SUSITNA HYDROELECTRIC PROJECT
AQUATIC MITIGATION REPORT SERIES

IMPOUNDMENT AREA FISH MITIGATION PLAN

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Preface

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

1. Access, Construction and Transmission Aquatic Mitigation Plan

2. Impoundment Area Fish Mitigation Plan

3. Middle River Fish Mitigation Plan

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

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1.0 INTRODUCTION

1.1 APPROACH TO MITIGATION

The Alaska Power Authority's (APA) goal for the Susitna Hydroelectric Project fisheries mitigation is to maintain the productivity of natural reproducing populations (APA 1982). This is consistent with the mitigation goals of the U.S. Fish and Wildlife Service (USFWS) and the Alaska Department of Fish and Game (ADF&G) (APA 1982, ADF&G 1982a, USFWS 1981). When possible, maintaining existing habitat quantity and quality is preferred. Where this is infeasible, replacement habitat will be provided in sufficient quantity and quality to support this productivity. If it is not possible to achieve this goal, APA will provide compensation for the impact with means agreed upon by the agencies.

The development and implementation of the fish mitigation plan follows a logical step-by-step process. This process and its major components are illustrated in Figure 1. The options proposed to mitigate for impacts of the Susitna Hydroelectric Project are analyzed according to the hierarchical scheme shown in Figure 2.

Mitigation options can be grouped into two broad categories based on different approaches:

(1) Modifications to design, construction, or operation of the project; or

(2) Resource management strategies.

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

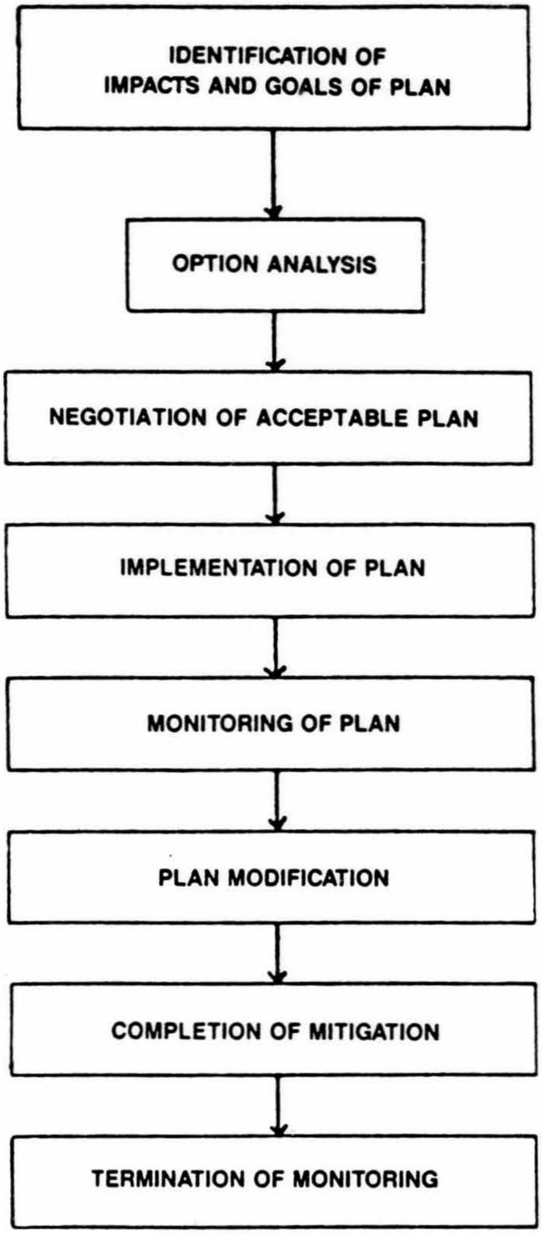

Figure 1 **Mitigation plan development and implementation**

ALASKA POWER AUTHORITY
SUSITNA HYDROELECTRIC PROJECT

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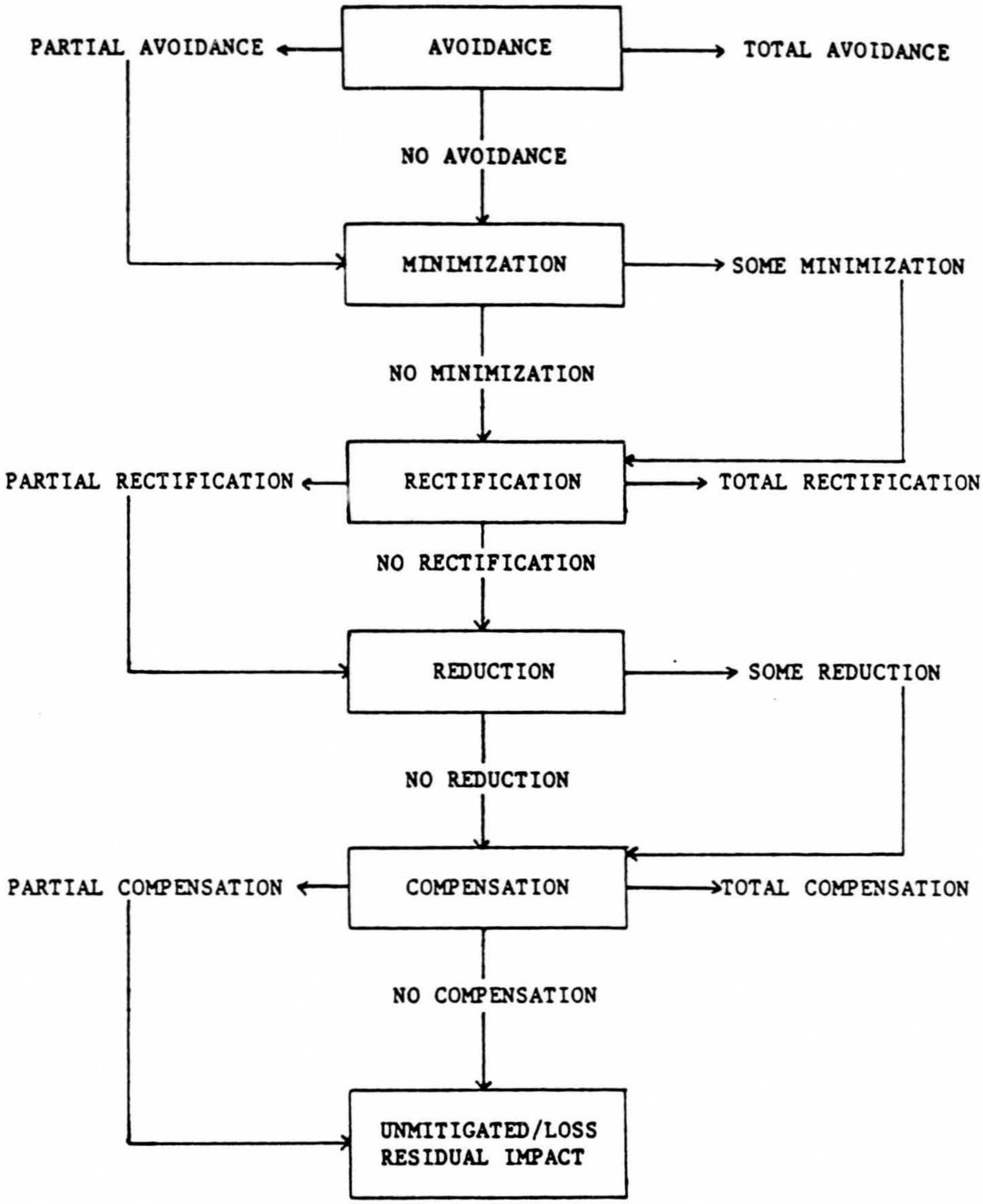

Figure 2 Option Analysis

ALASKA POWER AUTHORITY
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When impacts cannot be avoided or minimized by the first approach, measures that rectify, reduce or compensate will be implemented. These types of mitigation measures will require concurrence of resource management boards or agencies with jurisdiction over resources within the project area.

Mitigation planning for the Susitna Hydroelectric Project has emphasized both approaches. The sequence of option analysis from avoidance through compensation has been applied to each anticipated impact. If full mitigation can be achieved at a high priority option, lower options may not be considered.

Monitoring of mitigation features is recognized as an integral part of the mitigation process. And, in some cases, maintenance may be a necessary part of the mitigation plan. A general approach to monitoring has been developed by the APA and will be applied to the fishery resources and their habitats. As fish mitigation plans are agreed upon by the APA and the resource agencies, monitoring plans will be specified in greater detail.

1.2 SCOPE

This report presents analyses of mitigation measures that can be used in developing an acceptable fish mitigation plan for impacts resulting in the impoundment zones of the proposed Susitna Hydroelectric Project. Compensation is the highest mitigation option achievable for impacts in the impoundment zones. Higher priority options, such as avoidance, minimization, rectification and reduction, are considered infeasible.

Three measures for providing compensation for the expected losses of fish habitats and fishery resources in the impoundment zones are evaluated in this report. Based on input from resource agencies, acquiring public access to the Susitna River and its tributaries below Devil Canyon is the preferred compensation measure (ADF&G 1984). Secondary priority is given to habitat modifications or improvements in the middle Susitna River (between Devil Canyon and Talkeetna) that would enhance important resident species (rainbow trout or Arctic grayling) or important sport species of salmon (chinook or coho salmon). The third compensation measure evaluated is the hatchery propagation and stocking of Arctic grayling. Final decisions on the strategy to be

ByeBye Indian River

implemented will be made through negotiations between the APA and resource managers.

2.0 PROJECT DESCRIPTION AND OPERATION

In April 1985, the APA proposed that the Susitna Hydroelectric Project be changed from a two-dam, two-stage development to a two-dam, three stage development (APA 1985). Under the proposal, a 705 ft high material-fill dam will be built during Stage 1 development at Watana (RM 184). Stage 2 includes the construction of a 646 ft concrete-arch dam, with a fill saddle dam at Devil Canyon (RM 152). Stage 3 development will raise the Stage 1 Watana dam 180 ft to a crest height of 885 ft. Stage 2 and 3 developments will result in the two-dam system described in the FERC license application (APA 1983a, b).

not true only stage 3 stage 2 was lower Watana + D.C. !

Under the present schedule, construction of the Stage 1 Watana dam will begin in 1990, with all turbines on-line for power production by 1997. The Stage 2 development will begin at Devil Canyon in 1995 and be completed by 2002. The Stage 3 Watana Dam construction will commence in 2002 and be finished by 2008.

2.1 STAGE 1 - WATANA RESERVOIR

The Stage 1 development of the Watana dam (RM 184) will impound a reservoir of approximately 4.2 million acre-feet, with a surface area of 21,000 acres (APA 1985). The normal maximum water surface elevation (WSE) will be 2000 ft above mean sea level (MSL), while the normal minimum water level will be elevation (el.) 1850. At el. 2000, the maximum reservoir depth will be 550 ft, while the mean depth is expected to be about 200 ft.

The Stage 1 Watana reservoir will be operated in the store-and-release mode. Under average climatic conditions, the reservoir will be filled to el. 2000 by late August or early September. To meet power production needs, the reservoir will be drawn down from October through April. The maximum drawdown will be 150 ft and will proceed at an average rate of 0.7 ft per day. The minimum drawdown level of 1850 ft will usually occur in late April or early May. The reservoir will be refilled during the summer (May through August) when tributary runoff and glacial meltwater are high. During years of normal climatic conditions, refilling will increase the WSE 1.25 ft per day.

