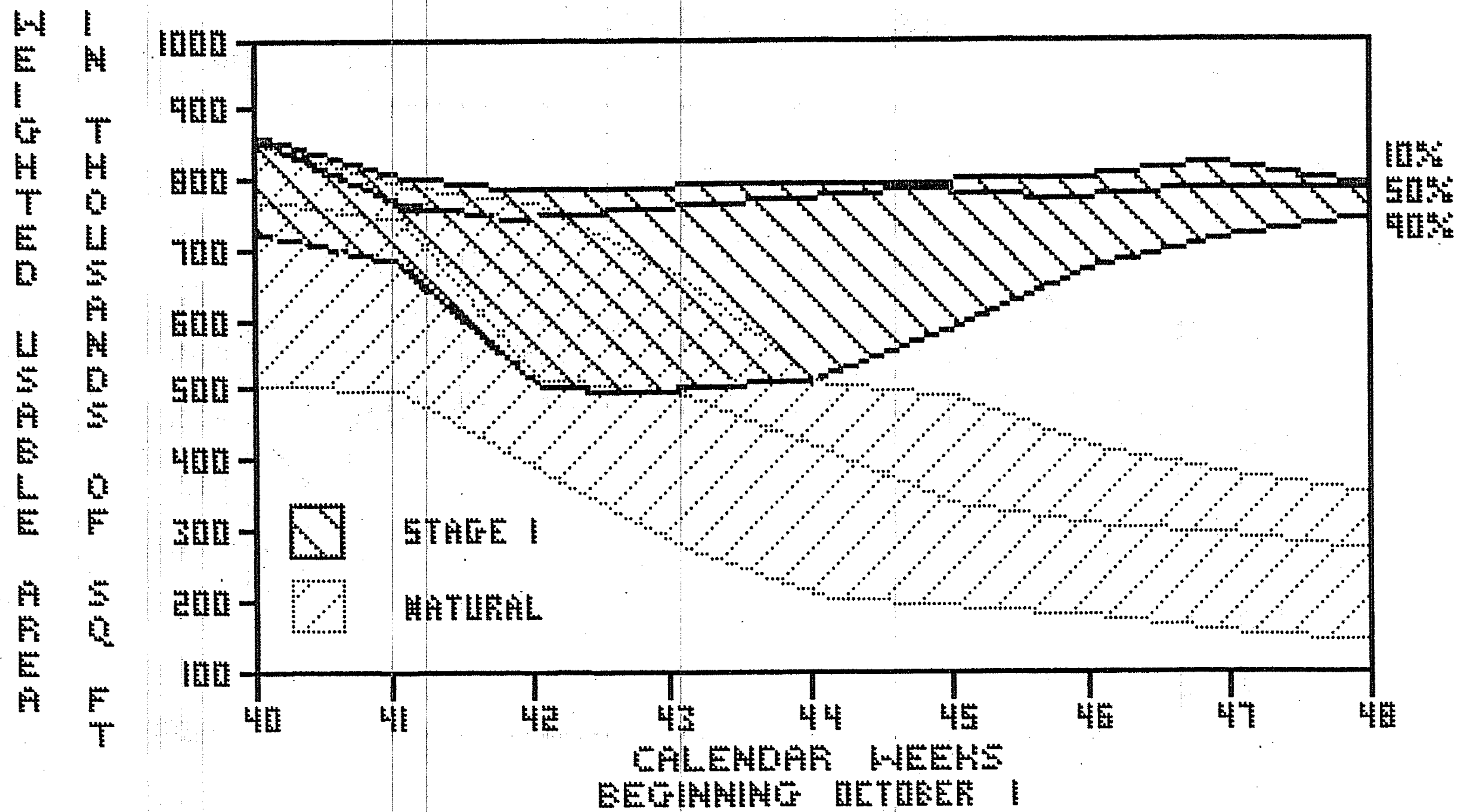
Chum Spawning Area in
Representative Groups 2,3,4
Under Stage I Flows

Figure E.3.2.78



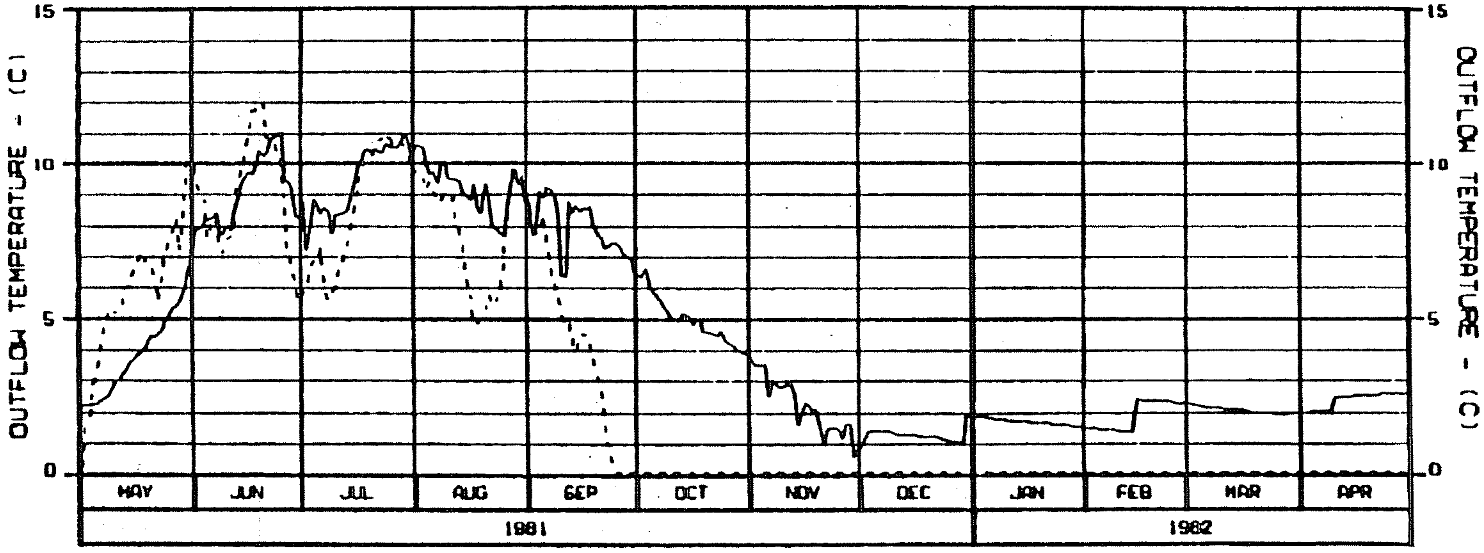
Chum Incubation Area in
IFG and DIHAB Model Sites
Under Stage I Flows

Figure E.3.2.79



Chum Incubation Area in Representative Groups 2,3,4 Under Stage I Flows

Figure E.3.2.80



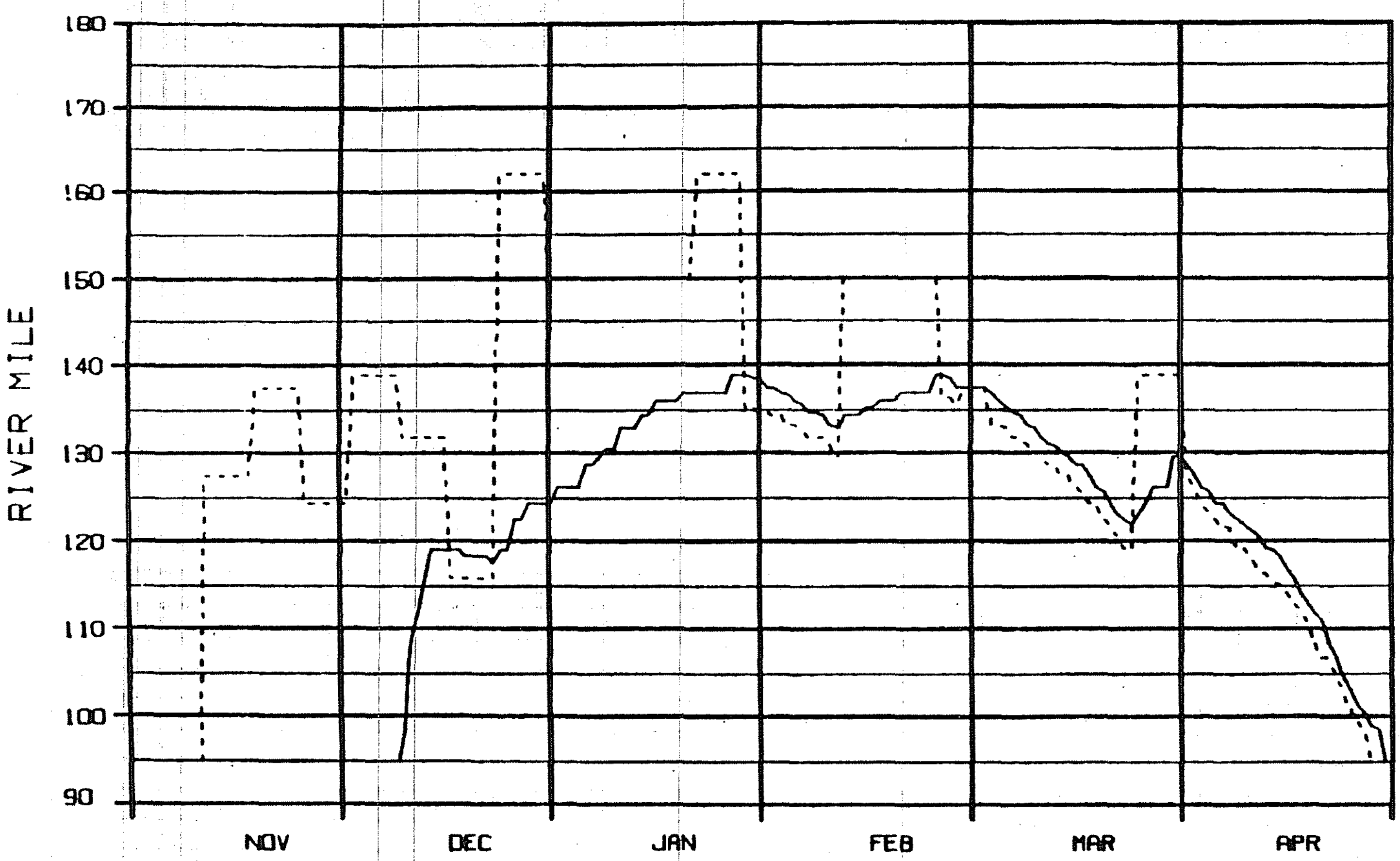
LEGEND: WATANA OPERATION IN STAGE I
CASE E-VI. NATURAL CONDITIONS AND HIGHEST LEVEL
——— PREDICTED OUTFLOW TEMPERATURE
- - - - - - - INFLOW TEMPERATURE

NOTES:
1. INTAKE PORT LEVEL 1 AT EL. 1964.6 FT. (599.9 m)
2. INTAKE PORT LEVEL 2 AT EL. 1926.6 FT. (587.4 m)
3. INTAKE PORT LEVEL 3 AT EL. 1998.6 FT. (576.8 m)
4. INTAKE PORT LEVEL 4 AT EL. 1860.6 FT. (664.2 m)
5. INTAKE PORT LEVEL 5 AT EL. 1812.5 FT. (552.6 m)
6. CONE VALVE AT ELEVATION 1791 FT (546.0 m)
7. SPILLWAY CREST AT ELEVATION 2149 FT (654.7 m)

STAGE 1 WATANA RESERVOIR
OUTFLOW TEMPERATURE

SOURCE: HE 1985h

FIGURE E.3.2.81



LEGEND:
——— ICE FRONT
- - - - - - - ZERO DEGREE ISOTHERM

WEATHER PERIOD : 1 NOV 81 - 30 APR 82

FLOW CASE E-VI TEMP: INFLOW-MATCHING
STAGE I WATANA
REFERENCE RUN NO. : 8101ENS

ALASKA POWER AUTHORITY

SUSITNA PROJECT

SUSITNA RIVER
PROGRESSION OF ICE FRONT
& ZERO DEGREE ISOTHERM

HARZA-EBASCO JOINT VENTURE

1863.142

FIGURE E.3.2.82

SOURCE: EXHIBIT E, CHAPTER 2

AGGREGATE CHINOOK REARING HABITAT QUALITY INDEX FOR LOWER RIVER SIDE CHANNEL / SIDE SLOUGH HABITATS

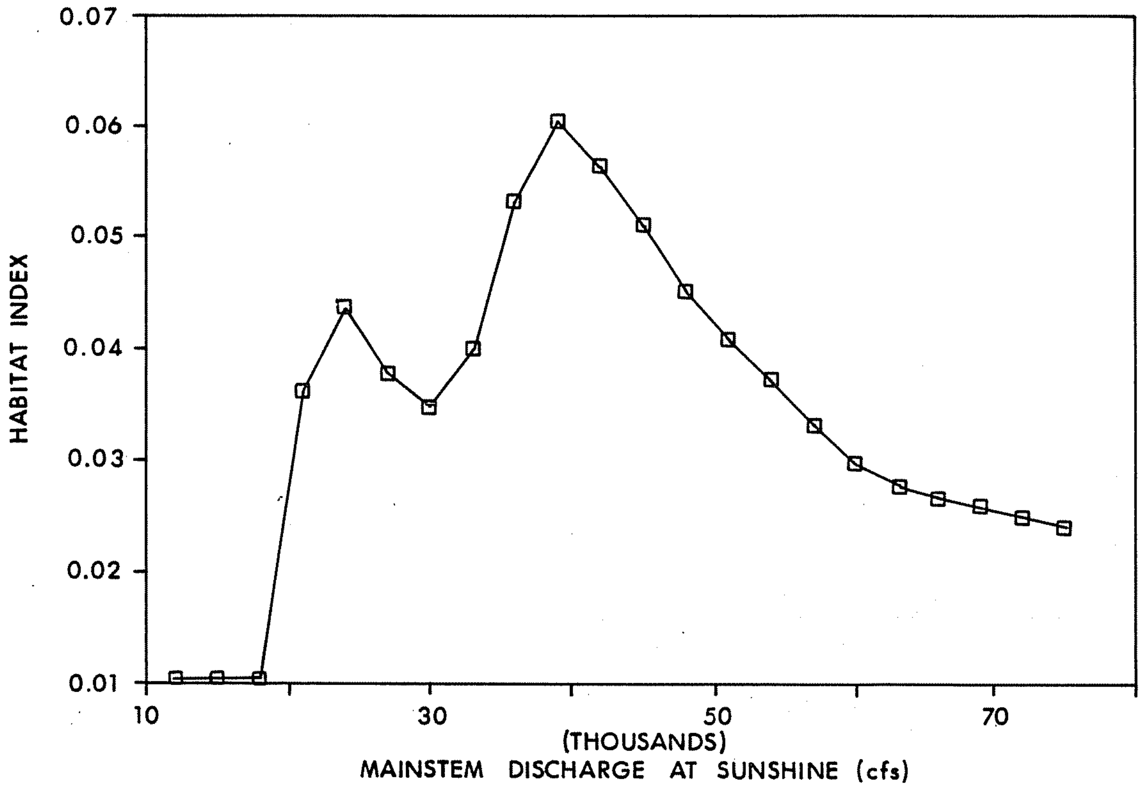


FIGURE E.3.2.83

SOURCE: ADF & G 1985c

AGGREGATE CHINOOK REARING HABITAT QUALITY INDEX FOR LOWER RIVER TRIBUTARY MOUTH HABITATS

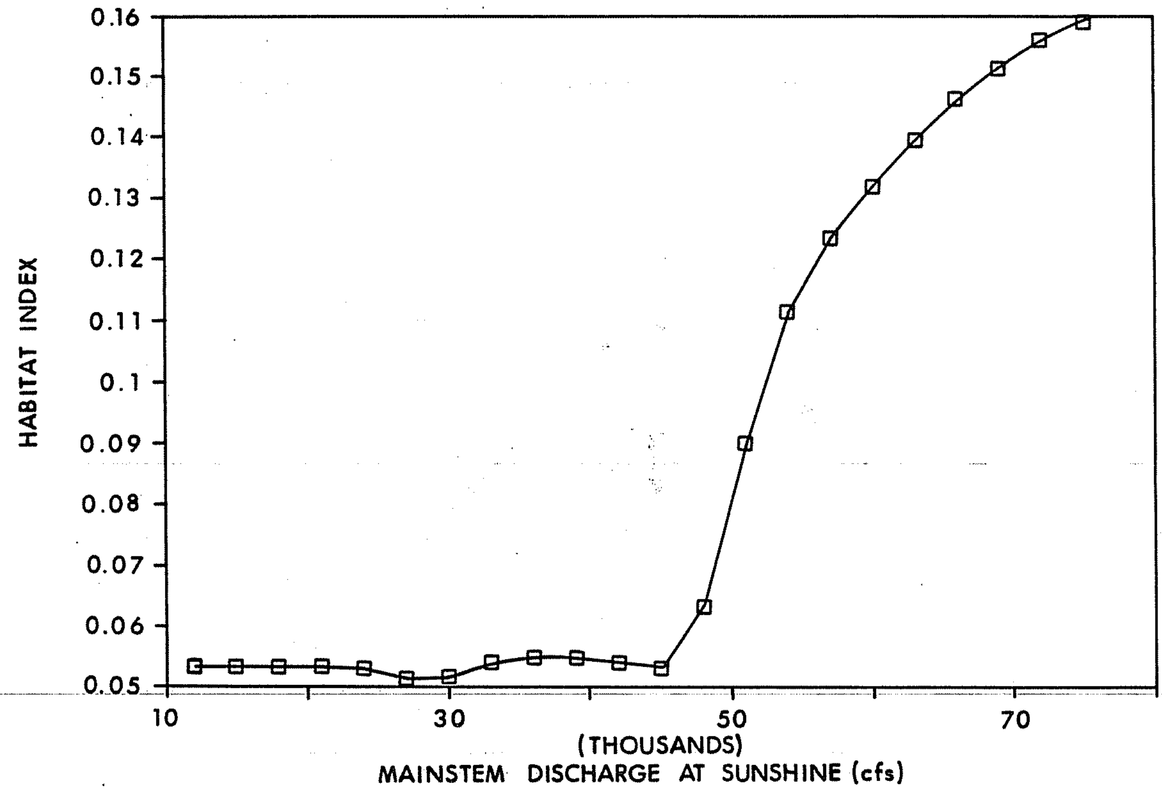


FIGURE E.3.2.84

SOURCE : ADF & G 1985 c

PLAN

WATER BODIES TO BE INUNDATED BY STAGE II DEVIL CANYON RESERVOIR

FIGURE E.3.2.85

DEVIL CANYON WATER SURFACE ELEVATION
MONTHLY SUMMARY

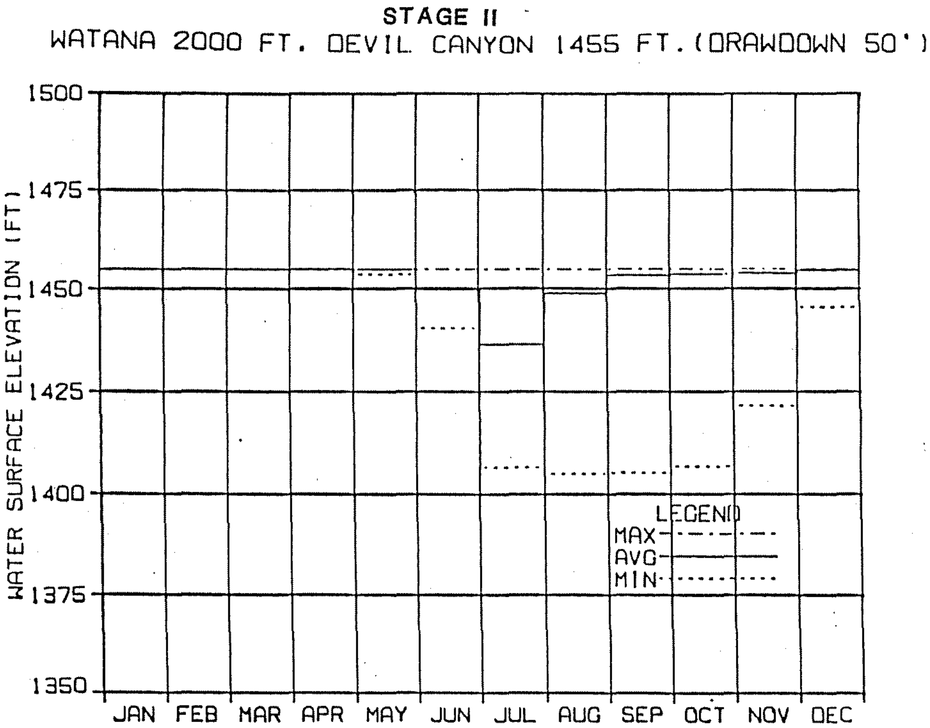
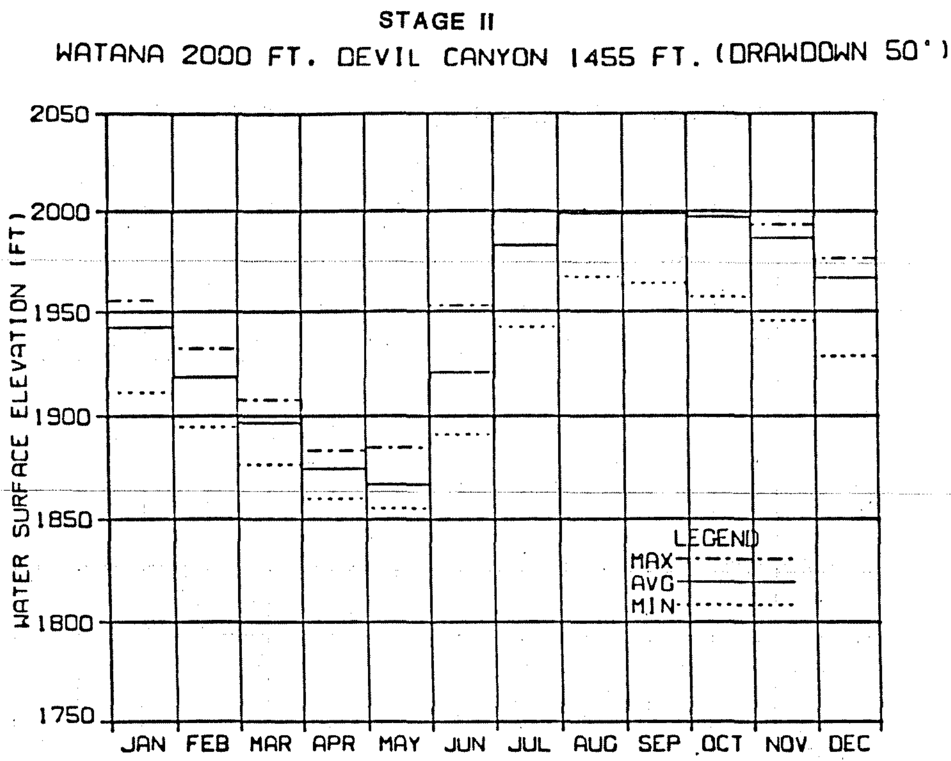


