SUSITNA HYDROELECTRIC PROJECT

ENVIRONMENTAL REPORT

TASK 7: ENVIRONMENTAL

FISH ECOLOGY -1980

MAY 1981

Prepared for:

ALASKA POWER AUTHORITY

Prepared by:

Terrestrial Environmental Specialists, Inc.

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ENVIRONMENTAL STUDIES ANNUAL REPORT 1980

SUBTASK 7.10 FISH ECOLOGY

JUNE 1981

by

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for

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SUMMARY

The following are the specific objectives of Terrestrial Environmental Specialists, Inc. (TES) with respect to fish ecology (Subtask 7.10) in the first year of the program: (1) identify areas of potential impact, (2) identify the information necessary to assess these impacts, (3) locate available information applicable to the Susitna River and the Susitna Hydroelectric Project, (4) identify information deficiencies, and (5) aid in the selection of a project development scheme. In addition, assistance has been given (under Subtask 7.04) in the development of hydrology and water quality sampling programs that will be beneficial in ascertaining possible impacts upon the fishery resource and aid in mitigating these impacts.

Alaska Department of Fish and Game (ADF&G) baseline fisheries studies commenced in late 1980. Data from the field studies is being included in ADF&G's first 1981 Quarterly Report, and thus were not available for this 1980 Annual Report.

TES is collecting pertinent literature on impact assessment and mitigation measures applicable to the Susitna Hydroelectric Project. The compilation of fundamental life history and ecology information on selected anadromous and resident fishes has also been assumed by TES to supplement the fishery field program results. This information is being obtained by contacting individuals with expertise in specific facets of fish ecology, searching personal libraries and files, gathering information from university and federal agency libraries, reviewing indexes of appropriate foreign publications, examining "in-house" programs for research and progress reports of appropriate federal and state agencies, as well as universities, and reviewing reports from the management agents of the ADF&G for the Susitna-Cook Inlet area and adjacent waters.

As a guide to compliance with the FERC criteria for license application, potential impact issues and the kinds of engineering, hydrological and biological information required have been compiled. This information is to be supplied to TES from Acres, R&M Consultants and ADF&G.

Acres has been provided with, by request and for use in their design considerations, information and recommendations concerning downstream flow, total dissolved gas pressure, and temperature of the discharge water. Reregulation of downstream flow from daily peaking operations has been recommended as an essential part of any development plan.

Potential program modifications and the concerns of federal, state, and local agencies in regard to the fish ecology studies have been addressed by TES. Recommendations have been submitted to Acres American.

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1 - INTRODUCTION

This Annual Report describes the information acquired by Terrestrial Environmental Specialists, Inc. (TES) and its consultants during Phase I (preceding license application) of the Susitna Hydroelectric Project with respect to Fish Ecology (Subtask 7.10). It also includes Subtask 7.04, coordination with the water quality program performed under Task 3.

The primary objectives of the fish ecology studies for the Susitna Hydroelectric Project are to (1) describe the fisheries resources of the Susitna River, (2) assess the impacts of development and operation of the Susitna Hydroelectric Project on this fishery, and (3) propose mitigation measures to minimize adverse impacts. Meeting the first objective is the responsibility of the Alaska Department of Fish and Game (ADF&G). The second and third objectives are the responsibility of Terrestrial Environmental Specialists, Inc. (TES). To accomplish these two objectives, TES and its consultants, Robert W. Williams, Clinton E. Atkinson, and Milo C. Bell, will rely heavily upon information gathered by Acres American, ADF&G, R&M, and the U.S. Geological Survey for the Susitna Hydroelectric Project, as well as upon available material from other sources.

The specific objectives of TES in the first year of the project were the following: (1) identify the areas of potential impact, (2) identify the information necessary to assess those potential impacts, (3) locate available data applicable to the Susitna River and the Susitna Hydroelectric Project, (4) identify information deficiencies, (5) aid in the selection of a project development scheme, and (6) assist in the development of hydrology and water quality sampling programs that will be beneficial in ascertaining possible impacts upon the fishery resource and aid in mitigating these impacts.

2 - METHODS

2.1 - General

The methodology section presents only those methods used during 1980. The procedures outlined in the TES Procedures Manual for Subtask 7.10 cover the literature review, impact assessment, mitigation planning, and data and program review. During 1980, much was done in literature review. A systematic search of all sources of pertinent published and unpublished information was initiated. The following procedure was used in the collection of needed material:

(a) search personal libraries and files;

(b) contact individuals that have worked in the specific field, and who may possess or have knowledge of bibliographies in those fields;

(c) examine published bibliographic lists and indexes for federal, state and other publications;

(d) search the file catalogues of the libraries of the University of Washington, the Alaska Department of Fish and Game (Juneau), and the National Marine Fisheries Service (NMFS) (Seattle, Auke Bay);

(e) obtain bibliographic computer print-outs for key words (i.e., subjects) through the inter-library and other literature search and retrieval services, and arrange for copies of the most pertinent articles;

(f) review the indexes of appropriate foreign publications, especially the literature and reports of work being done in Canada, Japan, the USSR, and the northern European countries;

(g) examine "in-house" programs for research, progress reports, and budget requests for the National Marine Fisheries Service, the Alaska Department of Fish and Game, and the Universities of Washington, British Columbia, and Alaska for information on on-going and unpublished studies; and

(h) review reports from the management agents of the Alaska Department of Fish and Game for the Susitna-Cook Inlet area and adjacent waters.