2.2 STAGE 2 - DEVIL CANYON RESERVOIR

When the Devil Canyon dam (RM 152) is completed, the Stage 1 Watana dam will be used primarily for power-peaking and reserve energy production, while the Devil Canyon dam will be operated to meet baseload energy demands. The Devil Canyon reservoir will optimize power production at a normal maximum WSE of 1455 above MSL from November through July (APA 1983a). Drawdown will occur during July, August and early September during average or dry years to meet power production needs and downstream flow releases while the Watana reservoir is refilling. The normal maximum drawdown will be 50 ft, to el. 1405, with refilling occurring during late September and October. In wet years, there will be no need to drawdown the Devil Canyon reservoir.

At the normal operating water level of 1455 ft, the Devil Canyon reservoir will have a volume of 1.09 million acre-feet and a surface area of 7,800 acres. The reservoir's maximum depth will be 565 ft, while the mean depth will be 140 ft (APA 1983a).

2.3 STAGE 3 - WATANA RESERVOIR

The Stage 3 development of the Susitna Hydroelectric Project will raise the pool of the Watana reservoir 185 ft. The total volume of the Stage 3 Watana reservoir will be approximately 9.47 million acre-feet, with a total surface area of 38,000 acres (APA 1983a). The normal maximum WSE of the reservoir will be el. 2185, while the normal minimum water level is expected to be el. 2065. At el. 2185, the maximum reservoir depth will be 735 ft.

The Stage 3 Watana reservoir will operate in the store-and-release mode (APA 1983a). The drawdown and refill cycle will follow a pattern similar to that of the Stage 1 reservoir drawdown. Under average climatic conditions the reservoir will be filled to el. 2185 by late August or early September. Drawdown will occur from October through April, with refilling taking place from May through August. The maximum drawdown will be approximately 120 ft and will occur at an average rate of 0.5 ft per day. Refilling will increase the water level in the reservoir an average of 1.0 ft per day.

The drawdown and refill cycle of the Stage 2 Devil Canyon reservoir with Stage 3 Watana in place is expected to be the same as projected for the Stage 1/Stage 2 development. The magnitude, timing and duration of the drawdown and refill cycle of the Stage 2 Devil Canyon reservoir was described in Section 2.2.

3.0 FISH RESOURCES IN THE IMPOUNDMENT ZONES

Nine species of fish have been observed in the impoundment zones (Table 1). Excluding burbot and lake trout, fish were caught or observed primarily in tributaries, near tributary mouths and in clearwater sloughs. Burbot were captured throughout the mainstem, while lake trout were found in one lake: Sally Lake (ADF&G 1983a). A brief summary of life history information and distribution and abundance data of the fish species observed in the impoundment areas is presented in the following sections (3.1 through 3.9).

3.1. ARCTIC GRAYLING

Arctic grayling are abundant throughout the upper Susitna River basin and are widely distributed in tributary habitats during the summer (ADF&G 1981a, 1983a). During the fall, it is suspected that most fish move into the Susitna River mainstem to overwinter, except in tributaries that have fish passage barriers (e.g. Deadman Creek). Fish residing upstream of the waterfalls in Deadman Creek likely overwinter in deeper pools of Deadman Creek or move into Deadman Lake (Sautner and Stratton 1984).

Arctic grayling move from the mainstem back into tributaries to spawn in the spring (late April and May). Spent fish were captured in tributaries immediately after spring breakup (ADF&G 1983a). Depending upon the actual timing of spawning, incubation extends from May into June (Morrow 1980). Adult grayling rear in tributaries throughout the summer. However, juvenile grayling rear in natal tributaries and in the mainstem near tributary mouths. Smaller fish are likely excluded from higher quality tributary habitats by the territorial behavior of older, aggressive adults (ADF&G 1983b, Morrow 1980).

The size of Arctic grayling populations has been estimated in the reaches of the larger tributaries in the impoundment zones (Tables 2 and 3). Based on mark and recapture estimates in 1981 and 1982, over 16,300 Arctic grayling (greater than 150 mm in length) reside in tributary reaches that will be inundated (ADF&G 1983a). Arctic grayling also occur in Sally Lake, which will be inundated by the Stage 3 Watana reservoir. In 1982 attempts were made to estimate the population size of grayling in Sally Lake. However, due to few

Table 1. Common and scientific names of fish species observed in the Watana and Devil Canyon impoundment zones.

Scientific Name	Common Name
Salmonidae	
Coregonus pidschian	humpback whitefish
Oncorhynchus tshawytscha	chinook salmon
Prosopium cylindraceum	round whitefish
Salvelinus malma	Dolly Varden
Salvelinus namaycush	lake trout
Thymallus arcticus	Arctic grayling
Catostomidae	
Catostomus catostomus	longnose sucker
Gadidae	
Lota lota	burbot
Cottidae	
Cottus cognatus	slimy sculpin

Source: ADF&G 1981a, 1983a; Sautner and Stratton 1984

Table 2. Arctic grayling population estimates in selected tributaries of the Watana impoundment zone.

Tributary	River Mile	Estimated Grayling per Mile [1]	Estimated Tributary Miles Inundated [2]			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	333	7.8	4.0	11.8	2,597	1,332	3,929
Kosina Creek	206.8	1,232	3.0	1.5	4.5	3,696	1,848	5,544
Jay Creek	208.5	455	2.3	1.2	3.5	1,047	546	1,593
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			15.1	10.8	25.9	11,010	8,387	19,397

[1] Modified from ALF&G 1983a.

[2] Assumes reservoir levels at probable maximum flood stage: Stage 1 Watana = el. 2020, Stage 3 Watana = el. 2200.5.

[3] Estimated grayling per mile in Deadman Creek was calculated by ADF&G (1983) for the reach of stream below 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 3. Arctic grayling population estimates in selected tributaries of the Devil Canyon impoundment zone.

Tributary	River Mile	Estimated Tributary Miles Inundated[1]	Estimated No. 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. 1466.

2 Source: ADF&G 1983a.

recaptures of tagged fish, an estimate based on mark and recapture was not made. Alaska Department of Fish and Game personnel believe that the population size of Arctic grayling in Sally Lake is in the vicinity of 5,000 fish (ADF&G 1983a).

3.2 BURBOT

Burbot are found in mainstem-influenced habitats of the upper Susitna River. To date, they have not been captured in tributaries or lakes that will be inundated. Burbot are relatively sedentary throughout the year, except during the winter when they move to spawning areas (ADF&G 1983b, Morrow 1980). Studies by ADF&G in the middle and lower reaches of the Susitna River indicate that burbot spawn between January and March under the ice in the mainstem, in tributary mouths and in slough mouths (ADF&G 1983b). It is assumed that burbot in the upper Susitna River exhibit similar reproductive timing and choice of habitat types.

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During 1982, trotlines were set for burbot at six mainstem and one tributary mouth sites in the Watana Impoundment Zone (ADF&G 1983a). Of the 135 burbot captured, 55 fish were caught in the Watana Creek mouth (RM 194.1), while the remaining fish were captured in the six mainstem sites (Table 4).

An attempt was made to estimate the population size of burbot within the impoundment zones by the mark and recapture method in 1982. However, few tagged fish were recaptured during the study and an estimate was not made (ADF&G 1983a).

3.3 DOLLY VARDEN

Dolly Varden are found in tributaries throughout the upper Susitna River basin during the summer (ADF&G 1983a). However, they are the dwarf stream-resident variety described by Morrow (1980) that are rarely sought by sport fishermen.

Therefore they are less valuable

Table 4. Burbot total catch and catch rates in the Watana impoundment zone, 1982.

Mainstem Site	River Mile	Catch (Catch Rate) May	June	July	August	Sept.	Total
1	189.0	--(--)	--(--)	3(0.8)	6(1.5)	7(1.8)	16(1.3)
2	191.5	--(--)	--(--)	3(0.8)	1(0.3)	0(0.0)	4(0.3)
3	197.8	--(--)	8(2.0)	3(0.8)	--(--)	--(--)	11(1.4)
3A	201.6	--(--)	--(--)	--(--)	6(1.5)	7(1.8)	13(1.6)
4	201.2	--(--)	5(1.3)	10(2.5)	7(1.8)	2(0.5)	24(1.5)
5	208.1	--(--)	4(1.0)	2(0.5)	4(1.0)	2(0.5)	12(0.8)
Watana Cr. Mouth	194.1	7(3.5)	17(0.6)	9(0.3)	13(0.4)	9(0.4)	55(0.5)
Total		7(3.5)	34(0.8)	30(0.6)	37(0.7)	27(0.6)	135(0.7)

Catch = number of burbot.
Catch Rate = Catch per trotline day.
Dashes indicate no survey.

Source: ADF&G 1983a.

In 1981 one Dolly Varden was captured at the mouth of Watana Creek, while in 1982 16 fish were caught in Cheechako, Devil, Watana, Jay and upper Deadman creeks. The total lengths of the captured fish ranged from 120 to 235 mm (ADF&G 1981a, 1983a).

No population estimate of Dolly Varden in tributaries of the impoundment zones has been done. Few fish (17 total) were caught during two years of extensive field reconnaissance and sampling effort (ADF&G 1981a, 1983a). This suggests that Dolly Varden populations are few in number and are scattered throughout the tributaries in the impoundment zones.

Although field data are not available to confirm the life history and habitat requirements of Dolly Varden in the upper Susitna River, it is suspected that they are similar to those described by ADF&G in the middle Susitna River (ADF&G 1983b) and by Morrow (1980). It is likely that Dolly Varden spawn in tributaries in October and November, with incubation occurring until March or April. Rearing likely occurs in tributaries, while overwintering may take place in the deeper pools of tributaries or in the mainstem of the Susitna River.

3.4 LONGNOSE SUCKER

Longnose sucker were captured in the upper Susitna River primarily near tributary mouths in 1981 and 1982 (ADF&G 1981a, 1983a). Of the 210 adult fish caught, 197 were captured near tributary mouths. The remaining fish were caught at mainstem sites. Watana Creek mouth produced the highest catches of longnose sucker in 1981 and 1982, with over half of the total catch occurring at this site.

It is suspected by ADF&G that longnose sucker spawn in tributaries in May and June (ADF&G 1983b). Juvenile fish likely rear in tributaries, sloughs of the mainstem and in the mainstem, while adults rear near tributary mouth habitats. Overwintering likely occurs in the mainstem of the Susitna River.

3.5 ROUND WHITEFISH

In 1981 and 1982, 38 adult round whitefish were captured near tributary mouths in the upper Susitna River (ADF&G 1981a, 1983a). Due to low catches, life history information and habitat requirements for this species in the upper Susitna River is limited. Spawning & Habitat requirements of round whitefish this reach of the Susitna River are similar to those described by ADF&G in the middle Susitna River (ADF&G 1983b) and by Morrow (1980). Fish likely spawn in tributaries and mainstem areas in October, while rearing occurs near tributary and slough mouths and in the mainstem. Overwintering likely takes place in the mainstem.