FIGURE E.3.2.86

SOURCE: APA 1985h

WATANA WATER SURFACE ELEVATION MONTHLY SUMMARY



SOURCE: APA 1985h

FIGURE E.3.2.87

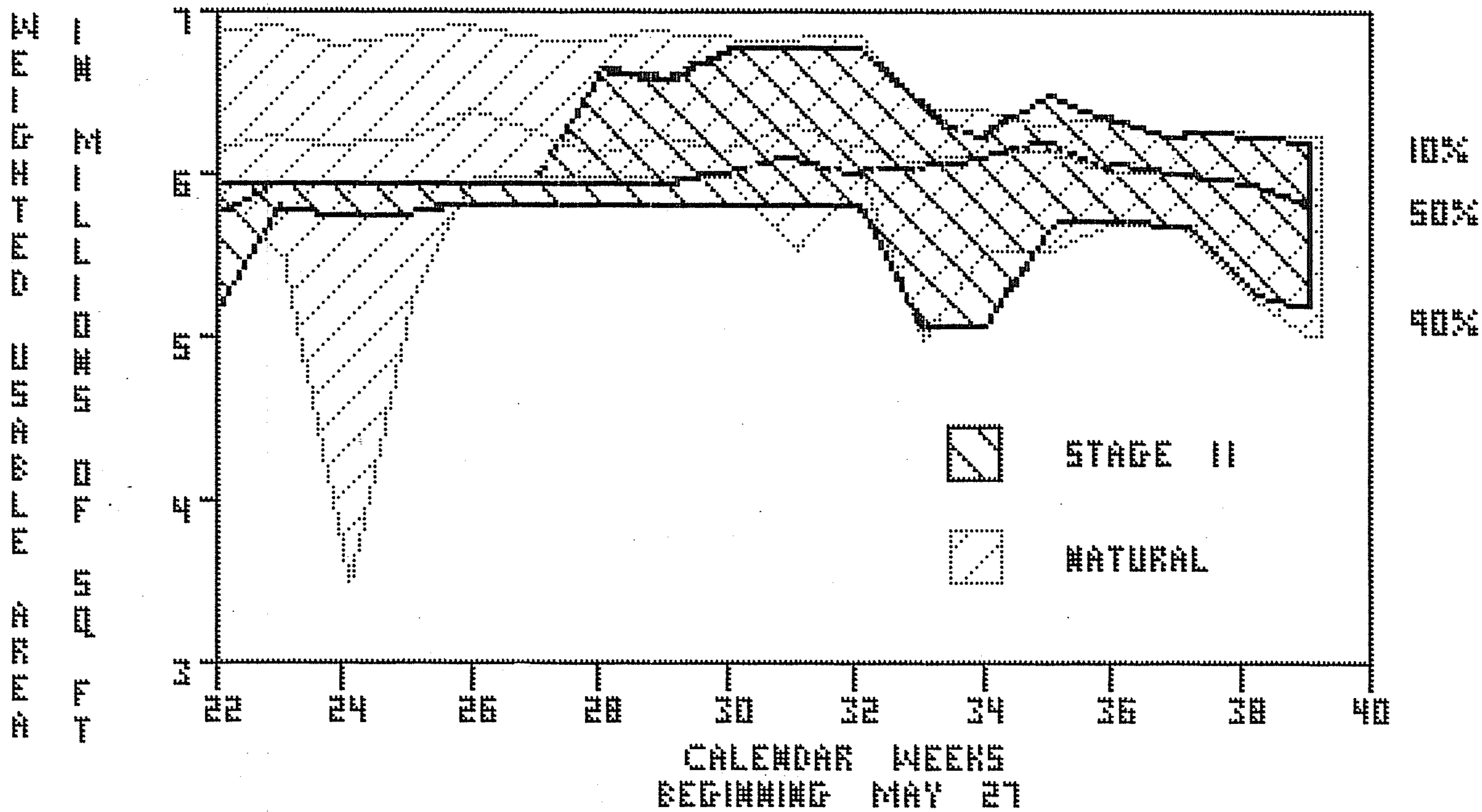


Figure E.3.2.88 : Chinook Rearing Habitat Area Under Stage II Flow Regime In All Representative Groups

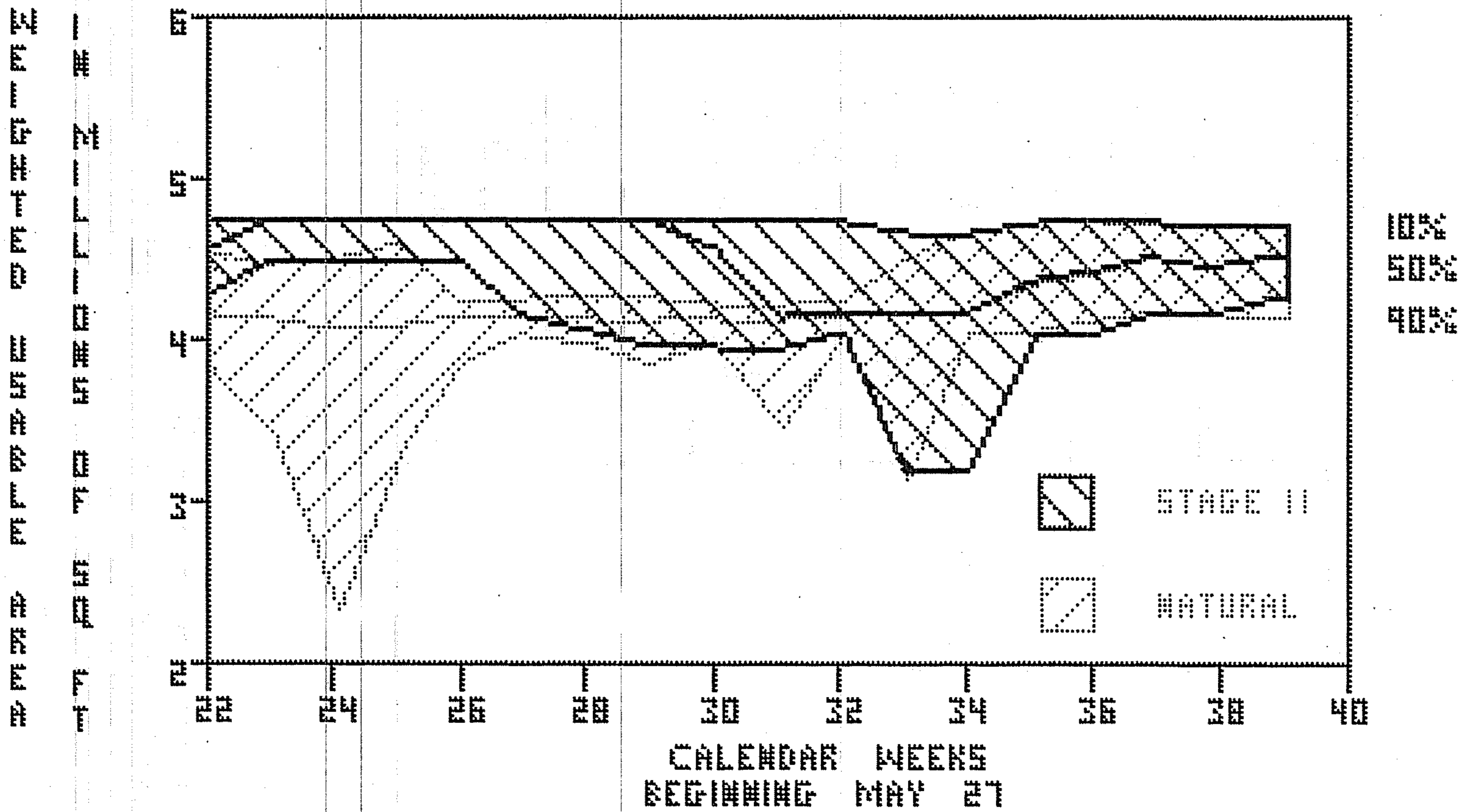
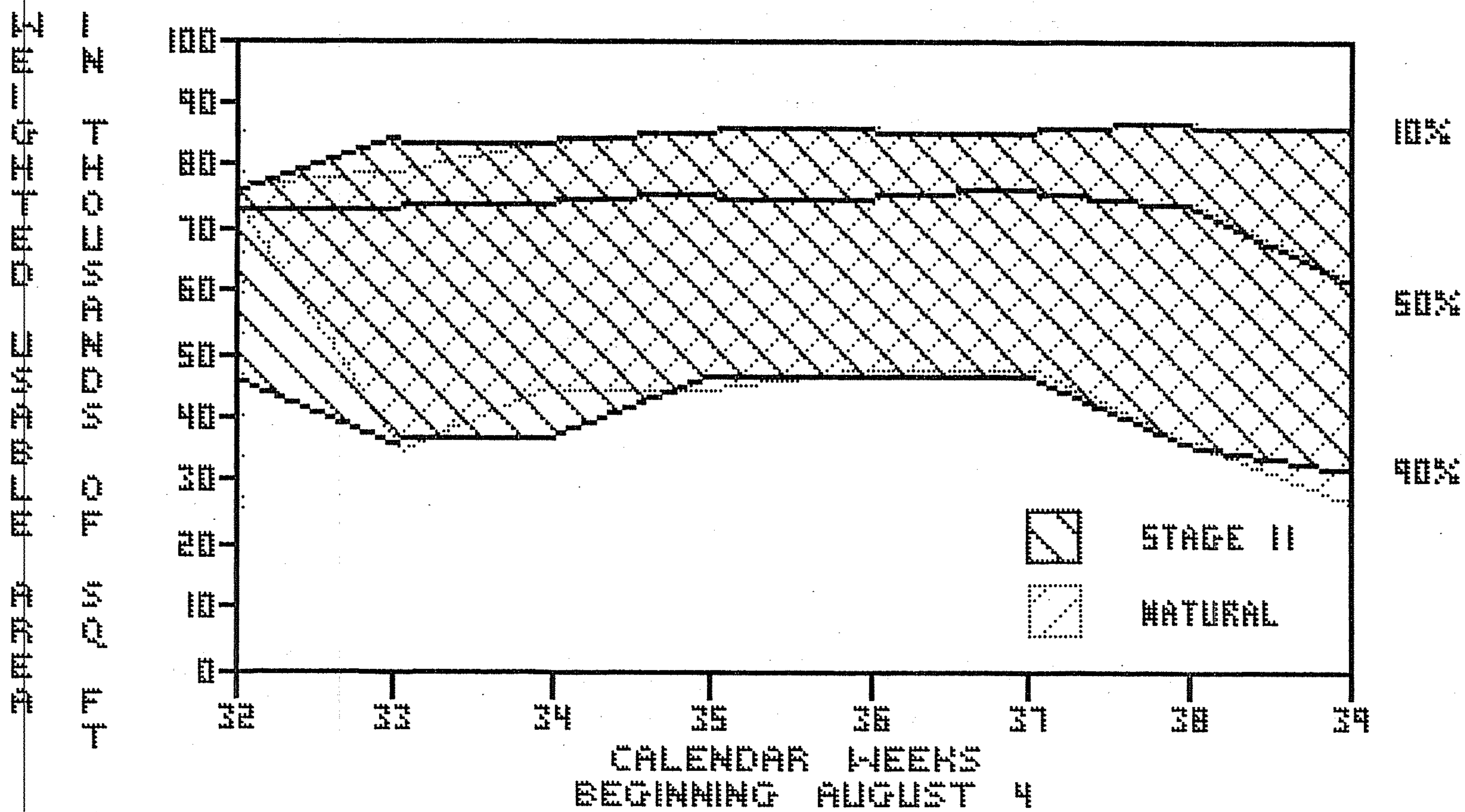
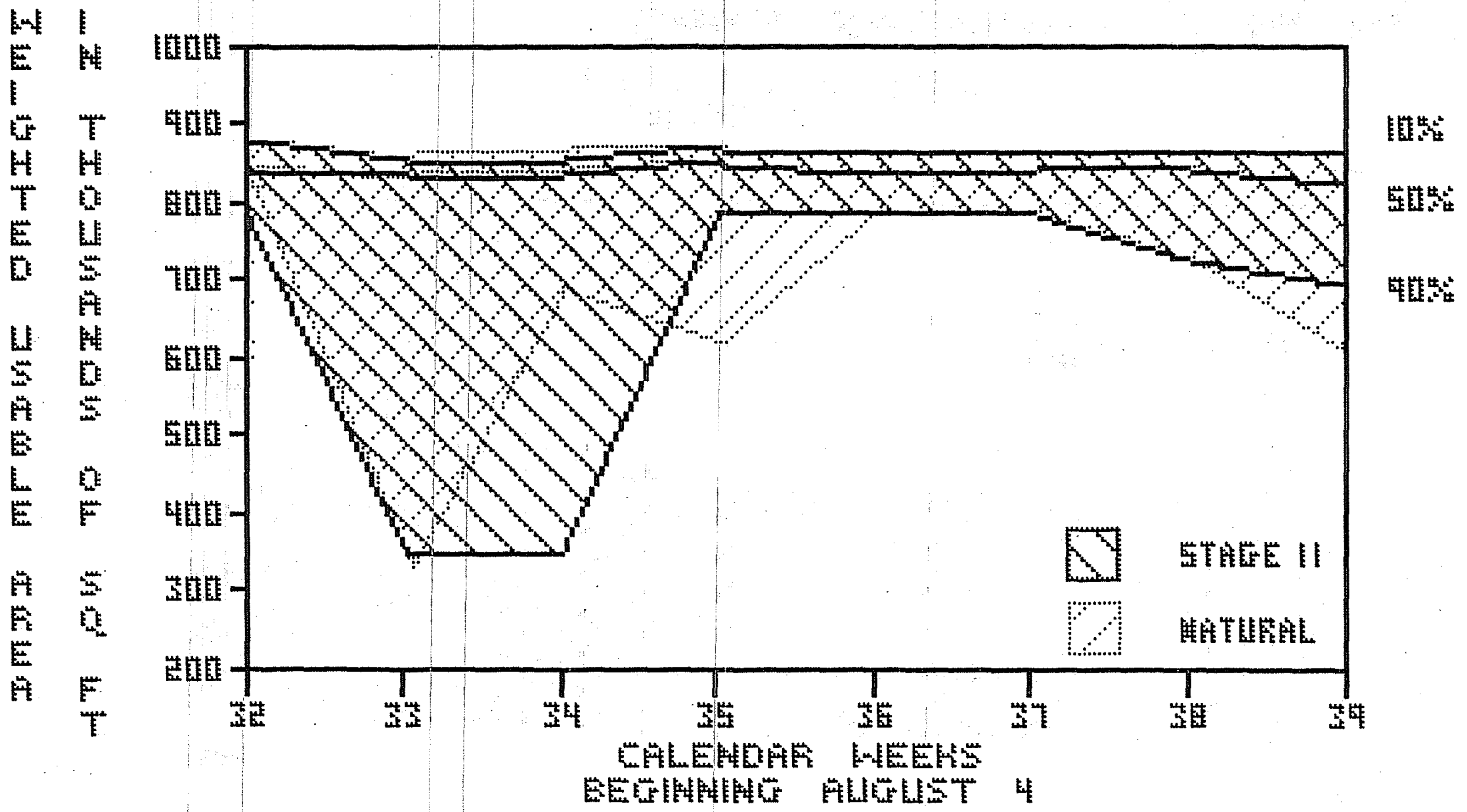


Figure E.3.2.89: Chinook Rearing Habitat Area Under Stage II Flow Regime In Representative Groups 2,3,4

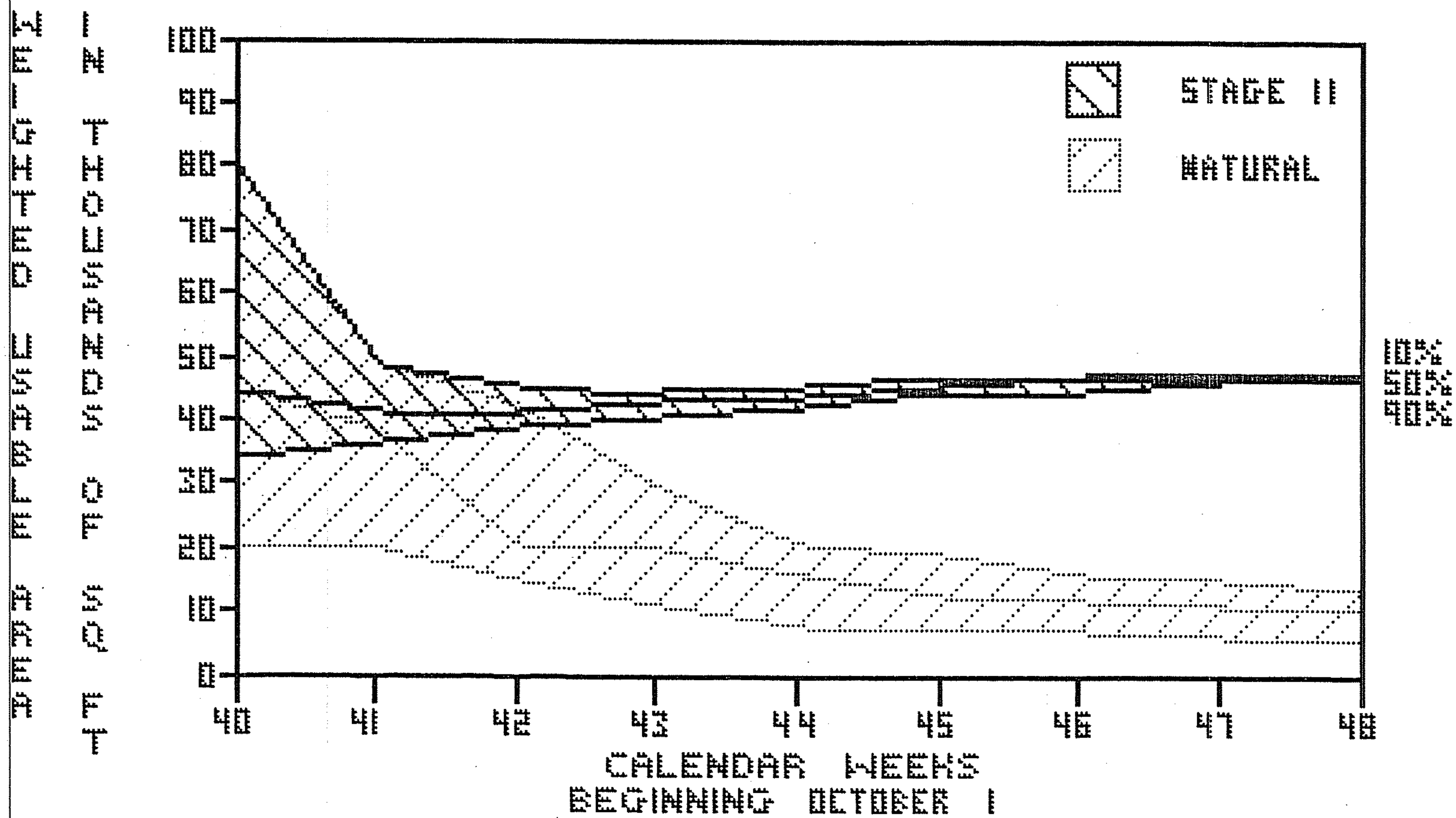


Chum Spawning Area in
IFG and DIHAB Model Sites
Under Stage II Flows

Figure E.3.2.90

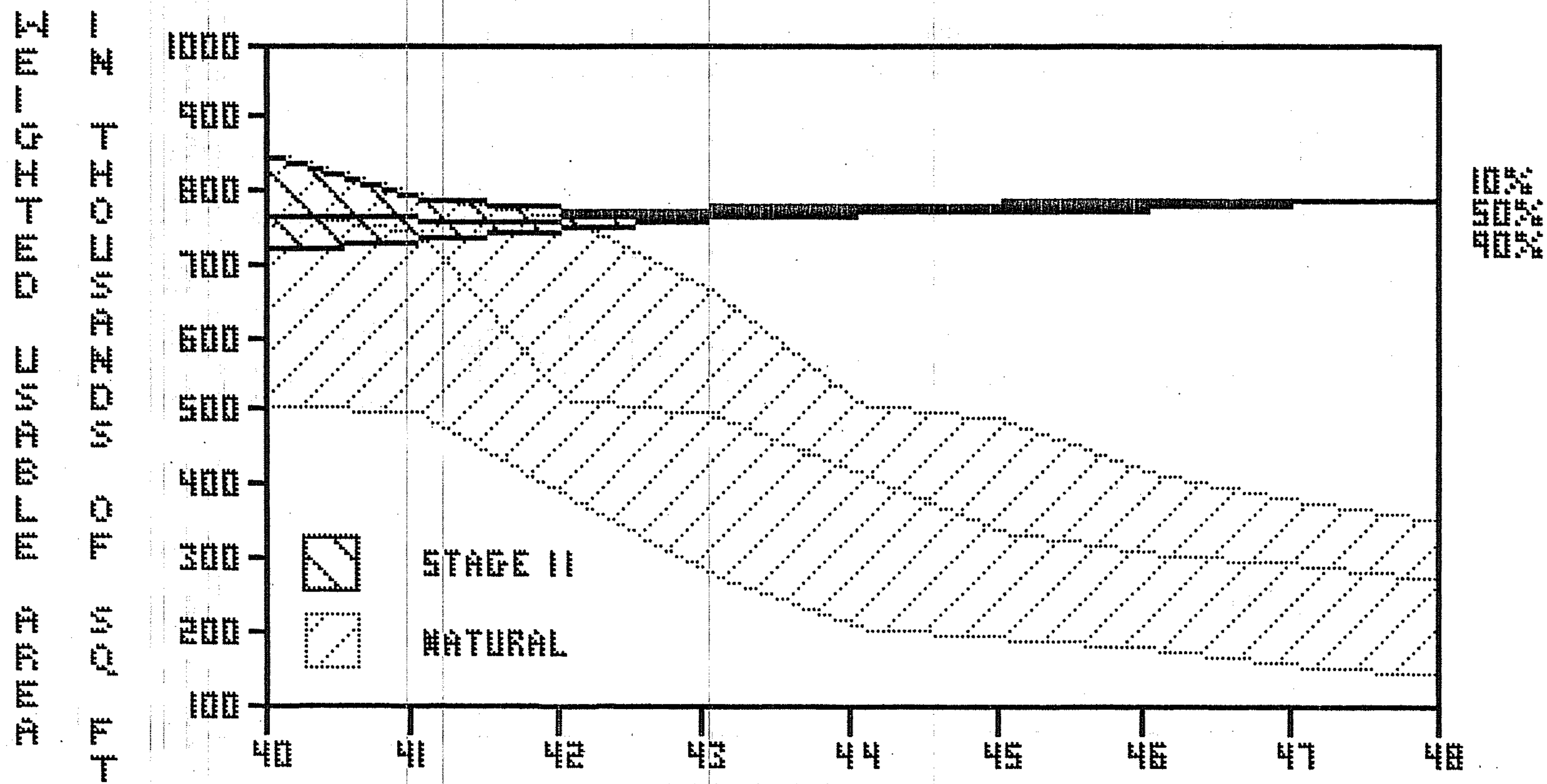


Chum Spawning Area in
Representative Groups 2,3,4
Under Stage II Flows
Figure E.3.2.91