Pertinent reports and other materials are being examined. The findings relating to potential impacts and their mitigation are being catalogued. In general, this information relates the biological, physical, and chemical factors of the environment to the movement, reproduction, growth, and survival of anadromous and resident fishes found in the Susitna drainage. A bibliography is being prepared in a form suitable for ready reference of team members involved in the Susitna Hydroelectric Project.

The primary effort in the areas of impact assessment and mitigation planning was in providing Acres American with expert advice, upon request, in evaluating and planning alternative plans for project development. This input was concentrated in the last three months of 1980 and was directed towards reviewing four alternatives that included a dam at Watana and power tunnels extending downstream, and various staging alternatives to two dam schemes (Olson, High Devil Canyon and Vee vs. Devil Canyon and Watana).

The task of data and program review in which TES will review the scopes of work for water quality and fish ecology investigations being performed by other groups was delayed by the late start of some of the programs. TES was able to review the water quality program being done by R&M Consultants, as well as offer recommendations on installation of a continuous monitoring station for water quality measurements to be located at the Watana site.

Review of the ADF&G fish ecology programs was not possible because ADF&G did not produce their detailed procedures manual in 1980. TES does, however, agree with the objectives in the RSA agreement between the Alaska Power Authority and ADF&G.

2.2 - Definition of the Study Area

The study area encompassed by Subtask 7.10, Fish Ecology, includes the entire Susitna River from the Tyone River downstream to Cook Inlet. This includes areas that are likely to be affected by post-project flows (i.e., subreaches of the Susitna River mainstem, sloughs and side channels, tributary confluences, and lakes and ponds. Anadromous and resident fish populations will be studied by ADF&G in relation to their habitat requirements. Studies of fish populations in the proposed impoundment area will be included. There are no rare or endangered fish species listed for Alaska by the United States Fish and Wildlife Service (Richard Wilmot, pers. comm.). Additionally, data concerning migrational usage of the Susitna River by salmon species as well as mainstem spawning observations and rearing information will be collected.

For the purpose of Phase I work, the Susitna River has been divided into three segments: Cook Inlet to Talkeetna, Talkeetna to Devil Canyon, and Devil Canyon to the Tyone River. Within these defined reaches, the following objectives and related tasks will be addressed, according to the proposed ADF&G work plan for 1981 (ADF&G, pers. comm. February-March 1981).

(a) Determine the seasonal timing, distribution and relative abundance of adult anadromous fish populations within those portions of the basin directly affected by the proposed Susitna Hydroelectric Project.

(i) Identify spawning locations which are likely to be affected by post-project flows (i.e., subreaches of the mainstem, sloughs and side channels, tributary confluences, lakes and ponds, etc.) and estimate their comparative importance.

(ii) Determine the timing and nature of migration, milling and spawning activities.

(iii) Enumerate and characterize the runs of the adult anadromous fish.

(iv) Collect field data to define the range (or limits) of streamflow dependent physical and chemical characteristics which appear to be influencing the suitability of the various habitat types for spawning.

(b) Determine the seasonal timing, distribution and relative abundance of selected resident fish and juvenile anadromous fish populations within those portions of the basin directly affected by the proposed Susitna Hydroelectric Project.

(i) Identify spawning and rearing locations for resident species as well as chinook, coho, and other anadromous juveniles, which are likely to be affected by the impoundment and post-project flows (i.e., subreaches of the mainstem, sloughs and side channels, tributary confluences, lakes and ponds, etc.) and estimate their comparative importance.

(ii) Obtain descriptive information on captured fish (species, site, age class) and discuss seasonal migration patterns of selected adult resident species.

(iii) Collect field data to define the range (or limits) of streamflow dependent physical and chemical characteristics which appear to be influencing the suitability of occupied and non-occupied habitat types.

(c) Characterize the seasonal habitat requirements of selected anadromous and resident species within those portions of the basin expected to be directly influenced by the proposed Susitna Hydroelectric Project.

(i) Through direct field observations and measurements, define the range of streamflow dependent physical and chemical characteristics which appear to be influencing the suitability of various habitat types for species and life history stages of interest.

(ii) Prepare a narrative description of the various habitat types found in the study area that are presently being utilized by anadromous and resident species.

(iii) Analyze the field measurements and provide a series of drawings which display the frequency at which the species/life history phases were observed in association with the streamflow dependent physical and chemical characteristics.

3 - RESULTS AND DISCUSSION OF BASELINE DATA

During the first year of the project, 1980, much time and effort has been spent in the development of the biological (fisheries) and the engineering/hydrological programs necessary to properly evaluate the effect of the proposed hydroelectric project on the fisheries of the Susitna River. To do this, it was first necessary to acquire a familiarity with the lower Susitna River and sites of the proposed dams and impoundments by overflights and by examination of the aerial photographs of the river channel area. Review and assistance has been given in the location and sampling schedules for the collection and analyses of water samples and the location of gaging stations, and in providing general engineering and fisheries information, although preliminary in scope, that would assist in the development of alternative locations, construction, and operation of the hydroelectric facility. Water quality reports containing data collected during this study were only recently available; therefore, assessment of the progress of this facet was not possible.

