Acres Amercian, Appendix A
Hydrological Studies,
Susitna Hydroelectric Project
Feasibility Report
Pages A-4-5 through A-4-8

Model results generally confirmed that single power intakes capable of drawing water at the lowest operating levels of the reservoirs would be unable to meet the minimum downstream temperature requirements of 42.5°F during summer (Section 3). In most months, draw off nearest to the reservoir surface yielded outflow temperatures closest to natural temperatures. An intake structure design with such capability to draw water at or close to the surface over the entire drawdown range of the reservoir at Watana was developed but not found to be cost-effective when compared to a relatively simple multi-level structure with four discrete opening levels. The latter configuration in combination with a single power intake at 70 feet below the reservoir operating level of 1455 feet generally provided downstream flow temperatures well above the minimum required during the summer months June through September.

In winter, the two reservoirs reach fairly close to isothermal conditions with water temperature around 39°F. The model is relatively crude in its representation of ice formation in the reservoir and the anamodous expansion of water between 39°F and 32°F. This results in the inability of the model to define winter temperature profile clearly in this range (see Figures A4.8 and A4.10). If thus appears that winter and outflow temperature will be close to 39°F no matter where the water is drawn. It is, however, logical to assume that somewhat cooler water may be drawn from close the surface below the ice cover when formed. Figures A4.7 and A4.10 present monthly temperature profiles in the two reservoirs. Plates A4.1 shows general arrangement of the selected intake facility at Watana.

Typical computer output for Watana and Devil Canyon temperature modeling are presented in Attachment 1.

3 - TEMPERATURE REGIME OF SUSITNA RIVER BELOW DAMS

3.1 - Introduction

An in-house computer model was used to study the temperature regime of the river below the dams. The Susitna River between the damsites and the confluence of the Chulitna River is divided into representative reaches. These reaches are selected to model effectively the hydraulic characteristics of the river. A daily heat balance in this series of river reaches is simulated in the model to determine the water temperature at the downstream end of each reach. The components of heat exchange used in the balance, determined from empirical relationships presented by Michel (3) are shown in Figure A4.11. Several other possible sources of heat such as the conduction of heat from within the ground and heat gained or lost from ground water flows have been neglected because of their relatively small magnitude.

The procedure involves a daily heat balance to be made stepwise starting from the upstream section of the first reach to the downstream section of the reach. The water temperature, calculated from the net exchange at the end of the first reach, is then used as the starting temperature of the second reach. This process was continued until water temperatures in all the reaches had been calculated. At each step, the net heat exchange was added to the volume of water passing through the sections.

3.2 - Data Input

The coefficients required for the computation of the components of heat balance are insolation, emissivity and albedo. These coefficients are described below:

- Insolation Coefficient is an index of energy transferred to the water due to solar radiation;

- Emissivity Coefficient is a measure of the radiation emitted by a surface. For water, the emissivity has a very small variation with temperature; and

- Albedo for Water is an index of the amount of the atmospheric radiation absorbed by the body of water.

The values of the insolation, emissivity and albedo coefficients adopted for the analysis are 0.97, 0.97, and 0.1, respectively. These values are the generally accepted values for water (3).

Long-term climatic records at Talkeetna and Summit collected by NOAA have been used as input in the analysis. The principal climatic parameters used in the model are average daily air temperature, ratio of recorded sunshine to maximum possible sunshine, wind speed, precipitation, barometric pressure, and relative humidity. Air temperature and the sunshine ratio are the two most important parameters of this set.

In the analysis, the average daily air temperature has been assumed to be the average for the period of record (1941-70) for Talkeetna and Summit Stations. The average temperatures of the two stations are used for the upper reaches (above Devil Canyon), since this portion of the river is at an intermediate elevation and latitude. Average Talkeetna daily air temperatures are used in the lower river reach. The ratio of bright sunshine to maximum possible sunshine is taken from the average number of clear, partly cloudy, and cloudy days for each month over the period of record for Summit, and have been given values of 0.9, 0.5, and 0.2, respectively.

The other climatological parameters such as wind speed, rainfall, snowfall, barometric pressure, and relative humidity are taken as the average monthly values at Summit for the period of record. The average monthly values of these variables were determined to be adequate due to their relatively small impact on the estimation of the change in water temperature.

The model in this analysis does not reflect the diurnal variations in water temperatures. In winter, this diurnal change in the water temperature may have a significant variation about the daily mean due to the normal range in air temperatures.