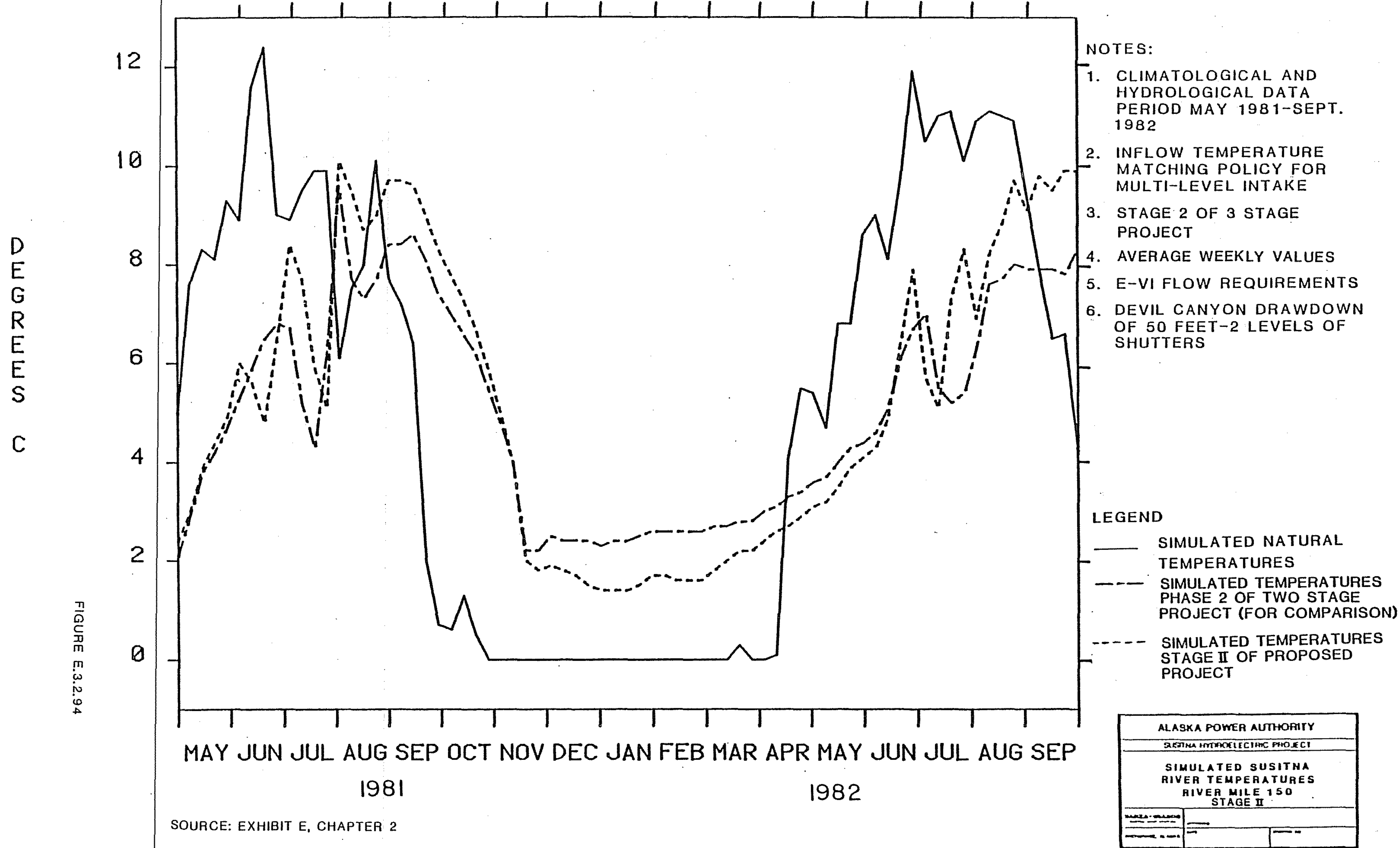
Chum Incubation Area in IFG and DIHAB Model Sites Under Stage II Flows

Figure E.3.2.92



Chum Incubation Area in Representative Groups 2,3,4 Under Stage II Flows

Figure E.3.2.93



SOURCE: EXHIBIT E, CHAPTER 2

FIGURE E.3.2.94

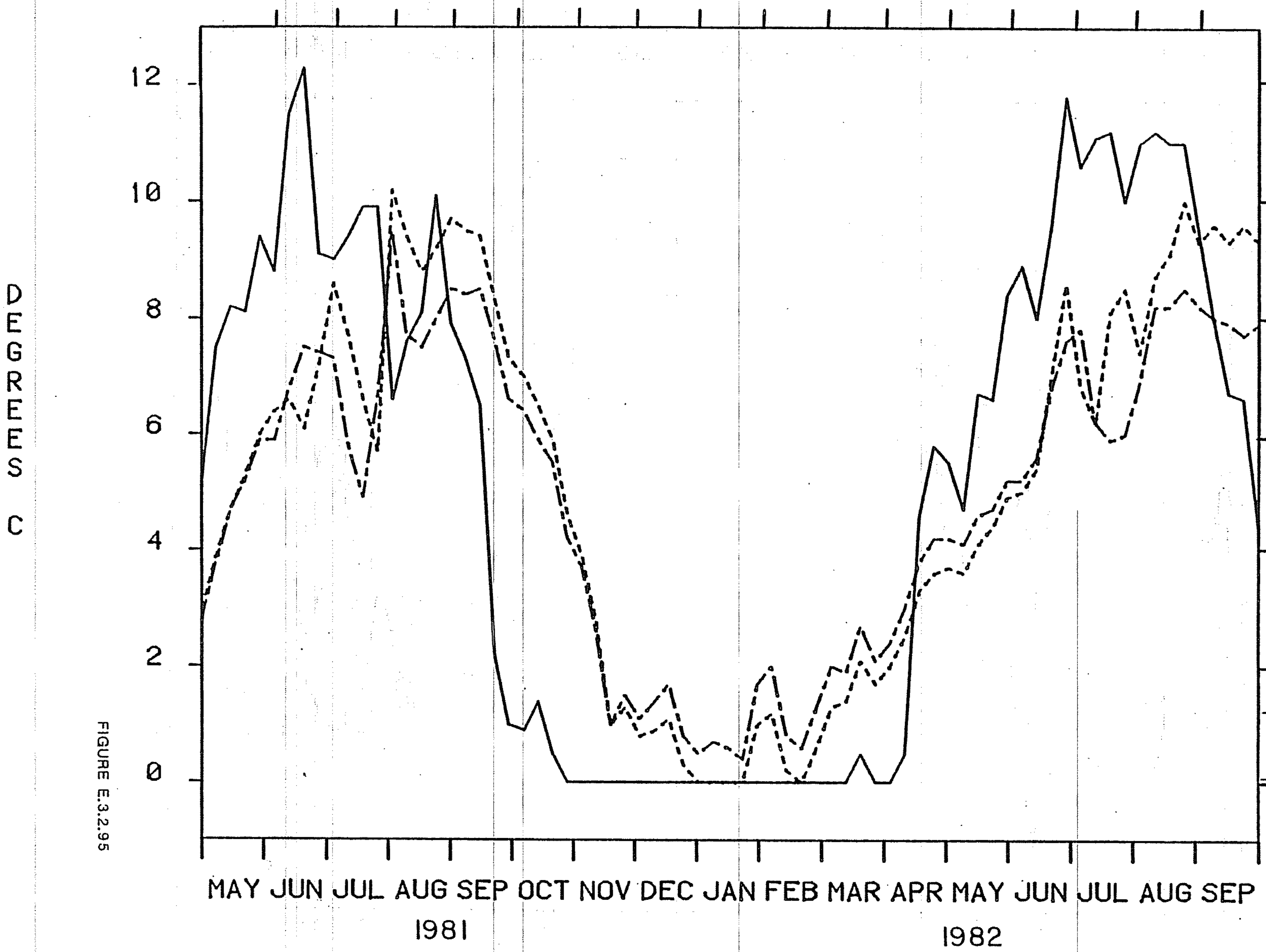


FIGURE E.3.2.95

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 JANUARY - 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-2 LEVELS OF SHUTTERS

LEGEND

SIMULATED NATURAL TEMPERATURES

SIMULATED TEMPERATURES PHASE 2 OF TWO STAGE PROJECT (FOR COMPARISON

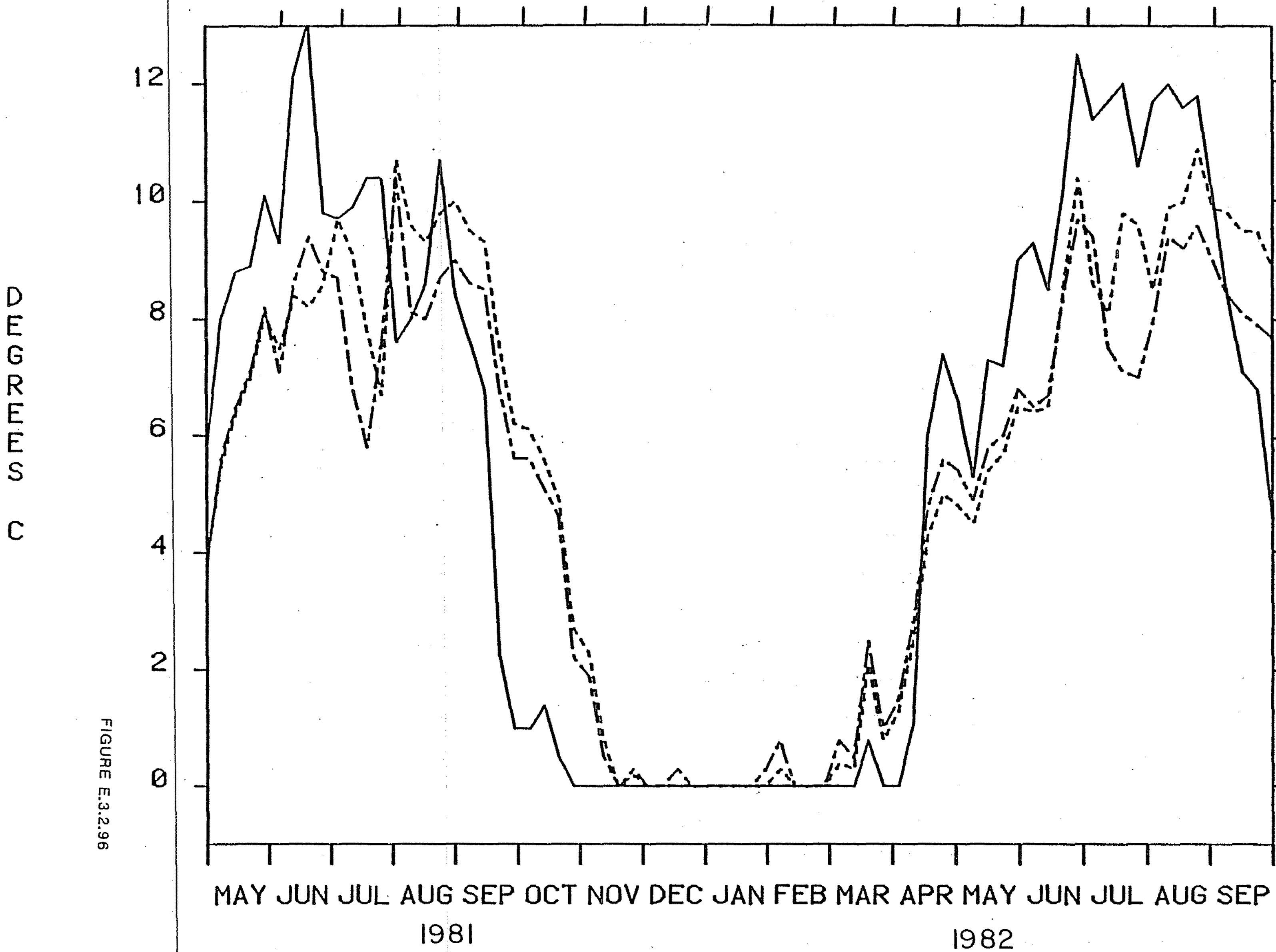
SIMULATED TEMPERATURES STAGE 2 OF PROPOSED PROJECT

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SIMULATED SUSITNA RIVER TEMPERATURES RIVER MILE 130 STAGE II

SOURCE: EXHIBIT E, CHAPTER 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-2 LEVELS OF SHUTTERS

LEGEND

SIMULATED NATURAL TEMPERATURES

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

SIMULATED TEMPERATURES STAGE 2 OF PROPOSED PROJECT

ALASKA POWER AUTHORITY

SUSITNA HYDROELECTRIC PROJECT

SIMULATED SUSITNA RIVER TEMPERATURES RIVER MILE 100 STAGE II

SOURCE: EXHIBIT E, CHAPTER 2

FIGURE E.3.2.96

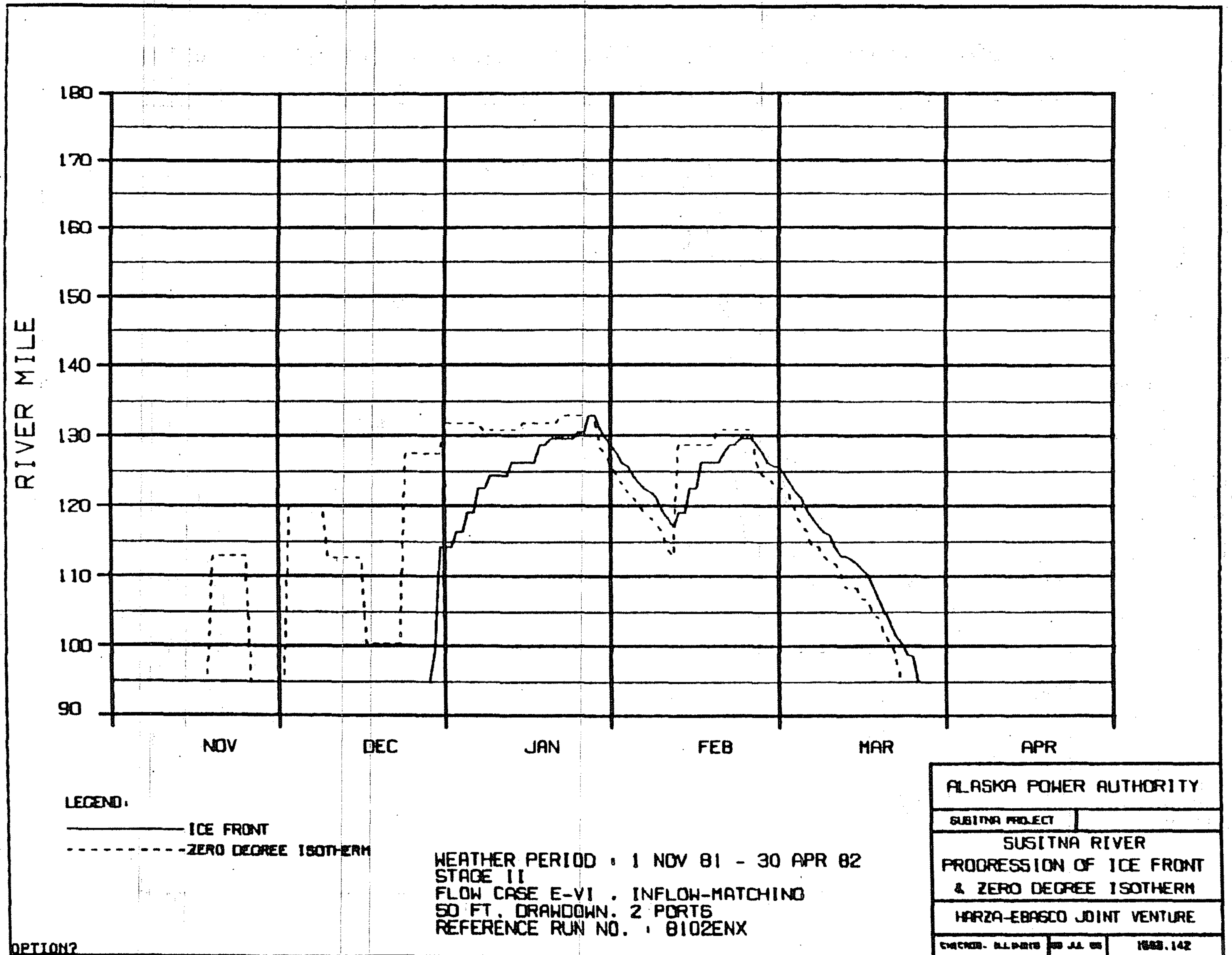
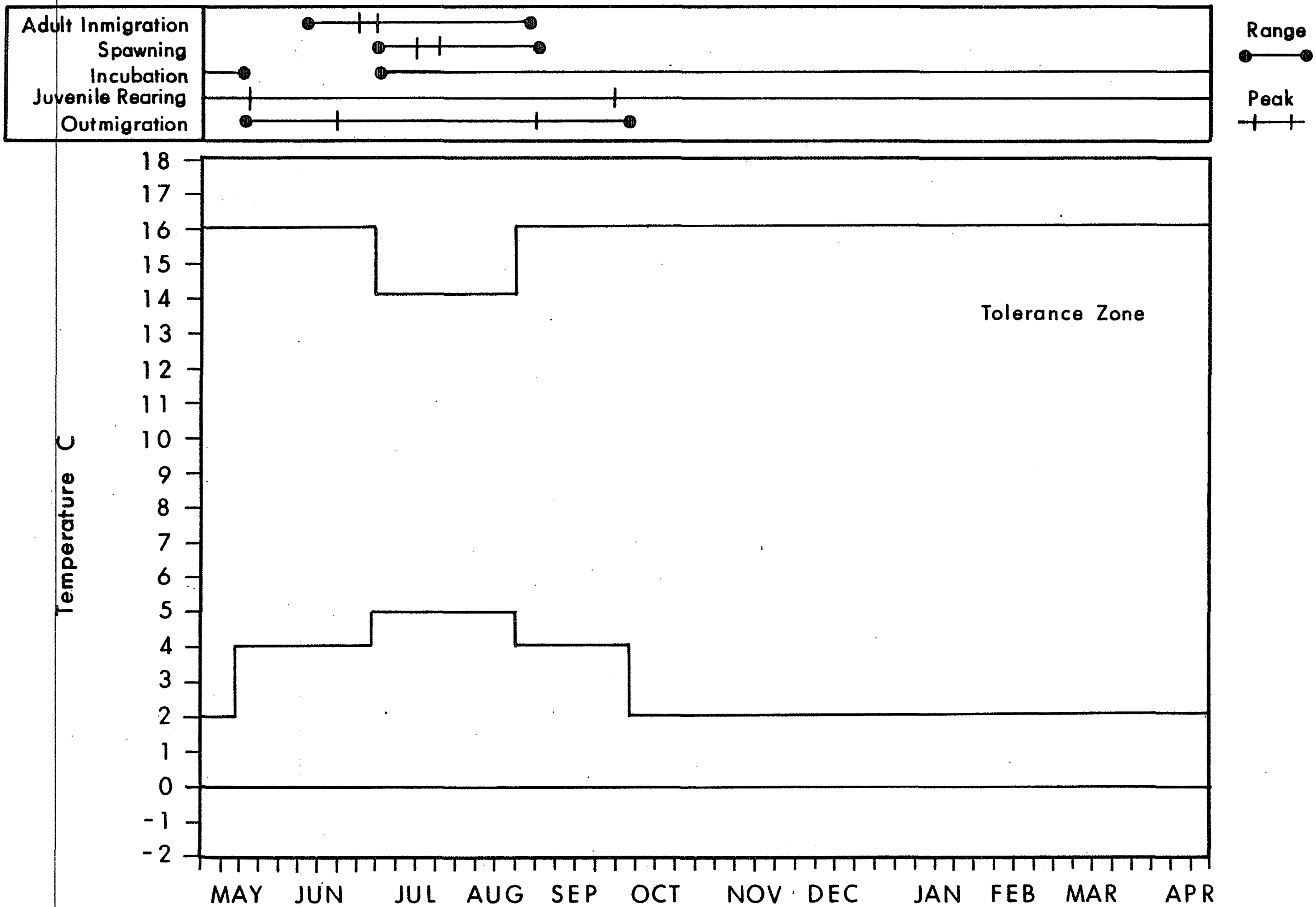