Of particular concern has been the delay in the initiation of the fishery program that will be conducted by the Alaska Department of Fish and Game (ADF&G). As stated during a meeting in Washington, D.C., the Federal Energy Regulatory Commission (FERC) will insist upon at least two years, or the equivalent of two years, of comprehensive field studies on the fisheries of the Susitna River before considering any application for license. However, ADF&G fisheries baseline study began on November 17, 1980 and will continue through the license application review period. Data from the winter 1980-1981 studies should be presented in the first quarterly report for 1981. This will allow evaluation, prior to license application, of two winters of data on juvenile anadromous fish and winter resident fish distribution. The remaining seasonal data will be augmented by previous studies conducted by ADF&G and supplemented with data collected during 1982 and the following collecting periods.

Attention has been given by TES to a comprehensive search of the available literature for information that would complement the results expected from the proposed fishery field program. This has required a great deal of effort. For more than 100 years, the Pacific salmon, because of their importance to the people living along the Pacific coasts of the United States, Canada, Japan, and the U.S.S.R., have been the subject of studies by scientists and agencies within these four countries. One would judge that more studies have been made and reports written on the Pacific salmon per se than any other fishery in the world. Yet there are still gaps in our knowledge as to the effect of certain environmental factors on the survival and growth of fish in the streams of northern regions.

While there is an abundance of information on the Pacific salmon, there is a paucity of information on the resident species found in the Susitna drainage and other similar streams. Much of the information that is available is found in the Canadian or Russian literature. The first step in the study, accordingly, has been to develop a bibliography of northern salmon and resident fish studies. Approximately 1,000 references have been compiled at the present time (about half of which are from the Russian literature). Most of the references have been obtained from the private library of Mr. Atkinson and from the publications and other materials available in the libraries at the Northwest and Alaska Fisheries Center (NMFS, Seattle) and at the University of Washington.

Although not used extensively to date, the references and other material available at the Auke Bay Laboratory (NMFS Auke Bay/Juneau, Alaska) have been examined. Perhaps most valuable in this collection is the series of reports prepared by the various Management Agents for the regulatory districts before Alaska statehood. Fortunately, the information contained in these reports has been summarized and is available for our reference and use in the following unpublished report:

United States Fish and Wildlife Service and the University of Washington Fisheries Research Institute. 1954. Cook Inlet Lake and Stream Records, 1927-1952, with accompanying descriptive material. Seattle, Washington.

We have also received a series of unpublished ADF&G reports relating to the fisheries of the Susitna River and Cook Inlet. Several of these reports will augment the existing field program (Barrett 1974; Friese 1975; Riis 1975 and 1977; ADF&G 1978).

There are three existing compilations of literature on biological criteria for salmon: "Pacific Salmon Compendium" (Maxfield 1964), "Fisheries Handbook of Engineering Requirements and Biological Criteria" (Bell 1973), and "Design of Fishways and Other Fish Facilities" (Clay 1961). The Pacific salmon work by Maxfield, however, is confined to the United States and Canadian literature on salmon through the early 1960's. The information given in the two handbooks is generally based on the salmon, environmental studies, and experiences in the rivers and streams of British Columbia, Washington, Oregon, and northern California. These reports exclude the results of many studies on the Pacific salmon made in Japan and the U.S.S.R., which are especially important in our studies because of the similarities (due to climate) between the Susitna and streams of the Soviet Far East.

Based on available literature, summary reports are being prepared by TES on the life history and ecology of anadromous and selected resident fish found in the Susitna River system. It is anticipated that separate reports will be prepared for each of the following species: Chinook Salmon, Coho Salmon, Pink Salmon, Chum Salmon, Sockeye Salmon, Eulachon, Arctic Grayling, Dolly Varden, Burbot, Rainbow Trout, and Lake Trout. Several of these summary reports are nearing completion and the remaining summaries should be available in at least draft form later in 1981. It is intended that these summaries will be available to the various participants in the Susitna Hydroelectric Project at the time of the preparation of the final reports and application for the FERC license.

Examples of the kind of information that will be available when these summaries are completed are shown in Table 1 and Figure 1. Table 1 is a comparison of the number of degree-days required to incubate (to time of hatching) eggs from five species of salmon from the United States and Soviet rivers. In Figure 1, a graphic comparison is made of the sediment size of the sand or gravel taken (by almost identical methods) from the area of the redds where the eggs are actually deposited. There is similar information available for composition of bottom sediment for the entire nest and the spawning area as a whole.

Finally, two tables have been prepared concerning the status and kinds of information required in the assessment of potential impact issues and mitigation of the effects of the Susitna Hydroelectric Project. These tables are presented in the impact section of this report.