3.3 - River Characteristics

In computing the heat balance of a river system, the model requires specific inputs which describe the hydraulic characteristics of the river and the flow conditions. The study section of Susitna River has been divided into 20 reaches from the Watana damsite to Talkeetna. Each of these reaches comprises several sub-reaches which have been surveyed (see Hydrographic Survey Report, Subtask 2.16) and is evaluated to determine relationships which would describe the mean velocity and average depth for a given discharge. The U.S. Army Corps of Engineers backwater program (HEC-2) has been used to obtain average depths and velocities at various discharges (4). A power curve fitting routine is then used to determine the relationship between mean velocity and depth flows.

As explained in Section 2, monthly water temperatures at Watana were synthesized from Gold Creek and Cantwell data. These data have been used to generally calibrate the model to simulate natural temperature regime in the reach above the Chulitna confluence and Watana damsite.

3.4 - Model Verification

During the summer of 1981, several thermographs were installed along the river by the Alaska Department of Fish and Game (ADF&G) as part of fisheries habitat studies (see Volume 2 of main report). Processed data from selected stations are now available (Table A4.5). Simultaneous data collected at Watana is also presented in Table A4.5.

No water temperature data at Watana is available for July 1981 due to a malfunction of the instrument. Difficulties with monitoring equipment at Watana and Devil Canyon resulted in poor data recovery in the months July through September 1981. Thus it was decided to use the observed water temperature at river Section 61 upstream of Portage Creek for the period of July 17 to September 30, 1981 along with simultaneous flows at Gold Creek and Talkeetna climatic parameters as input to the HEATSIM model and formulate the river stretch for over 20 miles to generate water temperatures at cross-sections 54, 47 and 34. These temperatures were compared with the observed water temperatures during this period. Table A4.6 shows that on the average monthly temperatures simulated and observed compare favorably (± 1°F) except for the river Section 54 which may be due to local floods, lack of tributary flow and temperature data or gross averaging effects of the model procedures. However, the closeness of results suggest that the physical heat exchange processes are modeled reasonably and that the model may be used to estimate post-project river conditions.

3.5 - Environmental Considerations

In order to establish target water temperatures to be achieved in the river reaches below the dams, extensive discussions were held with the fisheries study team and ADF&G. It was decided that a minimum temperature of around 42.5°F should be reached in the river below the dams during the predominant salmon runs between early June and mid September. Higher temperatures would, however, be advantageous during the months of July and August. To take account of model accuracy as interpreted from the calibration and verification procedures, a minimum summer outflow temperature of 45° was set as target temperature below the dams and several iterations for power intake levels were made until target temperatures were achieved. The winter temperatures of 39°F will be somewhat detrimental to the fisheries, but lower water temperatures as one progresses further downstream from the dams reduces such adverse impacts. Impacts of fisheries of the temperature regime in the river under post-project conditions are discussed in Volume 2 of the main report.

3.6 - Model Analyses and Results

The calibrated model was used to determine the temperature regime of the river below the dams for the following phases of development:

- Filling sequence of the Watana reservoir;
- Operation of the Watana development only; and
- Operation of both Watana and Devil Canyon developments.

The chief concern during the filling sequence of the Watana reservoir lasting over three summers is that the minimum flow releases from the reservoir will be made through the low level discharge facilities (Section 15, Volume 1 of the main report). Temperature of this discharge is estimated to be close to 39°F all through the year. HEATSIM modeling of the river reach below the dam up to the confluence of Chultina was made and results presented in Table A4.7. A river reach of over 10 miles in the Devil Canyon area between Devil Creek and just above Portage Creek are not modeled due to lack of river cross-section and inability to model the rapids. It is estimated that the temperature regime presented in Table A4.7 would be somewhat conservative.

Results of the model runs are presented in Tables A4.8 to A4.11 for reservoir operations in average, wet and dry years of record as well as for Case A and D operations. Figures A4.12 to A4.17 present these results along with simulated natural water temperatures at selected rivers sections below the dams.

It should be emphasized that the temperature modeling though performed on a daily basis is only a tool to predict average monthly conditions due essentially to gross discretion of all input parameters. The results are believed adequate to picture the post-project effects on the river thermal regime to assess environmental impacts. More detailed data collection program should be initiated to enable use of sophisticated modeling of the reservoir operations and river characteristics in later phases of work.

4 - MICROCLIMATIC CHANGES DUE TO THE IMPOUNDMENTS

A preliminary assessment of the microclimatic changes at and downstream of the proposed impoundments was made and the following sesctions discuss the findings.

4.1 - Temperature

On the average the reservoir will be ice covered during the period from October through April and, although shoreline cracking may occur as a result of drawdown, the area of exposed water will be insufficient to cause any significant temperature change.

During the period from May through September when the reservoir is expected to be ice free, the surface water temperature will range from 15°F below the average daily maximum to some 5°F above the average daily minimum air temperatures.