FIGURE E.3.2.97

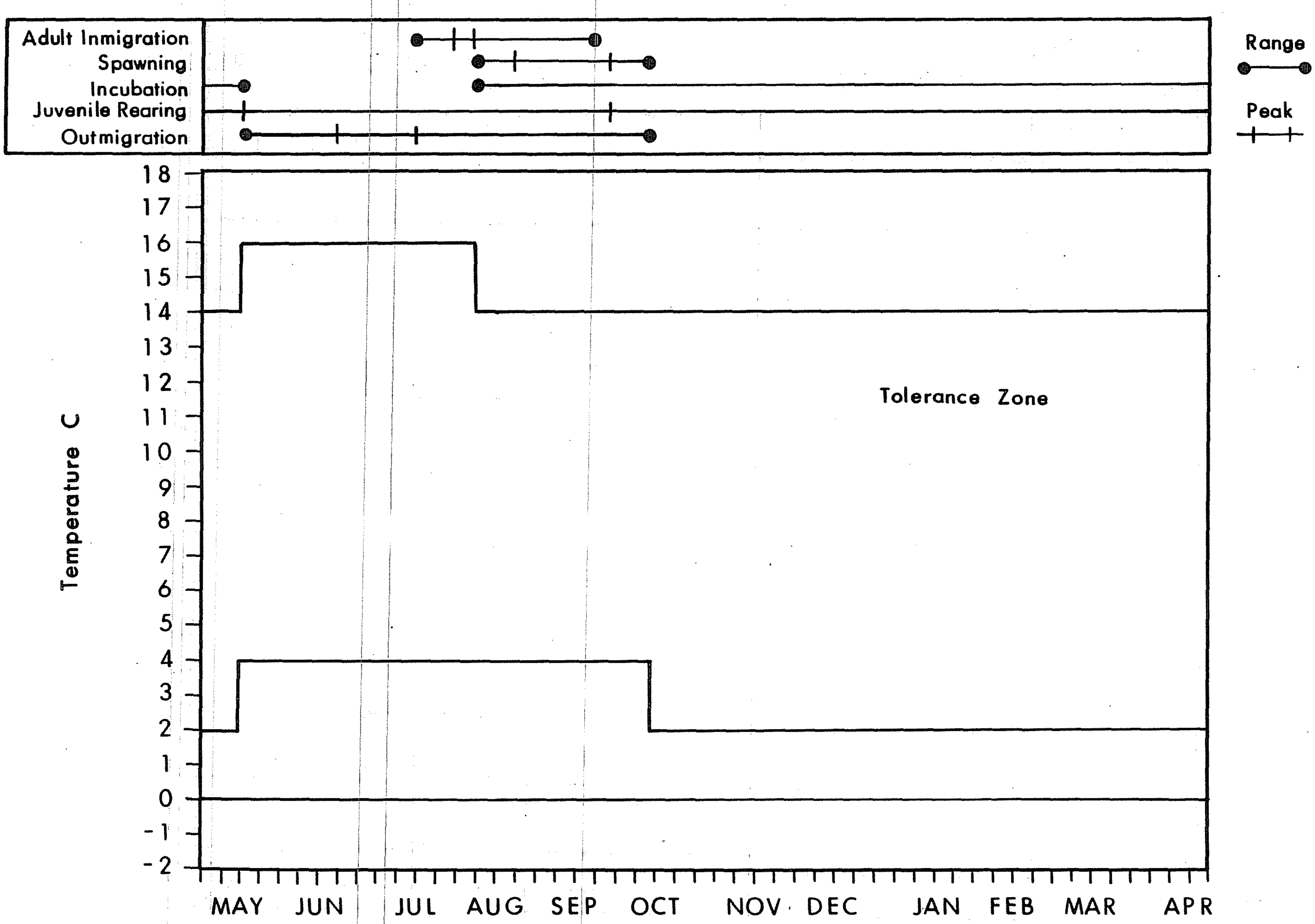
SOURCE: EXHIBIT E, CHAPTER 2



SOURCE: AEIDC 1984b

TEMPERATURE TOLERANCE FOR CHINOOK SALMON

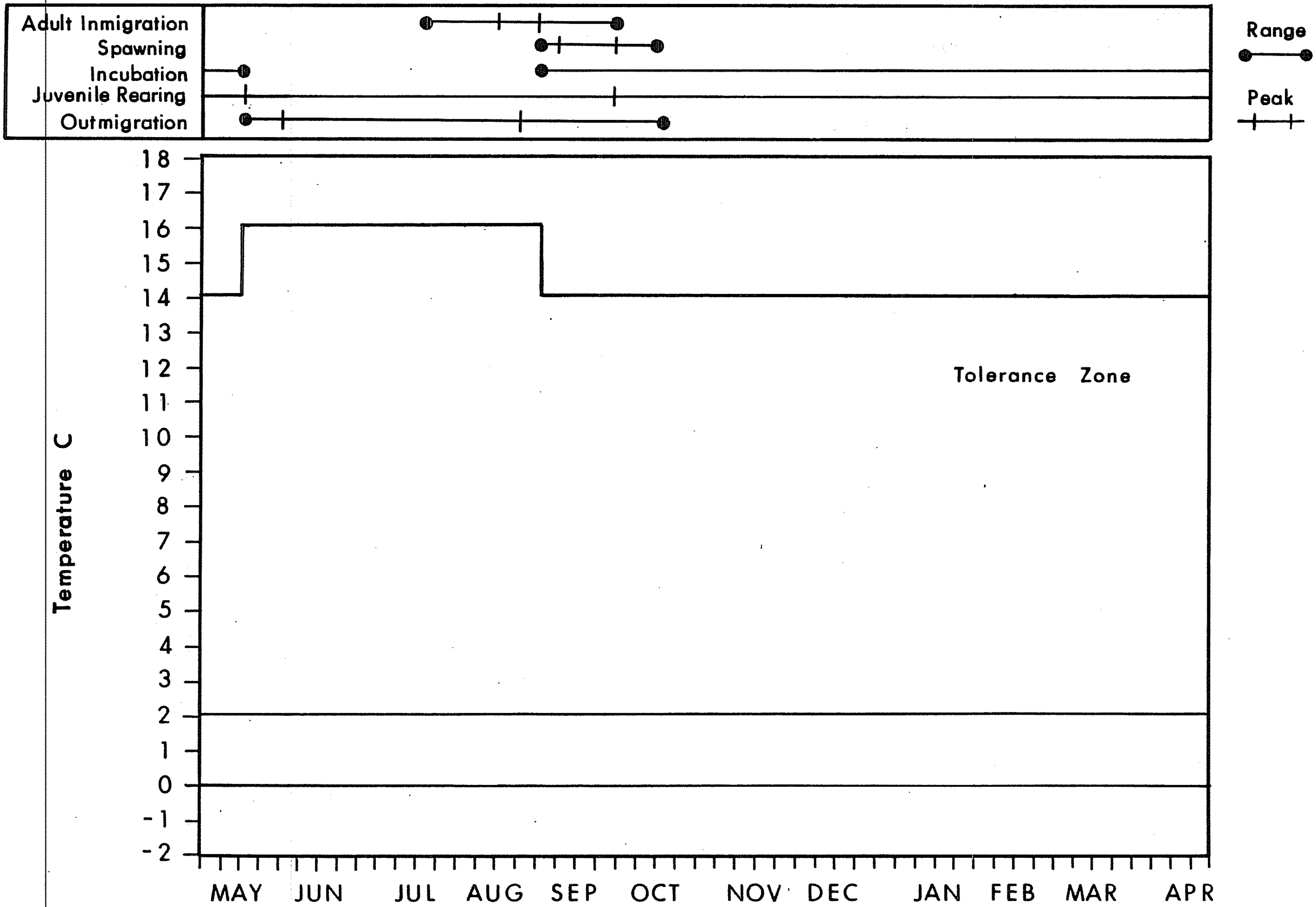
FIGURE E.3.2.98



SOURCE: AEIDC 1984b

TEMPERATURE TOLERANCE FOR SOCKEYE SALMON

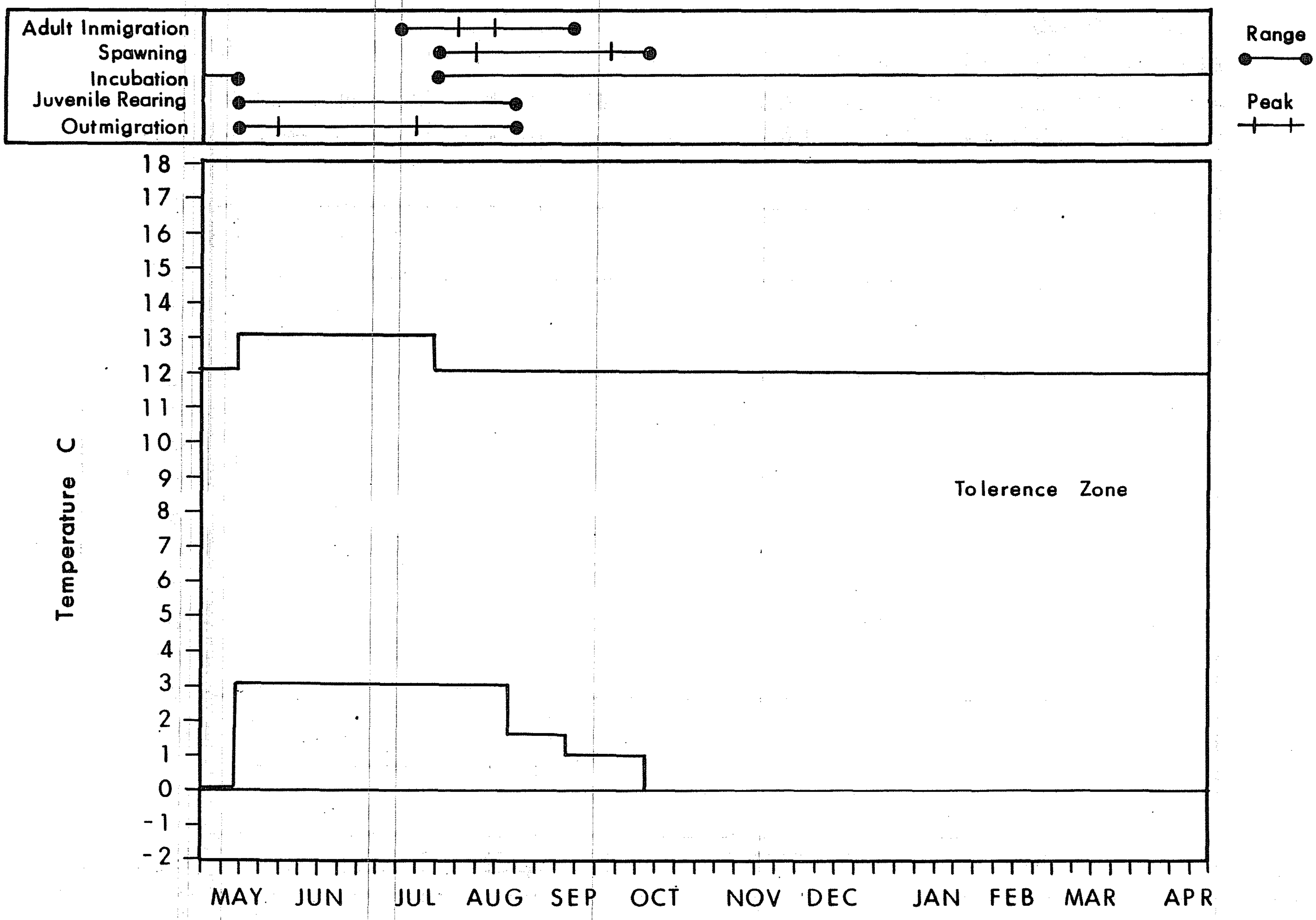
FIGURE E.3.2.99



SOURCE: AEIDC 1984b

TEMPERATURE TOLERANCE FOR COHO SALMON

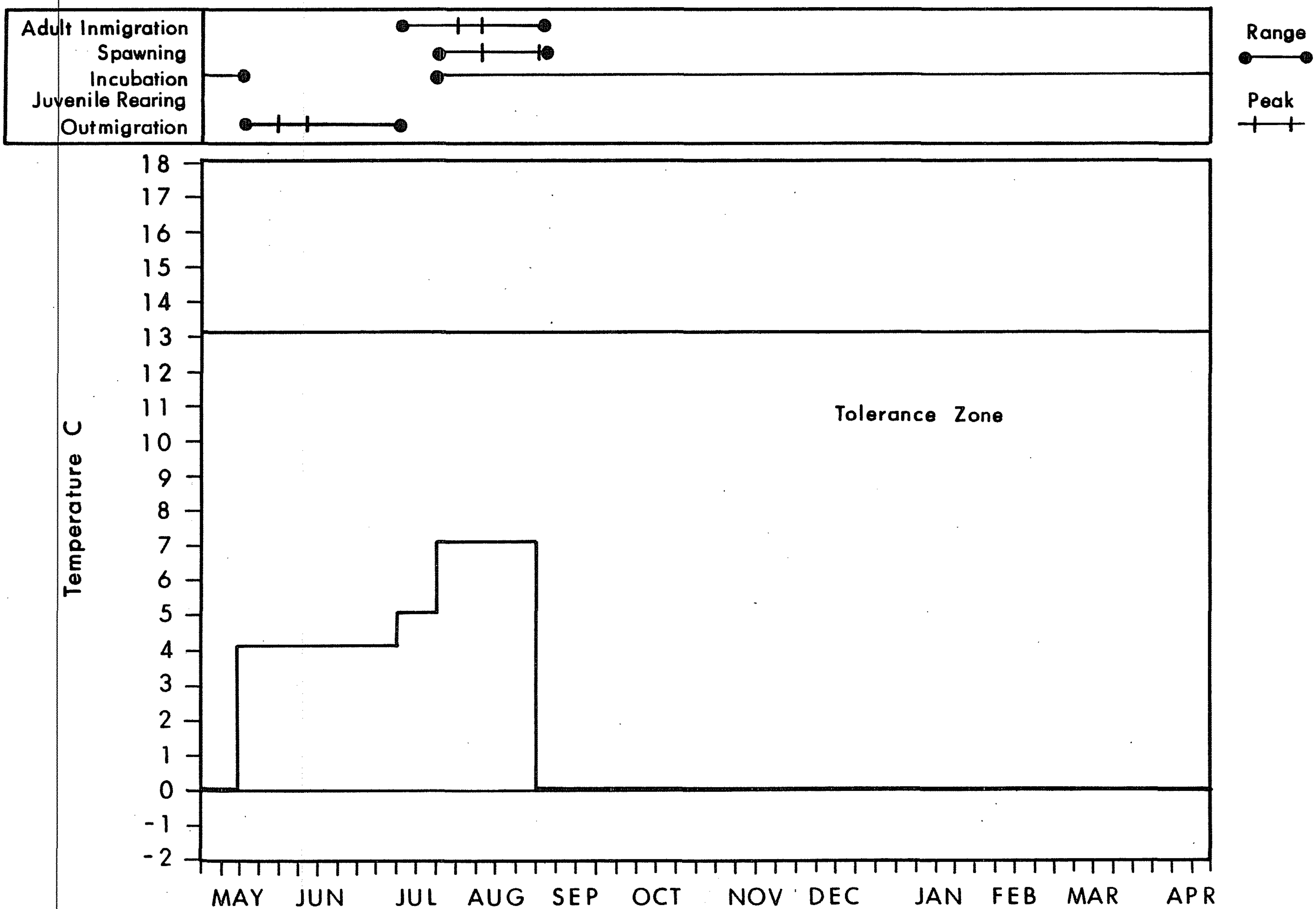
FIGURE E.3.2.100



SOURCE: AEIDC 1984b

TEMPERATURE TOLERANCE FOR CHUM SALMON

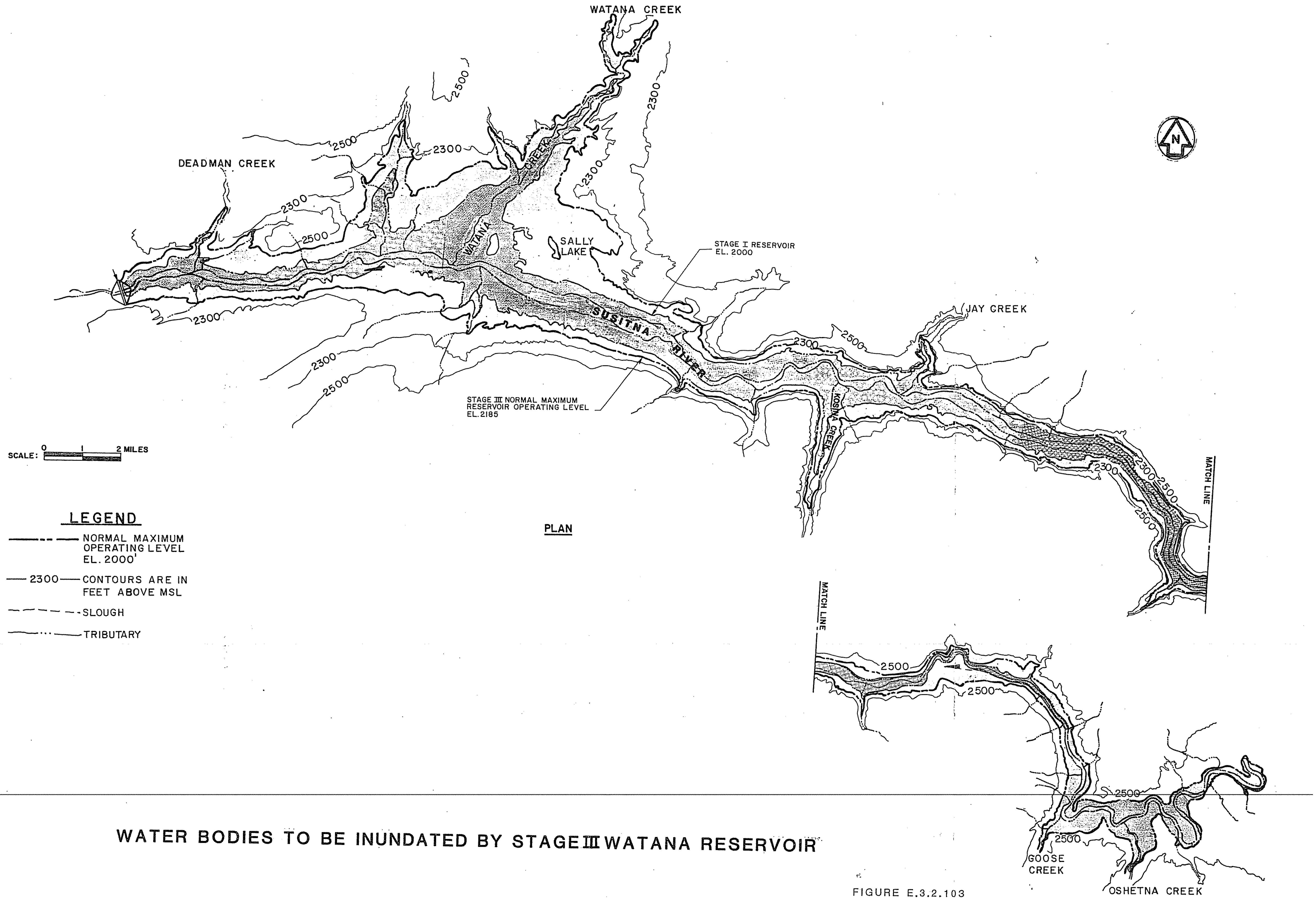
FIGURE E.3.2.101



SOURCE: AEIDC 1984b

TEMPERATURE TOLERANCE FOR PINK SALMON

FIGURE E.3.2.102



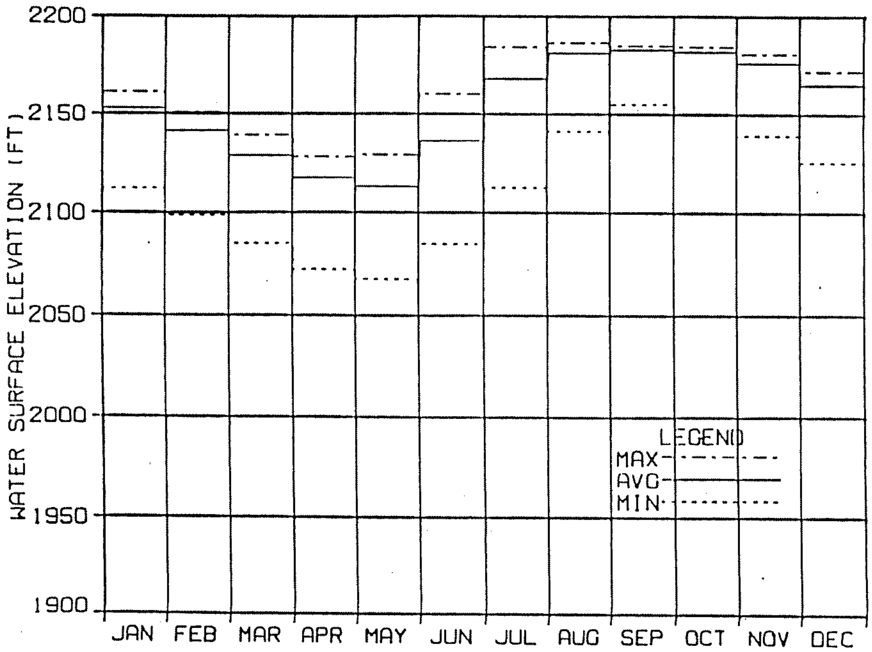
WATER BODIES TO BE INUNDATED BY STAGE III WATANA RESERVOIR

FIGURE E.3.2.103

WATANA WATER SURFACE ELEVATION
MONTHLY SUMMARY

EARLY STAGE III,

WATANA 2185 FT. DEVIL CANYON 1455 FT.