TABLE 1

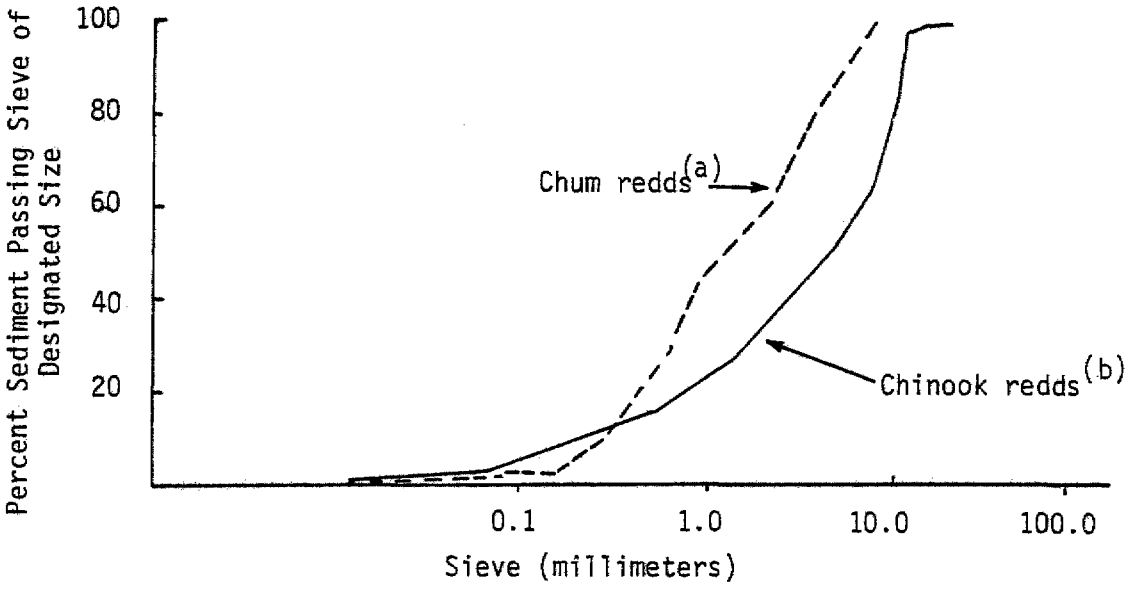
Comparison of incubation times[a] (to hatching) that have been reported by U.S. and Soviet sources for the five species of Pacific salmon

Species of Salmon	United States[b]		Soviet[c]	
	Average Temp. (°C)	Degree-Days	Average Temp. (°C)	Degree-Days
Pink salmon	10	583	8.4-10.7	645-708
Chum salmon	8.5-10	517	3.2	408-420
			9.9	521-530
Sockeye salmon	3.3	523	3.2	450-463
Coho salmon	3.3-7.7	455	2.2	300-346
			2.9	397
			4.1	371
			8.8-9.0	445-486
Chinook salmon	10	482	12.9	537-563
			14.0	476

a. Incubation time is expressed in degree-days. Water temperature affects incubation time. Additional residence time is required for fry to develop to swim-up stage. This table shows the need for measuring normal river temperatures.

b. Bell (1978).

c. Smirnov (1975).



a. Chum data from Levanidov (1968).

b. Chinook data from Platts, Shirazi and Lewis (1979).

Figure 1. Comparison of particle size distribution of sediment sample from the egg strata of spawning redds of chum and chinook salmon.

4 - IMPACT ASSESSMENT

The 1980 impact assessment has been limited to using historical information concerning hydroelectric projects elsewhere and providing Acres American with the information that will aid them in designing the hydroelectric project and in avoiding impacts that have occurred elsewhere as a result of design or operational procedures. Areas that have been discussed include downstream flow, timing and temperature of water releases, reservoir drawdown, and excessive dissolved gases as a result of spillway design. Any hydroelectric facility that releases water for peaking (whether it is daily, weekly, or any other power demand schedule) will deviate more severely from the impounded stream's natural flow regime than would a baseload operation. Therefore, operational procedures may impact the downstream habitat. Fluctuations in downstream flow that change the depth of the stream sufficiently to flood the dry areas of the stream bed on a daily basis would adversely affect fish at all life stages, through stranding. However, it is possible, with reregulation of downstream flow, to eliminate the problem of stranding. It may be possible to improve upon the natural conditions in some reaches of the stream by maintaining downstream flows that would increase the amount of usable habitat available to the fish.

Table 2 is a list of the various potential impact issues that has been prepared for the TES Fish Ecology Procedures Manual (Terrestrial Environmental Specialists, Inc. 1980a), and an evaluation has been made of the present availability of information required to address those impact issues. It must be noted, however, that in almost all items, reference is made to the necessity of having results from the present and/or pending studies available before the status of information required can be established with any certainty. Comments that biological criteria are adequate or probably adequate mean that there is some available information upon which to base the FERC license application. Of course, data from current field studies would be preferable, in areas where such data are being collected.

TABLE 2

Status of information required for assessment of potential impact issues[a] concerning fish ecology.