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3.6 HUMPBACK WHITEFISH

Two humpback whitefish were caught in the upper Susitna River during 1981 and 1982 (ADF&G 1981a, 1983a). In 1981 one fish was captured near the mouth of Kosina Creek, while in 1982 a single fish was caught at RM 208.1 in the mainstem of the Susitna River. Other than its occurrence in the upper Susitna River, little is known of the humpback whitefish distribution and habitat requirements in this reach of river.

3.7 LAKE TROUT

Lake trout were captured in Sally Lake in 1981 and 1982 (ADF&G 1981a, 1983a). They have not been captured in mainstem or tributary habitats. Sally Lake, which is at elevation 2025, will be inundated by the Stage 3 Watana reservoir.

A total of 62 lake trout were caught in Sally Lake during gillnet and hook-and-line sampling conducted in 1981 and 1982 (ADF&G 1981a, 1983a). The population size of lake trout has not been estimated by the mark and recapture method, due to insufficient recaptures of marked fish. ADF&G personnel believe that the population size is small, with approximately 1,000 or fewer lake trout inhabiting Sally Lake (ADF&G 1983a).

3.8 SLIMY SCULPIN

Slimy sculpin are apparently distributed in all habitats of the impoundment zones. In 1981, 38 sculpin were caught in the impoundment zones, while in 1982 no record of sculpin catches was reported (ADF&G 1981a, 1983a).

3.9 CHINOOK SALMON

Salmon are usually prevented from migrating within or upstream of the Devil Canyon dam site (RM 152) by high water velocities in Devil Canyon. However, in 1982, 1983 and 1984 a few chinook salmon were observed upstream of Devil Canyon in four tributaries and tributary mouths. In 1982, 21 chinook salmon were observed in Cheechako and Chinook creeks (ADF&G 1982b). Thirty-four chinook salmon were counted in Cheechako, Chinook and Devil creeks in 1983, while in 1984, 46 fish were observed in Cheechako, Chinook and Fog creeks (Barrett et al. 1984, 1985).

Life history information, abundance and distribution data, and habitat requirements for chinook salmon in the Susitna River have been reported by ADF&G (ADF&G 1981b, c, 1982b, 1983b; Barrett et al. 1984, 1985; Schmidt et al. 1984).

4.0 ANTICIPATED IMPACTS

4.1 STAGE 1 - WATANA RESERVOIR

4.1.1 Inundation

The Stage 1 Watana reservoir will inundate about 44 miles of the Susitna River from RM 184 to 228. The stream gradient averages about 12 feet per mile in this reach of river (APA 1983a). Steep-walled canyons confine the river primarily to a single channel with intermittent islands. The bed materials consist mainly of large gravels and cobbles. The Stage 1 Watana impoundment will change the physical and chemical characteristics of the Susitna River between RM 184 and 228 to characteristics associated with the lake-like environment of a large turbid impoundment.

Approximately 15 miles of four named tributaries of the Susitna River will be inundated by the Stage 1 Watana reservoir. The affected lengths and stream gradients of these tributaries are listed in Table 5. Additionally, numerous smaller unnamed tributaries will have portions of their lower reaches inundated (APA 1983a). A waterfall located about one mile upstream from the mouth of Deadman Creek will be inundated. This waterfall prevents upstream movements of fish into upper Deadman Creek. Removal of this fish barrier will not expand fish populations into new habitat because upper Deadman Creek currently supports a population of Arctic grayling. The potential project impacts on Arctic grayling in upper Deadman Creek are discussed by Bradley et al. (1985).

Eight lakes will be inundated by the Stage 1 Watana reservoir. These lakes range in size from less than one acre to about 10 surface acres in size. Fish have not been reported to occur in any of these lakes.

4.1.2 Drawdown

As previously mentioned in Section 2.1, the Stage 1 Watana reservoir will operate in the store-and-release mode. The reservoir will be drawndown from October through April and refilled from May through August. The normal

Table 5. Topographical features of selected tributaries within the proposed Stage 1 Watana impoundment.

Tributary	Susitna River Mile	Approximate Elevation at confluence w/ Susitna	Stream gradient of inundated reach (ft/mi)	Total length of stream inundated[1] (mi)	Approximate length in drawdown zone[2] (mi)	Approximate length permanently inundated (mi)
Deadman Creek	186.7	1515	253	2.0	0.7	1.3
Watana Creek	194.1	1550	60	7.8	2.8	5.0
Kosina Creek	206.8	1670	118	3.0	1.5	1.5
Jay Creek	208.5	1695	143	2.3	1.2	1.1
Total				15.1	6.2	8.9

[1] Assumes reservoir level at probable maximum flood stage = el. 2020.

[2] Assumes minimum reservoir level = el. 1850.

Source: Adapted from ADF&G 1983 and APA 1985.

maximum drawdown zone will be 150 ft. Due to the drawdown and refilling cycle, about 12 miles of the upper Susitna River between RM 216 and 228 will alternate between reservoir and riverine habitat. Reaches of the tributaries will also alternate between reservoir and riverine habitat. The approximate lengths of the four named tributaries in the drawdown zone are listed in Table 5. Three lakes in the Stage 1 Watana impoundment zone will remain permanently inundated. Figure 3 shows a schematic of the Stage 1 Watana Reservoir drawdown refilling cycle.

4.1.3 Water Quality

(a) General Description

The Stage 1 Watana reservoir will exhibit characteristics similar to deep, glacial lakes in Southcentral Alaska (e.g. Bradley and Eklutna lakes). The drawdown and refilling cycle, along with the characteristics associated with a deep, turbid reservoir are expected to affect the fish populations that presently are found in the upper Susitna Basin.

Water temperatures and suspended sediment and turbidity levels are expected to be altered significantly by the Watana reservoir. These factors are discussed in Sections 4.1.3, b & c. Dissolved oxygen, nutrients, total dissolved solids, conductivity, pH, total hardness, total alkalinity, metals and other water quality characteristics are also expected to change after impoundment; however, similar to the Stage 3 reservoir (APA 1983a), it is anticipated that their levels will not be significantly altered and will not be detrimental to aquatic organisms inhabiting the reservoir. Therefore, they are not discussed in further detail.

(b) Temperature

Under existing conditions, water temperatures in the upper Susitna River range from near $0^{o}C$ throughout the winter (October through May) to a summer high near $14^{o}C$. Instantaneous water temperatures taken by ADF&G from May through mid-September 1982 recorded a low of $0.1^{o}C$ on May 14 and a high of $13.6^{o}C$ on June 24 (ADF&G 1983a).

TO BE INCLUDED IN FINAL REPORT
(DATA NOT AVAILABLE)

Figure 3 Stage 1 - Watana reservoir water levels

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Tributaries of the upper Susitna River exhibit temperature regimes similar to the mainstem. Water temperatures are near $0^{o}C$ throughout the winter and reach highs above $15^{o}C$ during mid-summer. From mid-June to mid-October 1982, temperatures were recorded continuously in four tributaries of the upper Susitna River (ADF&G 1983a). The tributary surface water temperatures ranged from 0 to $16.5^{o}C$ during this period.

The thermal characteristics of the Stage 1 Watana reservoir will be similar to other deep glacial lakes in Southcentral Alaska (e.g. Bradley and Eklutna lakes). The reservoir is expected to stratify during the summer and winter, while water temperatures will approach isothermal conditions ($4^{o}C$ throughout the water column) in the spring and fall.

During mid-summer, when thermal stratification will be the strongest, the maximum surface water temperature is expected to be between 10 and $12^{o}C$ (Harza-Ebasco 1985a). Temperatures will decrease with increasing depths to $4^{o}C$ near the reservoir bottom. The depth and strength of this stratification will depend on climatic conditions and will vary from year to year. Stage 1 Watana reservoir temperature simulations can be found in a report by Harza-Ebasco (1985a).

As the reservoir's water temperatures cool, the thermal stratification will weaken until isothermal conditions prevail (October or early November). Surface water temperatures will continue to cool until an ice cover forms (late November or early December) (Harza-Ebasco 1985a). The ice cover is expected to last into early May. Due to the winter drawdown cycle of the Stage 1 Watana reservoir, ice along the edge of the impoundment will fracture and remain draped on the bank similar to that expected in the Stage 3 reservoir (AEIDC 1985). During the winter, temperatures near the bottom will remain near $4^{o}C$ while the surface waters just below the ice cover will be near $0^{o}C$. Temperatures at a depth of 100 ft range between 1.5 and $3.0^{o}C$ during winter (Harza-Ebasco 1985a). Thus, the impoundment will become inversely stratified. After spring breakup, the reservoir will warm rapidly due to solar radiation and tributary inflow.

The major changes in the thermal regime of the Stage 1 Watana impoundment are that water temperatures are expected to be warmer in the winter and cooler during the summer compared to natural pre-project conditions and the spring warming and fall cooling rates will be retarded.

(c) Suspended Sediments and Turbidity

Suspended sediment and turbidity levels in the Susitna River are generally high during spring breakup and summer, with reduced levels in the fall. During winter, the Susitna River is typically clear. Suspended sediment values in the mainstem range from winter lows near 10 mg/l to highs of over 5,000 mg/l during the summer at Denali Station (RM 289.5), the gaging station nearest the glacially-fed headwaters. Maximum summer concentrations at Gold Creek (RM 138.7) of over 2,000 mg/l have been observed (APA 1983a).

Turbidity values in the mainstem are near zero in the winter. In January and February 1982, values of 1.1 Nepholometric Turbidity Units (NTU) or less were measured by the USGS at Gold Creek (RM 138.7). Turbidity levels over 700 NTU have been measured at Vee Canyon (RM 223) during July (APA 1983a). Turbidity levels in tributaries of the upper Susitna River are generally low (20 NTU or less) throughout the year. In these clearwater streams, peak turbidity and suspended sediment levels occur during spring breakup and during high flows associated with heavy rainfall events. The Oshetna River is an exception to this, as its headwaters originate from glaciers. In 1982 turbidity values in selected tributaries of the upper Susitna River ranged from near zero in all tributaries sampled to 42 NTU in the Oshetna River (ADF&G 1983a).

The Stage 1 Watana reservoir will change the naturally-occurring suspended sediment and turbidity levels and patterns. Levels in the mainstem will decrease during the summer compared to natural conditions due to the settling out of most (80 percent or more) of the suspended sediments as the sediment-laden Susitna River enters the reservoir. However, the smaller-sized sediments (particle diameters of 4 microns or less) are expected to remain in suspension, causing the reservoir to be turbid. The turbid reservoir will increase the summer turbidity and suspended sediment levels in the habitats that were previously clearwater tributaries. The reservoir will remain turbid throughout the year. Thus, the natural clearwater conditions that prevail in the mainstem and tributary habitats during the winter will be altered.

Slumping of reservoir walls and resuspension of shoreline sediments will create localized increases in suspended sediment and turbidity. The drawdown and refilling cycle will tend to aggravate the slumping of reservoir walls (APA 1983a).

Most of the suspended sediment load of the Susitna River will settle out as the river enters the reservoir. This process will cause the formation of a delta at the upstream end of the reservoir. The location and extent of the delta will vary with the drawdown and refilling cycle of Watana and streamflows of the Susitna River. During drawdown, the Susitna River will cut through the delta and transport sediments farther into the impoundment.

Although the tributaries to the Watana reservoir are generally clearwater streams, they can transport stream bed materials during spring breakup and periods of heavy rainfall. Therefore, it is expected that small deltas may form at the mouths of tributaries as they enter the reservoir. However, the deltas are not expected to impede fish movements into and out of tributaries. The location of tributary deltas will vary with the drawdown and refilling cycle.

