Susitna-Watana Hydroelectric Project Document
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1.1. Title of proposed Study

Ice Processes in the Susitna River

1.2. Requestor of proposed study

AEA anticipates resource agencies will request this study.

1.3. Responses to study request criteria (18 CFR 5.9(b))

1.3.1. Describe the goals and objectives of the study and the information to be obtained

- Document ice processes in the Susitna River.
- Model ice processes (including flow routing) in the Susitna River in order to estimate the potential for changes for a range of project operations.
- Provide ice processes data to fisheries, Instream flow, riparian, geomorphology, and groundwater studies.
- Assist Water Quality Modeling Study with reservoir ice predictions.

1.3.2. If applicable, explain the relevant resource management goals of the agencies and Alaska Native entities with jurisdiction over the resource to be studied.

To be completed by the requesting entity.

1.3.3. If the requester is a not resource agency, explain any relevant public interest considerations in regard to the proposed study.

Fisheries and aquatic resources are owned by the State of Alaska, and the Project could potentially affect these public interest resources by affecting ice processes.

1.3.4. Describe existing information concerning the subject of the study proposal, and the need for additional information.

Ice Process Documentation

- Ice processes were documented between the mouth of the Susitna River (RM 0) and the dam site (RM 184) between 1980 and 1985. Both freeze-up and breakup progression were monitored using aerial reconnaissance. Locations of ice bridges during freeze-up and ice jams during breakup were recorded each season. One winter, a time-lapse camera was installed in Devil Canyon in order to observe ice processes through the narrow, turbulent rapids.
- Additional ice data were collected to calibrate a model. These included ice thicknesses, top of ice elevations, air and water temperatures, slush ice porosity, and frazil density.

- Other entities (National Weather Service, USGS, and Army Corps of Engineers) have also collected ice thickness, breakup, and freeze-up data in various locations on the river, although these data were not collected for the purpose of understanding the potential effects of the dam. These data are available upon request from the agencies.

Ice Process Modeling

- Freeze-up and melt-out processes in the Middle River (between Gold Creek and Talkeetna) were modeled using ICECAL, a numerical model developed by CRREL. The model utilized the outputs from a temperature model developed for the river (SNTEMP), and empirical data on frazil production and ice-cover progression derived from observations. Both the Watana-only and Watana-Devil Canyon operations were modeled for a range of meteorological conditions. The results of the model included predictions of the extent of ice cover for cold, average, and warm winters, the timing of ice cover progression for this range, and the inundated area below the ice cover for selected cross-sections. Empirical data on frazil production and ice cover progression was used to estimate changes in ice cover progression up to Talkeetna.

Need for Additional Information

- Additional documentation of ice processes is needed to verify that locations of ice bridges, leads, ice jams, and timing of ice cover progression are similar to conditions observed in the 1980s. Ice bridging, leads, and ice jams are all influenced by channel geometry, and, in some cases, tributary mouth locations. In some cases, this geometry may have changed. In addition, the location of early freeze-up season frazil production varied significantly between study years. An assessment is needed to determine the importance of the Upper and Middle Susitna River in frazil production for a range of meteorological conditions.

- The ICECAL Model only simulated conditions upstream of Talkeetna. Under the proposed operations scenario, winter discharges would be higher than the natural range of variability downstream of the three-rivers confluence in Talkeetna.

- The ICECAL Model did not simulate flow fluctuations with a time-period shorter than one week, whereas it is likely that daily flow fluctuations will be considered when determining project operations.

- Updated fish habitat and geomorphology studies are needed to assess where ice processes may be important. In addition, updated ice modeling is needed to assess where project effects on fish habitat, geomorphology and riparian vegetation may be concentrated.

- Details on reservoir ice processes for the current project configuration are not available.

1.3.5. Explain any nexus between project operations and effects (direct, indirect, and/or cumulative) on the resource to be studied, and how the study results would inform the development of license requirements.

Project operations have the potential to directly influence ice formation and breakup in the following ways:

- Increased winter water temperature released from the reservoir will limit ice cover for some distance below the dam.
- The dam will restrict frazil ice produced in the upper basin from accumulating downstream. There is evidence that frazil ice from the upper river contributes to ice front progression on the lower river, thus the dam could slow ice cover progression in the lower river.
- Increased winter flows will result in a more extensive ice cover and winter water stages higher than the natural range of variability in the ice-covered reaches.
- Flow fluctuations in the winter have the potential to affect the stability of the winter ice cover.
- Lower spring snowmelt flows will reduce the severity of breakup on the Middle River. Higher water temperature releases from the reservoir may cause ice to thin and melt in place earlier.
- The reservoir area will behave differently than the narrow channel in the winter.