LATE STAGE III,

WATANA 2185 FT. DEVIL CANYON 1455 FT.

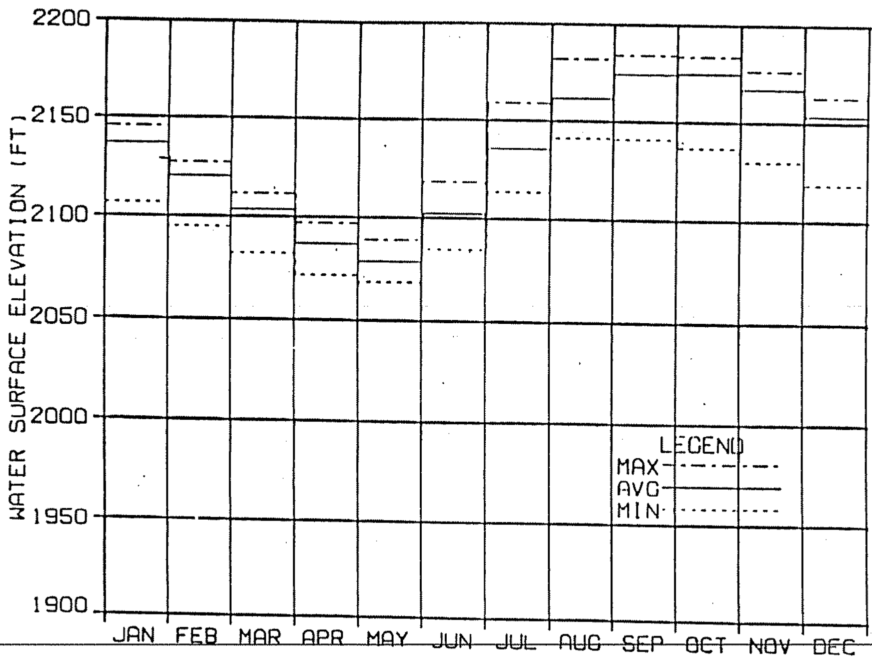
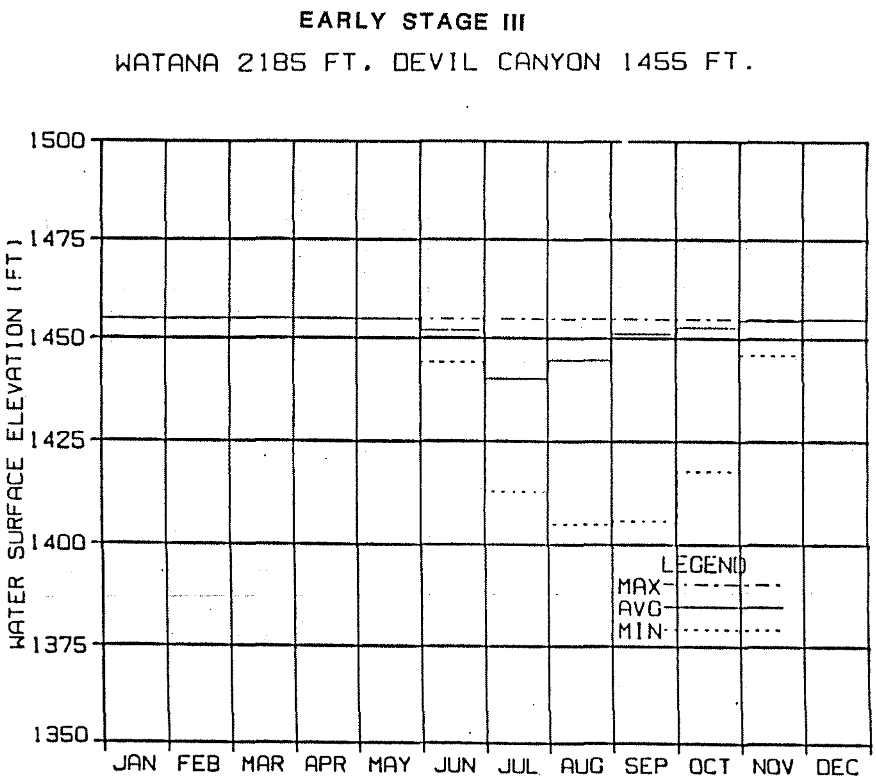
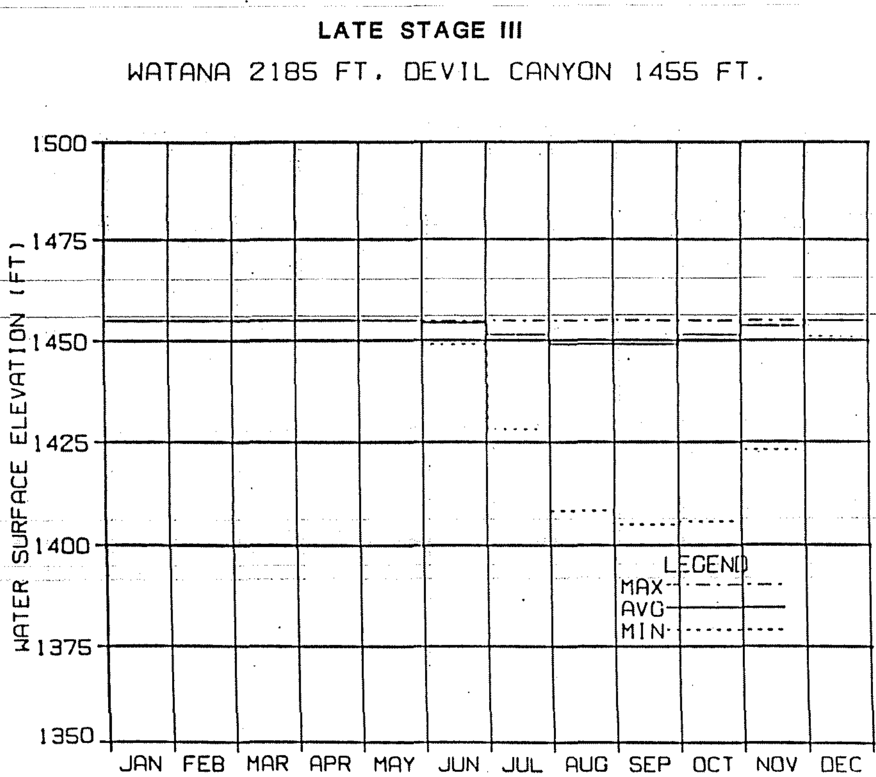


FIGURE E.3.2.104

SOURCE: APA 1985h

DEVIL CANYON WATER SURFACE ELEVATION
MONTHLY SUMMARY





SOURCE: APA 1985h

FIGURE E.3.2.105

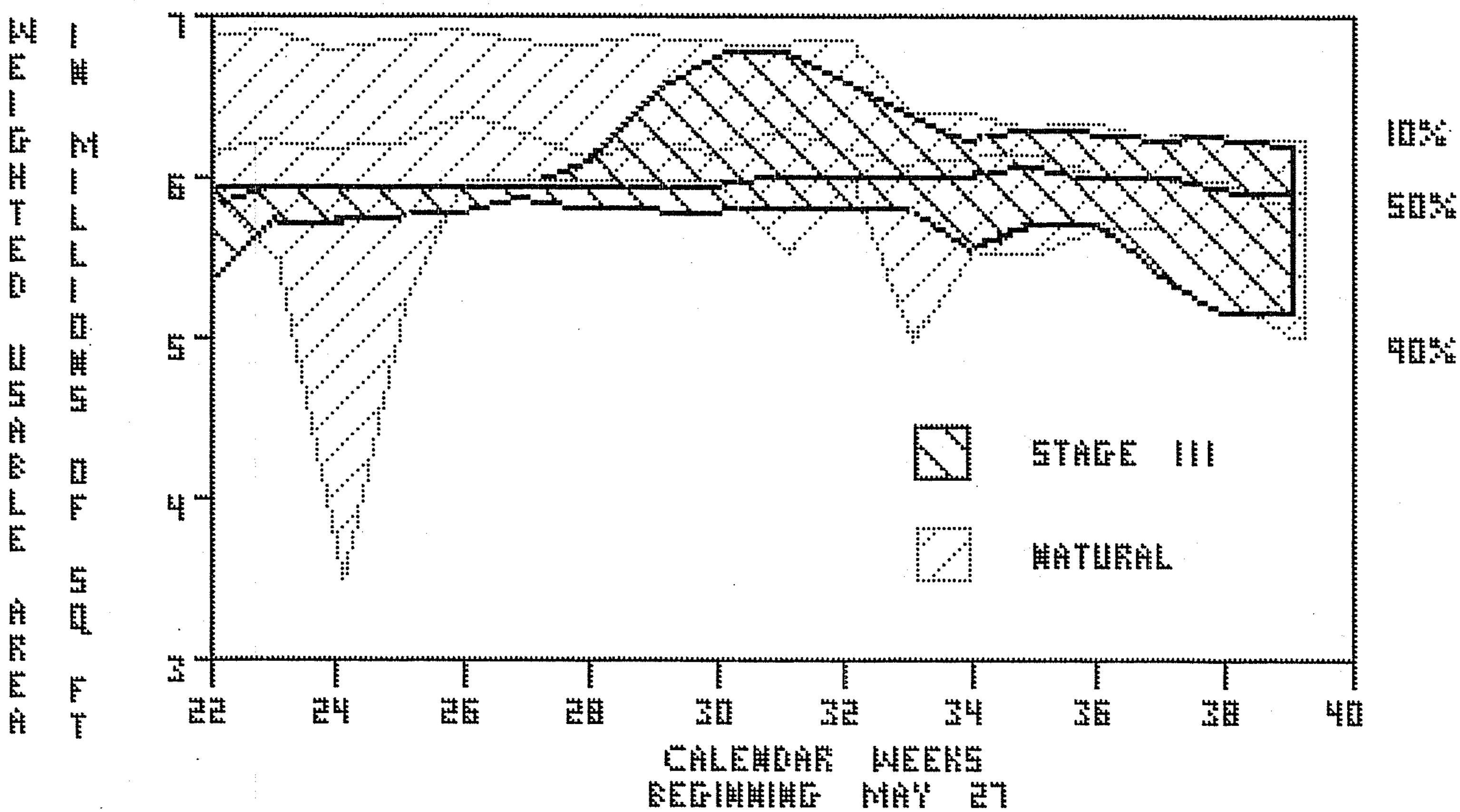


Figure E.3.2.106: Chinook Rearing Habitat Area Under Early Stage III Flow Regime In All Representative Groups

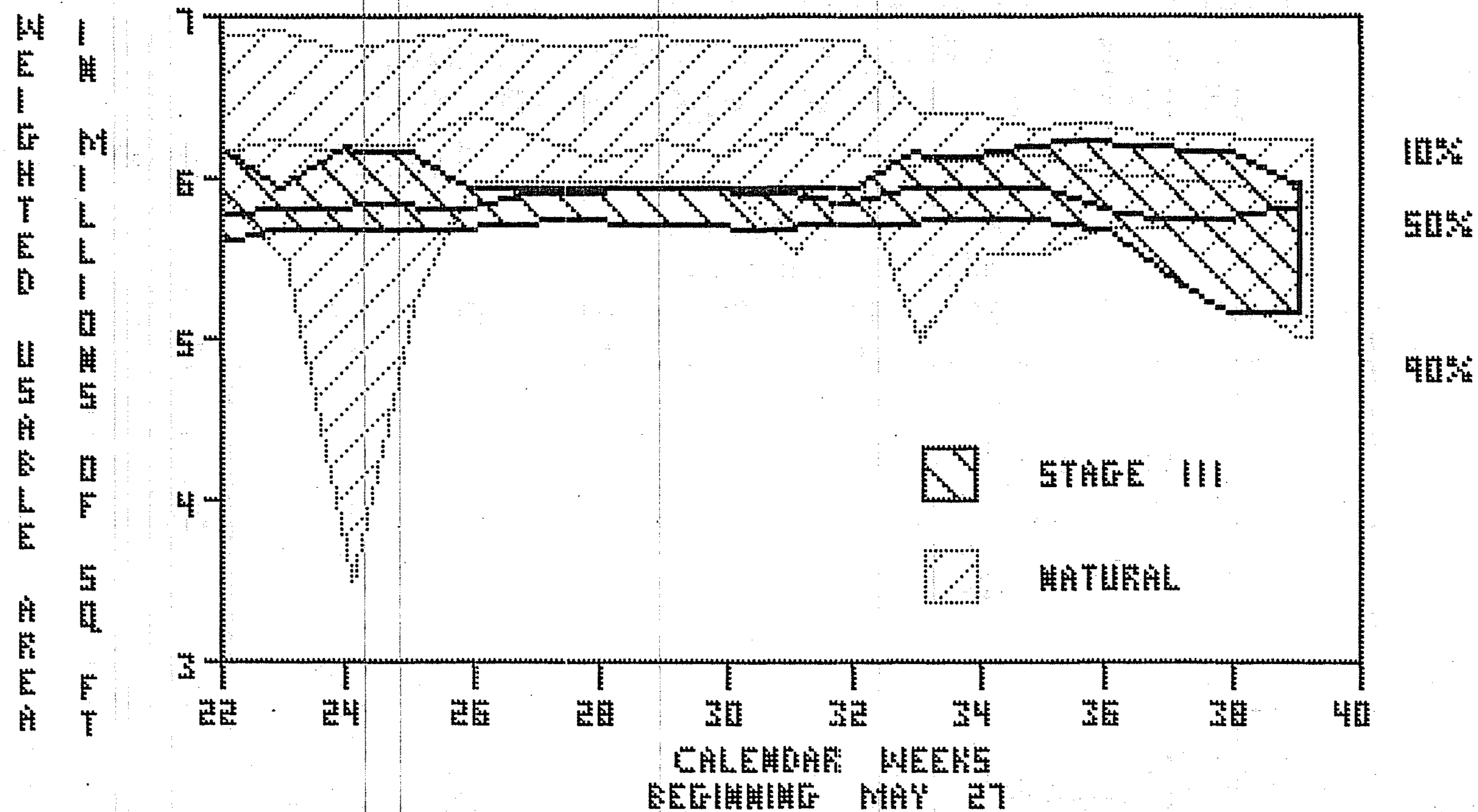


Figure E.3.2.107: Chinook Rearing Habitat Area Under Late Stage III Flow Regime In All Representative Groups

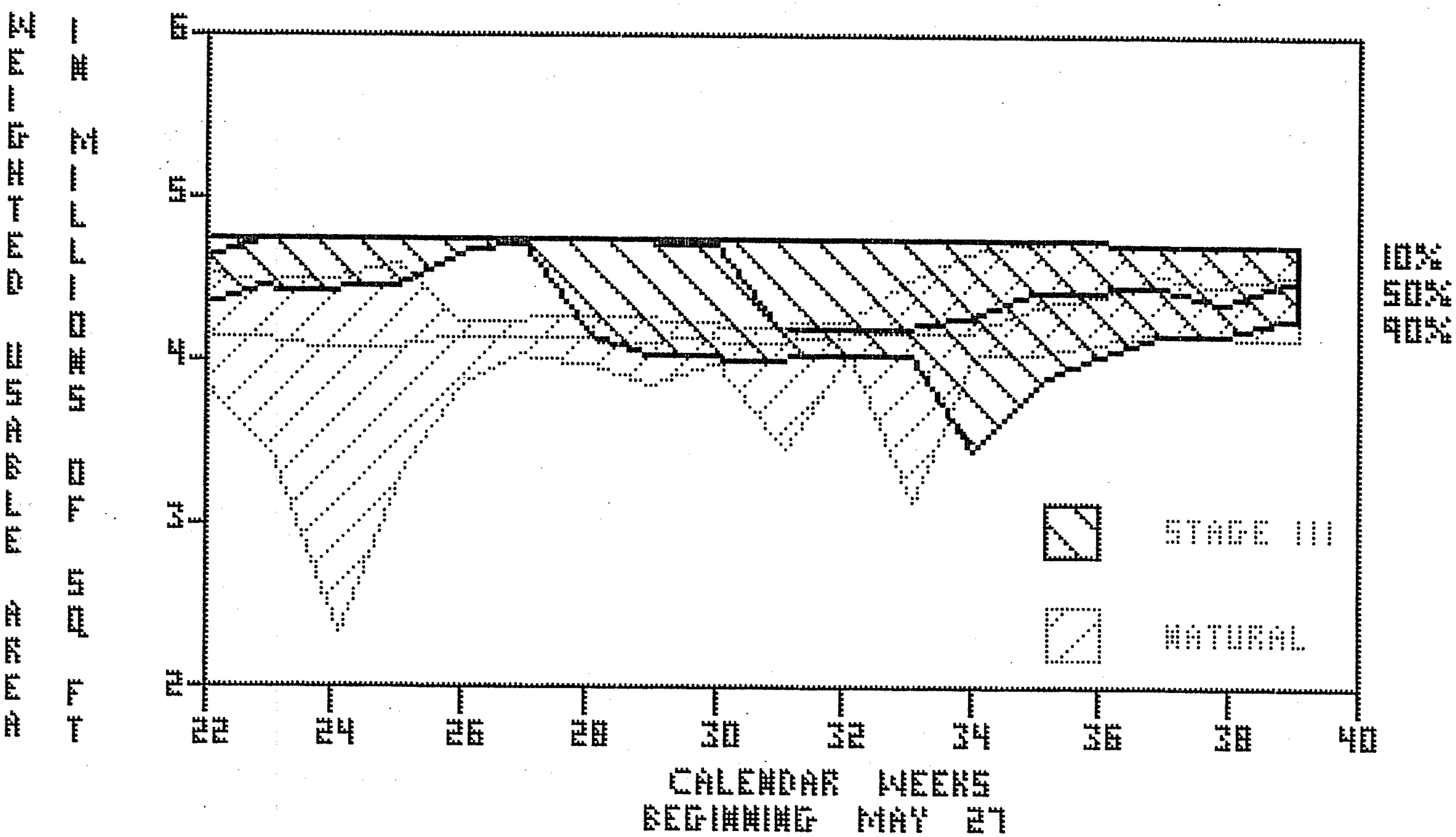


Figure E.3.2.108:
Chinook Rearing Habitat Area
Under Early Stage III Flow Regime
In Representative Groups 2,3,4