Also for slumps like on Watana Creek

The most important change in turbidity levels in the reservoir is that clearwater tributary habitats will be inundated with turbid water, increasing turbidity levels throughout much of the year.

4.1.4 Effects on Fish

The Stage 1 Watana reservoir is expected to significantly affect fish populations in the impoundment area. Inundation, the drawdown and refilling cycle, the reservoir's thermal regime and suspended sediment/turbidity levels are expected to be the dominant forces in altering habitats and subsequently affecting the populations of fish in those habitats. The anticipated impacts on species/life stages are described by the habitat types in which the anticipated impacts will occur.

(a) Tributary Habitat

(i) Arctic grayling

The spawning, incubation and rearing life stages of Arctic grayling will likely be adversely affected by the Stage 1 Watana reservoir. Spawning habitat will be lost in the reaches of tributaries inundated by the impoundment, because it is expected that grayling will not utilize the turbid reservoir for spawning. Grayling usually select spawning sites in lotic habitats (Morrow 1980). Spawning normally takes place during May which is when the reservoir will be drawn down. If the timing of spawning coincides with maximum reservoir drawdown, about 9 miles of spawning habitat in the larger, named tributaries would be lost (Table 5).

Spawning will likely occur in the reaches of tributaries within the drawdown zone. However, incubation success is expected to be low due to the refilling of the reservoir. Rising water levels will progressively inundate reaches of tributaries in the drawdown zone. Streambed materials carried downstream by the high flows of breakup will be deposited at the mouths of tributaries. The deposition of sediments will move upstream with rising water levels and cover spawning areas, which will likely cause mortalities on developing embryos. During May and June (the approximate period of grayling spawning and incubation) the reservoir's water level will rise 50 to 55 ft. Thus, in years when the reservoir is at maximum drawdown (1850 ft) in late April, embryos spawned below el. 1905 would be inundated prior to hatching.

Rearing habitat for Arctic grayling in the impoundment will likely be limited to the clearwater plumes near tributary mouths. Arctic grayling are not expected to utilize other areas in the reservoir as grayling are not found in lakes with turbidity levels similar to those anticipated in Watana (Russell 1980). Some displaced grayling will likely use rearing habitats in tributary reaches above the reservoir water levels. However, rearing habitats in tributaries are likely already occupied, as indicated by the high densities of grayling per mile (323-1835) reported by ADF&G (1983a). Thus, important tributary habitat will be lost, reducing Arctic grayling populations in the upper Susitna River. It is estimated that the mid-summer population size of Arctic grayling inhabiting tributary reaches inundated by the Stage 1 Watana reservoir is at least 11,000 fish greater than 150 mm in length (Table 2).

Most Arctic grayling in the upper Susitna River apparently overwinter in the mainstem, although it is likely that some may remain in tributaries throughout the winter. In either case, overwintering conditions will likely improve due to the warmer water temperatures in the reservoir. Present winter water temperatures in the mainstem and tributaries are near $0^{o}C$. Winter temperatures at a depth of 100 ft in the Watana reservoir will be in the range of 1.5 to $3.0^{o}C$ (Harza-Ebasco 1985a). The warmer water temperatures may increase the overwintering survival of fish in the impoundment, as it has been noted that fish are attracted to warmer water temperatures during winter (Umeda et al. 1981).

Table 6 summarizes the anticipated impacts of the Stage 1 Watana reservoir on the life stages of Arctic grayling inhabiting tributaries in the impoundment area. The spawning, incubation and rearing life stages will likely experience adverse impacts. Although overwintering habitat will likely improve, it is not expected to offset losses expected during the other life stages.

(ii) Dolly Varden

The Stage 1 Watana reservoir will likely have insignificant effects on Dolly Varden populations in tributaries of the upper Susitna River. Dolly Varden occupy a wide range of habitat types in Southcentral Alaska, including glacial lakes with a wide range of water quality (Russell 1980). Thus, it is expected that Dolly Varden will occupy the Stage 1 Watana reservoir throughout much of the year. Dolly Varden spawn in tributaries during the fall (October to November) (Morrow 1980). After impoundment, it is likely that they will continue to use tributaries for spawning. Dolly Varden densities in the upper Susitna Basin appear to be quite low, thus, spawning habitat above the impoundment water level is expected to be available as it is unlikely that all spawning habitat is presently utilized. Since Dolly Varden spawn in the fall when the reservoir's water levels will be stable or decreasing, incubating embryos will not be inundated by rising water levels.

Table 6. Summary of selected species abundance, sport value and sensitivity to habitat alteration in tributary habitats of the proposed Stage 1 Watana impoundment zone.

Species	Life stage	Abundance in tributary habitat[1]	Sport value of species[1]	Sensitivity of species/life stage to habitat alteration[2]
Arctic grayling	spawning	3	3	3
	incubation	3	3	3
	rearing	3	3	3
	overwintering	1	3	0
Dolly Varden	spawning	1	1	0
	incubation	1	1	0
	rearing	1	1	1
	overwintering	1	1	0

[1] 1 = low, 2 = moderate, 3 = high.

[2] 0 = no predicted change or, may be positive influence; 1 = low; 2 = moderate; 3 = high. Refer to text for discussion of species sensitivity to potential impacts.

Dolly Varden will likely utilize the Stage 1 Watana reservoir during the summer for rearing. However, turbid conditions and the drawdown/refilling cycle are expected to limit the development of littoral areas and limit productivity of the impoundment. These conditions will likely restrict the distribution of most fish in the reservoir to the clearwater plumes of tributary inflow.

As discussed previously, it is expected that overwintering conditions in the Stage 1 Watana Reservoir will improve over those that presently occur in tributaries and the mainstem. Dolly Varden will likely utilize the reservoir during the winter.

The anticipated effects of the Stage 1 Watana Reservoir on Dolly Varden populations in tributaries are summarized in Table 6.

(b) Mainstem Habitat

(i) Burbot

Burbot occupy the mainstem of the upper Susitna River throughout the year. After impoundment, mainstem habitats will be eliminated and replaced by a turbid lake-like impoundment. Since burbot are found in glacial lakes in Southcentral and Southwestern Alaska (Bechtel Civil and Minerals, Inc. 1981; Russell 1980), they will likely utilize the Stage 1 Watana reservoir year-round.

The winter drawdown of the Stage 1 Watana reservoir is expected to affect the incubation success of burbot in the impoundment. In lakes, burbot usually spawn in mid-winter (January to early March) in relatively shallow water (20 ft or less) (Morrow 1980). The Stage 1 Watana reservoir will be drawndown from November to May at an average rate of 0.7 ft per day. Thus, embryos in shallow water will become dewatered and freeze. This will substantially reduce the recruitment to burbot populations occupying the impoundment. Some burbot in the impoundment may move into the upper Susitna River to spawn.

The rearing and overwintering life stages of burbot are not expected to experience any adverse impacts from the project. Burbot will likely be distributed primarily near the clearwater plumes of tributary inflow, due to the expected abundance of prey species in those areas. Overwintering conditions may improve after impoundment, due to the warmer winter temperatures.

Table 7 summarizes the anticipated impacts of the Watana reservoir on the life stages of burbot.

(ii) Arctic grayling

Some juvenile Arctic grayling use mainstem areas near tributary mouths for summer rearing. These fish are apparently excluded from tributary habitats by the territorial behavior of larger, older fish (ADF&G 1983b, Morrow 1980). It is expected that the Stage 1 Watana reservoir will not have significant effects on these fish as replacement habitat will likely exist near the tributary mouths in the reservoirs.

Most Arctic grayling in upper Susitna River tributaries apparently move into the mainstem for overwintering. Overwintering conditions for grayling under existing and with-project conditions have been discussed previously (Section 4.1.4). It is likely that overwintering conditions will improve under project operation.

A summary of the expected impacts of the Stage 1 Watana reservoir on Arctic grayling in mainstem habitats is presented in Table 7.

(iii) Dolly Varden

Dolly Varden may utilize mainstem habitats for overwintering. As discussed previously, overwintering conditions will likely improve under project operation due to warmer water temperatures of the reservoir. Thus, if Dolly Varden do overwinter in the mainstem, conditions are expected to improve under with-project operation (Table 7).

(c) Lake Habitat

None of the lakes inundated by the Stage 1 Watana reservoir have been reported to contain fish. Most of the lakes are small, perched tundra lakes.

Table 7. Summary of selected species abundance, sport value and sensitivity to habitat alteration in mainstem habitats of the proposed Stage 1 Watana impoundment zone.

Species	Life stage	Abundance in mainstem habitat[1]	Sport value of species[1]	Sensitivity of species/life stage to habitat alteration[2]
Burbot	spawning	1	1	0
	incubation	1	1	3
	rearing	1	1	0
	overwintering	1	1	0
Arctic grayling	rearing	1	3	0
	overwintering	3	3	0
Dolly Varden	overwintering	1	1	0

[1] 1 = low, 2 = moderate, 3 = high.

[2] 0 = no predicted change or, may be positive influence; 1 = low; 2 = moderate; 3 = high. Refer to text for discussion of species sensitivity to potential impacts.

Therefore, the inundation of lakes by the Stage 1 Watana reservoir will likely have insignificant effects on fish.

4.2 STAGE 2 - DEVIL CANYON RESERVOIR

4.2.1 Inundation

The Devil Canyon reservoir will inundate about 31 miles of the Susitna River from RM 152 to 183. From Watana (RM 184) downstream to Devil Creek (RM 161) the stream gradient averages 11 ft per mile, while between Devil Creek and Devil Canyon (RM 152) the gradient increases to 31 ft per mile (APA 1983a). Steep canyon walls confine the river to a single channel throughout most of the river between Devil Canyon and Watana. About six miles of the lower reaches of five named tributaries will be inundated (Table 8), plus the lower reaches of numerous smaller, unnamed tributaries. Inundation will change the physical and chemical characteristics of the riverine habitats to those associated with a large, turbid impoundment.

Many of the tributaries in the Devil Canyon impoundment area are characterized by high stream gradients with occasional waterfalls. Cheechako, Devil and Tsusena creeks all contain waterfalls. However, none of these waterfalls will be inundated and would still function as barriers to upstream fish passage after impoundment.

One five-acre lake will be filled by the saddle dam during construction (APA 1983a). No lakes will be affected by impoundment of the Devil Canyon Reservoir.

4.2.2 Drawdown

Due to the nature of the two-dam system, Devil Canyon impoundment will operate at full pool (1455 ft) for most of the year (APA 1983a). During wet years there will be no need to drawdown the reservoir. However, during average and dry years, drawdown will occur during July, August and early September. The drawdown will help meet power production needs and downstream flow releases while the Stage 1 Watana reservoir is refilling. The

Table 8. Topographical features of selected tributaries within the proposed Devil Canyon impoundment.

Tributary	Susitna River Mile	Approximate elevation at confluence with Susitna	Stream gradient of inundated reach (ft/mi)	Total length of stream inundated[1] (mi)	Approximate length in drawdown zone[2] (mi)	Approximate length permanently inundated (mi)
Cheechako Cr.	152.4	920	321	1.7	0.2	1.5
Chinook Cr.	157.0	1065	308	1.3	0.2	1.1
Devil Cr.	161.4	1200	176	1.5	0.3	1.2
Fog Cr.	176.7	1375	72	1.3	0.9	0.4
Tsusena Cr.	181.3	1435	82	0.4	0.4	0.0
Total				6.2	2.0	4.2

[1] Assumes reservoir level at probable maximum flood stage = 1466 ft MSL.

