SUSITNA HYDROELECTRIC PROJECT

TASK 7 - ENVIRONMENTAL

SUBTASK 7.10 - FISH ECOLOGY

# INSTREAM FLOW ASSESSMENT FOR THE PROPOSED SUSITNA HYDROELECTRIC PROJECT

## ISSUE IDENTIFICATION AND BASELINE DATA ANALYSIS

1981 SUMMARY REPORT

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## ACKNOWLEDGEMENT

The following project staff contributed to this report. Linda Perry Dwight coordinated the production of the report and provided information on water rights, riparian vegetation and wildlife habitat, and river based recreation. Stephen Bredthauer and Jeffrey Coffin prepared material on flow regime, water quality, navigation, and the estuary. Dana Schmidt summarized all available information on fishery resources.

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# INTRODUCTION

Instream uses are uses made of the streamflow while it remains in the stream channel as opposed to uses made of water out of the channel. Traditional instream uses include hydroelectric power generation, navigation (commercial or recreational), and waste load assimilation (receiving water standards). Additional uses of streamflow that have more currently been recognized as potential instream flow considerations are: downstream delivery requirements to satisfy existing treaties, compacts, or water rights; freshwater recruitment to estuaries; streamflow requirements for riparian vegetation, fish and wildlife habitats, and river-based recreation; and the amount and timing of streamflow required to maintain desirable characteristics of the river itself (width/depth ratios, sediment and thermal regimes, channel gradient, streambed composition, riffle/pool ratio, reach velocity, etc.).

An instream flow assessment is a technical study undertaken to identify the effects that changes in streamflow have on various instream uses and resources. The assessment should include an evaluation of the effects that incremental changes in flow, stream temperature, channel morphology, and water chemistry might have on instream uses and resources.

The specific focus and degree of analysis involved in the instream flow assessment should, to a large extent, depend upon the nature of the existing and proposed uses, and on the concerns of local citizens, public interest groups, and government agencies regarding the tradeoffs that are likely to occur between these uses as a result of the proposed development. As part of the Alaska Power Authority's environmental program, a survey of federal and state agencies, public interest groups, and native corporations was undertaken in mid-January 1981 (6). Interviews were conducted to obtain a first-hand impression of the level of understanding and interest of various groups in the proposed Susitna hydroelectric project, and to record specific questions and concerns that the respondents felt needed to be addressed by an instream flow assessment. An attempt was also made to identify specific data and informational needs of state and federal agencies charged with issuing permits and/or reviewing the license application or environmental impact statements.

The results of that survey have served as a principal source in the preparation of a study plan for coordinating those elements of the Phase I engineering and environmental studies that were pertinent to the instream flow assessment for the proposed Susitna hydroelectric project (10). The envisioned instream flow assessment consists of three parts: issue identification and baseline data analysis, quantitative impact analysis, and mitigation planning. The 1981 study plan pertained primarily to issue identification and baseline data analysis. Instream Flow Studies, per se, were not scheduled to be funded until the summer of 1982 (J. Hayden, pers. comm.). The objective of the 1981 instream flow program was to utilize data and information from the ongoing engineering and environmental studies to:

(1) provide conclusive statements by March 1982 for some of the questions documented in the instream flow survey;

(2) provide preliminary statements by March 1982 for some of the questions documented in the instream flow survey; and

(3) define the scope of study that should be undertaken after March 1982 in order to further quantify impacts in some areas and to provide initial quantification of impacts in other areas, and provide the information necessary for developing a detailed mitigation plan.

This summary report addresses the first two of these objectives, in that it provides preliminary answers to many of the questions that were identified in the January 1981 survey. The answers are presented within eight topic areas and are based upon the data and information that is presented in the feasibility report (2) and appropriate support documents.

The topic areas and questions are presented in Table 1. Three types of answers are presented in this report: conclusive answers based on existing data; preliminary answers based on existing data; and answers that are anticipated, but not supported by data available at this time. All answers are necessarily limited by the current data and information base. Some questions are not likely to affect the overall feasibility of the proposed project. Other questions are dependent upon answers to questions that must be addressed sequentially. Cnly a minimal amount of effort was expended on answering questions in these two categories. Questions on some topic areas (e.g. river based recreation and estuarine concerns) could not be addressed in a cost effective manner during the Phase I studies, and therefore, answers to these questions must be deferred. For other topic areas (e.g. fishery resources, water quality, and riparian vegetation), sufficient data have not been assembled to address all questions, even though specific studies were initiated. A statement is provided for most of these questions that basically discusses the validity of the concern being raised. These statements are based upon experience of the project staff and application of information contained in the literature.

Table 1. Status of March 1982 answers to questions pertaining to project effects on instream uses and resources.

| Question: What effect would the proposed Susitna hydroelectric project have on the following instream flow related topics? | Type of Statement Provided | | |
|---|---|---|---|
| | Conclusive | Preliminary | Yet to be addressed |
| **FLOW REGIME** | | | |
| preproject streamflows | | x | |
| flood potential | x | | |
| river stage at downstream locations during different months | | x | |
| backwater from ice | | x | |
| ice jams during breakup | | x | |
| winter water temperatures in the reservoirs | | x | |
| downstream water temperatures | | x | |
| winter ice conditions (thickness and period of ice cover) | | x | |
| channel scour from ice | | x | |
| growth of aufeis | | x | |
| erosion near bridge piers | | x | |
| permafrost melt and frost heave near bridges | | x | |
| groundwater levels at reservoir site, and in downstream domestic wells, springs, and slough areas | | | x |
| stage and sediment deposition at mouth of tributaries | | x | |
| the ability of the river to cleanse itself of debris | | x | |
| channel scour below damsite | | x | |
| river morphology below Talkeetna | | x | |
| bedload movement associated with storm events | | x | |
| **FISHERY RESOURCES** | | | |
| existing fish populations above and below damsites | | x | |
| spawning and rearing habitat | | x | |
| fish passage and migratory behavior of adults | | x | |
| overwintering of juveniles and resident adults | | x | |
| scour or siltation of spawning areas | | x | |
| egg incubation and developing embryos | | | x |
| out migration | | x | |
| food base for rearing and resident species | | x | |
| postproject reservoir fishery potential | | x | |
| smelt runs in the lower river | | | x |
| **WATER QUALITY** | | | |
| the assimilative capacity of the Susitna River | | x | |
| the present "drinking water" classification for the Susitna River during both construction and operation | | x | |
| level of dissolved gasses in the Susitna River immediately downstream of the dams | | x | |
| suspended sediment and turbidity at various downstream locations | | x | |
| salinity levels in the mouth of the Susitna River | | | x |
| domestic and industrial waste disposal associated with the proposed capitol move | | x | |
| effects of placer mining on water quality during low-flow periods | | x | |
| **NAVIGATION** | | | |
| commercial navigation on the lower Susitna River | | x | |
| recreational boating on the Susitna River, sidechannels and sloughs | | x | |
| access to the Susitna River from established launch sites | | x | |
| boat and float plane access from the river to traditional recreation and state land disposal sites | | | x |
| navigation access into major tributaries | | x | |

Table 1. (Cont.) Status of March 1982 answers to questions pertaining to project effects on instream uses and resources.

| Question: What effect would the proposed Susitna hydroelectric project have on the following instream flow related topics? | Type of Statement Provided | | |
|---|---|---|---|
| | Conclusive | Preliminary | Yet to be addressed |
| **DOWNSTREAM WATER RIGHTS** | | | |
| future water rights | x | | |
| present day out-of-stream diversions | x | | |
| domestic wells along the river corridor | x | | |
| **RIPARIAN VEGETATION AND WILDLIFE HABITAT** | | | |
| surface area of various vegetation/habitat types in the river corridor | | x | |
| natural succession of vegetation | | x | |
| production of moose browse in lower river | | x | |
| habitat and populations of small terrestrial mammals and furbearers | | | x |
| **RIVER BASED RECREATION** | | | |
| winter travel on river ice cover by snow machine | | x | |
| sport fishing access | | | x |
| recreational hunting for moose and waterfowl | | | x |
| status of the Susitna River as a world class whitewater river | x | | |
| wild and scenic aspects of the Susitna River | | x | |
| recreational opportunities associated within the reservoirs | | x | |
| **ESTUARY** | | | |
| entrance of anadromous species into the Susitna River | | | x |
| estuarine survival of salmon fry/smolts | | | x |
| waterfowl production in wetlands surrounding the estuary | | | x |
| winter ice conditions in Upper Cook Inlet | | | x |
| use of estuary by beluga whales and seals | | | x |
| productivity of intertidal wetlands | | | x |

## SUMMARY DISCUSSIONS

A summary of methodologies, results, and conclusions is presented for each topic area in this section of the report. Answers to specific questions are contained in the following section.

### Flow Regime

The flow regime defines the seasonal timing, magnitude, and recurrence of certain streamflows, together with their associated hydraulic characteristics. This information is useful in analysis of the sediment regime and the river morphology, as most of the sediment transport occurs at high flows. It is also important in evaluating the effect of flow regulation on stream temperature.

#### Streamflows

In order to understand the effects of the proposed project on streamflows, R&M Consultants, Inc. (R&M) examined existing conditions. Preproject monthly and annual flow duration curves based on average daily flows were developed for the four mainstem Susitna River gaging stations: Denali, Vee Canyon (Cantwell), Gold Creek, and Susitna Station. They were also developed for three major tributaries, the MacLaren, Chulitna, and Talkeetna Rivers (17). A flow duration curve shows the proportion of time that discharge equals or exceeds various values. For each of the stations, the shape of the monthly and annual flow duration curves are similar and are representative of glacial rivers. The months of June through August have relatively flat flow duration curves, indicating that summer streamflows are consistently within a relatively narrow range.

Annual hydrographs were examined to determine sequences in which high and low streamflows occur. For the Susitna River, streamflow is low in the winter months, with little variation in monthly flow and no unusual peaks. Streamflow begins to increase slightly in April as breakup approaches. However, peak streamflows during May are an order of magnitude greater than in April. June has the highest peaks and the highest median flow, while late July and August streamflows frequently reflect regional rainstorm activity.

The 1-, 3-, 7-, and 15-day high and low flow values were determined for each month during the open water period (May through October) for the period of record for the Susitna River at Gold Creek, Chulitna River near Talkeetna, Talkeetna River near Talkeetna, and Susitna River at Susitna Station (17). The ratios of these values to corresponding average monthly flows were then determined in order to provide an indication of how well monthly streamflow values represent actual riverine habitat conditions (10).

Streamflow statistics indicate that daily flows may vary markedly from monthly values depending upon the time of year. Winter flows are quite stable with little variation between daily and monthly ratios. Hence monthly streamflow values during winter months are quite indicative of the streamflow conditions overwintering fish actually experience. Streamflows during May showed the most variability, as it is usually the month when breakup occurs. June and July generally exhibited less variability than the late summer months, August and September, primarily because June and July flows are dominated by snow melt runoff, whereas August and September flows are more influenced by glacier melt and rainfall.

Since midsummer streamflows are highly variable and often interrupted by major peaks, it may be inappropriate to use long-term average monthly streamflows as an index for estimating project effects on fish habitat during the May through October period. Monthly streamflow values will mask the natural variability in daily or weekly storm runoff events, which commonly occur during August, thereby underestimating the natural level of stress to which spawning salmon are being subjected. Consequently, the variation in daily flows will be determined by utilizing project releases and the 1-day daily/monthly flow ratios presented in the river morphology report (17).

A comparison was made between pre- and postproject annual flood frequency curves for the Susitna River at Gold Creek, Sunshine, Delta Islands, and Susitna Station. Sufficient streamflow records were available for the Susitna River basin and adjacent basins to define the preproject flood potential for different locations on the Susitna River. A dimensionless flood frequency curve and a regression equation based on basin characteristics have been developed to determine flood frequencies at ungaged points on the river. Annual peak discharges are forecast to be greatly reduced due to the storage effects of the proposed reservoirs. The annual flood peak at Gold Creek is expected to be reduced from 49,500 to 13,500 cubic feet per second (cfs), or by 73 percent. The 25-year peak flow is expected to be reduced from 94,000 to 38,000 cfs, or 60 percent. In the lower Susitna River, the annual flood at

Susitna Station is expected to decrease from 157,000 to 121,000 cfs (23 percent), and the 25-year event from 289,000 to 233,000 cfs (19 percent).

A comparison has been made of pre- and postproject streamflows of the Susitna River at Gold Creek, Sunshine, and Susitna Station based on the simulated 30-year monthly operation of the Watana and Devil Canyon reservoirs for two idealized operating schedules: Case A (maximum power production) and Case D (minimal impact on fisheries). Based on an analysis of 30 years of total streamflow data and simulated power flows, the long-term average monthly streamflows at Gold Creek are expected to be reduced. The present monthly streamflow would be reduced from between 20,000 and 25,000 cfs during June, July, and August to between 10,000 and 12,000 cfs under Case A development, or between 15,000 and 20,000 cfs under the Case D scenario. Flows during December through April would increase from approximately 1,200 cfs under natural conditions to 10,000 cfs under Case A, or to 8,000 cfs under Case D.