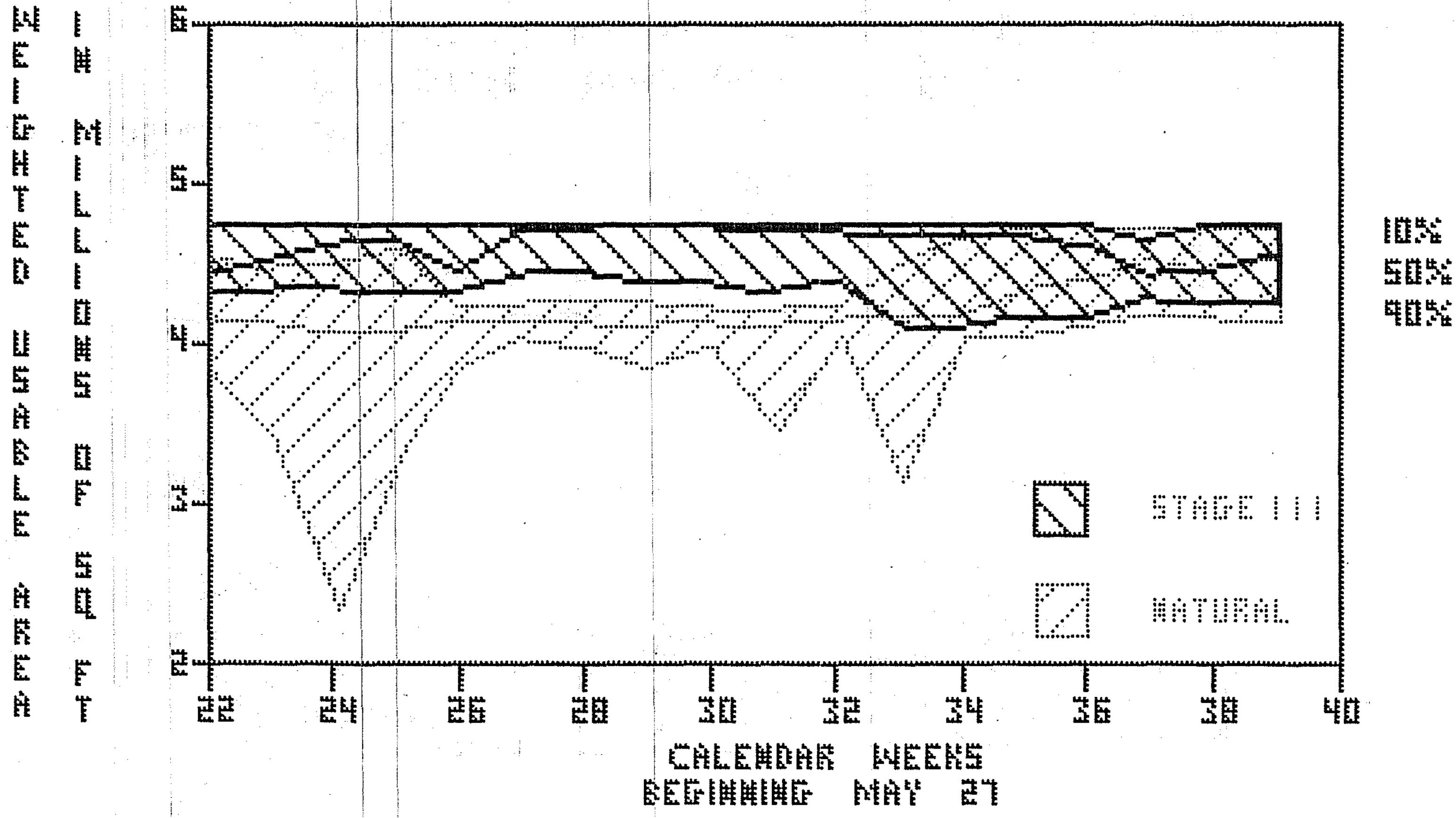
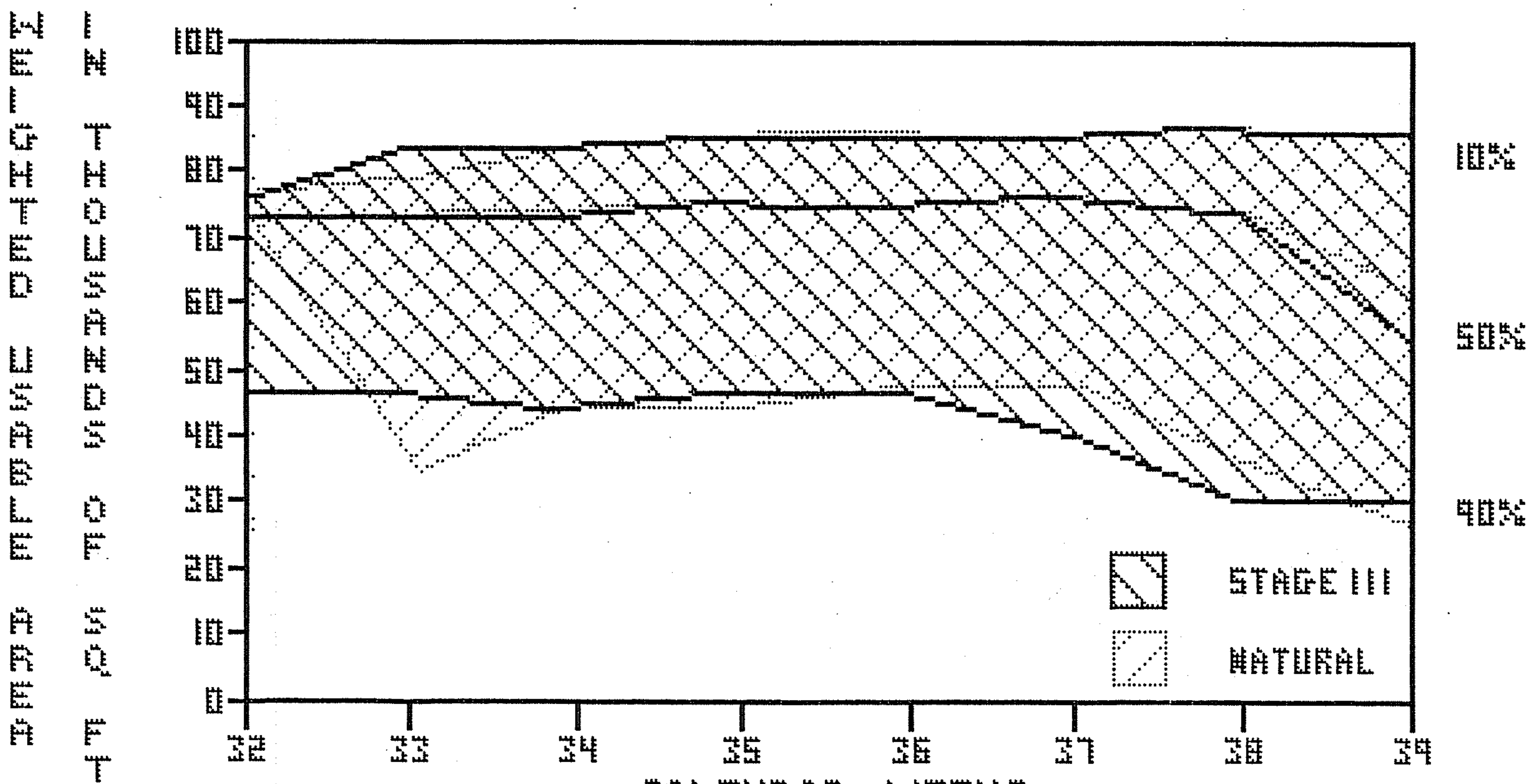
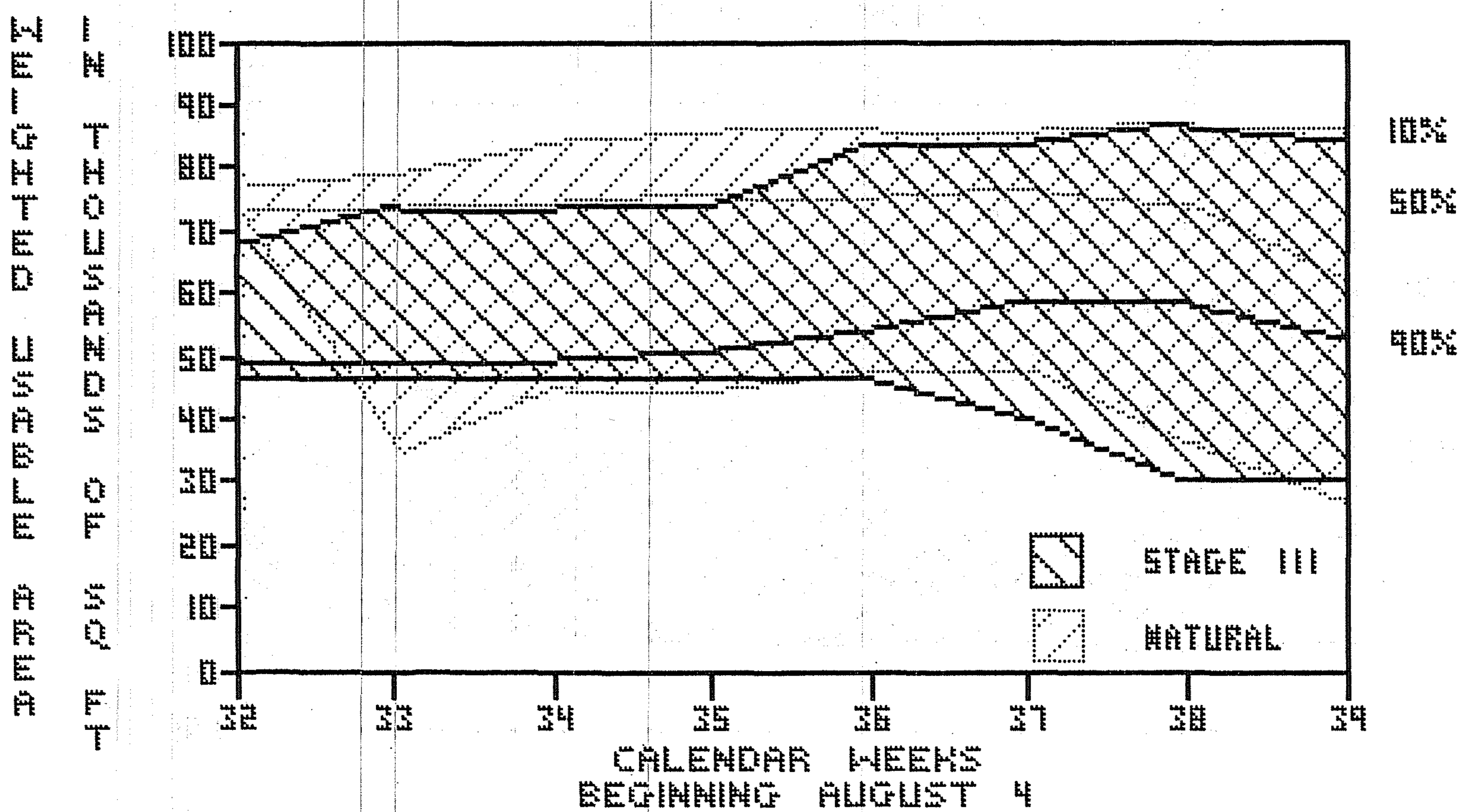


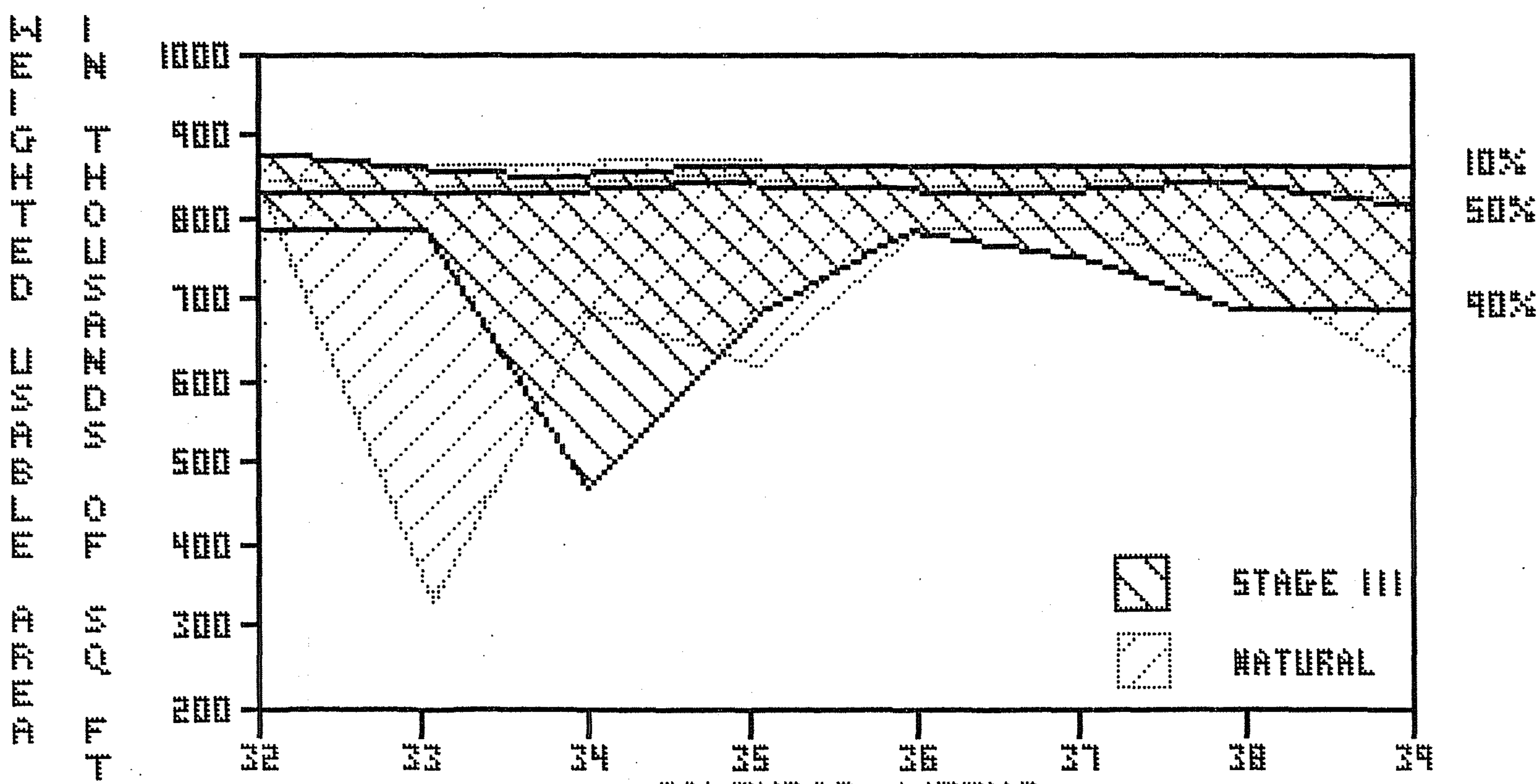
Figure E.3.2.109:
Chinook Rearing Habitat Area
Under Late Stage III Flow Regime
In Representative Groups 2,3,4



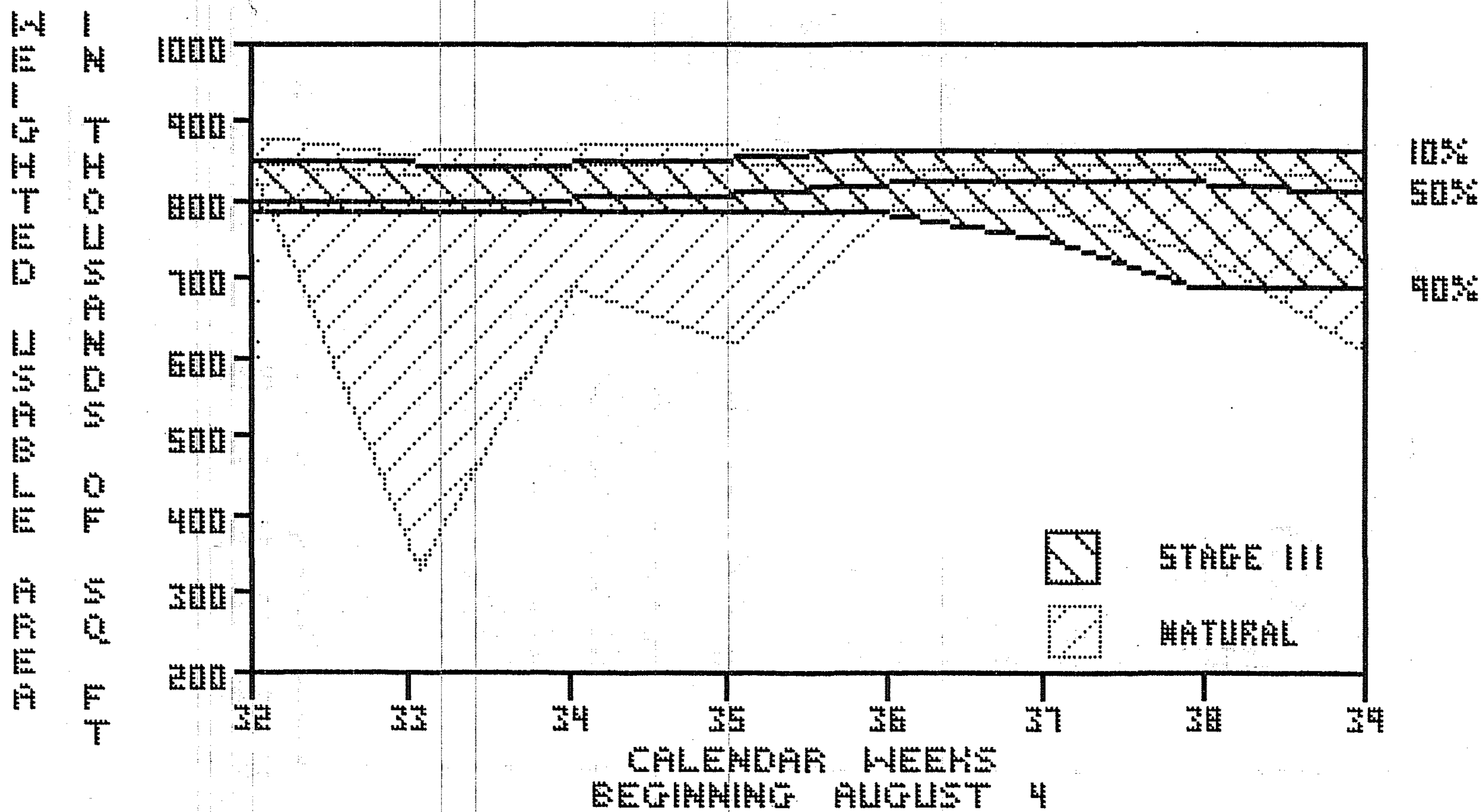
Chum Spawning Area in
IFG and DIHAB Model Sites
Under Early Stage III Flows
Figure E.3.2.110



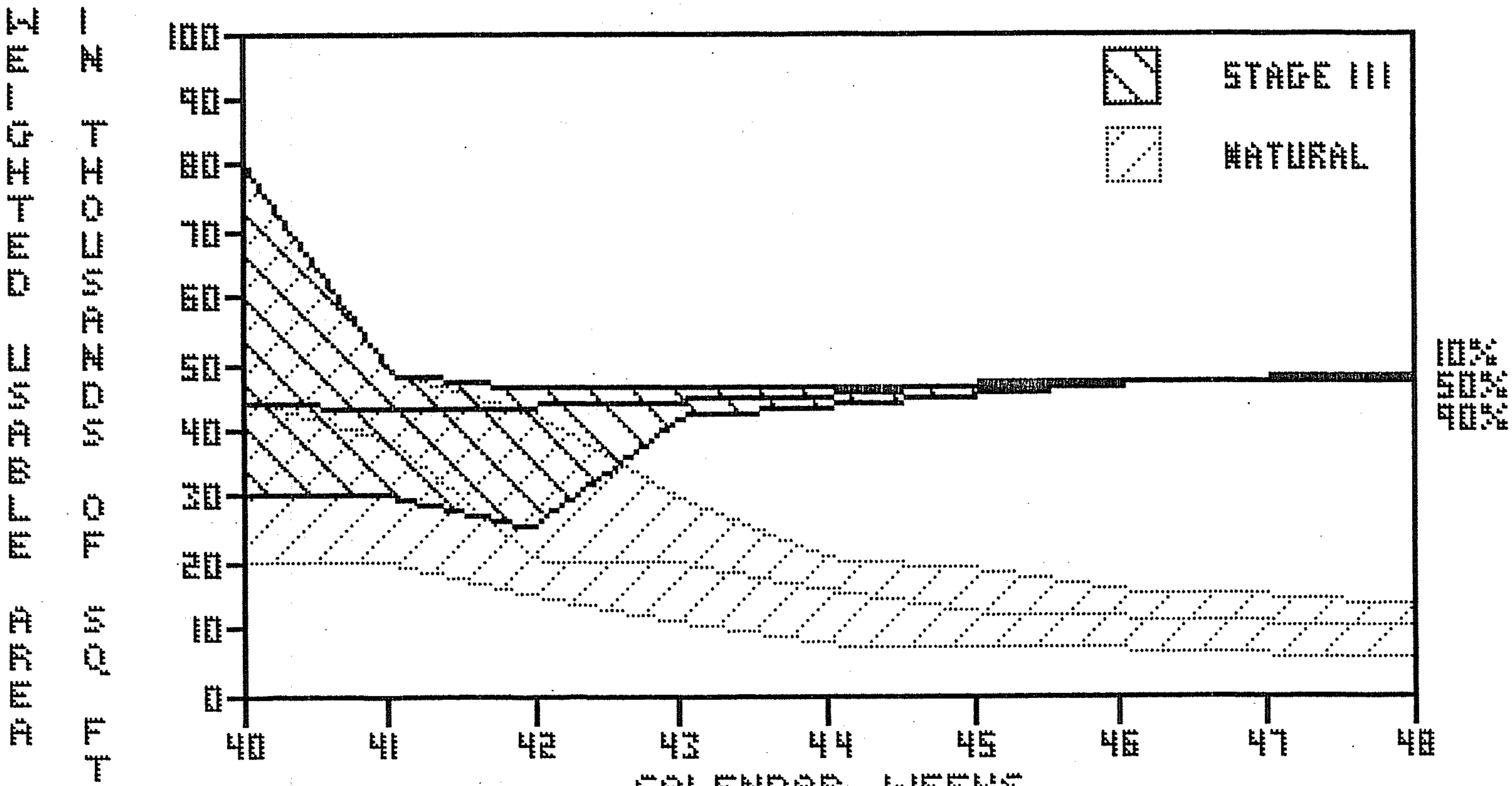
Chum Spawning Area in
IFG and DIHAB Model Sites
Under Late Stage III Flows
Figure E.3.2.111



Chum Spawning Area in
Representative Groups 2,3,4
Under Early Stage III Flows
Figure E.3.2.112