[2] Assumes minimum reservoir level = 1405 ft MSL.

Source: ADF&G 1983a.

normal maximum drawdown zone for Devil Canyon is expected to be 50 ft. Thus, the magnitude, timing and duration of drawdown for Devil Canyon reservoir is quite different from the Stage 1 Watana drawdown (Section 4.1.2).

About five miles of the Susitna River between RM 178 and 183 will alternate between reservoir and riverine habitat due to the drawdown of Devil Canyon reservoir. Reaches of tributaries within the impoundment area will also alternate between reservoir and riverine habitat. The approximate lengths of the five named tributaries in the drawdown zone are listed in Table 8. A schematic of the drawdown/refilling cycle in the Devil Canyon reservoir is shown in Figure 4.

4.2.3 Water Quality

(a) General Description

The water quality in the Devil Canyon reservoir will be similar to that in the Stage 1 Watana reservoir (Section 4.1.3). The impoundment is expected to significantly alter water temperatures and suspended sediment and turbidity levels of mainstem and tributary habitats. Other water quality parameters are not expected to change significantly (Section 4.1.3).

(b) Temperature

Baseline water temperature conditions in the upper Susitna River and its tributaries were described in Section 4.1.3(b).

The temperature regime of the Devil Canyon reservoir is expected to be similar to Stage 1 Watana reservoir. The Devil Canyon reservoir will experience weak summer and winter thermal statifications, interrupted by isothermal conditions in the fall and spring. Water temperatures during the summer in the Devil Canyon reservoir are expected to be cooler in comparison to pre-project conditions, while winter temperatures will be warmer than natural conditions. The fall cooling and spring warming periods are expected to shift, lagging behind natural conditions. The Devil Canyon reservoir temperature simulations are illustrated in reports by Harza-Ebasco (1985a, 1985b).

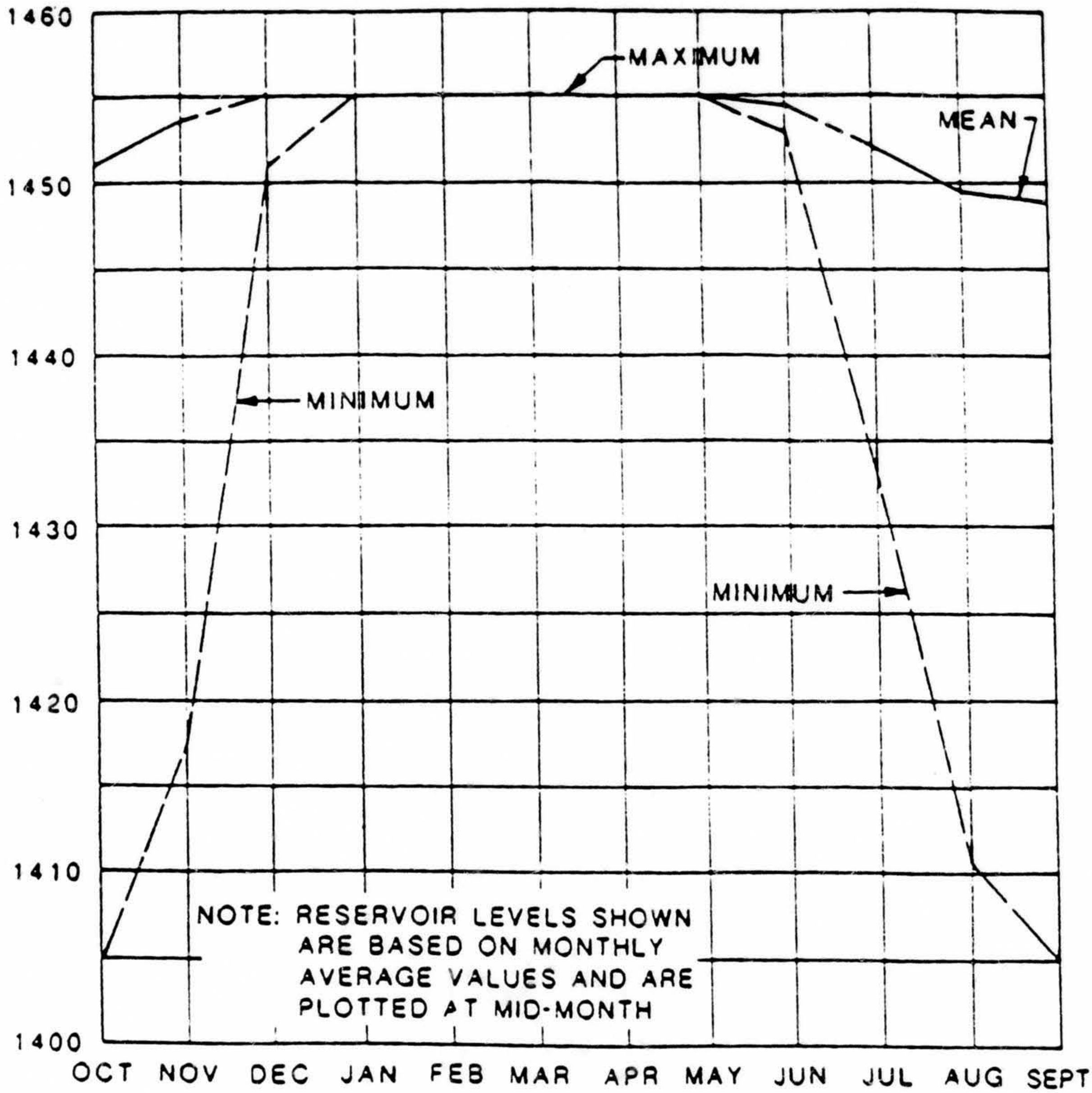

Figure 4 **Stage 2 - Devil Canyon water levels. 2020 simulation case E-VI**

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Due to its smaller size (7,800 surface acres, 1.09 million acre-feet) compared to the Stage 1 Watana reservoir (21,000 surface acres, 4.2 million acre-feet), the Devil Canyon reservoir will likely respond to meteorological conditions more rapidly, and in particular will be more susceptible to wind mixing.

The maximum surface water temperatures in the Devil Canyon reservoir are expected to be in the range of 10 to 12°C in August. During winter, an ice cover is expected to form on the Devil Canyon reservoir by late November, lasting until early May (Harza-Ebasco 1985a). Predictions indicate that winter water temperatures will be in the range of 2 to 4°C at a depth of 50 ft (Harza-Ebasco 1985a).

(c) Suspended Sediments and Turbidity

Suspended sediments of less than 4 microns in diameter will enter the Devil Canyon reservoir from the Stage 1 Watana reservoir. Only a small percentage of the suspended sediment is expected to settle out. Thus, suspended sediment levels will generally reflect those occurring in the Stage 1 Watana reservoir.

Due to the settling out of most sediments in the Stage 1 Watana reservoir, an extensive delta will not form at the upstream end of the Devil Canyon reservoir. Small deltas will likely form at the mouths of tributaries, similar to those expected in the Stage 1 Watana reservoir.

Some slumping of reservoir walls and resuspension of shoreline sediment will occur, particularly during reservoir drawdown. However, since the overburden layer is shallow, slumping and sediment entrainment should not create significant problems. Thus, increases in suspended sediment and turbidity levels will be localized and short-term.

Turbidity levels in the Devil Canyon reservoir are expected to follow the pattern and range of levels in the Stage 1 Watana reservoir. Turbidity values are expected to be lowest during the spring and increase during late summer and early fall.

The most important change in turbidity levels from natural conditions is that clearwater tributary habitats will be inundated by turbid water, increasing turbidity levels throughout much of the year.

4.2.4 Effects on Fish

The Stage 2 Devil Canyon reservoir will affect fish populations inhabiting the upper Susitna Basin. Inundation, drawdown and refilling, and the reservoir's thermal regime and suspended sediment/turbidity levels are expected to be dominant forces in altering habitats. The anticipated impacts on species/life stages are described by the habitat types in which impacts will occur.

(a) Tributary Habitat

The major alteration of tributaries is the inundation of these clearwater lotic habitats with a turbid lake-like environment. Anticipated impacts to fish species in tributary habitats are expected to be similar to those presented in Section 4.1.4(a) for the Stage 1 Watana reservoir.

(i) Arctic grayling

Arctic grayling are not expected to spawn in the turbid reservoir, as they prefer lotic habitats. The Devil Canyon reservoir will be at full pool (el. 1455) during the grayling spawning and incubation periods (May-June). Thus, about six miles of habitat in the larger, named tributaries would be lost due to inundation (Table 8). Because the reservoir will be at full pool, any spawning that occurs in tributaries upstream of the reservoir's water level will not be affected by the drawdown and refilling cycle.

Rearing conditions for Arctic grayling in the reservoir will be similar to those in the Stage 1 Watana reservoir (Section 4.1.4). It is expected that most of the 1,200 grayling residing in tributaries within the impoundment area (Table 3) will be displaced and lost.

The Devil Canyon reservoir will likely improve overwintering conditions for Arctic grayling in the impoundment area. The winter water temperatures are expected to be in the range of 2 to $4^{o}C$ at a depth of 50 ft (Harza-Ebasco 1985a). Thus, warmer than natural temperatures (near $0^{o}C$) will likely improve the overwintering survival of fish.

Table 9 summarizes the impacts of the Devil Canyon reservoir on the life stages of Arctic grayling inhabiting tributaries within the impoundment area.

(ii) Dolly Varden

The Devil Canyon reservoir is expected to have insignificant effects on Dolly Varden populations in the upper Susitna Basin. Dolly Varden are expected to utilize the Devil Canyon reservoir throughout much of the year.

Dolly Varden will likely spawn in tributary reaches above the reservoir's water level after impoundment. Some incubating embryos may be affected by the refilling cycle. Spawning occurs in October and November, which is when the reservoir will be filling during normal or dry years. Embryos spawned in the drawdown zone will likely experience higher mortality due to inundation and siltation (Section 4.1.4).

The Devil Canyon reservoir is not expected to provide favorable conditions for rearing fish. The steep walls and turbidity will inhibit the development of a littoral area and productivity of the reservoir. Similar to the Stage 1 Watana reservoir, it is expected that most fish will be distributed near the inflow of tributaries.

Table 9 summarizes the anticipated effects of the Devil Canyon reservoir on Dolly Varden populations in tributary habitat.

(b) Mainstem Habitat

(i) Burbot

Burbot are found in glacial lakes in Southcentral and Southwestern Alaska (Russell 1980) and are expected to utilize the Devil Canyon reservoir throughout the year. Unlike the Stage 1 Watana reservoir, the Devil Canyon

Table 9. Summary of selected species abundance, sport value and sensitivity to habitat alteration in tributary habitats of the proposed Devil Canyon impoundment zone.

Species	Life stage	Abundance of species in tributary habitat[1]	Sport value of species[1]	Sensitivity of species/life stage to habitat alteration[2]
Arctic grayling	spawning	3	3	3
	incubation	3	3	3
	rearing	3	3	3
	overwintering	1	3	0
Dolly Varden	spawning	1	1	1
	incubation	1	1	0
	rearing	1	1	1
	overwintering	1	1	0

[1] 1 = low, 2 = moderate, 3 = high.