In summary, it can be said that the natural variation of preproject streamflows is well defined and project effects on these patterns is generally understood. Under postproject conditions, releases from Devil Canyon would be relatively constant. Statistics presented in the river morphology report (17) and the regional flood frequency report (12) provide some indication of the influence of peak tributary flow on mainstem flooding, as do the flow variability indices. The variability of postproject flows determines the hydraulic effects on mitigation measures that may be required for the river segment between Devil Canyon and Talkeetna. Further investigation of the effects of alternative filling schedules on downstream flows has yet to be undertaken. The effects of the proposed two-and-a-half-year filling schedule on Gold Creek streamflows should be better defined, as well as effects from longer duration filling schedules.

Stream Reservoir Water Temperature

Water temperature is one of the major factors controlling salmon spawning and growth. Consequently, efforts were made to determine reservoir and river temperatures under postproject conditions.

Although salmon would not be migrating to the reservoir to spawn, it is necessary to determine the reservoir water temperatures throughout the year in order to estimate the temperature of the water released into the river. The water temperature would then be modeled as the water was routed downstream. Reservoir and downstream temperature models were developed by Acres American Inc. (Acres). These models require further refinement before the downstream temperature effects on the fisheries can be fully assessed. Insufficient data were available to develop a completely reliable reservoir temperature model. Accurately modeling reservoir water temperatures during the winter months proved to be especially difficult due to the large number of variables that affect initial ice cover formation. Although seasonal thermal characteristics of the proposed reservoirs are not well defined, worst case conditions for reservoir releases were assumed as input to the river temperature model.

The river temperature model was developed for the river segment between the Watana dam site and Talkeetna. The model incorporates the river hydraulic characteristics and reach lengths incorporated in the HEC-2 water surface profile model developed by R&M for the same reach. Air temperature, cloud cover, and solar radiation were obtained or estimated from regional climatic records. Predicted summer stream temperatures compared favorably to recorded stream temperature data collected at selected mainstem locations by the Alaska Department of Fish and Game (ADF&G). This comparison indicated that the stream temperature model is capable of accurately forecasting downstream water temperatures, provided that sufficient calibration data are available. Modeling of the worst case water temperatures released from the reservoir indicated that thermal analysis should extend from the reservoirs to beyond Talkeetna to model conditions after Devil Canyon is operational. Although water temperature data is available for one season from ADF&G, additional mainstem water temperature is required.

As a result of the ongoing Phase I engineering and environmental studies, a general understanding of preproject river temperatures exists. However, very limited information on intergravel temperatures in the salmon spawning areas has been obtained to date. The interaction between intergravel and mainstem water temperatures has yet to be determined. Stream temperatures were commonly recorded between 6 and 11 degrees centigrade (°C) during the summer of 1981 for the river segment between Devil Canyon and Talkeetna. ADF&G found that mainstem temperatures below Talkeetna were less variable, normally in the 8 to 10°C range.

At this time, project effects on downstream water and intergravel temperatures are unclear. However, initial studies and the literature searched indicate that late summer and early fall thermal characteristics of the reservoirs may have the most effect on the downstream fishery, although thermal concerns extend through all seasons.

## Sediment Transport

Determination of the rate of sediment accumulation in the proposed reservoirs and a preliminary assessment of the effects of postproject streamflows on the downstream river channel morphology were addressed in the river morphology report (17). The U.S. Geological Survey (USGS) also initiated work in early summer of 1981 to evaluate bedload movement in the project area. These studies provided an initial evaluation of the general hydraulic characteristics of the Susitna River above Talkeetna under pre- and postproject streamflow conditions, and have answered most questions pertaining to the general stability of the river channel above Talkeetna. Results from these studies will also provide the necessary insight to address more cost-effectively specific questions pertaining to the morphology of the lower Susitna River.

The large bed material in the channel above Talkeetna would preclude significant changes in main channel width and depth relationships or in the slope (except near tributaries). Deep scour holes at bends are expected to fill in to some degree, and gravel bars exposed above the new high water mark would have emerging vegetation. The sediment load plays an important role in the process of meander migration across alluvial plains by forming point bars from bedload deposition on the inside bank. Reduction of bedload may disrupt this process.

The bedload for the Susitna River is only poorly defined at this time. Bedload data on the Susitna River system was non-existent until 1981, when USGS gathered data at four sites for three different flows. Data collected from the Susitna River system have not been at peak floods, but at moderate to low flows.

Detailed analysis of the river below Talkeetna has not been conducted. However, it is known that this segment of the Susitna River reflects a relatively stable but complex braided pattern. In the Delta Islands reach, the river has a braided pattern on the west channel, and a multi-channel pattern along the east side of the floodplain.

Under postproject conditions, the bankfull stage, which now occurs about once every two years, would occur only once every five to ten years. These decreased flood levels would tend to decrease the frequency of occurrence of bed material movement and consequently retard changes in braided channel shape, form, and network.

The complex pattern of the Delta Islands should remain unchanged, as project-induced changes in flow and sediment regime would be diluted by contributions from tributaries and by the Susitna River satisfying its sediment load by reworking of the wide floodplain alluvial deposits. While local changes in the main channel position may occur, the basic channel geometry should remain relatively similar. Quantification of postproject morphologic changes is extremely difficult, if not impossible.

A trend towards relative stabilization of the floodplain features should occur over a long period. The active gravel floodplain may develop a more pronounced vegetation cover, and the minor subchannels are likely to become relatively inactive. However, unregulated flood flows would still occur in the Chulitna and Talkeetna Rivers and periodically disrupt the trend toward a more stabilized channel. Any significant observable changes will require several years.

The trap efficiency of the reservoirs for particle sizes above 50 microns has been well established, hence it is known that nearly all suspended sediments above this size class would remain in the reservoirs (16). It has been estimated that approximately five percent of the storage capacity of Watana reservoir would be filled in by sediments over a 100-year period.

Monthly suspended sediment concentrations (turbidity) and distribution within Watana reservoir have not been forecast, thus it is not known whether the penetration of sunlight would be sufficient to influence reservoir temperature profiles or biological productivity. Preliminary estimates indicate that between five and 30 percent of the suspended sediment could pass through the reservoirs. Problems have been encountered in determining how much of the very fine glacial sediment (in the two micron range) would settle. Consequently, downstream turbidity cannot be accurately quantified. However, tentative estimates indicate that turbidity will not exceed maximum values of 35 to 45 Nephelometric Turbidity Units (NTU) during peak flows, and would normally be in the 10 to 20 NTU range during summer months.

## Fishery Resources

Other major hydroelectric projects often have had adverse effects on the anadromous fish populations that occur in their drainages. These impacts include flooding of spawning and rearing habitat by the impoundments, blockage of anadromous fish migrations, and destruction of downstream habitat by fluctuating water levels or alteration of the natural thermal regime in response to operational characteristics of the dam. Other impacts include downstream mortality of juveniles and adults caused by dissolved gas supersaturation, and mortality to fish passing downstream over the spillways or through turbines installed at the dam. Because cascading rapids within Devil Canyon currently block the upstream migration of fish, problems that may be associated with the proposed development are basically limited to the flooding of resident fish habitat within the impoundment areas, and downstream effects of operational characteristics of the dams on streamflows, water temperature, and water quality.

Currently there is an insufficient information base on the fishery resources of the Susitna River to provide adequate answers to many of the questions recorded during the instream flow survey. To ensure that adequate information will be available to determine the impacts of the proposed hydroelectric project and to design proper mitigative measures, ADF&G has completed the first year of a data collection program. The first phase of ADF&G's program is separated into three sections: adult anadromous fisheries, resident and juvenile anadromous fisheries, and aquatic habitat studies. The primary objective of the adult anadromous study is to determine the seasonal distribution and abundance of the anadromous fish in the project area, particularly the timing of migration and spawning. The objective of the resident adult and anadromous juvenile study is to determine the seasonal distribution, abundance, and movement patterns of resident adult and anadromous juvenile fish in the project area. The objective of the aquatic habitat study is to locate and characterize the various types of fish habitat in the project area.

Terrestrial Environmental Specialists, Inc. (TES) prepared an initial report that identifies several potentially adverse and beneficial effects of the proposed Susitna hydroelectric project on the fishery resources of the watershed. The TES report is based on results of the Phase I engineering and environmental studies conducted by Acres, R&M, ADF&G, and various subcontractors. A summary of the known information on the biology and of the probable effects that the proposed development is likely to have on the fisheries resources is also provided in the TES document. It is highly unlikely that any additional major impacts resulting from construction or operation of the project will be identified during the course of future studies. However, it is expected that the questions addressed in a preliminary manner in this document will be more clearly defined by future studies.

The data base that is available as of spring 1982 is not sufficient to support a definitive impact statement. However, quantification of streamflows and stream temperature requirements of downstream fisheries has been identified as the most important question that needs to be answered. Because of the inherrent difficulty in predicting a biological response to the changes in streamflow and stream temperature that are expected to occur, some degree of uncertainty will always remain, regardless of the intensity of preproject investigations. However, substantial progress has been made in eliminating much of the uncertainty regarding the major fishery questions that are of importance to the development of the proposed project.

The impacts of secondary effects of the proposed project, such as increased fishing pressure, oil or toxic substance spills, or road and transmission line construction impacts, should also be considered. Although the general impacts of such activities can be discussed, additional biological data and evaluation of engineering and construction plans will be necessary to define specific impacts and develop specific mitigation plans. These secondary effects are not likely to influence the overall feasibility of the project. Therefore, their consideration has been deferred.

During the past year, questions concerning the elimination of anadromous fish enhancement opportunities in the Susitna River basin have been raised. Because of the extensive natural lake system on the Tyone River, the potential for a substantial increase in sockeye salmon production may be achieved if fish could pass through the high velocity barriers in Devil Canyon, and possibly Vee Canyon.

A cursory review of this issue was undertaken by TES, and their findings are presented in a separate document. The conclusions are:

1. Construction of the project would limit the options available for upstream enhancement by providing significant barriers to out-migrating smolt.

2. Construction of the dams does not necessarily eliminate the potential of using the Lake Louise system in the Tyone River basin for sockeye salmon production. Two options could be investigated. One involves a mechanical transport system past the dams down the Susitna River, and the other involves fish passage from Lake Louise into the Copper River system.

3. Much more intensive study would be required in order to evaluate the biological limitations to enhancement and to determine economic and/or engineering constraints.

## Water Quality

The Susitna River flows through a wilderness area of Alaska, with only very minor impacts by man on its water quality. Consequently, the available water quality data represents the conditions that could be expected to occur if the proposed Susitna hydroelectric project were not built. Existing water quality data was compiled for breakup, summer, and winter at five mainstem Susitna River stations: Denali, Vee Canyon (Cantwell), Gold Creek, Sunshine, and Susitna Station. Data from two major tributaries, the Chulitna and Talkeetna Rivers, have also been compiled (14). The ranges of existing data were then compared to state and national water quality standards to help assess natural conditions.

The Susitna River is characterized by wide seasonal fluctuations in discharge, which, along with the glacial character of the river, have a significant effect on water quality. Suspended sediment concentrations and turbidity levels are low during late fall and winter, but sharply increase at breakup and remain high throughout summer during the glacial melt period. Dissolved solids concentrations and conductivity values are high during low flow periods and low during the high summer flows.

The results of the Phase I water quality studies indicate that the Susitna River is a fastflowing, cold-water stream of the calcium bicarbonate type. It contains soft to moderately hard water during breakup and in the summer, and moderately hard water in the winter. Nutrients, namely nitrate and orthophosphate, exist in low to moderate concentrations. Dissolved oxygen concentrations typically remain high, averaging about 12 milligrams per liter (mg/l) during the summer and 13 mg/l during winter. Percentage saturation of dissolved oxygen has always exceeded 80 percent and averages nearly 100 percent in the summer. Winter saturation levels decline slightly from the summer levels. Typically, pH values range between seven and eight, exhibiting a wider range during the summer months as compared to the winter period. During summer, pH occasionally drops below seven, which is attributed to tundra runoff. The buffering capacity of the river is relatively low on occasion.

Concentrations of organic pesticides and herbicides were either less than their respective detection limits or were below levels considered to be potentially harmful. Concentrations of many trace elements monitored in the river were low or within the range characteristic of natural waters. The concentrations of some trace elements exceeded Alaska's water quality guidelines for the protection of freshwater aquatic organisms. However, these concentrations are the result of natural processes. There are no man-induced sources of these elements in the Susitna River basin.

Impoundment of the Susitna River would change existing water quality conditions within the basin. The following parameters may exhibit changes in values in the reservoir and downstream reaches as compared to the preproject levels: suspended solids, turbidity, color, nutrients, iron, manganese, and some trace elements. Dissolved oxygen concentrations are expected to remain high, at or near saturation, in the upper levels of both reservoirs and downstream from the dams.

Both reservoirs would be heat exporters, and the downstream reaches of the river would exhibit a reduction of the magnitude of seasonal temperature variation. Thermal stratification is not likely to occur in either reservoir, but a temperature gradient would exist. It is expected that vertical mixing would occur in the spring as a result of wind effects, surface water warming, and the large inflow of water.

## Navigation

The Susitna River has been designated "navigable" by the U.S. Bureau of Land Management (BLM) from its mouth to the eastern boundary of the Indian River remote parcel, about five miles above the confluence with Gold Creek. However, navigational use is known to occur beyond this point to Portage Creek. There has been a high level of concern expressed by both federal and state agency personnel regarding the effects of the proposed project on navigational use of the river for recreation, commerce, and land access below Devil Canyon dam.