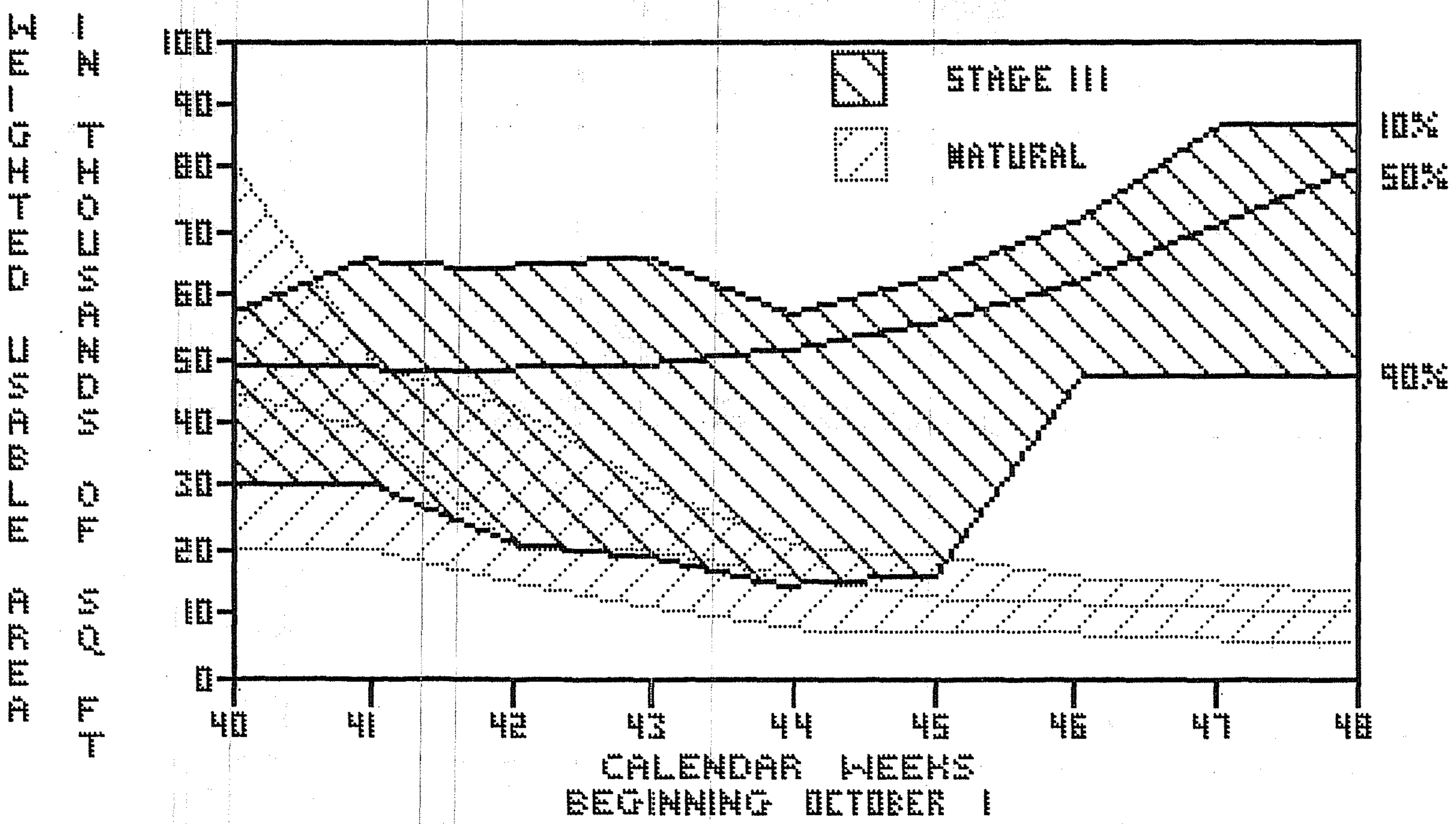


Chum Spawning Area in
Representative Groups 2,3,4
Under Late Stage III Flows
Figure E.3.2.113



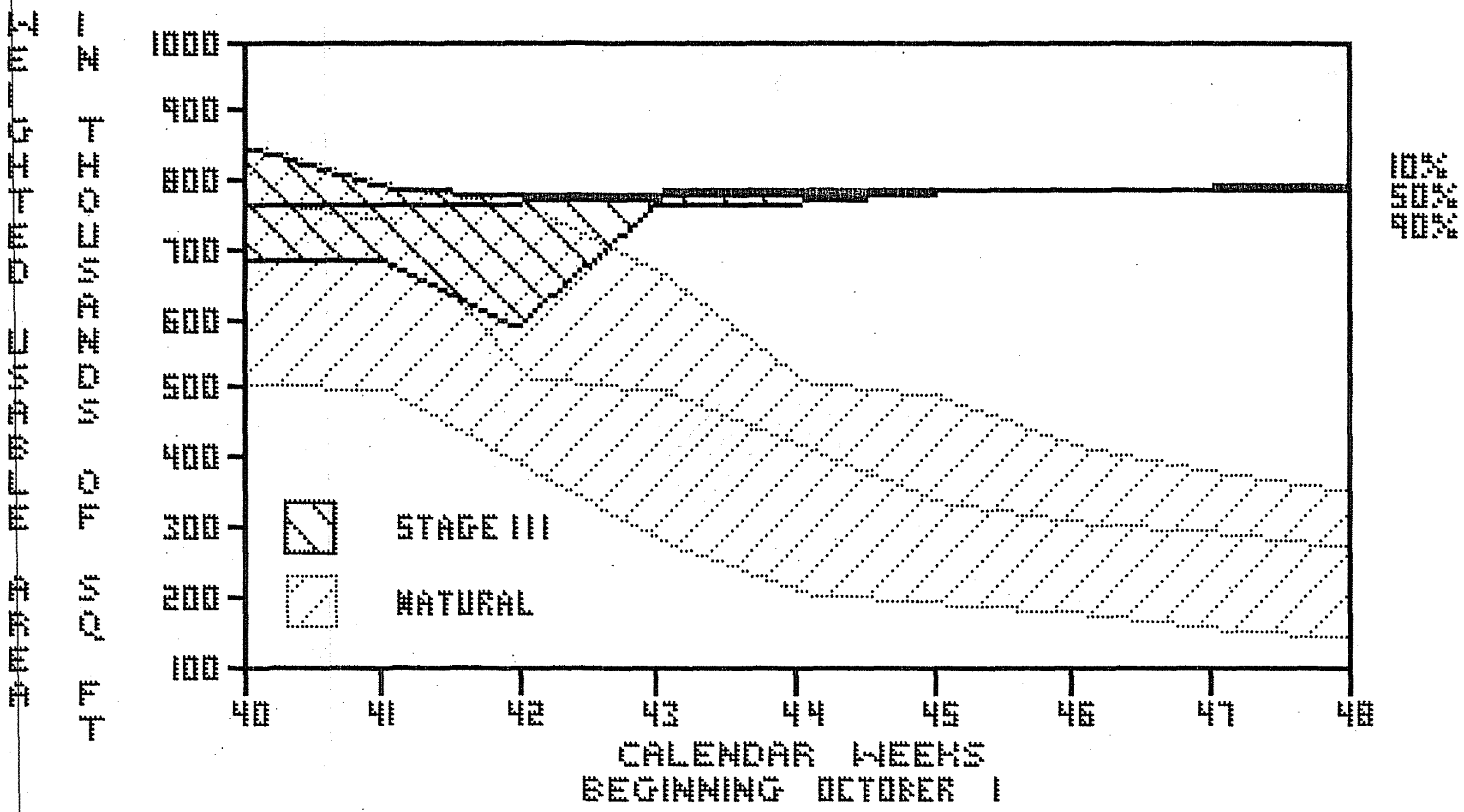
Chum Incubation Area in
IFG and DIHAB Model Sites
Under Early Stage III Flows

Figure E.3.2.114

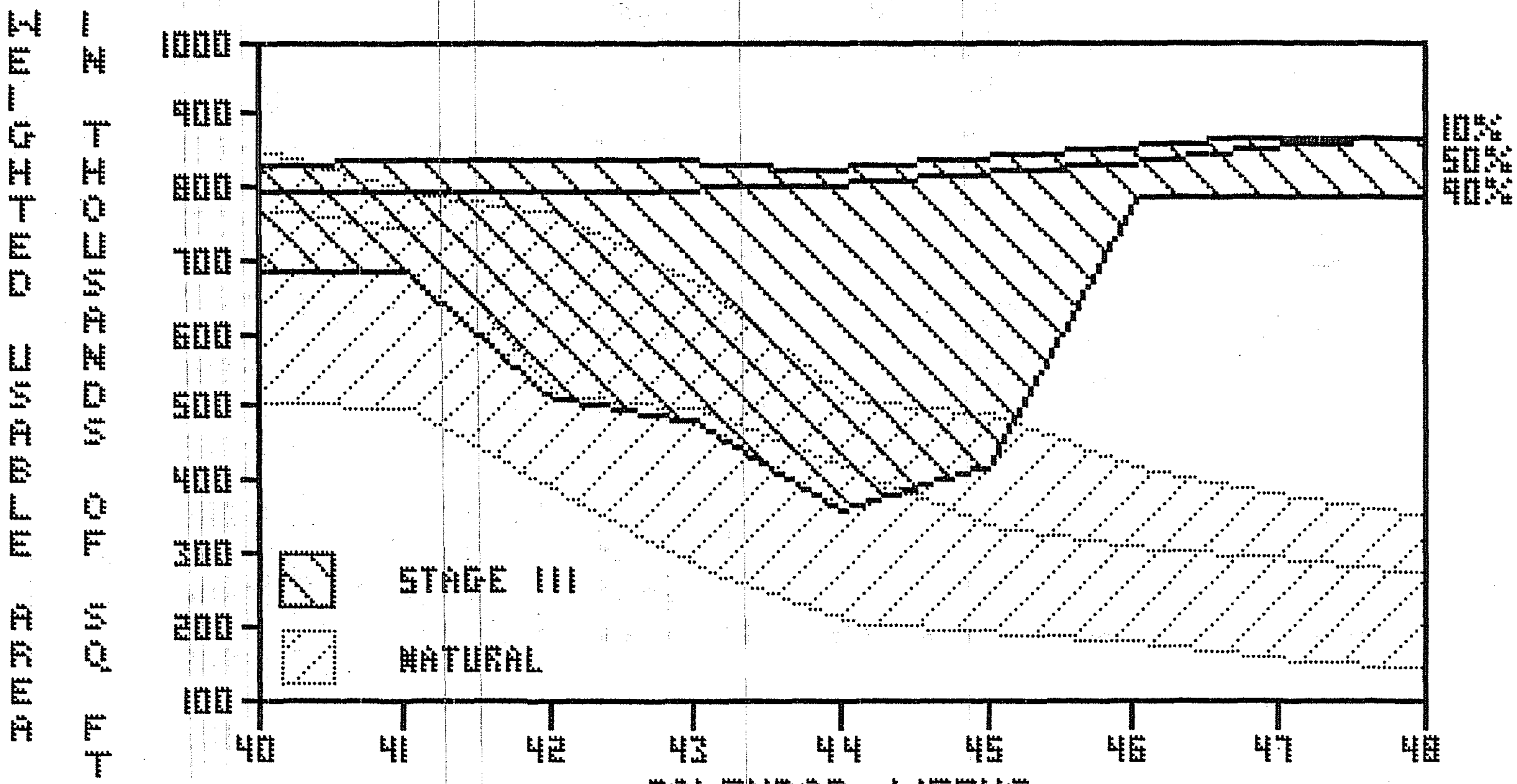


Chum Incubation Area in IFG and DIHAB Model Sites Under Late Stage III Flows

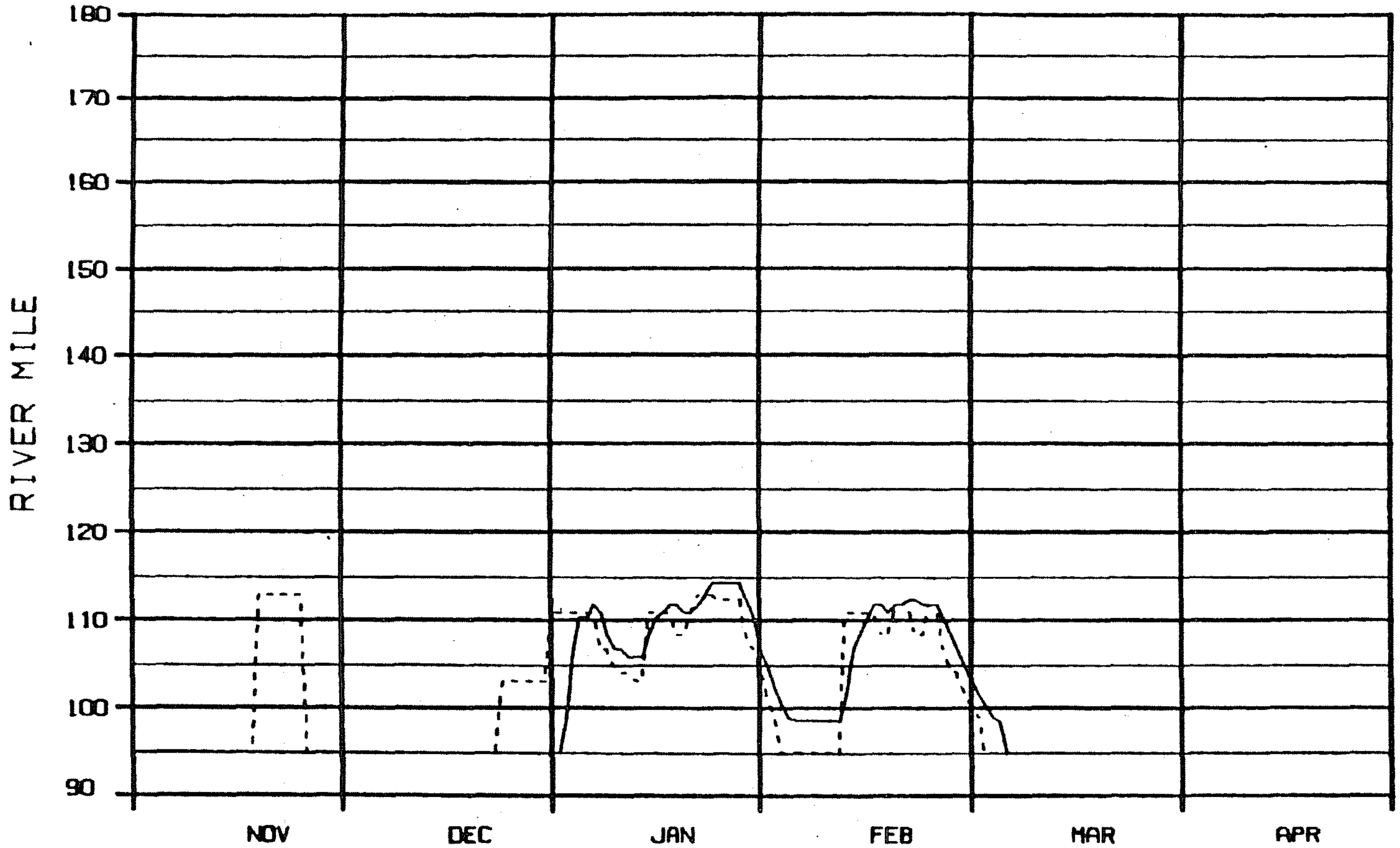
Figure E.3.2.115



Chum Incubation Area in
Representative Groups 2,3,4
Under Early Stage III Flows
Figure E.3.2.116



Chum Incubation Area in
Representative Groups 2,3,4
Under Late Stage III Flows
Figure E.3.2.117



LEGEND:
——— ICE FRONT
- - - - - ZERO DEGREE ISOTHERM

WEATHER PERIOD: 1 NOV. 71 - 30 APR 72
FLOW REGIME: LATE STAGE III
FLOW CASE: E-VI TEMP RULE: NATURAL
REFERENCE RUN NO. : 7120CNA

SUSITNA RIVER
PROGRESSION OF ICE
FRONT & ZERO DEGREE ISOTHERM

FIGURE E.3.2.118

SOURCE: EXHIBIT E, CHAPTER 2

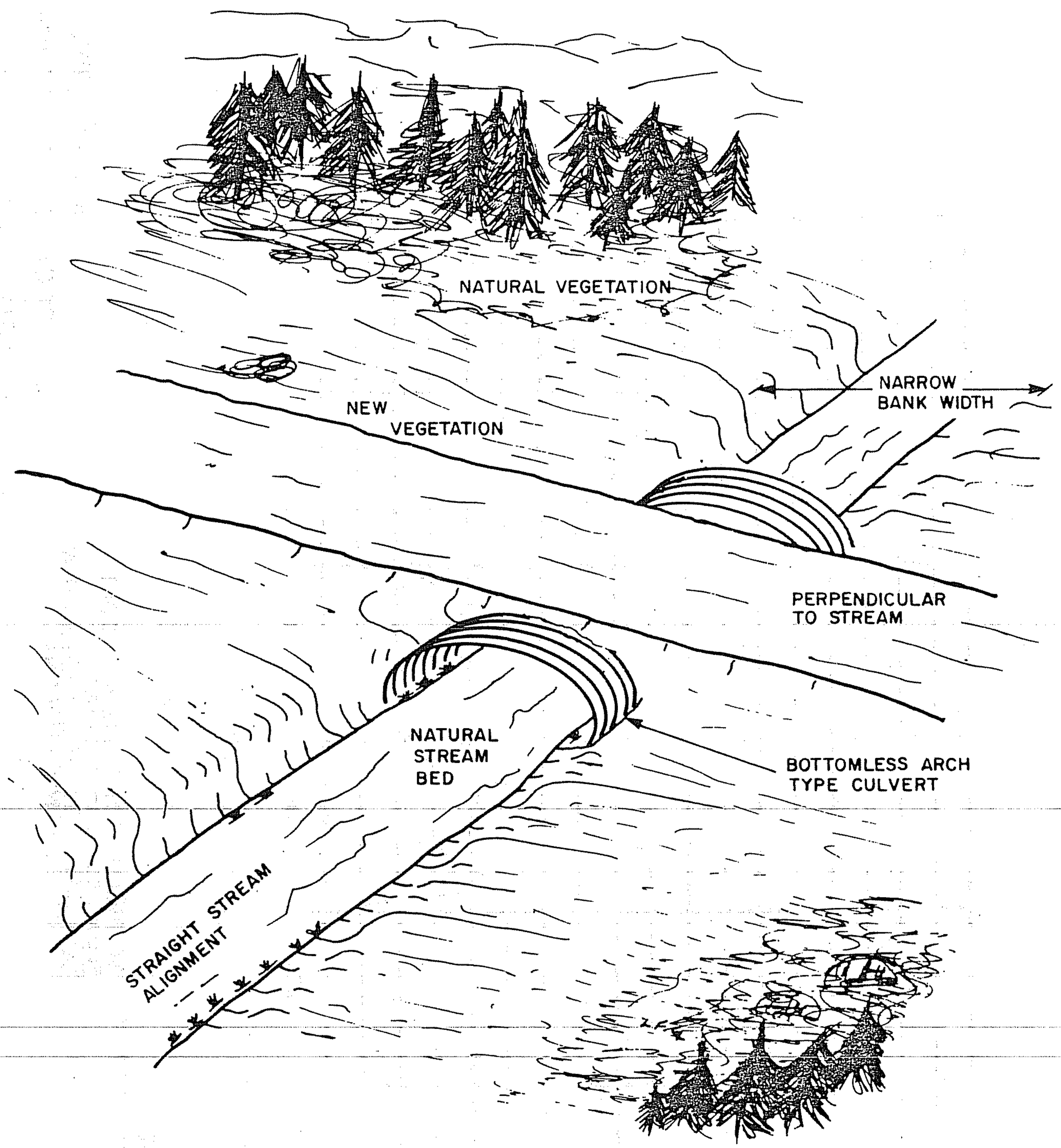
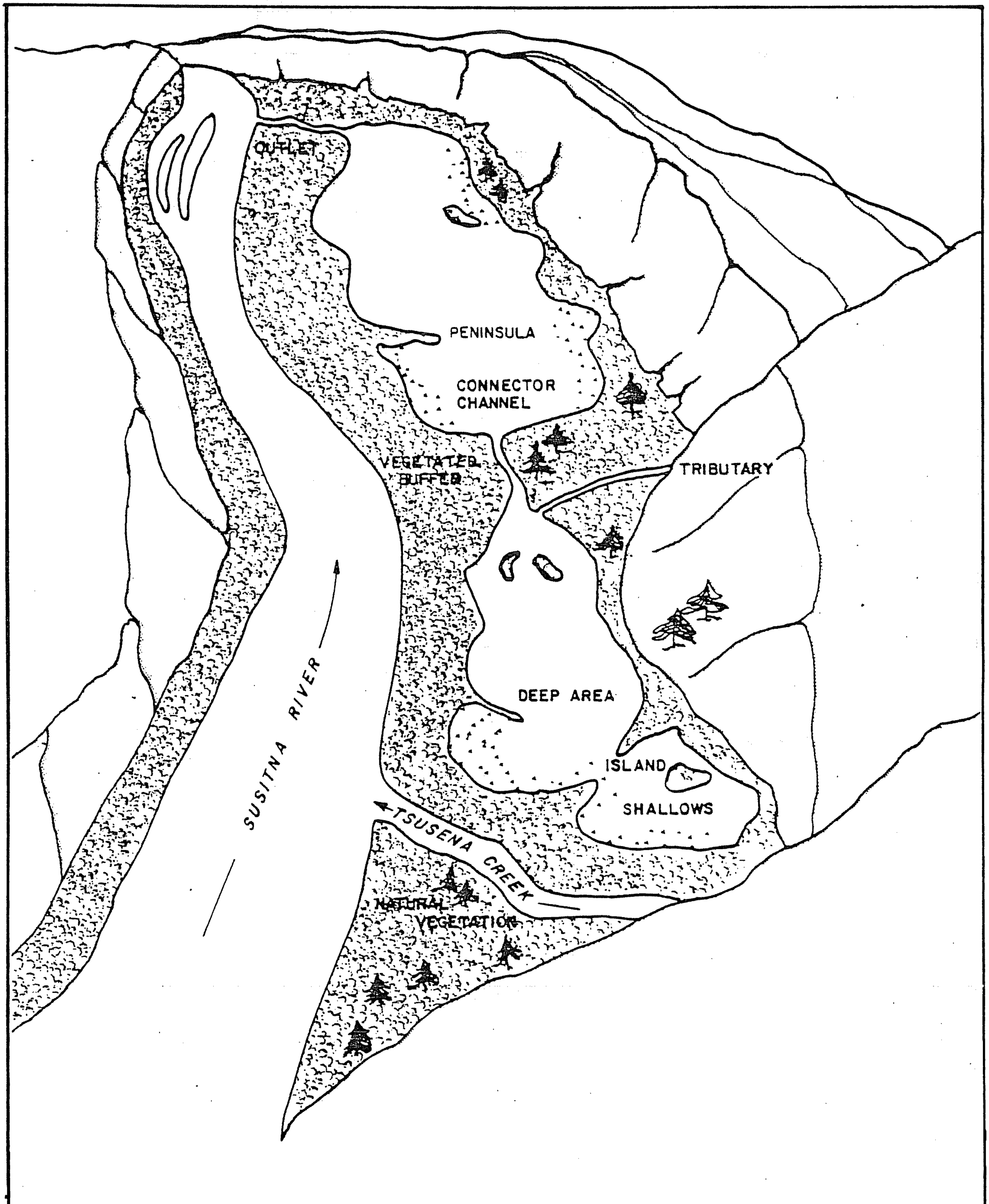