[2] 0 = no predicted change or, may be positive influence; 1 = low; 2 = moderate; 3 = high. Refer to text for discussion of species sensitivity to potential impacts.

reservoir's water level will be stable during winter. Thus, the drawdown and refilling cycle of the reservoir will not affect burbot embryo incubation.

No significant impacts are anticipated for burbot inhabiting the Devil Canyon reservoir (Table 10).

(ii) Arctic grayling

No significant impacts are anticipated for Arctic grayling in mainstem habitats of the Devil Canyon reservoir (Table 10). Conditions are expected to be similar to those dicussed in Section 4.1.4.

(iii) Dolly Varden

The anticipated effects of the Stage 1 Watana reservoir on Dolly Varden in mainstem habitats (Section 4.1.4[b]) are expected to be the same for the Devil Canyon Reservoir. No significant impacts are foreseen.

(iv) Chinook Salmon

A few chinook salmon migrate upstream of Devil Canyon (RM 152) to spawn. Construction of the Devil Canyon dam will prevent chinook salmon from utilizing habitats upstream of the dam site.

4.3 STAGE 3 - WATANA RESERVOIR

4.3.1 Inundation

The Stage 3 Watana reservoir will inundate an additional 11 miles of Susitna River from RM 228 to 239. Approximately 10.8 miles of six named tributaries will be inundated by the Stage 3 reservoir (Table 11). The total lengths of the named tributaries inundated by both Stage 1 and Stage 3 is about 26 miles. Additionally, numerous, unnamed tributaries will also be affected by the Stage 3 impoundment.

Table 10. Summary of selected species abundance, sport value and sensitivity to habitat alteration in mainstem habitats of the proposed Devil Canyon impoundment zone.

Species	Life stage	Abundance of species in mainstem habitat[1]	Sport value of species[1]	Sensitivity of species/ life stage to habitat alteration[2]
Burbot	spawning	1	1	0
	incubation	1	1	0
	rearing	1	1	0
	overwintering	1	1	0
Arctic grayling	rearing	1	3	0
	overwintering	3	3	0
Dolly Varden	overwintering	1	1	0

[1] 1 = low, 2 = moderate, 3 = high.

[2] 0 = no predicted change or, may be positive influence; 1 = low; 2 = moderate; 3 = high. Refer to text for discussion of species sensitivity to potential impacts.

Table 11. Topographical features of selected tributaries within the proposed Stage 3 Watana impoundment.

Tributary	Susitna River Mile	Approximate elevation of confluence with Susitna	Stream gradient of inundated reach (ft/mi)	Length of stream inundated (mi)[1] Stage 1	Stage 3	Total	Approximate length in drawdown zone[2] (mi)	Approximate length permanently inundated (mi)
Deadman Creek	186.7	1515	253	2.0	0.7	2.7	0.5	2.2
Watana Creek	194.1	1550	60[a]	7.8	0.7	8.5[a]	0.0	8.5
East Fork	N/A	2060[c]	113[b]	0.0	1.2	1.2[b]	1.2	0.0
West Fork	N/A	2060[c]	67[b]	0.0	2.1	2.1[b]	2.0	0.1
Kosina Creek	206.8	1670	118	3.0	1.5	4.5	1.1	3.4
Jay Creek	208.5	1695	143	2.3	1.2	3.5	0.9	2.6
Goose Creek	231.3	2060	114	0.0	1.2	1.2	1.1	0.1
Oshetna River	233.4	2110	41	0.0	2.2	2.2	2.2	0.0
Total				15.1	10.8	25.9	9.0	16.9

[1] Assumes reservoir level at probable maximum flood stage = el. 2200.5.

[2] Assumes minimum reservoir level = el. 2065.

[a] Watana Creek below forks.

[b] Watana Creek above forks.

[c] Elevation at confluence of Watana Creek forks.

Modified from ADF&G 1983a.

Twenty-three lakes will be inundated by the addition of the Stage 3 Watana development. Most of the lakes are relatively small, as 22 lakes are less than 10 surface acres. Sally Lake, with a surface area of 63 acres and a maximum depth of 27 ft, is the largest lake affected by the Stage 3 Watana Reservoir. Sally Lake is located on the north side of the Susitna River near the mouth of Watana Creek at an elevation of 2025 ft.

4.3.2 Drawdown

The Stage 3 Watana reservoir will be operated similar to Stage 1 Watana: the store-and-release mode. The Stage 3 reservoir will be drawndown from October through April and refilled from May through August. The normal maximum drawdown zone will be 120 ft. The drawdown/refilling cycle is shown in Figure 5.

Due to the drawdown and refilling cycle, about 9 miles of the upper Susitna River between RM 230 and 239 will alternate between reservoir and riverine habitat. Reaches of tributaries will also alternate between reservoir and riverine habitat. Table 11 shows the approximate lengths of the six, named tributaries in the drawdown zone. Most lakes, including Sally Lake, will remain inundated during drawdown.

4.3.3 Water Quality

The water quality associated with Stage 3 Watana reservoir is expected to be similar to that of Stage 1 Watana reservoir. The only significant change expected at this time is for winter water temperatures in the Stage 3 impoundment to be 1 to 1.5^{o}C warmer than the Stage 1 reservoir (APA 1985). This is attributed the larger reservoir volume and longer retention time associated with the Stage 3 reservoir. Ice formation on the Stage 3 reservoir will occur about mid-November and last until early May (Harza-Ebasco 1985a).

4.3.4 Effects on Fish

The Stage 3 Watana reservoir will alter habitats and affect fish populations similar to the Stage 1 Watana reservoir. Inundation, drawdown, water

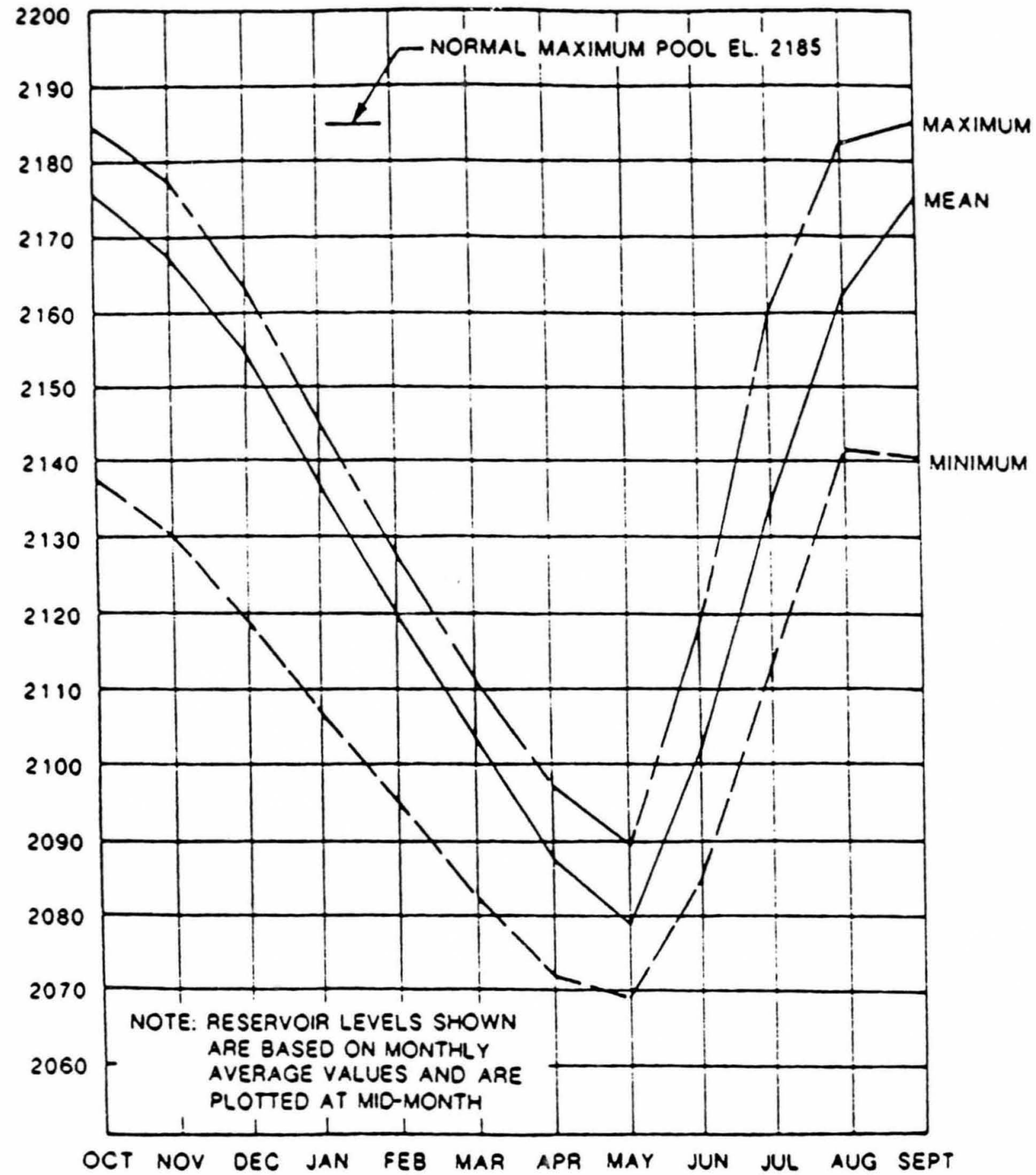

Figure 5 **Stage 3 - Watana reservoir water levels. Watana and Devil Canyon operating. 2020 simulation case E-VI**

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temperatures and turbidity/suspended sediment levels will continue to be the dominant forces affecting habitats and fish populations. Anticipated impacts associated with completion of the Stage 3 Watana reservoir are discussed by the habitats in which they will occur.

(a) Tributary Habitat

Arctic grayling and Dolly Varden inhabiting tributary reaches inundated by the Stage 3 Watana reservoir will be affected in ways described in Section 4.1.4 for the Stage 1 Watana reservoir. No significant impacts are expected for Dolly Varden. However, inundation of almost 11 additional miles of the larger named tributaries will affect summer habitat utilized by an estimated 8,400 Arctic grayling (Table 2). It is likely that most of the graying inhabiting clearwater tributaries inundated by the reservoir will be displaced and lost.

(b) Mainstem Habitat

Anticipated impacts of the Stage 1 Watana reservoir on fish inhabiting the mainstem were discussed in Section 4.1.4. It is expected that the Stage 3 Watana reservoir will affect mainstem habitats and fish populations in similar ways. The dewatering of burbot embryos spawned in shallow areas of the reservoir will continue to reduce recruitment to burbot populations of the upper Susitna River.

(c) Lake Habitat

(i) Arctic grayling

Arctic grayling occur in Sally Lake, which will be inundated by the Stage 3 Watana reservoir. The effects of the impoundment on grayling are expected to be similar to those discussed previously (Section 4.1.4). The spawning, incubation and rearing life stages will likely experience adverse impacts (Table 7).

(ii) Lake Trout

A small population of lake trout occurs in Sally Lake. Lake trout from Sally Lake are expected to survive in the Watana reservoir as lake trout are found in glacial lakes in Southcentral Alaska (Bechtel Civil and Minerals, Inc. 1981, Russell 1980).