	Potential Impact Issue	Engineering Information[b]	Biological Information[c]
1.	Change in water quality.	Dependent upon results from data collection and from available analyses.	Environmental criteria from available literature and ADF&G studies will be required for fishes specifically utilizing the mainstem Susitna.
2.	Alteration of the temperature structure of the stream.	Dependent upon results from present data collection and analyses.	See number 1.

a. From Table 2, Environmental Studies Procedures Manual, Subtask 7.10, Fish Ecology Impact Assessment and Mitigation Planning. Terrestrial Environmental Specialists, Inc., August 1980.

b. No definitive study and/or evaluation of the various potential impact issues can be made until the results of the present engineering and hydrological surveys are available and the location(s) and general design of the dam(s) are established.

c. In addition to the need for information noted in footnote b above, detailed information from the biological studies to be conducted by ADF&G will be required before any meaningful assessment of the potential impact issues can be made.

TABLE 2 (Cont.)

	Potential Impact Issue	Engineering Information	Biological Information
3.	Excessive dissolved gas concentrations caused by plunging flows.	Experience and remedial measures from dams on the Snake, Columbia and Kootenay rivers documented and available.	Available biological information is adequate.
4.	Changes in the chemical and physical conditions in the spawning areas of anadromous fish	Impoundment water quality, including temperature, changes in downstream flows by storages and releases, and changes in impoundment levels	Environmental criteria generally established for Pacific salmon and being confirmed and expanded by literature search; additional information on smelt and the euryhaline species (i.e., whitefish, char, etc.) and the effect of physical/chemical change on food organisms in northern waters will be obtained from the literature or Phase II studies.
5.	Impact of temperature structure on reservoir management and downstream conditions.	Balance of the input flows to reservoir volumes, thermocline and volumes of water at various temperatures.	Some literature available; additional study may be required in Phase II.

TABLE 2 (Cont.)

	Potential Impact Issue	Engineering Information	Biological Information
6.	Reduction of turbidity during the summer resulting in increased predation.	Particle size, settling rates and stratification in the reservoir.	Continuing literature search, but apparently little information available; additional study may be required in Phase II.
7.	Winter turbidity changes in the reservoir and downstream.	Same as number 6.	Same as number 6.
8.	Increase in nutrients in the reservoir and downstream from leaching.	Change in water quality brought about by flooded lands, entrapment in the reservoir, and upwelling.	Some baseline information available; Phase II studies may be required.
9.	Changing water quality conditions under the ice as a result of operation.	Water temperature at various times and various levels in the impoundment related to multi-level water releases; volume of release.	Environmental criteria required from the literature and ADF&G studies specifically for fishes utilizing the mainstem Susitna and expected in the reservoirs.
10.	Development of new ice-free areas with increased predation and density of small fishes in these areas.	New temperature regimes below the dam in the winter; new water levels in relation to sloughs and natural backwater areas.	Continuing literature search and some information available: additional study, if required, will be in Phase II.

TABLE 2 (Cont.)

	Potential Impact Issue	Engineering Information	Biological Information
11.	Development of frazil ice downstream	Relationship to open surface areas and new temperature regimes.	Probably adequate.
12.	Changed ice thickness downstream affecting temperature and downstream movement of fish.	Same as number 11.	Very little information available on the winter movements of fish in northern streams; ADF&G winter studies especially important.
13.	Summer and winter flow changes and the impact on fish reproduction, growth and predation.	Expected flow releases for power generation including peaking and minimum base loads; water clarity and quality, including temperature.	Relation of summer environmental conditions to reproduction and growth of anadromous fish generally adequate, but only limited information for resident species and predation in northern waters; Phase I and II studies required.
14.	Effect on present type of fish collection devices used in the Susitna River and Upper Cook Inlet estuary fishery.	Changes in river flow and water quality; how these changes will effect the oceanographic conditions in the upper estuary region.	The oceanography of upper Cook Inlet has been studied by University of Alaska (IMS) and data are available on movement

TABLE 2 (Cont.)

Potential Impact Issue	Engineering Information	Biological Information
		of juvenile and adult salmon through estuaries, but no recognizable pattern between areas. Additional study, if required, will be in Phase II.
15. Extension of upstream anadromous fishery.	Accessibility of new areas to fish; expected water supplies to such area throughout the year.	If engineering studies show access of anadromous fish above Devil Canyon feasible, then comprehensive survey required of accessible potential spawning/nursery areas; environmental criteria adequate.
16. Bank scour due to piping effect of increased flows under the ice or flows over the ice.	Winter operational flows in relation to the area below the the ice or over the existing ice layer; projected thickness of ice cover.	Continuing literature search and some information available; additional studies, if required, can be done in Phase II.
17. Bed scour as affected by changing flows and ice.	Same as number 16.	Same as number 16.

TABLE 2 (Cont.)

Potential Impact Issue	Engineering Information	Biological Information
18. Potential for increased production by the addition of new spawning areas and new rearing areas.	Physical details of the new area, including bed shapes, water depths, flows, velocities and total area accessibility.	Dependent upon the completion of present engineering and hydrological surveys and designs and operation plans for hydroelectric development; environmental criteria adequate.
19. Potential loss of many present productive areas.	Cross sections of the river as related to flow, levels of side channels, water cover over known spawning areas, and changed flow regimes.	Dependent upon completion of present studies noted in 18 above; environmental criteria probably adequate.
20. Formation (and management) of new lakes (impoundments).	Details on the expected limnological conditions of the impoundments, methods and type of water discharge, and expected fluctuations in water levels.	These must be considered as impoundments and their environmental regime quite different than a natural lake; apparently very little information available on conditions in northern impoundments but continuing literature search; may require additional Phase II study.