Commercial navigation, by traditional lower-48 definition, does not exist on the Susitna River. It is recognized, however, that navigational use is made of the Susitna River between Cook Inlet and Devil Canyon from which individuals receive income; for a few it is their livelihood. The craft that they operate are similar in size or are of a type that require the same draft as recreational watercraft. Therefore, it was not necessary to undertake separate studies to identify the effects of postproject streamflows on commercial and recreational navigation in the Susitna River. A single study was undertaken (8), and the results of that assessment apply equally well to both commercial and recreational navigation of the Susitna River.

A review of aerial photographs, river cross-sectional data, and simulated water surface profiles indicates that the proposed Susitna hydroelectric project is not likely to cause navigation problems in most areas above Talkeetna under Case D postproject flows (minimal impact on fisheries).

Case A streamflows (maximum power production) are likely to cause periodic navigation problems during the months of August and September.

The major area of concern is a broad shallow reach one to three miles below Sherman, where the main channel of the Susitna River crosses the floodplain. Navigation problems may be encountered in this reach in about one year out of three during August, and in about one year out of two during September under Case A postproject flows; they may occur in about one year out of 10 during June under Case D flows. Additional site specific study in the Sherman reach may be warranted.

Cross-sectional data were gathered on the main channel of the Susitna River below Talkeetna, on sloughs and side channels used for river access near Kashwitna Landing and Willow Creek, and at the upper access channel to Alexander Slough. While stage-discharge data at these sites are very limited, initial analysis indicates that no significant negative impacts on navigation are readily apparent in the main channel below Talkeetna, or at the Kashwitna Landing access point. At traditionally used access channels near Willow Creek, it appears that there would be some minor negative impacts on navigation during May under the Case D scenario. Case A streamflows are higher than Case D during May, thus navigation during this month is less likely to be adversely affected near Willow for Case A streamflows. During those months when navigation has traditionally occurred on the river (June through September), access channels to Willow Creek should be navigable. Phase I data are insufficient to define whether or not operation of the dams would have an adverse effect on navigational access to Alexander Slough.

## Water Rights

Water rights for 18 different areas in the Susitna River basin were examined, and the amount of surface water or groundwater appropriated for each type of use was tabulated (5). A summary table was prepared to indicate the total amount of surface water and groundwater appropriated within each area. This summary indicated that the only significant uses of surface water in the Susitna River basin occur in the headwaters of the Kahiltna and Willow Creek township grids. Its principal use is for mining operations on a seasonal basis. No surface water withdrawals from the Susitna River are on file with the Alaska Department of Natural Resources (DNR). Groundwater appropriations on file with DNR for the mainstem Susitna River corridor are minimal, both in terms of numbers of users and the amount of water being withdrawn. An analysis of topographic maps and overlays showing the specific location of each recorded appropriation within the mainstem Susitna River corridor indicated that neither the surface water diversions from small tributaries nor the groundwater withdrawals from shallow wells are likely to be adversely affected by the proposed Susitna hydroelectric project.

## Riparian Vegetation and Wildlife Habitat

A number of groups contacted during the instream flow survey were interested in knowing the effects of postproject streamflows on riparian vegetation. The major concern focused on whether or not postproject flows would maintain a disturbed environment conducive to the production of moose browse.

During the Phase I work, TES prepared vegetation maps of the river corridor from Devil Canyon to Talkeetna and quantitatively studied the natural succession of floodplain vegetation from Gold Creek to the Delta Islands. Investigators feel that vegetation patterns below Talkeetna are not expected to change appreciably as a result of the proposed project. Riparian vegetation communities in the reach between Devil Canyon and Talkeetna would probably advance to later successional stages, and newly exposed gravel bars would be invaded by early successional species that would advance eventually to later successional stages.

The comparative importance of spring break-up and late summer floods for maintaining early seral stages of vegetation within the river corridor was unknown. In addition, the effects of postproject streamflow and ice conditions on stream channel stability had yet to be determined. A further assessment of project effects on riparian vegetation has been deferred until the Phase I river morphology and ice studies are completed.

## River Based Recreation

During the conduct of the instream flow survey, it was noted that DNR's Water Management Section and the U.S. Fish and Wildlife Service's (USFWS's) Western Alaska Ecological Services felt that a recreational user needs survey was necessary because of the potential for the proposed project to change recreational opportunities in the project area and the present lack of information about what types of river based recreation are most preferred. River based recreation is to a large degree dependent upon the physical character of the river and its fishery resources.

Until enough is known about the limnology of the proposed reservoirs to describe the type of reservoir fishery that might exist, little can be said regarding increased recreational opportunities that might be provided by the impoundments. Likewise it was thought to be premature to undertake detailed study of project effects on river based recreation below Devil Canyon until a preliminary understanding of project effects on navigability, winter ice conditions, and existing fish populations was available.

As a result, the questions identified in the instream flow survey that pertain to river based recreation can only be addressed by very general statements at this time.

## Estuary

The objective of this component of the instream flow assessment was to identify the seasonal change in freshwater inflow to the estuary from the Susitna River and discuss its significance with respect to the biological resources of upper Cook Inlet.

The proposed Susitna hydroelectric project would not affect the long-term average annual volume of freshwater inflow into upper Cook Inlet. However, the magnitude of the seasonal inflows to the estuary would be altered.

A comparative analysis of pre- and postproject streamflows at Susitna Station indicates that the freshwater inflow to Cook Inlet from the Susitna River would nearly double during the winter (Table 2). Maximum decreases expected during the summer months would average about 15 percent.

Table 2. Comparison of average monthly flow rates at Susitna Station during winter months.

| | Preproject | | Case A | | Case D | |
|---|---|---|---|---|---|---|
| Month | cfs | 1,000 acre-feet | cfs | 1,000 acre-feet | cfs | 1,000 acre-feet |
| November | 12,658 | 753 | 19,643 | 1,169 | 17,572 | 1,046 |
| December | 8,215 | 505 | 18,371 | 1,130 | 15,037 | 925 |
| January | 7,906 | 486 | 17,027 | 1,047 | 14,232 | 875 |
| February | 7,037 | 394 | 14,745 | 826 | 12,566 | 704 |
| March | 6,320 | 389 | 13,343 | 820 | 12,057 | 741 |
| April | 6,979 | 415 | 13,601 | 809 | 11,441 | 681 |
| TOTAL | | 2,942 | | 5,801 | | 4,972 |

The net effect of this change in freshwater inflow to the estuary is uncertain. With respect to physical processes in the estuary, it is possible that the predicted reductions in freshwater inflow during the summer months are relatively unimportant. The expected increase in flows during winter may contribute to increased ice in Cook Inlet. With respect to biological processes, the small percentage decrease in freshwater inflow during summer may be more detrimental than the large increases expected to occur during the winter. To date, insufficient information is available to discuss either the physical or biological significance of seasonal changes in freshwater inflow to upper Cook Inlet.

## QUESTIONS AND ANSWERS

### Flow Regime

#### Introduction

Nearly twenty groups interviewed during the instream flow survey had questions and comments pertaining to project effects on the streamflow, temperature (including ice), and sediment regimes of the Susitna River. Many of these questions are associated with instream uses of water and demonstrate that the majority of those interviewed recognize that important relationships exist between the streamflow, thermal, and sediment transport characteristics of the river and a variety of instream uses. Several of the questions and concerns pertaining to this topic area are provided below:

> What would the stage be at selected locations during the different times of the year? What would the magnitude of change in flow be under post-project conditions, and how would this affect access to tributaries? What is the dampening effect on streamflows downstream? How would changes in water level affect people living near the river (flood potential)? What is the relationship of groundwater levels to the stream?
>
> Would the changes in water temperature be harmful to fish? What would be the effect of increased winter flows on icing? Would there be a greater accumulation of ice in the upper reach, with larger ice jams during break up? If power demand or operation of the reservoir required that water be dumped in winter in years that the snow pack indicated a high spring runoff, would there be a buildup of ice on the river (aufeis)? Could this be managed by controlled releases of water under the ice?
>
> The Alaska Railroad was particularly concerned about the effect of annual spring flooding on bridges. They felt that although ice jams at the bridge locations might decrease, there would be increased erosion of bridge piers due to decreased silt concentrations and channelization of the river. Other groups are also concerned about the effect of decreased sediment loads on scouring.

What would be the change in channel characteristics? What would be the effect of peak flow on sediment transport and stream morphology? How would the proposed project affect bedload movement associated with storm events? What would be the effect of reducing the sediment load and, therefore, associated nutrients, on downstream biota? How much sediment would be trapped in the reservoir, and would it have to be flushed?

## Questions

The following statements are provided on the basis of the data and information available from Acres and R&M as of March 1982 in response to specific questions that were recorded during the instream flow survey. Each response is provided in answer to the question, "what effect would the proposed Susitna hydroelectric project have on....?"

Preproject Streamflows

Due to the lack of long-term streamflow records at Sunshine and at Susitna Station, 30 years of preproject monthly flows were synthesized using records from the Susitna River at Gold Creek and the Talkeetna River and Chulitna River gaging stations. Daily postproject flows for the Susitna River below Devil Canyon are not available. However, the change in streamflow can be estimated based on forecasted monthly outflows from Devil Canyon dam. A comparison has been made of pre- and postproject streamflows at Gold Creek, Sunshine, and Susitna Station based on the simulated 30-year monthly operation of the Watana and Devil Canyon reservoirs for two idealized operating schedules: Case A (maximum power production) and Case D (minimal impact on fisheries). Based on an analysis of 30 years of total streamflow data and simulated power flows, the long-term average monthly streamflows at Gold Creek are expected to be altered as seen in Table 3.

Table 3. Monthly Streamflow for the Susitna River at Gold Creek in cfs.

| | Preproject | Case A | Case D |
|---|---|---|---|
| January | 1,454 | 10,574 | 7,779 |
| February | 1,236 | 8,943 | 6,765 |
| March | 1,114 | 8,137 | 6,851 |
| April | 1,368 | 7,990 | 5,830 |
| May | 13,317 | 10,418 | 8,071 |
| June | 27,928 | 12,061 | 9,335 |
| July | 23,853 | 10,220 | 14,996 |
| August | 21,479 | 9,553 | 19,924 |
| September | 13,171 | 7,711 | 12,371 |
| October | 5,639 | 7,788 | 6,901 |
| November | 2,467 | 9,452 | 7,380 |
| December | 1,773 | 11,930 | 8,595 |
| Average Annual | 9,567 | 9,567 | 9,567 |

Since the streamflow in tributaries entering the Susitna River below the dams would not be regulated, the effect of Devil Canyon outflows on monthly streamflows would be attenuated further downstream. The relative contribution of average monthly flows for pre- and postproject conditions at the confluence of the Susitna, Chulitna, and Talkeetna Rivers is shown in Tables 3.11 through 3.13 of the river morphology report (17).

Average monthly flows do not indicate the variability of monthly streamflows. Flow duration curves in the river morphology report, Section 3 (17) give additional information on the percentage of time various streamflows and water levels would be exceeded at three gaging stations on the mainstem Susitna River (Gold Creek, Sunshine, and Susitna Station) for both preproject and postproject conditions.

Additional information on the variability of preproject streamflows are also in the river morphology report (17). The ratio of annual 1-, 3-, 7-, 14-, 30-, 60- and 90-day low flows to the annual low monthly flow were computed for four gaging stations: Susitna River at Gold Creek; Chulitna River near Talkeetna; Talkeetna River near Talkeetna; and Susitna River at Susitna Station. The annual low daily flows are closely approximated by monthly flows. The low monthly flows occur in mid-winter, when the rivers are ice-covered.

Flow statistics indicate that the ratios of 1-, 3-, 7- and 15-day high and low flows vary both with time and with basin characteristics. For all rivers analyzed, May showed the most variability, as it is usually the month when high breakup flows begin to occur. This large variability in May is also evident on the flow duration curves. The ratios for May also had the greatest standard deviation for high flows, indicating significant changes from year to year. June and July generally exhibited less variability than the late summer months, primarily because flows are usually dominated by snow and glacier melt. In the regional flood analysis report (12), it was demonstrated that June had the greatest frequency of annual floods (55 percent). Floods in June are dominated by rain and snowmelt storms, resulting in high volume floods with relatively slow changes in daily discharge. Flow variability increases in the August through October period. Heavy rainstorms often occur in August, with 28 percent of the annual floods occurring in that month. The increase in the ratio of high daily flow to monthly flow for September and October is partially due to rainstorm floods and partially due to the decrease in flows due to cooler weather later in each month as winter approaches.

The monthly ratios for high and low flows may be used as indicators of the monthly high and low flow values for the unregulated portions of the river, i.e., that portion of flow on the Susitna River contributed below Devil Canyon. The two-dam reservoir system would have almost complete regulation of flows up to floods with about a 50-year recurrence interval. Table 3.21 of the river morphology report (17) indicates the average monthly spill from Devil Canyon.