Lake trout will likely spawn in the Stage 3 Watana reservoir. However, incubating embryos will be affected by the drawdown cycle. Lake trout usually spawn from late September to November at depths ranging from 3 to 110 ft (Morrow 1980). Drawdown (November to May) in the Stage 3 Watana reservoir will average 0.5 ft/day. As a result, embryos incubating in the upper 50 to 60 ft of the reservoir will be dewatered by March 1 (the approximate end of the incubation period), causing incubation success to be low in the drawdown zone.

The drawdown/refilling cycle and turbidity levels of the Watana reservoir are expected to limit the development of a littoral zone and restrict the productivity of the Stage 3 impoundment. Therefore, it is likely that rearing conditions will not be favorable in much of the reservoir. However, the clearwater plumes of tributaries are expected to provide favorable rearing habitats for fish. Lake trout may frequent these areas because of the availability of prey. It is expected that the growth rate of lake trout will be low because of the expected low productivity of the impoundment.

Overwintering conditions in the Watana reservoir will likely have insignificant effects on lake trout.

The expected effects of the Stage 3 Watana impoundment on lake trout populations are summarized in Table 12.

Table 12. Summary of selected species abundance, sport value and sensitivity to habitat alteration in lake habitats of the proposed Stage 3 Watana impoundment zone.

Species	Life stage	Abundance of species in lake habitat[1]	Sport value of species[1]	Sensitivity of species/ life stage to habitat alteration[2]
Arctic grayling	spawning	2	3	3
	incubation	2	3	3
	rearing	2	3	3
	overwintering	2	3	0
Lake trout	spawning	1	3	0
	incubation	1	3	2
	rearing	1	3	1
	overwintering	1	3	0

[1] 1 = low, 2 = moderate, 3 = high.

[2] 0 = no predicted change or, may be positive influence; 1 = low; 2 = moderate; 3 = high. Refer to text for discussion of species sensitivity to potential impacts.

5.0 SELECTION OF EVALUATION SPECIES

All three mitigation policies (APA 1982, ADF&G 1982a and USFWS 1981) imply that project impacts on certain sensitive fish species will be of greater concern than changes in distribution and abundance of less sensitive species. Sensitivity can be related to high human use value as well as susceptibility to change because of project impacts. Statewide policies and management approaches of resource agencies suggest that concern for fish and wildlife species with commercial, subsistence and other consumptive uses is greater than for species without such value. These species are often numerous, and utilize a wide range of habitats, as well as having high human use value. Such characteristics often result in these species being selected for detailed evaluation when their habitats are subjected to alterations.

In the impoundment zones, Arctic grayling are abundant and widespread in tributary habitats during summer, and reside in the mainstem during winter. This species has a high human value, as it is highly prized by sport fishermen. Grayling populations in the impoundment zones contain fish that are of trophy size (Schmidt and Stratton 1984). Based on impact assessments presented in the license application (APA 1983b) and in Section 4.0 of this report, it is likely that the impoundments will not provide suitable spawning, incubating or rearing habitats for Arctic grayling. Anticipated impacts to grayling habitats are considered unavoidable, as the inundation of tributary habitats by the turbid impoundments is a necessary part of the project design and operation. As a result of the expected loss of grayling habitats and anticipated reduction in populations, the Arctic grayling is selected as the primary evaluation species in the impoundment zones. It is the APA's goal to provide compensation for these losses by means that are mutually agreeable with resource managers.

The construction of the Devil Canyon dam (RM 152) will prevent chinook salmon from migrating upstream of Devil Canyon. Chinook salmon have a high commercial, subsistence and sport value and are numerous in the Susitna River below Devil Canyon. However, upstream of Devil Canyon they are not abundant, as high velocities of the Devil Canyon rapids usually limit upstream migrations of fish. Because of their low densities upstream of Devil Canyon, losses of chinook salmon are not considered to be significant. Compensation for lost chinook spawning habitat will be provided in one of two ways: (1) by mitigative flow releases for juvenile chinook salmon below Devil Canyon, or (2) by habitat improvements in the middle Susitna River as part of the impoundment mitigation (See Section 6.3).

The Stage 1 and 3 Watana impoundments may reduce the recruitment to burbot populations inhabiting the reservoir area (Section 4.1.4 and 4.3.4). However, burbot densities in the upper Susitna River are presently low and burbot are not highly sought by fishermen in this reach of the river. Therefore, no mitigative measures are planned for burbot, as any reduction in burbot populations in the impoundments is considered insignificant.

6.0 DEVELOPMENT OF MITIGATION PLAN

6.1 HISTORY OF IMPOUNDMENT MITIGATION PLANNING

The FERC license application (February 1983) for the two-stage, two-dam Susitna Project recognized that the loss of clearwater tributary habitat in the impoundment zones would be a significant project impact on Arctic grayling populations in the upper Susitna River (APA 1983b). The proposed mitigation included the following compensation to provide for lost grayling habitat in the impoundment zones: (1) fund research on the hatchery propagation of Arctic grayling, (2) expand or build a hatchery to propagate Arctic grayling, (3) stock Arctic grayling fingerling in suitable barren lakes within the project area, and (4) if Arctic grayling propagation proved to be technically infeasible, expand a rainbow trout hatchery and stock rainbow trout in the Devil Canyon reservoir. Stocking Arctic grayling in barren lakes within the project area was proposed as the primary means of compensation because of the desirability of in-kind, in-basin compensation.

Resource agency comments on this proposed mitigation plan were generally unfavorable and concluded that hatchery propagation of Arctic grayling must be judged as speculative (ADF&G 1983c, USFWS 1983). The agencies suggested that mitigation measures should have documented successes in Alaska if possible and, if mitigation measures are unproven, a demonstration of their effectiveness in the project area should be undertaken.

In the Fish Mitigation Plan (WCC 1984) options were evaluated that would mitigate impacts resulting from the project. The proposed mitigation for habitat losses in the impoundment zones was the expansion of a rainbow trout hatchery and the stocking of rainbow trout fingerling in out-of-basin lakes as the primary compensation. This was proposed because of the high probability for success. Hatchery propagation of rainbow trout in Alaska is a documented success and rainbow trout are highly sought by sport fishermen. The proposal of stocking Devil Canyon reservoir with rainbow trout was dropped, due to concern expressed about the expected low productivity and relatively high turbidity levels in the Devil Canyon reservoir. The propagation and stocking of Arctic grayling were also proposed as an option for achieving compensation, because of the desirability of in-kind replacement and progress in the technology of rearing grayling in hatcheries.

The ADF&G responded that rainbow trout hatcheries and stocking programs were already in place and that the department did not favor an expansion of this program as mitigation for lost habitat in the impoundments (ADF&G 1984). Instead, the ADF&G endorsed the acquisition of public access and the development of site facilities for recreational fishing in the Susitna River and its tributaries below Devil Canyon. The enhancement of middle Susitna River salmon stocks by habitat improvements was also favored. A summary of agency comments on impoundment mitigation is shown in Table 13.

As a result of agency comments on impoundment mitigation planning, this report evaluates three options for providing compensation for the expected losses of fish habitat in the impoundment zones: (1) acquiring public access to the Susitna River and its tributaries below Devil Canyon, (2) habitat modifications or improvements in the middle Susitna River that would enhance important resident species or important sport species of salmon, and (3) the expansion of an Arctic grayling hatchery, the hatchery propagation of grayling and the stocking of grayling within and out-of-basin areas.

6.2 ACQUISITION OF PUBLIC ACCESS

6.2.1 Background

Increases in population and tourism in Alaska have resulted in a high demand for recreational fishing. Recreational fishing is now considered an important factor in the total management of many of the state's fisheries (Mills 1984). In Southcentral Alaska, the high recreational use of fish resources in the region is largely attributable to the accessibility of many lakes and rivers by the road system, the close proximity of these areas to major population centers and healthy fish resources. The highest demand for recreational fishing is largely concentrated in areas that are accessible by road, which in some situations creates uneven use patterns of the resource and intensifies pressures on resource managers to provide additional recreational opportunities.

Table 13. Agency comments on Impoundment Mitigation Planning.

Agency	Date	Reason for Correspondence	Comments
ADF&G	13 Jan 83	Review of Draft Exhibit E, FERC License Application	Grayling propagation in experimental stages. Compensation by stocking grayling is speculative.
USFWS	14 Jan 83	Review of Draft Exhibit E, FERC License Application	Mitigation measures should have proven success in Alaska. Demonstration of hatchery-rearing of Arctic grayling needed.
USFWS	18 Dec 84	Comments on Fish Mitigation Workshop of 4 Dec 84	The APA appears to be planning impoundment mitigation with realistic objectives in accord with project mitigation policy.
ADF&G	31 Dec 84	Comments on Fish Mitigation Workshop of 4 Dec 84	ADF&G does not support the expansion of the rainbow trout stocking program and does not favor stocking of the impoundment. ADF&G endorses the acquisition of public access and developing site facilities for recreational fishing in the Susitna River and its tributaries below Devil Canyon. Also favors habitat improvements for salmon in the middle Susitna River (Talkeetna-to-Devil Canyon).

Source: ADF&G 1983c, 1984; USFWS 1983, 1984.

The State of Alaska, recognizing the need to rectify immediate recreational use problems and plan for future development and management of recreational areas, has developed a recreation action plan for Southcentral Alaska (ADNR and ADF&G 1984). This plan emphasizes the need for the designation of recreational areas, the acquisition of public access to currently utilized and future recreational areas, and the development of site facilities at recreational areas.

The Susitna River basin is a large recreational area, which is close to populations in Anchorage and the Mat-Su Valley and contains abundant fish resources. However, access to the lower 75 miles of the Susitna River is limited to one privately owned boat launch at Kashwitna Landing and to some of the eastside tributaries along the Parks Highway. Thus, resource managers have identified the need to acquire public access and develop site facilities in the Susitna Basin to even out resource utilization and create new fishing opportunities (ADNR and ADF&G 1984).

Five parcels of land in the Susitna Basin have been identified for acquisition in the recreation action plan (ADNR and ADF&G 1984). The five parcels are listed in the order of priority in Table 14. The first two priorities, Kashwitna Landing and Little Willow Creek, would increase the accessibility of the Susitna River. The others would improve access to lakes and tributaries in the basin, or provide hiking trails.

The recreation action plan also recommends the development of three recreational facilities in the Susitna Basin. The three facilities development projects are listed in Table 14. All three developments would improve access to the Susitna River by building roads, trails, or boat launches.

Resource managers have recommended that the Southcentral recreation action plan deserves timely implementation (ADNR and ADF&G 1984). However, it is recognized that the plan is an ambitious one that may take years to fully implement, particularly in view of the declining capital budget of the State of Alaska. Thus, the ADF&G (1984) has endorsed land acquisition and facilities development for recreational fishing in the Susitna River as the preferred

Table 14. Land acquisitions and facilities development projects currently proposed by the State of Alaska in the Susitna River Basin.