TABLE 2 (Cont.)

Potential Impact Issue	Engineering Information	Biological Information
21. Changes in tributary access for fish.	Details on the lower part of the streams to be inundated by the impoundment and effect on tributaries downstream of the impoundment.	Probably adequate.
22. Changes in the personal use fishery.	Flow levels, velocities and water clarity.	Major factor will be effect of change in turbidity (i.e., nets vs. hook-and-line); dependent upon present studies noted in 18 above; may require additional Phase II studies.
23. Potential stranding and exposure of redds due to diel variation.	Same as number 19.	Pink, chum and coho salmon and to some extent other anadromous and resident fish will seek shallower channels to spawn; Phase I studies required for less known species.
24. Changes in the habitats of resident fish populations.	Same as numbers 20 and 21.	Dependent upon present studies noted in 18 above; additional studies required in Phase I and II.

TABLE 2 (Cont.)

Potential Impact Issue	Engineering Information	Biological Information
25. Changes in the stream channel in terms of creation, alteration, or elimination of habitat.	Same as Numbers 18 and 19.	Generally engineering in scope, but will require definition and evaluation of productive fish habitat in northern waters: Phase I studies will be required.
26. Loss of existing fishery in impoundment area.	Determination of stream areas lost by inundation.	Engineering information noted in 20 above and Phase I biological studies by ADF&G; additional Phase II studies on environmental criteria for resident fish may be required.

In Table 3, a matrix has been developed by which the type of biological (fisheries) information for the various stages of freshwater life is paired with conditions that will most likely arise during construction and operation of the hydroelectric project. As the design and operational plans for the project develop and the results of the associated biological studies become available, the availability and/or need for additional information will become more and more apparent by simple inspection of the chart. Examination of any particular item indicates the need for the integration of the best available engineering information with biological information. In most cases, the biological information will be obtained by the field studies to be undertaken in 1981 and later years.

Impacts associated with the building of access roads and transmission lines can be expected. The greatest amount of impact would most likely occur during the actual construction period. Bank erosion, bottom disturbance, and siltation in the vicinity of the stream crossing sites could be harmful to spawning and nursery areas of both resident and anadromous fish. Newly constructed roads would also make previously inaccessible regions subject to increased fishing pressure by the public. This could affect the fishery resource considerably.

TABLE 3

Checklist[a] for study of the possible impacts upon the fishery resource in the study area as a result of construction and operation of the Susitna Hydroelectric Project.

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
FLOW CHANGES First filling time							
Normal drawdown							
Maximum drawdown							
Annual operational filling times							
Discharge from wheels, spillways & sluices							
Low, normal & high flow years & their occurrence							
Maximum discharge & time							
Minimum discharge & time							
Diel discharge Range Maximum Normal Minimum							

a. This checklist will be used to indicate that sufficient information is available to address or answer an impact question at a particular project development time.

TABLE 3 (Cont.)

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
FLOW CHANGES (Cont.)							
Changes on spawning grounds Depth Width							
Stranding							
Abandonment of nests by exposure of adults & fry to adverse conditions							
General stress							
Change in personal use areas							
Temperature							
Upstream movement of adults							
Effect on fishing nets Public safety							

TABLE 3 (Cont.)

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
RIVER BED CHANGES Aggrading							
Degrading							
Bank scour							
Bed load							
Silt load							
Changes in spawning areas							
Changes in food-producing areas							
Changes in tributary stream entrance slopes							
Loss of wintering areas							
Gain of wintering areas							

TABLE 3 (Cont.)

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
WATER QUALITY CHANGES RIVER & RESERVOIRS Chemical							
Silt							
Color							
Gas balance (release points)							
Temperature of reservoir storage (release point)							
Temperature of river							
RESERVOIR CHANGES Destruction of river environment							
Creation of lake environment							
Creation of silt & sediment basins							
Changing light penetration							
Changes in food organisms							

TABLE 3 (Cont.)

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
RESERVOIR CHANGES (Cont.)							
Changes in species composition & their relationships							
Level of thermo-cline (changes)							
Effect of mixing at face of power dam							
Access areas to Fishermen							
Species contribution by tributary streams							
Initial productivity versus long-term productivity							
Reestablishment of beach line							
Land slides							
Ice cover							
Effect of upwelling on ice cover							
Gas balance							

TABLE 3 (Cont.)

	Baseline study period	Cofferdam installation & removal	Dam & reservoir construction - including filling time	First year of operation	Normal maximum operations	Changes from baseline conditions	Recommendations
SPAWNING GROUND CRITERIA, FOOD PRODUCTION CRITERIA, TEMPERATURE Effect on time for hatching, emergence & swim-up							
Migration related to food blooms							
Change of winter growth rates							

5 - MITIGATION PLANNING

Early involvement of environmental personnel in the planning and design of the facility has occurred and will result in a project designed with fewer initial impacts. Such input is planned to continue throughout the project. In addition, we have provided Acres with requested information to aid them in the selection of a power development scheme for the Susitna River. Although protection of the fishery resource is but one aspect of the development of a hydroelectric project, we have continued to stress the importance of regulated downstream flows, control of total dissolved gas pressure, and regulation of the temperature of the discharge waters. These issues are essential to the fish ecology and, thus, an integral part of any development plan.