The spills would be completely regulated, i.e., reservoir outlets would be controlled so that average monthly flows are nearly constant for those months. The regional flood frequency analysis may be used to determine the frequency of flood flows from tributaries below Devil Canyon. The 1-, 3-, 7-, and 15-day high flow ratios may also be used as indices of the increase in flow contributed from tributary inflow below Devil Canyon, so that maximum flows expected between Devil Canyon and the Susitna-Chulitna-Talkeetna River confluence may be estimated. The regional flood frequency analysis may also be used to determine the frequency of flood flows from tributaries below Devil Canyon. Overall, the daily/monthly flow variability for the Susitna River at Gold Creek would be decreased significantly under postproject conditions. Once the Susitna-Chulitna River confluence is reached, there would also be some decrease in the daily/monthly flow ratios due to the storage effects of the reservoirs, but it would not be as significant as that above the confluence.

Flood Potential

As part of the regional flood studies (12), a regional equation was developed to determine mean annual flood flows based on basin characteristics. Eleven watershed parameters were considered: drainage area, main channel slope, stream length, mean basin elevation, area of lakes and ponds, area of forests, area of glaciers, mean annual precipitation, precipitation intensity, mean annual snowfall, and mean minimum January temperature. The most influential parameters in predicting the mean annual instantaneous peak flow were found to be drainage area, stream length, area of glaciers, mean annual precipitation, and mean annual snowfall.

Streamflow records at gaged sites allowed determination of flood frequencies at specific sites. Pre- and postproject flood flows and stages at selected sites on the Susitna River are tabulated in Table 4.

Postproject flood potential at ungaged areas below Devil Canyon can be estimated using the regional flood regression equation, releases from the dams, and the daily/monthly flow variability ratios. Refinement of the estimates of flooding contributed by unregulated tributaries below Devil Canyon will enable better determination of whether postproject floods might damage mainstem river spawning areas developed as fish mitigation measures.

Additional information on flood potential is available in the river morphology report (17) and the regional flood report (12).

Table 4. Estimates of Pre- and Postproject Flood Flows and Water Surface Elevations at Five Mainstem Locations for the Open Water Season.

**Devil Canyon Damsite**

| Recurrence Interval (years) | Preproject Flood Flow (cfs) | Postproject Flood Flow (cfs) |
|---|---|---|
| 2 | 47,000 | 11,000 |
| 5 | 61,000 | 12,000 |
| 1C | 71,000 | 13,000 |
| 25 | 84,000 | 28,000 |

**Susitna River at Gold Creek**

| Recurrence | Preproject | | Postproject | | Change |
|---|---|---|---|---|---|
| Interval (years) | Q (cfs) | Stage (feet) | Q (cfs) | Stage* (feet) | In Stage (feet) |
| 2 | 49,500 | 13.4 | 13,500 | 8.7 | -4.7 |
| 5 | 66,000 | 14.9 | 17,000 | 9.6 | -5.3 |
| 10 | 78,000 | 15.8 | 20,000 | 10.1 | -5.7 |
| 25 | 94,000 | 16.7 | 38,000 | 12.3 | -4.4 |

**Susitna River at Sunshine Station**

| Recurrence | Preproject | | Postproject | | Change |
|---|---|---|---|---|---|
| Interval (years) | Q (cfs) | Stage (feet) | Q (cfs) | Stage* (feet) | In Stage (feet) |
| 2 | 95,000 | 12.5 | 59,000 | 9.3 | -3.2 |
| 5 | 124,000 | 14.8 | 75,000 | 10.8 | -4.0 |
| 10 | 144,000 | 16.3 | 85,000 | 11.7 | -4.6 |
| 25 | 174,000 | 18.4 | 118,000 | 14.3 | -4.1 |

**Susitna River at Delta Islands**

| Recurrence | Preproject | | Postproject | | Change |
|---|---|---|---|---|---|
| Interval (years) | Q (cfs) | Stage (feet) | Q (cfs) | Stage* (feet) | In Stage (feet) |
| 2 | 105,000 | 94.6 | 69,000 | 92.7 | -1.9 |
| 5 | 138,000 | 95.6 | 89,000 | 94.0 | -1.6 |
| 10 | 159,000 | 96.3 | 101,000 | 95.0 | -1.3 |
| 25 | 193,000 | 97.3 | 137,000 | 96.0 | -1.3 |

**Susitna River at Susitna Station**

| Recurrence | Preproject | | Postproject | | Change |
|---|---|---|---|---|---|
| Interval (years) | Q (cfs) | Stage (feet) | Q (cfs) | Stage* (feet) | In Stage (feet) |
| 2 | 157,000 | 16.7 | 121,000 | 14.8 | -1.9 |
| 5 | 206,000 | 19.3 | 157,000 | 16.7 | -2.6 |
| 10 | 239,000 | 20.9 | 181,000 | 18.0 | -2.9 |
| 25 | 289,000 | 23.0 | 233,000 | 20.5 | -2.5 |

* Arbitrary datum

## Stage and Sediment Deposition at Mouth of Tributaries

The alteration of the natural streamflow regime by the reservoirs would also affect the seasonal water level (stage) of the river downstream of the dams. The degree to which the proposed project would affect naturally occurring water levels in the Susitna River is illustrated in the stage duration curves presented in the river morphology report (17). In general, river stages would be above preproject levels from October through April, and below preproject levels from May through September. The further downstream from Devil Canyon, the less river stage would be affected.

Project effects on stage at the mouth of tributaries above Talkeetna have been defined through use of the HEC-2 water surface profile model. The water surface elevations at varying stages for 66 cross sections are illustrated in the hydraulic and ice studies report (18). The stage would be impacted somewhat when the tributaries are flooding, but this is not anticipated to be major.

The tributaries would continue to transport their natural bedloads into the Susitna River, building alluvial fans at their mouths. The alluvial fans would continue to grow into the Susitna River, constricting flow in the channel until river velocities increase sufficiently to transport the sediment downstream. The alluvial fan growth is most likely to occur at three tributaries: Portage Creek; Indian River; and Fourth of July Creek. Since the natural flow in the tributaries would not be altered, it is anticipated that sufficient energy would exist to maintain a distinct channel for the tributary to flow through the alluvial fans and enter the mainstem river. As a result, it is not anticipated that the build up of alluvial deposits at the mouths of these tributaries would cause any problems to migrating fish.

Additional study can be undertaken during Phase II studies to confirm this hypothesis or develop mitigative measures if the hypothesis is found to be in error.

## Bedload Movement Associated with Storm Events

Reservoirs have a dual impact on bedload movement: (a) they trap all bedload entering the reservoirs, and (b) they generally reduce peak flows, which is when the greatest amount of bedload movement naturally occurs. Trapping of the bedload by the reservoirs can result in postproject flows entraining sediment in the reach immediately below the dams, causing degradation of the river bed.

The large bed material in the channel above Talkeetna would preclude significant changes in main channel width and depth relationships or in the slope (except near tributaries). Deep scour holes at bends are expected to fill in to some degree, and gravel bars exposed above the new high water mark would have emerging vegetation. The sediment load plays an important role in the process of meander migration across alluvial plains by forming point bars from bedload deposition on the inside bank. Reduction of bedload may disrupt this process.

The bedload for the Susitna River is only poorly defined at this time. Bedload data on the Susitna River system was non-existent until 1981, when USGS gathered data at four sites for three different flows. Data collected from the Susitna River system have not been at high floods, but at moderate to low flows.

Bedload movement depends upon a certain threshhold velocity; that is, bedload movement generally does not occur until a certain flow rate and velocity occur. Once that velocity is reached, bedload movement increases rapidly.

Significantly more bedload movement will occur as flows increase. However, the difficulties in obtaining the data also increase, as water velocities increase, and floating debris makes boating hazardous.

Definition of the bedload coming into the Chulitna-Susitna River confluence near Talkeetna will be important in defining the impact of the reservoirs on the morphology and flood stage near Talkeetna. The amount of bedload material entering the confluence from the Susitna River would be reduced, while the amount entering from the Chulitna and Talkeetna Rivers would remain the same. The majority of the bedload entering the confluence is from the Chulitna River. The peak flows in the Susitna River above Talkeetna would also be significantly reduced (Table 3.14, river morphology report). This may result in the gradual buildup of the river bed near Talkeetna due to the decreased ability of the river to transport bedload. The USGS will continue to gather sediment data in 1982. An analysis of river morphology and sediment transport is included in the river morphology report (17).

## The Ability of the River to Cleanse Itself of Debris

Winter ice conditions, flood peaks, and, therefore, flood stage for the Susitna River are predicted to be significantly reduced because of the dams. The principal mechanisms by which debris now enter the river are overtopping of vegetated islands and point bars, inundation of the flood plain and lateral cutting, and slumping of vegetated stream banks.

Above Talkeetna the postproject flood crests would be at a much lower stage and, therefore, would be expected to carry less debris down the river. Due to the reduction in summer flood stage and to the predicted lack of a winter ice cover, vegetation would tend to grow on exposed gravel bars, tending to form additional means of trapping debris and sediment during the occasional flood.

Below Talkeetna the river has a wide braided floodplain. Stage reduction would not be as noticeable below the confluence because ice processes and flood flows in the Chulitna and Talkeetna Rivers would be unaffected by the project. The river presently carries a large number of trees and debris during flood stage. These trees can accumulate, form log jams, shift, and break up several times during a single flood event. Location of debris accumulation is unpredictable. Once the stage drops, much of the debris grounds on gravel bars.

Additional information on flow levels, stage, and river morphology is included in the river morphology report (17).

Groundwater Levels at Reservoir Sites, and in Downstream Domestic Wells, Springs, and Slough Areas

The effect of river stage on groundwater levels is to contribute water to bank storage and adjacent aquifers when the river is high, and drain these areas when the river is low. Although river stage would be reduced, the affect on adjacent aquifers would be less than the change in stage, and would decrease with distance from the river.

Groundwater levels in the immediate vicinity of the reservoir sites are expected to rise due to the high water level, but this has not been rigorously analyzed. Project effects on springs downstream of Devil Canyon would probably be minimal, as their aquifers are draining the slopes above the river. Similarly, the impact of the project on downstream domestic well levels is probably minimal. The reduced water level downstream of the dams would reduce water levels in the slough areas, as many are hydraulically connected to the river through the river bed gravels (17).

Many side channels above Talkeetna do not have an upstream surface water connection to the Susitna River until the flow at Gold Creek exceeds 15,000 to 20,000 cfs, due to gravel berms at the upper ends of the side channels. However, water may percolate through the gravels and enter the side channels as groundwater. Analysis of the impact of varying stages below 20,000 cfs on the groundwater flow through the gravels is recommended for 1982, as it will have a significant effect on the aquatic habitat in the side channels.

Additional information on changes in flow and stage can be found in the river morphology report (17).

River Stage at Downstream Locations During Different Months

Operation of the reservoirs would significantly alter the monthly river streamflows and stages downstream of the dams. Flow duration curves for preproject and two postproject conditions (Case A, maximum power production, and Case D, minimal impact on fisheries) have been constructed for the Susitna River at Gold Creek, Sunshine, and Susitna Station, with stage-discharge relationships at these sites well-defined. The mean monthly stage levels at Gold Creek and at Sunshine for preproject and postproject flows are listed in Table 5.

Additional stage-discharge curves have been defined at stations between Devil Canyon and Talkeetna, with miscellaneous stage data below Talkeetna. The HEC-2 water surface profile computer studies have computed stage-discharge relationships at cross sections between Talkeetna and Devil Canyon, with six of these located at crest gage sites. The stage-discharge relationships at the other cross sections were computed using estimated hydraulic characteristics of the river. The HEC-2 studies have been verified to within ±1.0 feet at the crest gage locations. Additional information on the above studies are included in the hydraulic and ice studies report (18), and the river morphology report (17).

Interpolation of stage data to locations between cross sections is somewhat tenuous, depending on the river characteristics. If data is required at particular sites, additional stage data should be collected to verify interpolated results. Additional cross-sectional data may be required to improve HEC-2 results at given sections.

Below Talkeetna, stage-discharge relationships in the braided channels may vary from year to year due to changes in channel characteristics.

Table 5. Mean Monthly Stage Levels in Feet.

| | Susitna River at Gold Creek | | | Susitna River at Sunshine | | |
|---|---|---|---|---|---|---|
| | Preproject | Case A | Case D | Preproject | Case A | Case D |
| January | 2.0* | 8.0* | 7.2* | 1.6* | 3.6* | 3.0* |
| February | 2.5* | 7.6* | 6.9* | 1.4* | 3.2* | 2.9* |
| March | 2.0* | 7.3* | 6.9 | 1.3* | 3.0* | 2.9* |
| April | 2.7* | 7.3* | 6.5 | 1.5* | 3.0* | 2.6* |
| May | 8.7 | 8.0 | 7.3 | 5.8 | 5.4 | 5.1 |
| June | 11.1 | 8.4 | 7.7 | 9.8 | 8.2 | 7.9 |
| July | 10.6 | 7.9 | 9.0 | 9.7 | 8.4 | 8.8 |
| August | 10.2 | 7.7 | 9.9 | 9.0 | 7.8 | 8.8 |
| September | 8.6 | 7.2 | 8.4 | 6.4 | 5.7 | 6.3 |
| October | 6.5* | 7.2* | 6.9* | 3.7* | 4.1* | 3.9* |
| November | 4.6* | 7.7* | 7.1* | 2.2* | 3.6* | 3.2* |
| December | 3.6* | 8.3* | 7.5* | 1.8* | 3.8* | 3.3* |

* Assumes open-water rating curve. Actual stage will be higher due to the ice cover, but relative change should be about the same. Stages obtained from simulated streamflows and USGS rating curves (17).

