G-S4: Reconnaissance Level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel – DRAFT FINAL

Introduction

The Alaska Energy Authority (AEA) is preparing a License Application that will be submitted to the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project (Project), using the Integrated Licensing Process (ILP). The Project is located on the Susitna River, an approximately 300-mile-long river in the Southcentral region of Alaska. The Project's dam site will be located at River Mile (RM) 184. The results of this study and of other proposed studies will provide information needed to support FERC's National Environmental Policy Act (NEPA) analysis for the Project license.

Construction and operation of the Project as described in the Pre-application Document (PAD; AEA 2011) will affect the timing and magnitude of flow, sediment supply, and sediment transport capacity, which have the potential to alter aquatic habitat and channel morphology in the Lower Susitna River. Understanding existing aquatic habitat and geomorphic conditions, how those conditions change over a range of stream flows, and how stable/unstable the conditions have been over recent decades will provide a baseline that will be needed to predict potential aquatic habitat and geomorphic changes that could occur due to the Project.

The types, magnitudes, and extents of Project impacts on morphology are influenced by water and sediment inflow from tributaries downstream of the Project and the geology through which the river flows. As major tributaries join the Susitna, the impact of the dam on hydrology and sediment supply can be attenuated by the flow and sediment contributions from the tributaries. Two major tributaries, the Talkeetna and Chulitna Rivers, approximately double the flow near the upper end of the Lower River. These tributary influences result in the Lower River exhibiting different geomorphic characteristics than the Middle River and may lead to different responses to the Project than may occur in the Middle River.

Study Objective

The objective of this study is to assess, at a reconnaissance level, the potential for the Project to affect aquatic habitat and channel morphology in the Lower River. The specific objectives are as follows:

- Evaluate the relative magnitude of changes to the flow regime pre and post-Project;
- Assess potential changes to channel morphology and aquatic habitat pre and post-Project;
- Evaluate the relative magnitude of changes to the sediment regime pre and post-Project; and the potential impacts on sediment/substrate gradations, as well as vertical and lateral stability of the channel;

- Delineate large-scale geomorphic river segments with relatively homogeneous characteristics (e.g., channel width, lateral confinement by terraces, entrenchment ratio, sinuosity, slope, bed material, single/multiple channel, hydrology) for the purposes of stratifying the river into study segments.
- Conduct a geomorphic assessment of historic channel change and its drivers as well as determine whether changes have affected the frequency and distribution of meso-habitat units; and
- Provide information to assist AEA and licensing participants to develop the 2013-2014 study plans.

STUDY AREA

The study area includes the Lower River reach from the mouth of the river at Cook Inlet (RM~ 0) upstream to and including the three rivers confluence (RM~98).

NEXUS BETWEEN PROJECT AND RESOURCE TO BE STUDIED AND HOW THE RESULTS WILL BE USED

Project operations will change the timing and magnitude of flow, sediment supply and sediment transport capacity which have the potential to alter channel morphology and aquatic habitat in the Lower River. Results of this study will provide the initial basis for assessing the potential for changes to the Lower River reach morphology due to the Project. Additional studies will be planned for 2013-2014 if the results of this study plan identify a potential for channel adjustments and associated changes to important aquatic habitat in response to the Project.

Issues associated with geomorphic resources in the Lower River reach for which information appears to be insufficient were identified in the PAD (AEA 2011), including:

- G16: Potential effects of reduced sediment load and changes to sediment transport as a result of Project operations within the Lower River.
- F19: The degree to which Project operations affect flow regimes, sediment transport, temperature, water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity.

EXISTING INFORMATION

An analysis of the Lower River reach and how riverine habitat conditions change over a range of stream flows was performed in the 1980s using aerial photographic analysis (R&M Consultants, Inc. and Trihey and Associates 1985a). This study evaluated the response of riverine aquatic habitat to flows in the Lower River reach between the Yentna River confluence (RM 28.5) and Talkeetna (RM 98) (measured at Sunshine gage RM~75) ranging from 13,900 cfs to 75,200 cfs. The study also included an evaluation of the morphologic stability of islands and side channels by comparing aerial photography between 1951 and 1983.

In another study, 13 tributaries to the lower Susitna River were evaluated for access by spawning salmon under existing and with proposed stream flows for the original hydroelectric project (Trihey and Associates, 1985b). The study contains information regarding run timing, mainstem and tributary hydrology, and morphology. Based on the results of this study, it was concluded that passage for adult salmon was not restricted under natural flow conditions nor was passage expected to become restricted under the proposed Project operations.