Indirect effects of increased winter stages and decreased breakup stages include the following:

- Sediment transport during the winter may increase with increased flows, as well as turbidity.
- Wetted perimeter will increase in the winter, and sloughs and side channels that are not currently connected to the mainstem under winter flow conditions may become inundated by mainstem flow. This could increase flow velocities and decrease temperatures compared to winter conditions in sloughs that are currently fed by seeps.
- There is some evidence that ice jams are partially responsible for creating and maintaining sloughs and some side channels in the Middle River. If ice-jam stages are generally lower post-Project because of delayed snowmelt peaks, slough habitats may experience less scour.

Utilizing the results of ice processes studies, modifications to Project operations to decrease the likelihood of adverse effects owing to altered ice processes can be evaluated. Operational modifications could include different reservoir release elevations to regulate temperature of flow releases, limitations on load-following flow fluctuations during the winter, and limitations on maximum winter flows.

1.3.6. Explain how any proposed study methodology (including any preferred data collection and analysis techniques, or objectively quantified information, and a schedule including appropriate field season(s) and the duration) is consistent with generally accepted practice in the scientific community or, as appropriate, considers relevant tribal values and knowledge.

Proposed study methods include the following:

- Aerial reconnaissance and GPS mapping of ice features, including ice jams, ice bridges, frazil accumulations, and open leads during the breakup and freeze-up periods, Spring 2012-Spring 2014.

- Time-lapse camera monitoring of breakup and freeze-up at selected locations corresponding to flow routing model instrumentation and key fish habitat, in coordination with the fisheries studies.

- Field data collection in the Susitna River, including ice thickness and elevation measurements, Spring 2012-Spring 2014.

- Development and calibration of a dynamic thermal and ice processes model, in coordination with the Water Quality Modeling Study. The model would provide the ability to model river water temperature, ice cover progression and decay, ice cover extent and thickness, and the effects of flow fluctuation on ice cover development and stability. The model would also provide flow routing capability.

- Review and summarization of existing cold-regions hydropower projects and the effects of their operations on ice-covered rivers.

Ice processes field observation standards follow those of EM-1110-2-1612, Ice Engineering, developed by the Army Corps of Engineers. Modeling of dynamic ice-cover progression is still a relatively underdeveloped field. A one-dimensional dynamic and thermal ice model (either CRISSP1D, developed at Clarkson University, or River1D, developed at University of Alberta) with flow routing capability will be adapted for the Susitna River between the dam site and Talkeetna. Water temperature inputs to the river ice model will be obtained from empirical data or the reservoir water temperature model. If necessary, CRISSP2D or River2D will be used to model short reaches where additional ice process detail is needed. There isn't currently an accepted model that can predict dynamic ice processes on complex braided channels such as found in the Lower Susitna River below the three rivers confluence. A largely empirical approach, relying on repeat observations and simple models such as HEC-RAS, will be used to assess the level of impacts expected in the Lower River. If this approach, in conjunction with the results of the flow routing modeling (see Instream Flow Study) and water temperature modeling (this study and Water Quality Modeling Study), indicates that additional information is needed, then AEA will consult with stakeholders.

The one-dimensional ice model will also be used for flow routing and water temperature modeling during the freeze-up, ice-covered, and melt-out period, approximately between October and mid-May. Ice and flow routing effects to winter fish habitat, riparian vegetation, geomorphology, and groundwater will be handled in the Instream Flow, Riparian Instream Flow, Fluvial Geomorphology Modeling, and Groundwater-Related Aquatic Habitat studies, respectively.

If applicable, the ice process study will provide river ice data to the Water Quality Model Study to assist with reservoir ice modeling.

1.3.7 Describe considerations of level of effort and cost, as applicable, and why any proposed alternative studies would not be sufficient to meet the stated information needs.

Level of effort for field work will depend on the data needs of the chosen model, and related disciplines such as fisheries, instream flow, riparian, geomorphology, and groundwater. Below is a rough estimate of costs associated with field documentation and model development in 2013-2014, which are the major components of the ice study.

- Documentation of ice observations is anticipated to cost $850,000-$1.3 million for the Spring 2013-Spring 2014 seasons (two breakup and one freeze-up, plus winter ice thickness and elevation surveys). This does not include costs for additional transect surveys to augment model geometry, if that data becomes necessary.

- Assuming a year-long modeling effort will be required, development and calibration of ice routines for the thermal and hydraulic model is anticipated to cost between $800,000 and $1.5 million. The cost will depend on the length of the modeled reach, and the extent to which model code will need to be developed in order to adapt the model to the Susitna River.

1.3.7. Literature Cited

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