Ice Jams During Breakup

Based on the data and analysis to date, ice jams above Talkeetna are expected to be greatly reduced, if not eliminated, following construction of the dams. All ice formed on the river above the dams and on the reservoirs would be trapped by the dams. The relatively warm water (assumed to be 4°C) released from the reservoirs during the winter would prevent a thick ice cover from forming on much of the river above Talkeetna. Consequently, ice jams above Talkeetna should not prove to be a problem.

Below Talkeetna, ice jams during breakup may still occur at those locations where they are occurring under preproject conditions. The postproject flow levels during May would be similar to the preproject levels. However, less ice would be flowing downstream, since the Susitna River above Talkeetna would be contributing very little. Consequently, ice jams should also be reduced on the lower river. As the river below Talkeetna flows through a broad, braided floodplain, those ice jams that might occur would principally cause overflow into adjacent channels.

The potential for ice jams during freezeup would also be greatly reduced on the Susitna River above Talkeetna due to the relatively warm water released from the reservoirs. Below the Chulitna River confluence, the major changes during freezeup would be higher streamflow than that experienced currently and a reduction in the contribution of frazil ice from above the confluence.

Additional information is available in the ice observations report (11) on preproject conditions and in the hydraulic and ice studies report (18) on expected postproject conditions.

River Morphology Below Talkeetna

Detailed analysis of the river below Talkeetna has not been conducted. However, it is known that this segment of the Susitna River evidences a relatively stable but complex braided pattern. In the Delta Islands reach, the river has a braided pattern on the west channel, and a multi-channel pattern along the east side of the floodplain.

Under postproject conditions, the bankfull stage, which now occurs about once every two years, would occur only once every five to ten years. These decreased flood levels would tend to decrease the frequency of occurrence of bed material movement and consequently retard changes in braided channel shape, form, and network.

The complex pattern of the Delta Islands should remain unchanged, as project-induced changes in flow and sediment regime would be diluted by contribution from tributaries and by the Susitna River satisfying its sediment load by reworking of the wide floodplain alluvial deposits. While local changes in the main channel position may occur, the basic channel geometry should remain similar. Quantification of postproject morphologic changes caused by the projects is extremely difficult, if not impossible.

A trend towards relative stabilization of the floodplain features should occur over a long period. The active gravel floodplain may develop a more pronounced vegetative cover and the minor subchannels are likely to become relatively inactive. However, unregulated flood flows would still occur in the Chulitna and Talkeetna Rivers and periodically disrupt the trend toward a more stabilized channel. Any significant observable changes would require several years.

Additional information is contained in the river morphology report (17).

Backwater From Ice

Water releases from the reservoirs during winter months have been assumed to be relatively warm (4°C). Subsequent modeling of downstream water temperatures indicates that a continuous ice cover is not likely to form on the Susitna River downstream of the projects until about 15 kilometers (km) above Talkeetna. Staging (backwater from ice) of three to four feet was observed above Talkeetna during the winters of 1980-81 and 1981-82. Increased postproject flows during the winter months are predicted to cause a five-foot increase in the water surface elevation of the river at Gold Creek. If staging similar to that observed during the winters of 1981 and 1982 occurs in the vicinity of the ice cover formation, a significant rise in water level during ice cover formation can be expected near Talkeetna. It is also possible that backwater from ice may occur below Talkeetna.

Additional information on preproject and expected postproject conditions may be obtained, respectively, from the ice observations report (11) and from the hydraulic and ice studies report (18).

Permafrost Melt and Frost Heave Near Bridges

Operation of the proposed Susitna hydroelectric project would modify the annual flow regime of the river. Because of this, the Alaska Railroad has expressed concern over possible changes in the ground thermal regime near the river and whether these changes in the ground thermal regime could result in permafrost melt of frost heaving near existing bridge piers.

Surface water greatly influences the distribution and thermal regime of permafrost. A thaw basin always exists beneath rivers that do not freeze to the bottom in winter. Due to the effects of the much warmer water temperature on the underlying ground, the thermal effects extend not only below the river but also to some distance beyond the water-land interface.

The average flow of the Susitna River at Gold Creek from November through April would be increased 1,569 cfs under preproject conditions to 9,504 cfs under Case A (maximum power production) or to 7,200 cfs under Case D (minimal impacts on fisheries). In addition, the water released from the reservoir will be between 2 and 4°C, instead of the natural winter temperature of 0°C. Consequently, the heat transferred to the surrounding ground from the river water during the winter months would be greatly increased, increasing the size of the thaw bulbs.

The only existing bridge over the Susitna River above Talkeetna is the Alaska Railroad bridge at Gold Creek. The piers and the approaches to the bridge are constructed on terraces and floodplain deposits with low potential for frost heaving or thaw settlement. The piers at this bridge are located between the river banks. As previously mentioned, no permafrost exists under the river, so permafrost melt would not present a problem.

The only other existing bridge over the Susitna River is the Parks Highway bridge at Sunshine. The previous discussion of the effects of the river on permafrost also applies to this site. Permafrost is not present at the bridge piers, and would not form under postproject conditions.

Permafrost melt and/or frost heave could occur at bridges identified along the alternative access routes. Terrain unit mapping along the access road alternatives has identified several crossings where the soils have high potential for both thaw settlement and frost heave. Terrain unit maps and information on soil characteristics can be found in the access planning study report (15).

Winter Ice Conditions (Thickness and Period)

The analyses indicate that ice regime in the river reach above Talkeetna would be significantly altered after the projects are operational. When Watana development is on-line, it is expected that the ice cover formation above Talkeetna would be delayed by two to three weeks to the middle of December and would progress about 15 miles (to about LRX-15) by the end of January. It is unlikely that any significant ice cover would exist above this section under average weather conditions. With both Watana and Devil Canyon dams operating, it appears that little ice cover would form above Talkeetna except close to the Chulitna River confluence in late January.

It has not been possible to estimate, with any accuracy, the postproject ice regime in the river below the Talkeetna River confluence. Field observations of the freeze-up phenomena in 1980 indicate that about 80 percent of the frazil ice below the confluence is generated by the Susitna River. With both dams in place, there is likely to be a significant drop in the amount of frazil ice generated in the Susitna River above the confluence, thus delaying the ice cover formation in the lower river.

Additional information is available on preproject conditions in the ice observations report 1980-81 (11) and on postproject conditions in the hydraulic and ice studies report (18).

Erosion Near Bridge Piers

Both bedload movement and the suspended sediment load below the reservoirs would be greatly decreased during the summer months due to the sediment trapping characteristics of the reservoirs and reduced summer flows. Stream bed material near the Gold Creek railroad bridge is very coarse. Consequently, no significant erosion is anticipated to occur near piers at the Gold Creek railroad bridge. Similarly, summer streamflows would be reduced at the Parks Highway Bridge at Sunshine, reducing the sediment transport capacity in that river segment. Thus erosion is not expected to be a problem at this location.

The sediment regimes for several small tributaries that are crossed by the Alaska Railroad between Talkeetna and Gold Creek are not expected to be affected by the project. Theoretically, it is possible for reduced stage in a mainstem river to stimulate a downcutting process in lower reaches of adjoining tributaries with fine grained streambeds. This trenching action results in increased gradients and velocities, which can lead to bank instability, increased local scour, and possible major changes in the geomorphic character of the tributary stream. The erosion potential at the bridges is dependent on bed material size and movement, stream discharge, stream gradient, and distance from the mainstem Susitna River. Although this problem has not yet been specifically addressed, such a condition is not expected to occur at tributary crossings along the Alaska Railroad between Talkeetna and Gold Creek. The question could be adequately discussed following field trips in summer of 1982.

## Fishery Resources

### Introduction

A major category of concern expressed in the instream flow survey was the effects of the postproject flow regime on the fishery resources of the Susitna River basin. One third of the comments reported in that survey pertain to project effects on the fishery resources. Several questions and concerns were repeatedly expressed:

> Would there be enough water to support existing fish populations? Would the reduction of peak flows affect fishery utilization of side channels and backwater areas? How many sloughs, oxbows, and side channels would be dewatered or have limited access? How would changes in flow regime affect spawning, intradrainage movement, outmigration, and seasonal habitat use? Would higher stream velocities associated with increased winter flows affect young-of-the-year that migrate into the mainstem from tributaries during winter months? What overwintering of anadromous juvenile and resident fish occurs in the main channel and how would it be affected?
>
> What would be the change in channel characteristics? What would be the effect of peak flow on sediment transport and stream morphology? How would the proposed project affect bedload movement associated with storm events? What would be the effect of reducing the sediment load and, therefore, associated nutrients, on downstream biota? How much sediment would be trapped in the reservoir, and would it have to be flushed?

### Questions

The following statements are provided in response to questions recorded during the instream flow survey. These statements are offered as a preliminary indication of the effects that the proposed Susitna hydroelectric project is likely to have on the existing fishery resources.

Many of the statements, by necessity, remain unsubstantiated at this time. They are based upon the data that are available for the project area and the professional opinions of the project staff. The statements provided for most of these questions basically discuss the validity of the concerns being raised.

Existing Fish Populations Above and Below Damsites

The most notable fishery impact identified to date upstream from the proposed Devil Canyon dam would be the effect of the proposed project on an estimated 10,000 Arctic grayling (4). These fish reside in those portions of the clear water tributaries that would be inundated by the proposed Devil Canyon and Watana reservoirs. The largest percentage of this population reside in tributary streams within the Watana impoundment area. Insufficient data are available to describe the size of the populations of burbot, whitefish, and longnose sucker that also inhabit streams within the impoundment zone. However, the limited available data suggest that these populations are much smaller than the grayling population.

The possibility of establishing new sport fish populations within the reservoir has yet to be determined. At this time, the opportunity is not able to be defined. However, the impoundment would eliminate existing habitat used by resident species above Devil Canyon dam if the project were constructed.

Downstream of the proposed damsites, the fisheries that are most susceptible to being significantly affected are the anadromous salmon runs dependent upon the slough and side channel habitat for spawning and rearing areas. Under the proposed operational scenario for maximum power generation, the expected decreases in streamflows would result in such a lowering of the water surface elevations of the river (stage) during the spawning period that access would be denied to almost all of the spawning habitat within the sloughs. The estimated population of chum salmon using the side slough habitat in the Talkeetna to Devil Canyon reach is about 90 percent of the 20,000 adults that returned to this river segment in 1981 (approximately 15 percent of the Susitna River chum run). The other portion of this population uses the clearwater tributaries. A sockeye salmon population of 3,400 fish (about one percent of the Susitna River run based on the 1981 population estimate) would be similarly affected.

There would also be a possible loss of spawning habitat for even-year run pink salmon. No data have been obtained on the location of spawning areas or the number of even-year run pink salmon that spawn in the river segment between Talkeetna and Devil Canyon.

Coho and chinook salmon primarily spawn in the clear water tributaries to the Susitna River. Hence their principal spawning areas would not be directly affected by the proposed project. However, juveniles of these species are dependent upon the slough habitat adjoining the mainstem during both the summer and winter. The overall effect of the project on the availability or quality of rearing habitat in the river system has not been determined. Insufficient information exists to suggest whether a net loss or gain is likely to occur.

To date, the data base does not suggest that any significant losses would occur to populations of any anadromous or resident species below the confluence of the Susitna, Chulitna, and Talkeetna Rivers. Additional emphasis will be placed on determining significant project effects, positive or negative, during the coming year.

## Spawning and Rearing Habitat

Although the effects have yet to be quantified, the proposed project is expected to inundate spawning and rearing habitat of importance to resident species upstream from Devil Canyon, and dewater spawning and rearing habitat of importance to anadromous species between Devil Canyon and Talkeetna. Project effects on spawning and rearing habitat below Talkeetna have yet to be identified.

The impoundments would flood rearing habitat, and possibly some spawning habitat, for Arctic grayling. A similar loss may occur for other resident species that inhabit the mainstem Susitna River and adjoining tributaries within the impoundment zones. The spawning habitat in the sloughs between Devil Canyon and Talkeetna would probably not be usable, because regulated flows during the spawning season would result in water levels too low to provide access to the sloughs during most years. Although it is expected that rearing habitat for juvenile salmon would be altered by the proposed project, currently there is insufficient information to suggest how these changes would be reflected in terms of the overall run strength of the salmon populations using this river segment.

Available data suggests that 90 percent of the chum salmon that occur in this reach of the river use the slough or side channel habitats for spawning, and essentially 100 percent of the sockeye salmon use this habitat. The remaining 10 percent of the chum salmon in this river segment principally spawn in the small clear water tributaries.

Small numbers of coho and pink salmon spawned in this habitat during the small odd-year pink run of 1981. No data are available on the use of this habitat during the large even year pink run. No chinook salmon were observed to spawn in side channel or slough areas.

Mainstem spawning sites were identified by the ADF&G program during this past field season. The investigation was not sufficient to make any statement on their overall importance to the fisheries population or on the impact that flow reduction or other physical or chemical parameter alterations would have on them. Further studies are planned to evaluate the extent and importance of these habitats and to measure the response of these habitats to changes in mainstem discharge and temperature.