Many adverse impacts of hydroelectric development can be avoided or minimized through mitigation planning in the determination of the design and operational mode of the hydroelectric facility. Unavoidable impacts may be offset by improving the resource elsewhere, if deemed necessary. Options for such resource enhancement are discussed in the TES Procedures Manual for Subtask 7.10.

Mitigation of adverse impact on resident fish must be addressed in two areas: (1) above Devil Canyon and (2) below Devil Canyon. These two areas are separated by the natural barrier to fish passage reported to exist in the Devil Canyon area. The area above Devil Canyon will be materially altered by the creation of the impoundments. The downstream area may be treated with the salmon impact mitigation approach, to be applied if required to the area of the Susitna River below Devil Canyon.

Based upon information from ADF&G concerning existing resident fishes and the sport fishing in the area and upon Acres' projections concerning limnological conditions of the reservoir, an assessment will be made in regard to those species most adaptable to the reservoir conditions and that could provide sport fishing opportunities. This information is not yet available.

The stream areas lost by inundation may not be readily replaceable; however, this loss cannot be measured until the ultimate reservoir elevations are equated to the existing contours of the streams. Assuming they cannot be replaced, reservoir stocking may be recommended. Assuming that the reservoir(s) will provide better access to the now almost inaccessible areas for sport fishermen, an improved sport fishery could be provided in those areas to at least partially compensate for the areas lost to impoundment. These assumptions and corresponding mitigation options will be addressed as information becomes available to assess potential impacts.

If significant losses to anadromous fish populations are predicted in the impact analysis, design and operational plans should be developed for ameliorating them. Likely mitigation methods include multi-level discharge for release of water at a desired temperature and release of predetermined flows, to maintain downstream fish habitat. Timing the water release to match the needs of migrating salmon would be another possible operating procedure that may be considered. Without the necessary data to evaluate the impact(s), mitigation methods and the need for mitigation of fish losses is nothing more than conjecture. The necessary information to evaluate the impacts on anadromous fish and, thus, plan for the mitigation of their losses has not been gathered as of this report.

Mitigation planning during 1980 has been confined to the project development plans. Initially, downstream maximum flow and minimum releases were suggested to allow the planning activity to continue within the guidelines. However, the flow constraints were very preliminary because of the lack of information available for making firm recommendations. The range was sufficiently broad to allow the design work to continue. In late 1980, the environmental aspects of four schemes that involved a dam at Watana and power tunnels extending downstream to locations near Devil Canyon were reviewed (Terrestrial Environmental Specialists, Inc. 1980b). The tunnel scheme that provided for constant flow downstream of Devil Canyon was recommended as the best of the group. Constant flows would reduce or eliminate the possibility of fish being stranded during any life stage. Daily

peaking, on the other hand, could raise and lower the river sufficiently to strand fish. Also, in late 1980, staging options for two alternative dam development schemes were reviewed: Watana/Devil Canyon and Vee/High Devil Canyon/Olson (Terrestrial Environmental Specialists, Inc. 1981). This draft report recommended, as a mitigation procedure in the design, that constant downstream flows be considered essential. However, a dam at Olson was considered unacceptable because of the anadromous fishery at Portage Creek, upstream of the Olson site. None of the preliminary plans evaluated called for constant flow downstream as a part of the Stage 1 development, although, reregulation was identified as a possibility. Some of the plans included constant downstream flows in later development stages, but the time period, 10 or more years, was considered too great and adverse impacts from daily peaking would already have occurred. It is our understanding that plans have since been changed to provide reregulation from commencement of operation.

6 - REFERENCES

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Maxfield, G. 1964. Pacific Salmon Compendium. United States Fish and Wildlife Service. (Unpublished report). Seattle, Washington.

Platts, W. M., M. A. Shirazi and D. H. Lewis. 1979. Sediment Particle Sizes Used by Salmon for Spawning with Methods for Evaluation. U. S. Environmental Protection Agency. EPA-600/3-79-043 (Apr. 1979). (Corvallis Environmental Research Laboratory, Corvallis).

Riis, J. C. 1975. Pre-authorization Assessment of the Susitna River Hydroelectric Project: Preliminary Investigations of Water Quality and Aquatic Species Composition. Alaska Department of Fish and Game, Sport Fish Division. (Unpublished report). Anchorage, Alaska.

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Terrestrial Environmental Specialists, Inc. 1980a. Susitna Hydroelectric Project Environmental Studies, Procedures Manual Subtask 7.10, Fish Ecology Impact Assessment and Mitigation Planning. Terrestrial Environmental Specialists, Inc., Phoenix, New York.

Terrestrial Environmental Specialists, Inc. 1980b. Susitna Hydroelectric Project Environmental Studies, Preliminary Environmental Assessment of Tunnel Alternatives. Terrestrial Environmental Specialists, Inc., Phoenix, New York.