Project	Description	Estimated Costs: Capital Costs	Estimated Costs: Operating Costs
Land Acquisitions			
Kashwitna Landing	Boat launch on Lower Susitna R.	$ 500,000	----
Little Willow Creek	Provide access from Parks Hwy. to Susitna R.	$ 180,000	----
Neil Lake	Floatplane access to the Deshka R.	$ 600,000	----
Moose Creek	Road access for river use	$ 200,000	----
Nancy Lakes	Inholdings acquisition for trails	$ 250,000	----
Facilities Development			
Willow Creek State Recreational Area	Major fishing area	$7,735,000	$212,500
Talkeetna Boat Launch	Campground/access/boat launch	$ 173,000	----
Sheep Creek	Trail to fishing area near Parks Hwy.	$ 200,000	----

Source: ADNR and ADF&G 1984.

measure of compensation for lost fish habitat and reductions in fish populations resulting from the impoundments of the proposed Susitna Hydroelectric Project.

6.2.2 Site Selection

The selection of specific parcels of land and the development of recreational facilities will require close coordination between the APA and resource agencies. After the license to build the project has been granted, potential land acquisitions and facilities development projects within the Susitna Basin will be prioritized with input from resource managers. The Southcentral Alaska recreation action plan (ADNR and ADF&G 1984) and any forthcoming planning documents on this subject will serve as the basis for site selections.

Factors that will likely be considered during the selection process include:

1. identification of potential sites,
2. historic use levels of the sites,
3. benefits associated with land acquisitions or facilities developments,
4. cost appraisals of lands or developments,
5. location of sites in the Susitna Basin,
6. timetable for acquisitions or developments, and
7. the probability of acquiring or developing sites by conventional funding sources.

After land parcels or facilities developments have been selected, the APA will take the necessary steps to complete the acquisition of selected lands or the development of site facilities with the highest ranking. This will occur within a time frame mutually agreed to by the APA and the agencies. In the event that selected acquisitions or developments are found to be infeasible the APA, with concurrence of the agencies, will negotiate the acquisition or development of the next highest priority.

6.2.3 Costs

In Exhibit E of the FERC license application, costs for expanding an existing hatchery to propagate Arctic grayling were developed (APA 1983b). Capital costs were estimated to be $750,000 in 1982 dollars, while annual operating and maintenance costs were an estimated $110,000. It was proposed that $190,000 be spent to develop Arctic grayling propagation technology. Thus, a total capital budget of $940,000 plus an operating budget of $110,000 per year, was proposed to provide compensation for lost grayling habitat in the impoundment zones. Since compensation for lost grayling habitat is of primary concern in impoundment mitigation planning, the costs developed in the license application can be used as a basis to budget for land acquisitions or recreational facilities development projects.

6.2.4 Monitoring Studies

After the acquisition of lands or the development of recreational facilities is completed, it is assumed that resource agencies will manage and maintain the lands and facilities. Therefore, monitoring studies are not planned for these measures at this time.

6.3 HABITAT IMPROVEMENTS

6.3.1 Background

The Alaska Department of Fish and Game (1984), in review comments on the Fish Mitigation Plan (WCC 1984), indicated that habitat improvements enhancing salmon stocks in the middle Susitna River (Talkeetna to Devil Canyon) should be considered as compensation for lost fish habitat in the impoundment zones. Since the lost habitat primarily affects important sport species in the upper Susitna Basin, mitigation planning has focused on the enhancement possibilities for important sport species of salmon in the middle Susitna River: chinook and coho. Additionally, habitat improvements enhancing important resident sport fish (rainbow trout and Arctic grayling) in the middle Susitna River are also considered.

6.3.2 Site Selection

Most mitigation planning and associated field data collection in the middle river have concentrated on mitigating for potential losses of chum salmon spawning habitat in sloughs and side channels. Because the downstream impacts of the three stage project have not yet been addressed, it is unknown if slough excavations and other mitigation measures proposed to rectify impacts resulting from the two stage project will still be appropriate. However, if slough excavations are needed to maintain chum salmon spawning habitat, additional modifications can be done to enhance coho rearing and possibly juvenile rainbow trout and Arctic grayling habitat. For example, in spawning channels constructed in the Chilkat River near Haines, Alaska, rip-rap added to the sloping sides of the channel to stabilize the banks also provided habitat for juvenile coho salmon (B. Bachen, NSERA, pers comm., 1985). When specific mitigation measures are proposed for downstream impacts, this type of habitat improvement can be incorporated.

Other improvements are also under consideration in the middle Susitna River. In the 1985 field season, studies will examine the potential for removing fish passage barriers and the expected amount of habitat to be gained from such removals. Several sites to be examined and the potential benefits are listed below.

1. Fourth of July Creek - expand rainbow trout and possibly coho salmon habitat.

2. Gash Creek - expand coho habitat.

3. Portage Creek lake systems - expand rainbow trout and Arctic grayling habitat.

After field data are available, the feasibility of these habitat modifications and potential benefits can be assessed.

Upland sloughs will also be examined for potential habitat improvements in the 1985 field season. Mitigation measures that will improve rearing and overwintering conditions for juvenile salmon and for resident species will be evaluated.

Additionally, habitat improvements in the lower Susitna River basin may be evaluated in the future, if improvements in the middle river are found to be unattractive.

6.3.3 Costs

The costs associated with placing rip-rap along both banks of a 1,000' long excavated slough or side channel in the middle river is shown in Table 15. The costing assumes that the channel will be excavated under the downstream impacts mitigation budget and that equipment used during excavation will be used to haul and place the rip-rap. Railroad transportation to the slough or side channel is also assumed.

The costs of rip-rapping a hypothetical slough or side channel are intended to give a relative magnitude estimate. They do not represent a proposed budget for impoundment mitigation compensation. It is assumed that budgeting for habitat improvements in the middle river will be developed within the total budget set forth in the license application (APA 1983b) (Section 6.2.3 of this report). After the 1985 field season, specific mitigation measures to improve habitat in the middle Susitna River will be proposed. Detailed budgets will be proposed with the associated habitat improvement.

6.3.4 Monitoring Studies

If habitat improvements are chosen in the middle Susitna River to provide compensation for lost fish habitat in the impoundment area, monitoring studies will be conducted to evaluate the success of the improvements. It is assumed that monitoring efforts required for habitat improvements will be coordinated with the monitoring for other mitigation measures in the middle Susitna River.

The estimated costs of a 2 person crew making 4 one-week field trips to the site(s) to assess fish utilization and abundance and the preparation of a year-end summary report are shown in Table 16. The scope of work for monitoring studies and budget details will be refined when specific habitat improvements are proposed.

Table 15. Costs associated with rip-rap placement along both banks of a 1,000' long excavated slough or side channel in the middle Susitna River[1].

Description		Amount
Material[2]		$ 15,500
Equipment		3,000
Labor		13,500
Eng/Mgt		3,000
	Total	$ 35,000

[1] Mobilization and demobilization costs have not been evaluated as equipment and personnel are assumed to be onsite conducting slough modifications for downstream impacts.

[2] Includes transportation of riprap to the site.

Table 16. Annual monitoring costs for evaluating habitat improvements in the middle Susitna River.

Description		Amount
Labor		$ 36,500
Transportation		600
Equipment		2,500
Data Analysis		4,000
	Total	$ 43,600

6.4 HATCHERY PROPAGATION OF ARCTIC GRAYLING

6.4.1 Background

Habitat alterations resulting from the impoundments will primarily affect Arctic grayling populations in the upper Susitna River. When possible, it is desirable to compensate anticipated reductions of fish populations with in-kind replacement (USFWS 1981). The hatchery propagation and stocking of Arctic grayling is an in-kind compensation measure. However, since Arctic grayling propagation technology is still in the developmental stages and cannot be fully relied on to provide compensation, the ADF&G (1984) has recommended other options to provide compensation for lost fish habitat in the impoundments. At present, the hatchery propagation and stocking of Arctic grayling is the least preferred of the three options evaluated in this report.

6.4.2 Hatchery Propagation Technology

Arctic grayling artificial propagation is being conducted by the Fisheries Rehabilitation Enhancement and Development (FRED) Division of ADF&G at Clear, Alaska. Arctic grayling broodstock have not yet been developed at Clear Hatchery, so eggs are taken from wild fish and transported to the hatchery for incubation. In 1984, over 2.0 million eggs were taken from grayling in three lakes: Moose, Jack and Tahneeta (Parks et al. 1985). Using wild fish as an egg source is not a fail-safe method, but in the absence of an established hatchery-production brood stock program it is the best method available.

Eggs are incubated at Clear Hatchery using Heath Techna stacks. Water temperatures are varied between 3.5 and 10.5^{o}C to manipulate the emergence timing of fry. In 1984, egg-to-fry survival was over 70 percent (Parks et al. 1985).

Grayling are usually stocked as sac-fry. However, because the stocking success of planting sac-fry is generally low, efforts are underway to develop fingerling production at Clear Hatchery (Parks et al. 1985). In 1984, about 125,000 grayling were reared to fingerling size (2.0 gram weight). The average survival rate of 560,000 sac-fry to the fingerling stage using nine different diets was approximately 22 percent. Fish raised on diets of krill, liver, and OMP mash exceeded the average survival rate. Survival rates were 72 percent with the krill diet, 66 percent with the liver diet and 52 percent with Omp mash diet. Fish raised on the other six diets had survival rates of 30 percent or less (Parks et al. 1985). Although fingerling production is still in the developmental stages, the results of experimental efforts in 1984 indicate large-scale fingerling production of Arctic grayling is feasible.

6.4.3 Stocking Program Site Selection

If a grayling stocking program is found to be feasible and is selected as a mitigation measure, stocking sites will be selected in close consultation with resource managers. Sites will be evaluated within the Susitna Basin and outside the Susitna Basin.

The potential sites for stocking grayling within the project area appear to be limited. Most lakes and streams in the upper Susitna Basin contain unexploited fish populations that are currently utilizing most of the available fish habitat, as indicated by the high densities of fish (ADF&G 1981a, 1983a, Sautner and Stratton 1984). Barren lakes or streams with barriers to fish movements could be stocked. However, these sites will need to be evaluated for their capacity to successfully overwinter fish and their accessibility to anglers.

It may be possible to plant grayling in borrow pits resulting from the construction of the project access roads and dams. However, unless the proposed side-borrow technique for building access roads is inadequate, no gravel pits will be excavated during access road construction. The major gravel pit used during construction of the Watana dam at Borrow Site E will be rehabilitated and connected to the Susitna River, allowing fish utilization of this area without the need for stocking (Bradley et al. 1985). Most of the other borrow sites used during construction will be inundated by the impoundments (APA 1983a,b). Therefore, the possibility of stocking borrow sites with grayling will depend on the siting of pits and requirements of gravel fill for the three stage project.

Stocking grayling in out-of-basin areas could supplement existing stocking programs or create new fishing opportunities. Site selection will need to be done in close consultation with the Sport Fish Division of ADF&G. In 1984, 65 sites throughout Alaska were stocked with grayling (Parks et al. 1985). Thus, an active stocking program of Arctic grayling exists, when fry and fingerling are available from the hatchery.

6.4.4 Costs

The costs associated with implementing a grayling stocking program were developed in the FERC license application. The cost of expanding an existing hatchery facility is approximately $750,000 in 1982 dollars, while the operating and maintenance costs are an estimated $110,000 per year (APA 1983b).

6.4.5 Monitoring Studies

Monitoring the success of a stocking program is an integral part of this mitigation option. The costs for monitoring are assumed to be similar to the monitoring budget proposed for habitat improvements (Table 16). The actual scope and budget of a monitoring program will be developed if this option is selected and when specific stocking sites are chosen.

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