Fish Passage and Migratory Behavior of Adults

The overall effect of the proposed project on adult migration in the mainstem Susitna River does not appear to be significant, based on available data. The effects of temperature needs further investigation. Decreased streamflows during migratory periods are not expected to inhibit migration rates, and may actually result in adult salmon expending less energy in their upstream movement. The migration of adult salmon into side sloughs would be effectively eliminated under the proposed flows for maximum power development. The ability of mitigation to preserve their use of side sloughs is in the process of being addressed.

The project flows proposed to date should not affect the passage of fish into the Susitna River above the Chulitna River confluence, nor the movement of adults into the steep to moderate gradient clear water tributaries (e.g.. Portage Creek, Indian River). The gravel delta at the mouth of each of these streams is expected to increase, but the gradient and discharge of the tributary is believed sufficient to allow the small stream to downcut a channel to the new elevation of the Susitna River capable of passing fish. Low gradient tributaries may form a delta and lack sufficient energy to downcut a new channel and therefore become perched, limiting the access of migrating adults to these streams.

Predicted summer water temperatures during project operation are not yet well enough defined to determine effects on migration. The question of water temperatures during reservoir filling needs further study.

Overwintering of Juveniles and Resident Adults

Postproject winter conditions for juveniles and resident adults may be an improvement over current overwintering conditions. However, it has not been established that existing mid-winter conditions are limiting the present fish populations in the river.

Postproject streamflows would result in an increase of the amount and size of wetted areas in the mainstem available to fish during the winter period. The effects of increased winter flow in the mainstem on the slough springs has not been established. The increased velocities that would exist in the mainstem may reduce the amount of total wetted area in the mainstem available to juveniles for overwintering habitat. The slough areas that provide overwintering habitat should not be adversely affected by mainstem flows as they are dependent on groundwater influences. The slight increase in winter turbidity is not projected to have significant impacts on the fishery.

Scour and Siltation of Spawning Areas

Significant decreases would occur in suspended sediment between Devil Canyon dam and Talkeetna during the summer months. This may result in the gradual cleansing of silt and sand sized particles from various portions of the mainstem. It should also reduce turbidity during the summer months in the mainstem above Talkeetna. The magnitude and frequency of scouring floods, which presently remove spawning gravels and damage salmon redds and invertebrate populations, would be substantially reduced. This may provide a potential for improving the fisheries.

Under the Case A flow scenario, sedimentation and gradual vegetation of the sloughs and their associated spawning and rearing habitat is likely to be accelerated because of a lack of high flows to maintain a defined water course. The Case D flow scenario was proposed to provide adequate downstream flows to maintain the slough habitat for spawning salmon.

The reach of river below Talkeetna would have significant changes in the peak flood frequency. However, the suspended sediment concentrations are not expected to change appreciably. Although less stream bed movement may occur, this would probably not result in any significant changes in the fisheries habitat in this reach.

The possibility exists that the winter flows would have an increased sediment load above the normal level due to suspended glacial flour in the reservoirs. Because this fraction of the sediment would be most likely to settle in the reservoirs, if it were to settle at all, it should not create any adverse conditions in the lower river by settling in critical fisheries habitat during the winter months.

Egg Incubation and Developing Embryos

Fertilized eggs and developing embryos from the salmon that spawn in the river segment above Talkeetna incubate in streambed gravels from late August through May. The effects of changes in water surface elevations and stream temperatures on incubating eggs and alevins in the mainstem cannot be discussed in any detail because a sufficient number of spawning sites have not been examined.

Spawning sites that are associated with the side sloughs are wetted throughout the winter months by upwelling intergravel flow, which originates from some yet-to-be-defined subsurface sources, rather than by surface flows. The existence of these flows from springs during the winter months is an essential factor to consider when evaluating incubation success in the side sloughs. However, data are not yet available to determine either the nature or the extent of the relationship that may exist between streamflows and the flows from springs in the sloughs. A pilot program to explore the relationship is planned for the spring of 1982.

The effects of forecasted changes in mainstem water temperature on the water temperature in the sloughs must also be determined. Elevated mainstem water temperatures may result in increased water temperatures in the sloughs. Changes in water temperature during the winter months could accelerate incubation and advance the emergent time for juvenile fish. Studies performed on chum salmon incubation by Clear Air Force Base hatchery personnel demonstrated that a significant relationship existed between emergence and incubation temperatures. Their study suggests that emergence times could be altered with significant temperature changes.

However, other investigators (7) have found that salmon below a hydroelectric project in Washington had some ability to compensate for small temperature changes, as the change had little effect on emergent dates. The Cook Inlet Aquaculture group has tested the effects of cooler water during initial stages of incubation on chum salmon eggs in association with the proposed Eklutna hatchery. These studies also showed insignificant changes in emergent times.

A data collection program is currently under way that will obtain preliminary information on intergravel water temperatures and emergence dates in a few selected locations. Although the information obtained from this pilot study will not resolve the question, it will provide sufficient data and information to design a cost effective approach to determining the overall importance of actually resolving the question of postproject thermal effects on incubation rates.

Outmigration

A limited amount of fisheries data exists on the outmigration of juvenile salmon, but the evidence suggests that pink and chum outmigrate from the Susitna River in May and June. Coho and chinook juveniles apparently migrate downstream during June through August. The older age classes are found only downstream of Talkeetna by late summer.

Concern has been raised regarding the importance of maintaining high streamflows during spring to assist with the outmigration of juveniles, particularly pink and chum salmon. Sufficient water may naturally occur from spring flows and local snow melt runoff to provide for the outmigration of immature fish from the side sloughs. It is questionable whether mainstem streamflows below the range of naturally occurring May and June streamflows are detrimental to the outmigrating of fry and smolt. This question will probably not be resolved by any preproject field observations, since the forecasted postproject streamflows for the outmigration period do not occur during May or June under natural conditions. It is also doubtful whether an intensive hydraulic simulation modeling effort would indicate anything different about general changes in velocity other than that which can be discerned from careful examination of hydraulic forecasts obtainable from the present HEC-2 model. Studies will be conducted during 1982 and 1983 that can compare outmigration with discharge, but the actual relationship between mainstem discharge and outmigration will be difficult, if not impossible, to establish. A cursory examination of the literature does not provide any clues as to whether a sudden increase in streamflows or water temperature are required to trigger outmigration, although they are coincident. The suggestion has been provided that decreased velocities attributable to regulated streamflows would require outmigratory fish to expend more energy and remain in the system longer before entering estuarine rearing environments. Hydraulic calculations to estimate an order of magnitude change in travel time between pre- and postproject flows may be helpful in providing some insight regarding the validity of this concern, but the question of project effects on overall survival during outmigration will probably remain unanswered until after the project actually comes on line. If adverse effects should develop, they could be mitigated by providing short duration releases from reservoir storage during the critical outmigrant periods.

Food Base for Juvenile and Resident Species

Previous investigators determined that the basic food source for juvenile salmonids is concentrated in the clear water tributaries and slough areas (3), with respect to juvenile salmon. Resident species such as burbot apparently find adequate foraging in mainstem areas.

Project effects on food production within the slough areas is at this time unknown. The predicted decrease in suspended sediment concentrations within the mainstem Susitna River during summer months may be sufficient to significantly increase primary productivity and populations above present levels. This could improve the food base for summer resident populations and may provide for increase in salmon juvenile rearing capabilities if other physical and water chemistry parameters do not limit this potential.

Minor increases in turbidity are projected for the winter months. Cold water temperatures, and extensive ice cover and short days limiting light penetration, result in limited growth during the winter. Therefore, the overall effect of the project-induced change in turbidity during this period is thought to be relatively insignificant. Further studies relating light penetration to turbidity levels should provide for a more detailed assessment of postproject conditions in the mainstem as well as in the reservoir.

Increased dissolved nutrient levels downstream from the dams may result from the inundation of organic materials within the impoundments. Such a condition may increase downstream primary productivity during the summer months. However, present nutrient levels in the Susitna River appear to be adequate, with high turbidity levels retarding light penetration and probably limiting the amount of primary production. In addition, scouring summer flows are suspected of constantly disrupting the establishment of invertebrate populations of the mainstem. Hence the overall effect of the proposed project on the food base for rearing and resident fish is thought to be positive. Provided that downstream flow and temperature do not limit primary productivity or the establishment of an invertebrate population, the change in downstream suspended sediment concentrations may result in greater light penetration and an overall increase in the food base, particularly in the river segment between Talkeetna and Devil Canyon. These statements are all preliminary and may be revised after further data are obtained on water quality conditions (particularly turbidity) in the reservoirs.

Postproject Reservoir Fishery Potential

To date, the fishery potential of the reservoirs has not been clearly defined. However, it can be concluded on the basis of available project data and past experiences with problems associated with the development of fisheries on other reservoirs that there will be problems in developing a fishery in the Watana and Devil Canyon reservoir.

Because the downstream passage of juvenile salmon past the dams presents significant technological and biological problems, it is not feasible to attempt the development of a population of anadromous sockeye salmon within the reservoirs. Based on experiences at several other hydroelectric projects, the general tendency is for juvenile sockeye salmon not to outmigrate, but to remain in the reservoirs after being introduced to the system. This occurs even at those dams where downstream passage facilities for juveniles have been installed.

The proposed operating schedule for the Watana reservoir would result in an average 90-foot with a maximum 140-foot fluctuation of the reservoir surface. This in itself would preclude development of a littoral zone and associated fishery habitat. Reservoir fluctuation of Devil Canyon is on the order of 50 feet. This would preclude development of a littoral zone in that reservoir. Thus it is expected that a very limited potential exists for spawning and rearing littoral habitat to develop within the new reservoirs. Dependent on the limnological conditions of the reservoirs, plankton feeding species and predators may develop significant populations.

Specifics regarding the settling characteristics of glacial flour in the reservoirs have not been established. Estimates range from near zero (complete settling) to 45 NTU. Because this NTU range has highly divergent effects on primary productivity, little can be said about the availability of a food base to support a potential resident fishery in the reservoirs at this time.

The water chemistry characteristics of the reservoir waters are not anticipated to preclude development of a reservoir fishery. Concentration of toxic levels of dissolved metals, or depressed oxygen levels, are not expected to occur. Nutrient levels within the reservoirs are expected to increase because the flooding of organic matter should be substantial. Concentrations of nutrients would be expected to increase most substantially during the initial years of operation of the reservoirs. Because of the uncertainty regarding the degree of reservoir turbidity, it is not known what light penetration and water temperature might be. Hence the effect of increased nutrient levels on reservoir fisheries cannot be accurately defined.

The reservoirs should provide sufficient habitat to maintain the existing populations of burbot, whitefish, and long nosed suckers that are associated with the mainstem Susitna River, and they are also expected to provide abundant overwintering habitat for grayling populations using the clear water tributaries draining into the impoundments.

Smelt Runs in the Lower River

The baseline fishery data indicates that the Eulachon apparently used the mainstem Susitna River upstream to Kashwitna River with substantial runs occurring in the spring. Very little is known about spawning behavior, although runs are apparently stimulated by water temperature changes.

The physical condition of the Susitna River below the Kashwitna River would be within the normal variation of the system at the time of these runs. This includes discharge, temperature, and sediment concentration. It is not known how the size of smelt runs in past years have responded to variations in these conditions.

## Water Quality

### Introduction

During the conduct of the instream flow survey, agency concerns associated with postproject water quality effects downstream from the reservoir on future users were documented.

> The Alaska Department of Environmental Conservation questioned the general effects of the proposed change in flow regime on the assimilative capacity of the Susitna River. Both the sediment and thermal regimes of the Susitna River are expected to change. Thus, future discharge permit applicants might be required to incur additional treatment costs before meeting Alaska's water quality standards. In a somewhat similar fashion, the U.S. Army Corps of Engineers indicated an interest in having the anticipated postproject flow regimes reviewed with respect to the granting to 404 permits to the postproject applicants. The interests of both agencies were accented by renewed discussion of the capital move. Alaskans for Alternative Energy and ADF&G's Su-Hydro Team also mentioned the capital move and questioned the effects of postproject flows on domestic and industrial waste disposal.

### Questions

The Phase I water quality studies were principally limited to the compilation of background information that either existed or could be obtained through a minimal sampling effort. Data analysis focused on the preparation of a preliminary discussion of the types of changes that were likely to occur in seasonal water quality conditions as a result of constructing Watana reservoir. Specific attention was not given to questions recorded during the instream flow survey that pertain to water quality concerns. Therefore, the following statements are provided only as indicators of the types of effects the proposed development may have on existing water quality conditions.

## Assimilative Capacity of the Susitna River

The assimilative capacity of the Susitna River is dependent on the flow rate. The greater the flow rate, the greater the assimilation of wastes. The operation of the proposed Susitna hydroelectric project would alter the natural flow regime of the Susitna River, decreasing summer flows and increasing the winter flows, as seen in Table 6, for stations at Gold Creek and Sunshine.

The assimilative capacity of the Susitna River would be altered in a similar manner. Above Talkeetna, the assimilative capacity would be increased in the winter months and somewhat decreased in the summer months. However, the level of development above Talkeetna is such that this reduction is not believed to be serious.