The *AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report* (URS 2011) states that "if additional information is collected, the existing information could provide a reference for evaluating temporal and spatial changes within the various reaches of the Susitna River." The gap analysis emphasizes that it is important to determine if the conditions represented by the data collected in the 1980s are still representative of current conditions, and that at least a baseline comparison of current and 1980s morphological characteristics in each of the identified subreaches is required. This comparison should include not only an identification of change, but should consider if the relative proportion of the various meso-habitat types remain constant within a reach.

METHODS

Work conducted for the 2012 *G-S4: Reconnaissance-Level Geomorphic and Aquatic Habitat Assessment of Project Effects on Lower River Channel* study will quantify the magnitude of change associated with stream flow, riverine habitat features, and sediment transport under the existing pre-Project and proposed post-Project conditions. In addition, a geomorphic assessment of channel change will be conducted. The following sections describe the specific analyses that will be performed.

Stream Flow Assessment

Comparison of Pre- and Post-Project Stream Flow

Pre-Project and available post-Project hydrologic data will be compared. This will include a comparison of the monthly and annual flow duration curves (exceedance pots) and plots/tables of flows by month (maximum, average, median, minimum) for the Susitna River at the Sunshine and Susitna Station gaging stations. Additional hydrologic indicators may be used to further illustrate and quantify the comparison between pre- and post-project stream flows. The pre-Project data analysis will include the extended record being prepared by the United States Geological Survey (USGS). The Post-project data will be provided with and without consideration for climate change over the next 50 to 100 years.

Comparison of Pre- and Post-Project Flood Frequency and Flood Duration at the Sunshine and the Susitna Station Gages

Using the extended record currently being prepared by the USGS, a flood-frequency and flood-duration analysis for pre- and post-Project annual peak flows will be performed. The post-Project data will be provided with and without consideration for climate change over the next 50 to 100 years. The flood-frequency analysis will be performed using standard hydrologic practices and guidelines as recommended by USGS (1982).

Riverine Habitat-Flow Relationship Assessment

River Stage

A tabular and graphical comparison of the change in water surface elevations associated with the results of the pre- and post-Project stream flow assessment (above) will be developed using the stage-discharge relationships (rating curves) for the Sunshine and Susitna Station gaging stations. This comparison will include monthly and annual stage duration curves (exceedance plots) and plots/tables of stage by month (maximum, average, median, minimum). Additional parameters to describe and compare the pre- and post-Project water surface elevations may be performed. A graphical plot of a representative cross section at each gaging station will be developed with a summary of the changes in stage (water surface elevation) for the two flow regimes. If the historic gage shift information is available, a specific gage analysis will be conducted to determine the relative stability of the channel section at the two gaging stations. If possible, the location of the active channel and the floodplain will also be identified on the cross section.

The availability of USGS winter gage data with respect to discharge and ice elevation/thickness will be investigated. Coordination with the *WR-S2: Documentation of Susitna River Ice Breakup and Formation Study* will occur to obtain information on ice elevation/thickness, as appropriate. The potential need for an analysis of discharge effects on ice elevation will be identified and conducted, if feasible.

Synthesis of the 1980s Aquatic Habitat Information

A synthesis/summary of the 1980s *Response of Aquatic Habitat Surface Area to Mainstem Discharge Relationships in the Yentna to Talkeetna Reach of the Susitna River* (R&M Consultants, Inc. and Trihey & Associates 1985a) will be provided. A synthesis/summary of the *Assessment of Access by Spawning Salmon into Tributaries of the Lower Susitna River* (R&M Consultants, Inc. and Trihey & Associates, 1985b) will also be provided. Data will be summarized with respect to the anticipated pre- and post-Project flow changes, where applicable (see Stream Flow Assessment section above).

Contingency Analysis to Compare Wetted Channel Area

Based on the results of items 1 and 2 (above) and the Geomorphic Assessment of Channel Change (below), coordination with licensing participants to determine the need for additional analysis to compare wetted channel area at high and low flows will occur. If additional analysis is required, then two sets of aerial photography of the Lower River (RM 0 to RM 98) will be obtained that are most representative of the pre and post-Project flow effects (see Stream Flow Assessment above). For example, 1 set representative of the median June flow at Sunshine gage under existing pre-Project and 1 set under anticipated post-Project median June flow will be obtained. June is the time when the reservoir would be filling and may be when the Project has the most effect on stream flows. The difference in wetted surface area of the main channel and side channel riverine habitats (as defined in Trihey & Associates 1985[1]) will be compared

[1] The geomorphic types are defined in: Response of Aquatic Habitat Surface Areas to Mainstem Discharge in the Talkeetna-To-Devil Canyon Segment of the Susitna River, Alaska, November 1985, prepared by Trihey & Associates (document No. 2945) for the Alaska Power Authority.

between the pre and post-Project flow for approximately a total of 25 miles of river between RM 0 to RM 98. Twenty-five miles of river will be selected for analysis from three to five different river segments that are representative of the Lower River.