DIAGRAM OF FISH STREAM CROSSING

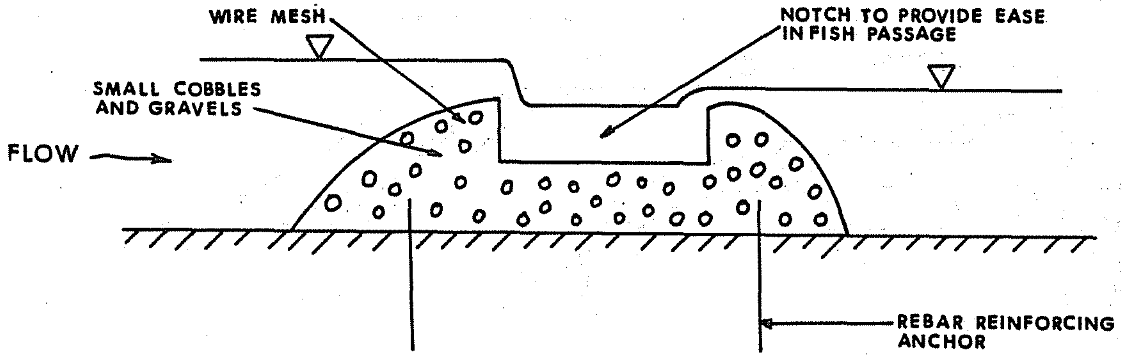
FIGURE E.3.2.119



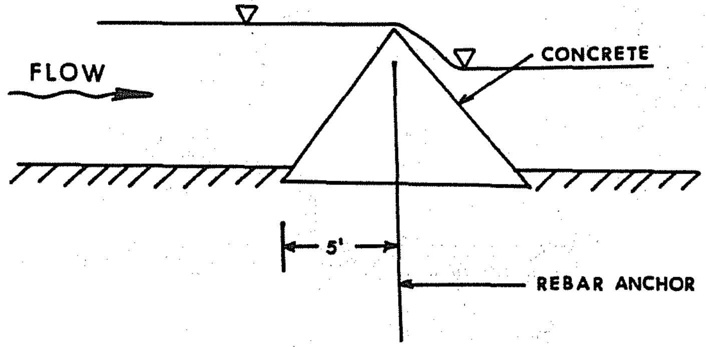
REHABILITATED BORROW SITE E

SOURCE: WCC 1985c

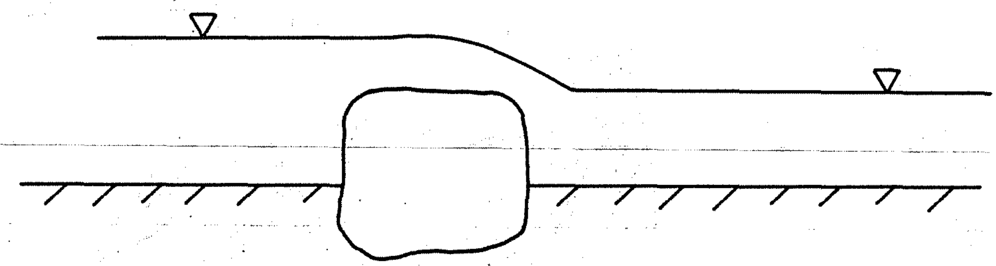
FIGURE E.3.2.120



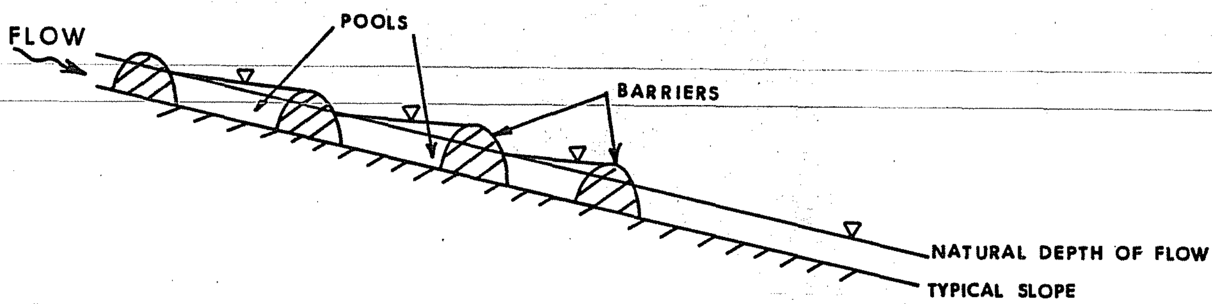
GABION BARRIER



CONCRETE SILL



ROCK SILL BARRIER

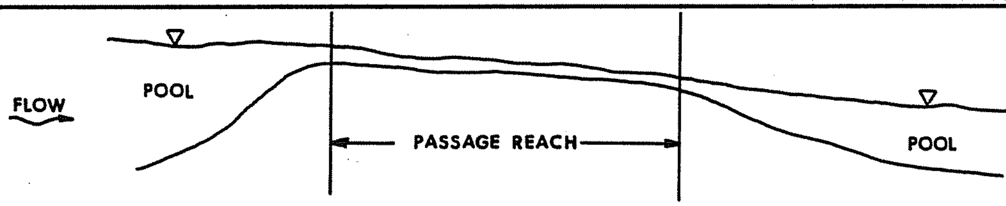


POOL AND WEIR STRUCTURE CREATION OF POOLS BETWEEN BARRIERS

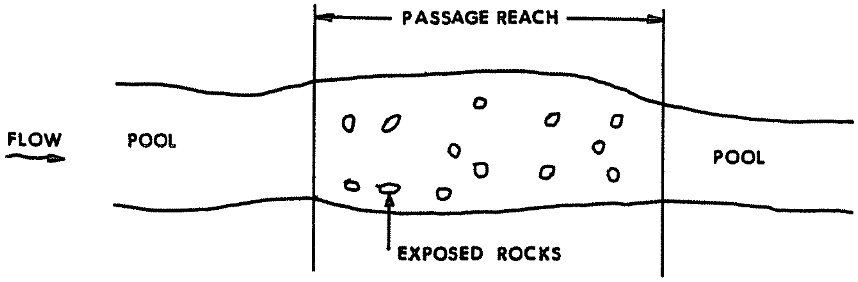
FISH PASSAGE MITIGATION UTILIZING BARRIERS

SOURCE: WCC 1984a

FIGURE E.3.2.121

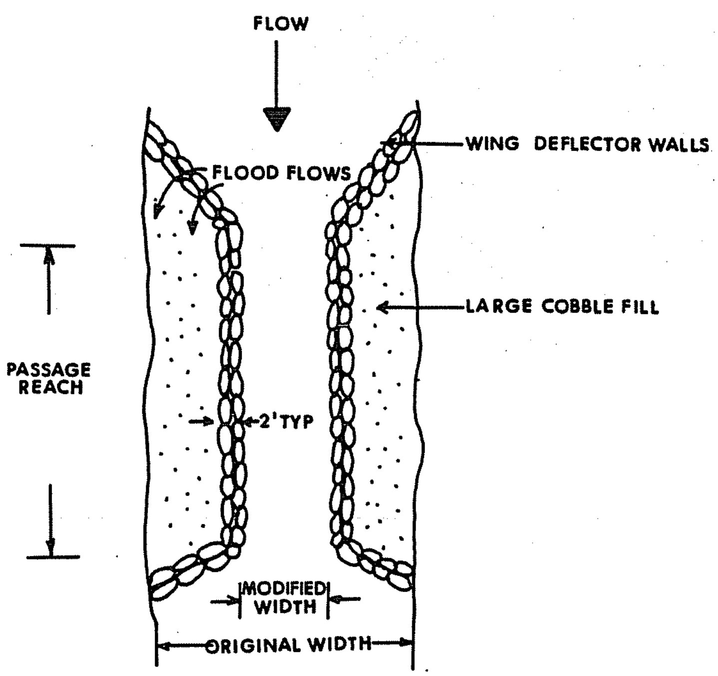


SIDE VIEW

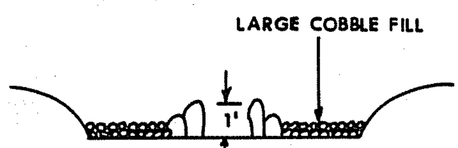


PLAN VIEW

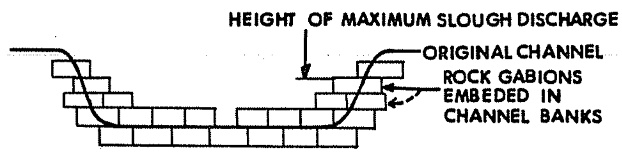
TYPICAL PASSAGE REACH OF SLOUGH ALONG
MIDDLE SECTION OF THE SUSITNA RIVER



PLAN VIEW
WING DEFECTOR



WING DEFLECTOR

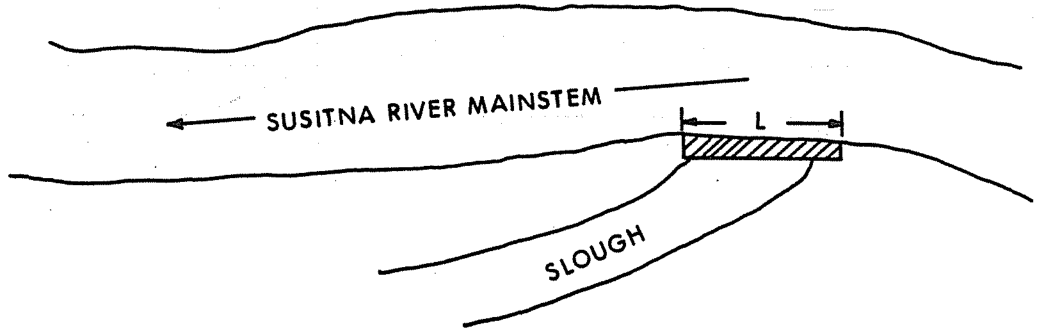


ROCK GABION CHANNEL

FISH PASSAGE MITIGATION BY MODIFYING CHANNEL WIDTH

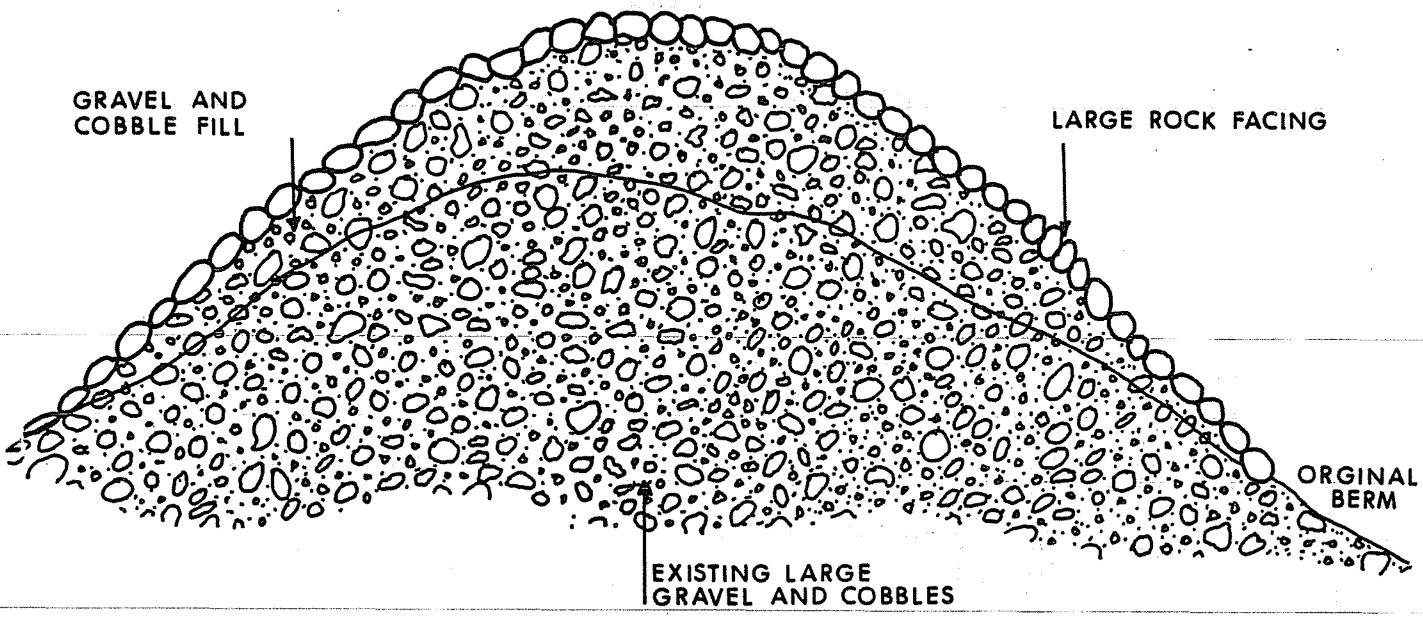
SOURCE: WCC 1985b

FIGURE E.3.2.122



PLAN VIEW

L=LENGTH OF BERM

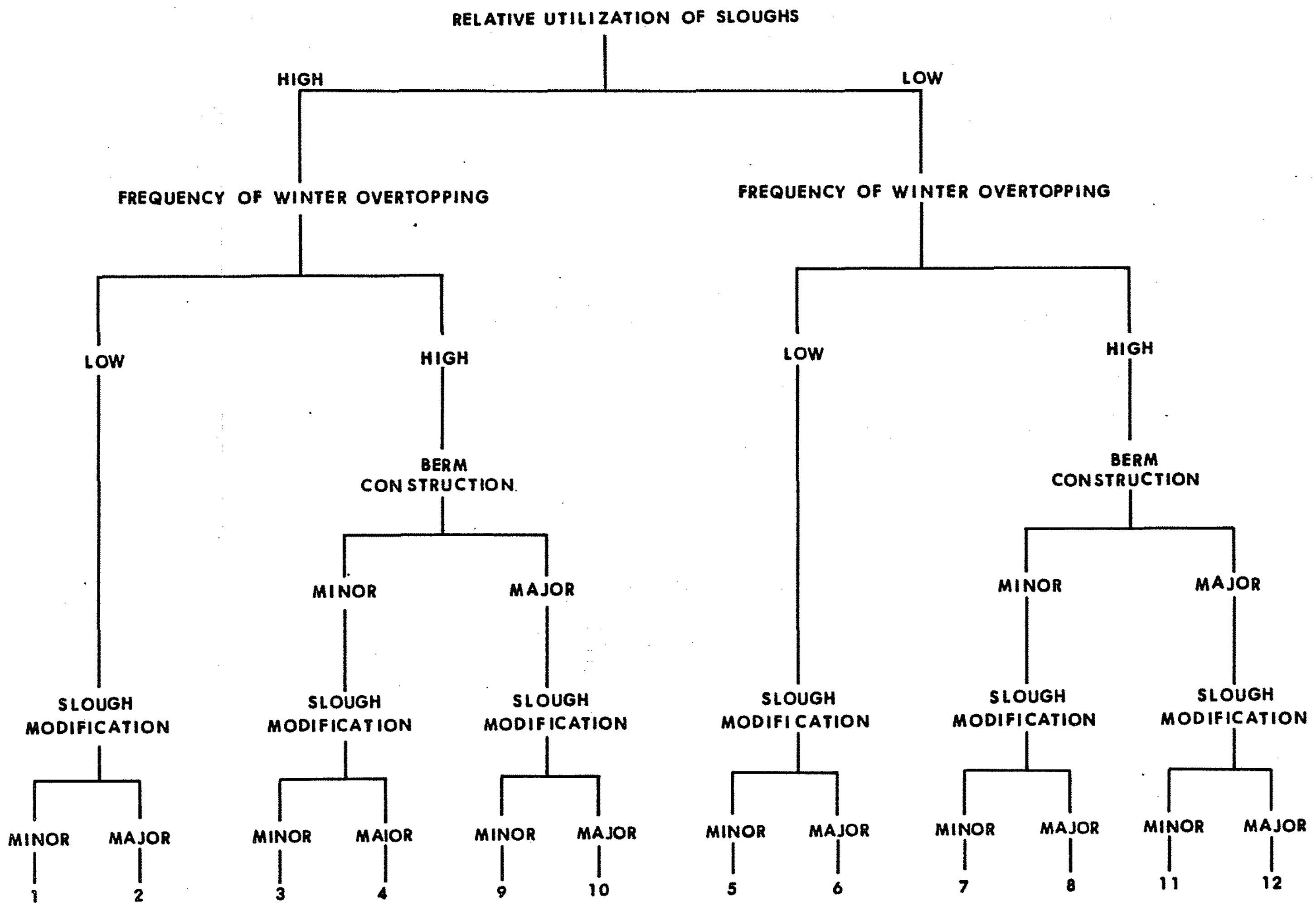


CROSS SECTIONAL VIEW

OVERTOPPING PREVENTION MITIGATION
BY INCREASING BERM HEIGHT

SOURCE: WCC 1984a

FIGURE E.3.2.123

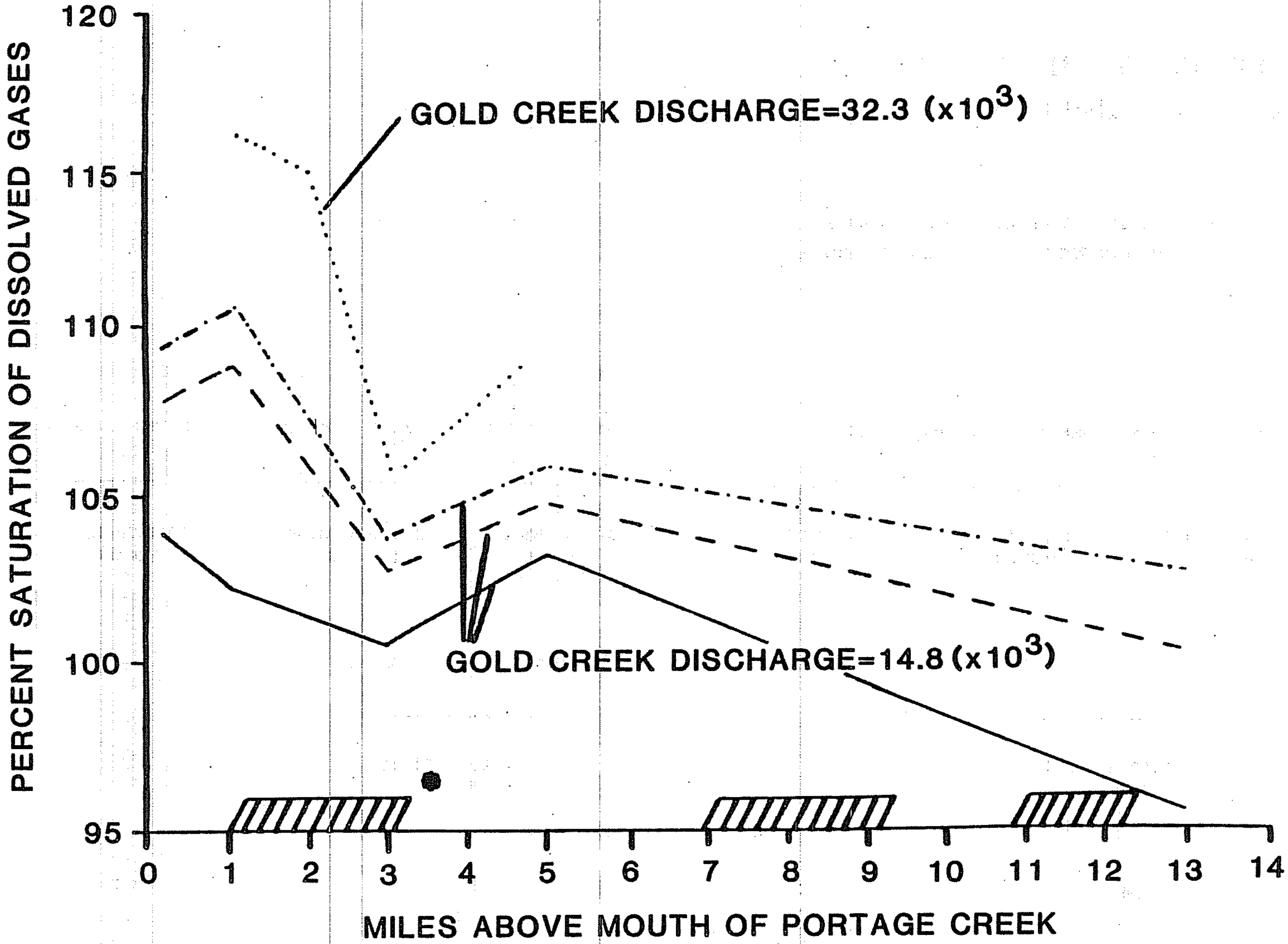


* THE SMALLER THE RANK VALUE AT A SITE, THE MORE COST-EFFECTIVE WOULD BE MITIGATION WORK AT THE SITE.

FLOW CHART FOR RANKING SITES FOR MITIGATION DECISION MAKING

SOURCE: WCC 1985b

FIGURE E.3.2.124



TOTAL GAS SATURATION – – – AND ········

NITROGEN SATURATION –·–·–

OXYGEN SATURATION ———

● INDICATE AREAS OF RAPIDS

SOURCE: ADF& G 1983m

CONCENTRATIONS OF DISSOLVED GASES IN DEVIL CANYON RAPIDS COMPLEX

FIGURE E.3.2.125