Below Talkeetna, the reduction during the summer months would not be as significant as above Talkeetna, due to the unregulated flows from the Chulitna and Talkeetna Rivers. The assimilation of wastes during the winter months would be significantly increased due to the flow regulation on the Susitna.

Table 6. Alteration in Flow Regime.

| | May-October | November-April |
|---|---|---|
| Susitna River at Gold Creek | | |
| Preproject | 17,570 | 1,570 |
| Case A | 9,630 | 9,500 |
| Case D | 11,930 | 7,200 |
| Susitna River at Sunshine | | |
| Preproject | 42,830 | 3,710 |
| Case A | 34,890 | 11,650 |
| Case D | 37,200 | 9,350 |

## The Present Drinking Water Classification for the Susitna River During Both Construction and Operation

The Susitna River is not known to be used as a source of drinking water. Were it to be developed as a source, the main contaminants that currently exist are turbidity and color. The concentrations of these parameters, as have four others, have exceeded state drinking water standards on occasion in the past at Gold Creek, Sunshine, or Susitna Station.

Impoundment of the river in two proposed reservoirs would change its water quality. Changes in concentrations from preproject levels would be noted in the reservoirs and in the downstream reaches for suspended solids, turbidity, color, nutrients, iron, manganese, and some trace elements. The impoundment effects are discussed in the water quality interpretation report (20), and summaries of water quality measurements in the Susitna River and major tributaries are presented in the 1981 water quality annual report (14). The effects during construction would not be significantly different than the preproject conditions, since the entire river flow would be diverted around the dam construction areas.

Volume 1 of the feasibility report (2), under Engineering and Economic

## Level of Dissolved Gases in the Susitna River Immediately Downstream of the Dams

Dissolved oxygen would likely be reduced in the lower levels of the reservoirs if a stable stratification develops. Significant natural turbulence in the reach immediately below the proposed Devil Canyon Dam, however, is expected to return the dissolved oxygen to or near saturation within a short distance. The river immediately below the Watana Damsite is less turbulent and could conceivably retain low levels of dissolved oxygen down to the Devil Creek rapids, approximately 20 miles upstream. Anticipated project effects on water quality are described in the water quality interpretation report (20).

Another dissolved gas problem, supersaturation of dissolved nitrogen, can occur downstream of dams when aerated flows are subjected to pressures greater than 30 to 40 feet of head, which forces excess nitrogen into solution. This occurs when water is subjected to the high pressures that occur in deep plunge pools or at large hydraulic jumps. The excess nitrogen would not be dissipated within the downstream Devil Canyon reservoir, and a buildup of nitrogen concentration could occur throughout the body of water. It would eventually be discharged downstream from Devil Canyon with harmful effects on the fish population. On the basis of an evaluation of the related impacts and discussions with interested federal and state agencies, spillway facilities were designed to limit discharges of water from either Watana or Devil Canyon that may become supersaturated with nitrogen to a recurrence period of not less than 1:50 years. The spillway design considerations are discussed in

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Volume 1 of the feasibility report (2), under Engineering and Economic Aspects, Sections 9.10 (Watana Spillway Facilities Alternatives) and 10.7 (Selection of Devil Canyon Spillway Capacity).

Suspended Sediment and Turbidity at Various Downstream Locations

When a river flows into a lake or reservoir, the water velocity sharply decreases due to the increase in depth and width of the channel. The reduction in velocity results in a reduction in the sediment transport capacity of the water. Consequently, much of the suspended sediment is deposited in a reservoir. On the Susitna River, most of the suspended sediment would be deposited in Watana reservoir, with some additional deposition in Devil Canyon reservoir. Suspended sediment concentrations and turbidity between Talkeetna and the reservoirs would thus be significantly decreased during the summer months. Very fine suspended sediment (smaller than two microns) would not settle as rapidly as larger particles and may stay in suspension into the winter months. This may result in water drawn from the reservoir during the winter having higher turbidity than under natural winter conditions. However, turbidity is not expected to significantly impact overwintering fish, and should not be any worse than that occurring in the Kenai River during summer.

Salinity Levels in the Mouth of the Susitna River

Assuming the salinity levels in the mouth of the Susitna River would be dependent on the river flow at the mouth, very little difference from preproject conditions would be noticeable during the open-water months of May through October. As shown in Figure 3.6 and discussed in the river morphology report (17), the summer-time flows at Susitna Station (26 miles above the mouth) would be reduced only slightly from existing flows. Since the natural flow level through the winter months is normally quite low, however, and the project releases in the winter would be comparatively high, the postproject streamflows at Susitna Station would be substantially higher (one and a half to three times higher) than current conditions. Thus, the salinity levels at the mouth would most likely be lower than existing levels during November through April.

## Domestic and Industrial Waste Disposal Associated with the Proposed Capital Move

Increased waste disposal from the proposed new state capital site near Willow should be nearly unaffected by operation of the proposed Susitna hydroelectric project. Any wastewater discharges would presumably be into Willow Creek or one of its tributaries and would presumably be required to meet effluent water quality standards. Willow Creek's confluence with the Susitna River is in the vicinity of the Delta Islands, downstream of Sunshine. Figure 3.7 of the river morphology report (17) gives a graphical comparison of preproject and postproject streamflows at Sunshine on a monthly basis. The Delta Islands flow (both pre- and postproject) should be greater than the Sunshine flow by about 20 to 30 percent of the Sunshine preproject flow.

In essence, wintertime (October - April) flow levels during project operation at Delta Islands would be above existing levels by two to three times. This would increase the assimilative capacity of the Susitna River during its normal low-flow period. In the open-water period (May - September), post-project Susitna River flows at the Delta Islands would be reduced by zero to 20 percent from preproject flows. This naturally would reduce the capacity of the river to assimilate waste discharges, but it would be occurring when the main river flows are already high. Thus, the effect is not anticipated to be significant.

## Effects of Placer Mining on Water Quality During Low-Flow Periods

The major effect of placer mining on water quality is an increase in sediment concentration and turbidity, with minimal changes in dissolved constituents. Relatively little study has been done of specific placer mining effects in Alaska (9), so the impacts of such activities on the Susitna River and its tributaries cannot be quantified at this time.

The Susitna River streamflows would be generally decreased in the summer and increased in the winter from preproject conditions. Following completion of the reservoirs, the Susitna River downstream of the dams would exhibit lower levels of suspended solids, turbidity, and some dissolved elements than currently exist during the summer months. Below the project and above Talkeetna, placer mining on tributary streams would probably have a more visible effect on the Susitna River than it currently does. Turbidity in the Susitna River would sharply increase at the confluence with the Chulitna River, so placer mining should not have increased visible effects on the Susitna River downstream of Talkeetna. Discussion of the preproject water quality conditions and anticipated effects of the impoundments on water quality is contained in the water quality interpretation report (20).

## Navigation

### Introduction

Questions identified in the instream flow survey that pertain to anticipated effects of the proposed project on recreational navigation fall into two major areas: 1) access to the river by water, air, and land; and 2) movement within the river itself.

> Boat and float plane access to side channels and small tributaries and to the west side of the lower Susitna River was questioned by USFWS's Fishery Resources Program, the Fairbanks Environmental Center, and ADF&G's Su-Hydro Team. The Anchorage Fish and Game Advisory Committee and the National Marine Fisheries Service were concerned about sport fishing access, primarily downstream from Talkeetna. The Sierra Club's Knik Group asked whether recreational access, in general, would be reduced or enhanced. The main concern of DNR was whether or not stream flow alteration would affect access to land disposal sites.
>
> The Sierra Club's National Representative was specifically concerned about project related effects on whitewater boating (kayaking, boating, and rafting) between the Denali Highway and Talkeetna. Trustees for Alaska questioned whether movement within the lower Susitna River would become more hazardous as a result of reduced summer streamflows.

### Questions

The following answers are provided as a preliminary indication of the likelihood of the proposed Susitna hydroelectric project adversely affecting navigational use of the mainstem river between Devil Canyon and the estuary. The statements are based on information provided in a report entitled, "A Preliminary Analysis of Potential Navigational Problems Downstream of the Proposed Hydroelectric Dams on the Susitna River" by DNR's Water Management Section (8).

## Commercial Navigation on the Lower Susitna River

Commercial navigation, by traditional lower-48 definition, does not exist on the Susitna River. It is recognized, however, that several individuals receive income from navigational use made of the Susitna River. For a few, it is their livelihood. The craft that they operate are similar in size, or are of a type that requires the same depth of flow, as recreational water craft. Hence any statements that are made regarding project effects on navigation apply equally to commercial or recreational navigation. Thus the answer to this question is contained in the following three sections, which provide responses to questions concerning project effects on recreational navigation.

Recreational Boating on the Susitna River, Side Channels and Sloughs

During the fall of 1980, R&M surveyed 66 cross sections for the 50-mile river segment between the confluence of the Susitna and Chulitna Rivers and Devil Canyon. The HEC-2 water surface profile computer program was used by R&M to forecast water surface profiles for the Susitna River above Talkeetna. Water surface elevations were predicted for six different flow rates at each of the 66 cross sections. This information, along with a description of its development, is presented in Appendix B.7 of the hydraulic and ice studies report (18).

A review of aerial photographs, river cross-section data, and simulated water profiles indicates that the proposed Susitna hydroelectric project is not likely to cause navigation problems in most areas above Talkeetna under Case D postproject flows (minimal impact on fisheries). Case A streamflows (maximum power production) are likely to cause periodic navigation problems during the months of August and September.

The major area of concern is a broad shallow reach one to three miles below Sherman, where the main channel of the Susitna River crosses the floodplain. Navigation problems may be encountered in about one year out of three during August, and in about one year out of two during September, in this reach under Case A postproject flows, and in about one year out of 10 during June under Case D flows. Additional site specific study in the Sherman reach is warranted during Phase II engineering and environmental studies, as the adverse conditions mentioned above are based on limited data, principally derived from a hydraulic simulation model.

The work which has been completed to date did not address the questions of project effects on navigation in side channels and sloughs. This question can be answered at a later date with the same data base (staff gage and stream flows) that will be required to define project effects on fish access to the side channels and sloughs.

Access to the Susitna River from Established Launch Sites

Although a site specific evaluation was not made, navigational access to the Susitna River at Talkeetna is not expected to be a problem.

Cross-section data were gathered on sloughs and side channels used for river access near Kashwitna Landing and Willow Creek, and at the upper access channel to Alexander Slough. While stage-discharge data at these sites are very limited, initial analysis indicates that operation of the dams would have no significant negative impacts on navigation access at Kashwitna Landing. At access channels near Willow Creek, it appears that there would be minor negative impacts in May for Case D. Case A streamflows are higher than Case D during May, thus navigation during this month is less likely to be adversely affected near Willow. Between the months of June through September, access channels to Willow Creek should be navigable.

Phase I data are insufficient to define whether or not operation of the dams would have an adverse effect on navigational access to Alexander Slough.

## Navigation Access into Major Tributaries

Most boating activity is concentrated on the Susitna River below Talkeetna. Navigation is also an important consideration on the Yentna River and its tributaries, the Skwentna and Kahiltna Rivers, the Deshka River (Kroto Creek), and Willow and Alexander Creeks. Navigation on the Yentna River is principally associated with fishing, seasonal transportation, and access to hunting areas. The Deshka River receives extensive use by sport fishermen and guides during the chinook salmon season. The Talkeetna River receives heavy use by trappers, subsistence users, recreationists, and miners. Riverboats, many with jet units, commonly pass back and forth between these tributaries and the Susitna River.

The postproject streamflows being evaluated at this time are expected to result in less than a one foot decrease in flow depth near the mouths of these major tributaries (17). This decrease in depth is not expected to adversely effect navigational access into these streams from the Susitna River.

## Water Rights

### Introduction

The instream flow survey identified the following agency concerns, which are pertinent to water use.

> A fundamental question asked by the Alaska Miners Association and ADF&G's Su Hydro Team was "what permitted or licensed water use rights presently exist in the Susitna River basin?" Two additional questions raised by ADF&G's Su Hydro Team and Susitna Power Now were: whether operation of the dam would allow present day out-of-stream diversions to be maintained; and whether postproject flows would result in a change of water table conditions that would adversely affect domestic wells or surface water supplies. DNR's Water Management Section staff indicated that Susitna River basin water rights applications had not been adjudicated, but doubted that any existing out-of-stream diversions would be affected by the proposed Susitna hydroelectric project.

### Questions

The following answers are provided to questions concerning project effects on downstream water rights. These answers are based on a report entitled, "A Review of Existing Water Rights in the Susitna River Basin" (5).

Present Day Out-of-Stream Diversion and Future Water Right

No surface water withdrawals from the Susitna River are on file with DNR. Within a one mile corridor along the mainstem Susitna River, only .153 cfs or 50 acre-feet per year (ac-ft/yr) of surface water has been appropriated for all purposes. These surface water appropriations occur on small clear water tributaries to the Susitna River that will not be affected by the project. The only significant uses of surface water in the Susitna River basin occur in the headwaters of Kahiltna and Willow Creek. The principal use of this water is for mining operations on a seasonal basis. Water appropriations are 125 cfs or 37,000 ac-ft/yr in the Kahiltna area and 18.3 cfs or 5,660 ac-ft/yr in the Willow Creek area.