Sediment Transport Assessment

Sediment Load Comparison

The sediment transport measurements that the USGS has collected will be used to develop bedload and suspended load rating curves to facilitate translation of the periodic instantaneous measurements into yields over longer durations (e.g., monthly, seasonal, and annual). Since gradations of transported material will be available, the data will allow for differentiation of transport by size fraction. Previous studies have documented the potential for bias in suspended load rating curves due to scatter in the relationship between sediment concentration or load and flow (Walling 1977a). Specifically, the bias can result from the construction of linear least-squares regression relationships of logarithmic transformed concentrations or loads and flows (Walling 1977b, Thomas 1985, Ferguson 1986). Various procedures are available to address the bias, including accounting for seasonal differences in sediment transport, and accounting for hysteresis related to rising and falling limbs of flood hydrographs (Guy 1964, Walling 1974). Koch and Smillie (1986) and Cohn and Gilroy (1991) describe methods of handling the bias correction depending on the expected distribution of errors. The USGS Office of Surface Water (1992) endorsed the recommendations in Cohn and Gilroy (1991) to use the Minimum Variance Unbiased Estimator (MVUE) bias correction for normally distributed errors, or the Smearing Estimator (Duan 1983) when a non-normal error distribution is identified. Once the sediment measurements are available for review, the potential for bias in the sediment rating curves will be considered and addressed as appropriate.

The total sediment load delivered to the Lower River for pre- and post-Project conditions will be evaluated using the sediment rating curves developed from the historical data (and, if available in time, combined with any new sediment transport data being collected by the USGS under Study *G-S1: Determine Bedload and Suspended Sediment Load by Size Fraction at Tsusena Creek, Gold Creek, and Sunshine Gage Stations*) for the Sunshine and Susitna Station gaging stations. The total sediment load at the Sunshine and Susitna Station gaging stations will be compared for an average, wet, and dry year for pre-Project and adjusted post-Project using adjusted post-Project rating curves. The calculation will be based on the assumption that the post-Project sediment load at both gaging stations will be adjusted by reducing 100 percent of the total bedload and 90 percent of the total suspended load obtained from historical USGS measurements and rating curve for the Gold Creek gaging station.

Integrate Sediment Transport and Flow Results into Analytical Framework

Based upon the above analyses, an assessment of anticipated Project effects on the Lower River channel type and morphology will be developed. Using the data developed for the pre- and post-Project flood frequency, flood duration, and sediment load, the geomorphic response of the Susitna River in an analytic framework along the longitudinal profile of the river system from the three rivers confluence through Lower River reach will be predicted. The analytical framework developed by Grant et al. (2003) that relies on the dimensionless variables of (1) the ratio of sediment supply below the dam to that above the dam, and (2) the fractional change in frequency of sediment transporting flows will be used to predict the nature and magnitude of the Lower River geomorphic response. Other analytical approaches may be considered to demonstrate potential for geomorphic adjustments in the river reaches due to the Project.

Geomorphic Assessment of Channel Change and Geomorphic Reach Delineation

Compare Historic and Present-Day Channel Planform Pattern

An appropriate set of historical (1980s) and current aerial photographs to compare historic and present-day channel planform and pattern will be obtained for the Lower River. For example, if the R&M Consultants, Inc. and Trihey & Associates (1985) aerial photography can be located, it will be used to compare with current aerial photography at a similar flow. Planform shifts of the main channel and side channels will be identified between the 1985 and current aerial photography. The three rivers confluence area is also a part of the analysis (extended to RM 99). Geomorphic features that are visible between the 1980s and current images, including the presence and extent of side channels, mid-channel bars, vegetated bar areas, and changes at tributary deltas will be mapped and characterized. If existing aerial photography is not available, then coordination with AEA's Spatial Data Consultant to obtain aerial photography will occur.

Delineate Geomorphically Similar (Homogeneous) River Segments

The Lower River (RM 0 to RM 98) will be delineated into large-scale geomorphic river segments (a few to many miles) with relatively homogeneous characteristics, including channel width, entrenchment, ratio, sinuosity, slope, geology/bed material, single/multiple channel, braiding index and hydrology (inflow from major tributaries) for the purposes of stratifying the river into relatively homogeneous study segments.