Terrestrial Environmental Specialists, Inc. 1981. Susitna Hydroelectric Project Environmental Studies, Environmental Considerations of Alternative Hydroelectric Development Schemes for the Upper Susitna Basin (draft). Terrestrial Environmental Specialists, Inc., Phoenix, New York.

United States Fish and Wildlife Service and the University of Washington Fisheries Research Institute. 1954. Cook Inlet Lake and Stream Records, 1927-1952, with accompanying descriptive material. United States Fish and Wildlife Service and the University of Washington. Seattle, Washington.

7 - AUTHORITIES CONTACTED

7.1 - Federal Agencies

Federal Energy Regulatory Commission
Washington, D.C.

Quinton Edson, J. Mark Robinson, Dean Shumway, Paul Carrier, and Donald Clarke

- Meeting in Washington, D.C.; May 30, 1980; explained the sampling schedule and discussed the adequacy of historical data.

J. Mark Robinson and Dean Shumway

- Tour of Susitna River study area; July 16, 1980; viewed upper and lower river and had informal discussions about study program.

- Informal meeting in Anchorage, Alaska; July 17, 1980; discussion of instream flow needs.

U.S. Fish and Wildlife Service
Anchorage, Alaska

Donald McKay

- Tour of Susitna study area; July 16, 1980; viewed upper and lower river and had informal discussions about the study program.

Richard Wilmot

- Discussion with Dana Schmidt; March 16, 1981; request for most recent information on endangered fish species in Alaska.

National Marine Fisheries Service
Auke Bay Biological Laboratory
Auke Bay, Alaska

Dr. William Smoker, Director
- Contacted by C. Atkinson to obtain fisheries literature; old documents, management reports, etc., will be supplied if needed.

7.2 - State Agencies

Alaska Department of Fish and Game
Anchorage, Alaska

Thomas Trent, Susitna Coordinator (after Oct. 1980); Regional Supervisor - Habitat Protection Section (prior to Oct. 1980).
- Meeting in Anchorage, Alaska; May 23, 1980; discussion of hydrology program and fishery data needs.

- Telephone call from R. Williams; May 27, 1980.

- C. Atkinson called on June 20, 1980; inquiry as to status and operational aspects of the fisheries study as well as to thank him for his assistance in assembling various reports.

- Meeting in Anchorage, Alaska; September 8 and 10, 1980; discussion of hydrology and fishery studies locate; river cross sections.

- Meeting in Anchorage, Alaska; September 22, 1980; discussed ADF&G fisheries program, established need for fall field work (1980), and identified winter 1980-81 study area.

- Meeting in Anchorage, Alaska; October 13, 1980; discussed coordination and administration concerns.

- Telephone call from R. Williams; October 27, 1980; inquiry of status of ADF&G program.

- Meeting in Anchorage, Alaska; November 14, 1980; discussed overall program and extended an invitation to a meeting that afternoon with the Cook Inlet Aquaculture Association.

- Meeting in Anchorage, Alaska; November 17, 1980; informed T. Trent of results of meeting with Cook Inlet Aquaculture Association Board of Directors.

- Meetings in Anchorage, Alaska with D. Schmidt; February - March 1981; continuous discussions of field programs and Procedures Manual.

Alaska Department of Fish and Game
Division of Commercial Fisheries
Juneau, Alaska

Dr. Gary Finger, Chief of Research
- Informal discussions with C. Atkinson; offered to supply informal information and unpublished reports.

Alaska Department of Natural Resources
Anchorage, Alaska

Mary Lou Harle
- Meeting in Anchorage, Alaska; May 23, 1980; discussed hydrology program and fishery data needs.

7.3 - Other Organizations and Individuals

Cook Inlet Aquaculture Association
P.O. Box 50
Soldotna, Alaska

Floyd Heimbach, Director; Thomas Mears, Biologist; and Thomas Walker, Economist.

- Meeting in Anchorage, Alaska; November 14, 1980; explain the fishery program to CIAA.

Board of Directors

- Meeting in Soldotna, Alaska; November 15, 1980; E. Yould (APA) and R. Williams presented a description of the Susitna Hydroelectric Project and answered questions.

Susitna Hydro Steering Committee

A. Carson, Chairman; T. Trent, Vice Chairman.

- TES representatives presented the various aspects of the Susitna program, including the TES fish ecology program; July 17-18, 1980. Other agency attendees were: D. Shumway (FERC), D. Foote (FERC), J.M. Robinson (FERC), D. Sturdevant (ADEC), W. Weler (HCRS), B. Smith (NMFS), J. Rego (BLM), L. Baxter (COE), H. Noonan (DEPD), and M. Harle (ADNR).

- Reply to comments on Procedures Manual; December 1980.

Arctic Environmental Information Center
Anchorage, Alaska

David Hickock, Director

- Librarian provided C. Atkinson with all of their references on the Susitna River region.

British Columbia Hydro and Power Authority
Vancouver, British Columbia

Dr. Robert Furgeson

- C. Atkinson visited Dr. Furgeson and made arrangements for an exchange of environmental literature. A copy of an intensive survey of several deep lakes, including Williston Lake, on the Peace River was obtained.