There is only one area where surface water appropriations are located within one mile of the mainstem Susitna River. In the vicinity of Sherman, at mile 258 of the Alaska Railroad, Sherman Creek and an unnamed stream have been appropriated for two single family dwellings (325 gallons per day (gpd)) and law and garden irrigation (50 gpd). The surface water appropriations at Sherman are 50 to 100 feet above the present elevation of the Susitna River and would not be influenced by changes in water surface elevation of the Susitna River. Future use of these surface water appropriations is not likely to be affected by construction or operation of the proposed Susitna hydroelectric project.

Domestic Wells Along the River Corridor and Future Water Rights

There are only four areas where groundwater appropriations are located within one mile of the mainstem Susitna River.

Immediately downstream from the Delta Islands, on the west bank of the Susitna River, a single family dwelling has a certificate for 650 gpd of groundwater from a well of unlisted depth. The certificate includes .5 ac-ft/yr for crop irrigation for three months. About six miles below Talkeetna, and 0.25 miles inland from the west bank of the Susitna River, a single family dwelling has a certificate for 500 gpd of groundwater from a 90-foot deep well. Postproject water surface elevations for the mainstem river below Talkeetna are expected to be approximately three feet higher during winter months and from one half to one and a half feet lower during the summer months. Such a moderate range of fluctuation is not expected to adversely affect the groundwater zones being tapped by two small capacity domestic wells in the Delta Islands and Trapper Creek areas.

In Talkeetna, groundwater from three shallow (20, 27, and 34 feet) wells have been appropriated for a single family dwelling (500 gpd), the grade school (910 gpd), and the fire station (500 gpd). In the vicinity of Chase, between mile 235 and 236 of the Alaska Railroad, several unnamed streams, lakes, and creeks have been appropriated for single family dwellings (1,250 gpd), lawn and garden irrigation (100 gpd), and crops (1 ac-ft/yr).

The three shallow wells (20- to 34-foot depth) recorded in Talkeetna are approximately 1.5 miles downstream from the confluence of the Chulitna and

Susitna Rivers and 0.13 miles downstream from the confluence of the Talkeetna River. From all visual indications, the Talkeetna River appears to be up gradient and is the principal recharge source for these wells. It appears that the water surface elevation of the Susitna River could be influencing the groundwater level by providing the down gradient base elevation for the water table. However, the anticipated maximum decrease in average monthly water surface elevation of the Susitna River near Talkeetna is forecast to be from one to one and a half feet. At worst, this might reduce the water surface elevations of the local water table one to one and a half feet.

In the vicinity of Chase, all surface water appropriations are from small tributary streams and lakes at an elevation of 450 to 500 feet mean sea level (msl). The Susitna River is approximately 0.25 miles from the nearest appropriation and is at an elevation of approximately 400 feet msl. The anticipated change in water surface elevation for the mainstem Susitna River near Chase is unlikely to have any affect on surface water diversions from small streams or lakes located 50 to 100 feet above the river on the hillsides.

Future use of the groundwater appropriations is not likely to be affected by construction and operation of the proposed Susitna hydroelectric project.

## Riparian Vegetation and Wildlife Habitat

### Introduction

Although a number of groups contacted during the instream flow survey acknowledged that riparian vegetation is important, there were few specific questions raised.

The effect of postproject flows on maintaining moose habitat in the lower reaches of the Susitna River was often mentioned as a possible impact on hunting, as were the effects of postproject flows on boat access to the hunting areas. The major concerns focused on whether or not postproject flows would maintain a disturbed environment conducive to the production of moose browse. USFWS's Western Alaska Ecological Services questioned whether flows to maintain early seral stages of vegetation would need to be designed into the project operation as part of the mitigation plan. However, the U.S. Soil Conservation Service (SCS) felt this would not be necessary. SCS was doubtful whether project-induced vegetation changes below the Chulitna River confluence would be measurable.

### Questions

The following statements are provided in reply to those questions raised during the instream flow survey that pertain to project effects on riparian vegetation and wildlife habitat. The responses are based in information developed by TES.

Surface Area of Various Vegetation/Habitat Types in the River Corridor

Data have been compiled on the characteristics of each dominant species for each vegetation type described below, and the portion of the river corridor occupied by each vegetation type has been mapped.

A vegetation/habitat map at a scale of 1:24,000 was prepared for the floodplain from Devil Canyon to Talkeetna. An estimate of the relative amount of each major vegetation/habitat type within the floodplain downstream to the Delta Islands was also prepared. This estimate was based on aerial checks of points placed along transects running parallel to the long axis of the floodplain.

For the purposes of impact analysis, an estimate was made on the amount of land on the floodplain that would be exposed at postproject flows. This estimate was made for the Devil Canyon to Talkeetna reach. This exposed land would potentially be invaded by vegetation, and, barring future disturbance, eventually develop into later successional stages.

Natural Succession of Vegetation

Vegetation types in the floodplain of the Devil Canyon to Talkeetna reach were studied by TES during summer 1981 and are described generally as follows. Project effects on vegetation succession were not quantified, although an estimate of the amount of land exposed, and thus available for vegetation invasion, was prepared.

1. Early succession stages -- those commonly found on the floodplain were dominated by horsetail, horsetail-willow, horsetail-balsam poplar, balsam poplar, or dryas vegetation. Horsetail was generally the first species to invade silty or sandy sites. Willow and balsam poplar did not become established until after horsetail, and alder appeared two to three years later.

2. Mid succession stages -- vegetation was characterized by thin leaf alder or by immature balsam poplar, which had developed into tall shrubs or trees. The alder type is the first phase of the mid-succession stage. Deposition of sand and silt to elevate sites above the level of frequent flooding and disturbance from ice and flood water appeared to be necessary for the transition to this state.

3. Late succession stages -- these are characterized by mature balsam poplar or by birch-spruce stands that replace decadent balsam poplar on more stable sites. Birch-spruce stands were the most diverse of all vegetation types found on the floodplain. There was some

evidence that these stands are self-perpetuating, that is, upon overmaturity, the birch overstory falls, making the spruce more susceptible to wind throw, thereby allowing a paper birch shrub-alder/highbush cranberry-prickly rose community to become established. The shrub community then advances again to the birch-spruce forest condition. The woody species composition and density of the seral brush phase makes it ideal moose habitat, especially as it is interspersed with the more mature forest.

Production of Moose Browse in Lower River

Streamflows would be substantially reduced in the river segment above Talkeetna during the growing season (May to September). Seasonal floods would essentially be eliminated. As a result, some of the presently unvegetated bank areas in the reach from Devil Canyon to the Susitna-Chulitna River confluence would begin to develop horsetail, dryas, willow, and balsam poplar communities. TES is currently preparing an estimate of the amount of surface area this would involve. Barring disturbances from ice jams (an ice cover is not expected to form on the river above Talkeetna), willow and balsam poplar saplings would develop within five years of the last disturbing influence on sites presently having sandy or silty substrates.

Establishment of significant vegetative cover on rocky sites may require several decades; even then, vegetation would be dwarfed and slow-growing for several more decades. Floodplain areas above the 40,000 cfs water line are presently vegetated. Below that elevation, most of the river channel consists of a rocky substrate, not conducive to supporting lush plant growth. Consequently, the overall potential for an increase in vegetation to occur within this reach of the river is limited. The most notable changes would occur in the side channel slough areas where more suitable soil conditions are found.

Since the Devil-Canyon-to-Talkeetna reach of the river is expected to remain largely ice-free, a principal environmental force maintaining early successional vegetation would be removed. This would allow existing early successional vegetation to advance toward more mature types.

Below Talkeetna, the effects of changes in seasonal streamflows would be moderated by the unregulated inflows of the Chulitna and Talkeetna Rivers. While the degree of moderation is uncertain, trends in vegetation responses can be forecast. For example, the primary effect of decreased summer flow would be the opportunity for early successional vegetation to become established on sites that are presently submerged by summer flows. A general tendency would exist for early successional stands to migrate toward the postproject high water mark, while those existing successional stands that would be less affected by high flows would develop toward more mature vegetation types. Trends of this nature, however, may be somewhat masked by periodic floods, caused by the contributions from the unregulated Chulitna and Talkeetna Rivers. Quantification of the area that may be involved in these trends is difficult to predict.

The time required for early successional stands of willow and balsam poplar to develop into mid-successional stages of immature balsam and alder is roughly equal to six to eight years. That is approximately the same amount of time required for establishment of new early successional stands. Thus, the total area covered by the new stands is expected to be nearly equal to that lost to mid-successional vegetation (2).

# River Based Recreation

## Introduction

Many groups contacted during the instream flow survey indicated an interest in this topic. Questions and comments often reflected preconceived personal biases rather than an objective consideration of project effects on recreational use.

> The potential for increased recreational opportunities was recognized by several groups, but both DNR's Water Management Section and the ADF&G's Su Hydro Team questioned the public's acceptance of reservoir recreation as a replacement to an established riverine use in the upper basin. The proposed reservoirs are expected to be very deep glacial lakes with a precipitous shoreline and fluctuating water surface. Such characteristics are not expected to draw many reservoir recreationists.
>
> Several groups, such as the U.S. Heritage, Conservation, and Resource Service concentrated on recreational opportunities that would be lost. BLM's Resources Section questioned to what extent the aura of the wild and scenic aspects of the river would be degraded, while the Anchorage fish and Game Advisory Committee and ADF&G;s Sport Fish Division were interested in quantifying project impacts on fishing success. Many respondents raised questions and offered comments pertaining to project affects on sportfishing.

## Questions

The following statements are provided as a preliminary indication of the effects that the proposed Susitna hydroelectric project is likely to have on various recreational uses that are currently made of the river corridor. Responses are based on information developed by TES.

Winter Travel on River Ice Cover

In the winter, the Susitna River is used as an avenue of transportation by dogsleds and snowmobiles. These means of transportation are principally used for subsistence hunting, trapping, and local travel by residents. There are river crossings at Willow, Kashwitna, Talkeetna, and Montana Creeks; however, these crossings receive less use than before the construction of the Parks Highway (B. Anderson, pers. comm.) Dogsled races are held at Montana Creek every weekend, and the course crosses the river (B. Anderson, pers. comm.). Very limited recreational travel occurs along in the river corridor during winter months.

Ice studies conducted by Acres have predicted that, during project operation, an ice cover is unlikely to form on the Susitna River between Devil Canyon dam and Talkeetna. This would preclude the continued use of this section of river for winter travel by snowmobiles and dogsleds.

A stable ice cover is expected to continue forming below Sunshine, so winter travel in this area should not be affected. Ice cover conditions from the confluence area downstream to the Sunshine area are not well determined. Thus it is unclear to what degree winter travel might be affected in that area.

Status of the Susitna River as a World-Class Whitewater River

The Susitna River is highly regarded and utilized by rafters and kayakers. The rapids of Devil Canyon are considered world class whitewater, but few kayakers have successfully negotiated the gorge. The impoundments would inundate a river segment that presently receives relatively low levels of boating and rafting use. Kayaking through Vee Canyon and Devil Canyon would be eliminated. In place of these activities, the reservoirs would provide a seasonal opportunity for slack water boating. Rafting and kayaking would likely continue downstream of Devil Canyon.

Recreational Opportunities Associated with the Reservoirs

Presently, there are no publicly developed recreation facilities within the vicinity of the project. The only recreation facilities in this area are three privately owned lodges, which are used chiefly for fishing, hunting, boating, hiking, and skiing. Access to these lodges is primarily by air. In addition to the lodges, there are also numerous private cabins in the project area. These cabins are generally utilized by individual owners on a seasonal basis for hunting, fishing, trapping, and other recreational activities.

TES has developed a tentative plan for recreation development of the impoundments, which is still subject to approval by the Alaska Power Authority and review by other agencies.

According to the TES plan, the greatest concentration of use is expected to occur near the Devil Canyon and Watana dam sites, where there would be access to the reservoirs. Recreation facilities to be provided include developed auto campgrounds, picnic grounds, boat launches, and parking areas. Emphasis would be on rustic facilities with a minimum level of services and a maximum of natural aesthetic features.

The Devil Canyon dam would serve as a focal point for recreational activities. A mix of day-use and overnight facilities would be available to visitors. Day-use facilities available at the dam site would include picnic and rest areas with orientation and interpretive information and a scenic overlook of the reservoir. Recreational development at Devil Canyon reservoir is somewhat limited by the reservoir's narrow gorge and steep canyon walls. Farther up the impoundment, the slopes more suitable for the development of recreational facilities.

Watana reservoir would probably receive low-volume, dispersed use, mostly for boating, hunting, and sightseeing activities. Access to the reservoir would be via a boat ramp and parking area at Deadman Creek.

Wild and Scenic Aspects of the Susitna River

Watana reservoir, at full pool, would extend upstream approximately fifty miles, and approximately four miles into the Watana Creek drainage. Thus the reservoir would have an average width of one mile, and a maximum width of nearly five miles. Devil Canyon reservoir would be about 25 miles long and one-half mile wide. These reservoirs would replace a 75-mile segment of river canyon with more than 70 square miles of visible surface area. The effect of this change on the wild and scenic aspects of the river has not been quantified. However, there are no plans to do this (K. Young, pers. comm.).

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