The first step in geomorphic reach delineation effort will be the identification of the system to classify and delineate the reaches. Numerous river classifications exist (Leopold and Wolman 1957; Schumm 1963, 1968; Mollard 1973; Kellerhals et al. 1976; Brice 1981; Mosley 1987; Rosgen 1994, 1996; Thorne 1997; Montgomery and Buffington 1997; Vandenberghe 2001), but no single classification has been developed that meets the needs of all investigators. Several factors have prevented the achievement of an ideal geomorphic stream classification, and foremost among these has been the variability and complexity of rivers and streams (Mosley 1987; Juracek and Fitzpatrick 2003). Problems associated with the use of existing morphology as a basis for extrapolation (Schumm 1991) further complicates the ability to develop a robust classification (Juracek and Fitzpatrick 2003). For purposes of classifying the Susitna River, available classification systems will be reviewed and it is anticipated that a specific system will be developed that borrows elements from several classifications system. The classification scheme will consider both form and process. Development of this system will be coordinated with the Instream Flow Study, Instream Flow Riparian Study, Ice Processes Study and Fish Study so it is consistent with their needs. These studies may require further stratification to identify specific conditions of importance to their effort, in which case, these studies will further divide the river into subreaches. However, the overall reach delineations developed in the

Geomorphology Study will be used consistently across all studies requiring geomorphic reach delineations.

Since there are several studies that will require a reach delineation for planning 2012 field activities, an initial delineation that will be primarily based on readily available information (most recent high quality aerials, bed profile from the 1980s, geomorphic descriptions from the 1980s) will be developed by early April. As additional information is developed—such as current aerials and transects—the delineation will be refined and the various morphometric parameters will be determined. Coordination with the WR-S1: River Flow Routing Model Transect Data Collection Study will occur in order to obtain cross-section channel/floodplain data. Coordination with the Instream Flow Study, Instream Flow Riparian Study, Geomorphic Modeling Study and Ice Process Study will occur to ensure that the river stratification is conducted at a scale appropriate for those studies.

A reconnaissance-level site visit of the Lower River will be conducted that will be coordinated with other studies to take advantage of scheduled boat and helicopter trips as well as opportunities to coordinate with other studies. The purpose of this site visit will be to provide key Geomorphology Study team members an overview of the river system.

STUDY PRODUCTS

Study products to be delivered in 2012 will include:

Summary of Interim Results. Interim reports will be prepared and presented to the Work Group to provide study progress. Reports will include up-to-date compilation and analysis of the data and ArcGIS spatial data products.

ArcGIS Spatial Products. Shapefiles with current riverine habitat types, the geomorphic assessment and the reach delineation will be created. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection, and North American Datum of 1983 (NAD 83) horizontal datum consistent with ADNR standards. Naming conventions of files and data fields, spatial resolution, and metadata descriptions will meet the ADNR standards established for the Susitna-Watana Hydroelectric Project.

Technical Memorandum. A technical memorandum summarizing the 2012 results will be prepared and presented to resource agency personnel and other licensing participants, along with spatial data products. At a minimum, the technical memorandum will include:

- Monthly and annual flow duration tables and curves for pre- and post-Project conditions.
- Flood frequency and duration tables and curves for pre- and post-Project conditions.
- Tabular and graphical curve comparison of the pre- and post-Project river stage for Sunshine and Susitna Station gaging stations.
- Summarized historical information regarding the effects of stream flow on aquatic habitat.

- Maps comparing present-day and historical (1980s) channel pattern and planform changes, including position of main and side channels, presence of mid-channel bars, vegetated bar areas, and tributary deltas.
- Comparison of the relative proportion of the geomorphic features within each reach between present-day and the historical channel pattern.
- Develop sediment rating curves for historical record and 2012 USGS data (if available).
- Tabulation of the total sediment load comparing pre- and post-Project total sediment load for the Sunshine and Susitna gaging stations, for an average, wet, and dry year type.
- Determination of the fractional change in sediment transporting flows pre- and post-Project and change in sediment supply pre- and post-Project applied to the Grant et al. (2003) analytical framework to predict magnitude and direction of potential geomorphic changes in the Lower River reach.

SCHEDULE

The following schedule for the 2012 scope of work is tentative.

Milestone	Date of Completion
Summary of Interim Results	May 21, June 29, and September 30, 2012
Final ArcGIS Spatial Products	December 17, 2012
Final Technical Memorandum on 2012 Activity	December 17, 2012

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