G-S2: AQUATIC HABITAT AND GEOMORPHIC MAPPING OF THE MIDDLE RIVER USING AERIAL PHOTOGRAPHY – 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 flow and sediment transport and delivery, which may impact aquatic habitat and channel morphology below the Watana Dam site. Understanding existing, baseline geomorphic conditions, how geomorphic conditions and aquatic habitat change over a range of stream flows, and how stable/unstable the geomorphic conditions have been over recent decades provides a baseline set of information needed to provide a context for predicting the likely extent and nature of potential changes to flow, sediment supply, and sediment transport capacity that will occur due to Project operations.

This study will provide a comparison of the habitat mapping conducted in the 1980s (Trihey and Associates 1980) with habitat mapping developed at similar discharges in 2012. This information will help inform the Geomorphology Study, Instream Flow Study, Riparian Instream Flow Study, Ice Processes Study and potentially other studies regarding changes that have occurred since previous efforts conducted in the 1980s. The information obtained during this study will inform the development and execution of the 2013–2014 study plans.

STUDY OBJECTIVES

Understanding the extent to which current (2012) aquatic habitat and geomorphic features are similar to or different from 1980s conditions will not only provide information on the long-term equilibrium of the channel, but will also help inform the extent to which other data sets collected in the 1980s can be relied upon to describe and supplement more recent aquatic habitat and geomorphic data. Quantifying geomorphic features and aquatic habitat types will also provide a basis for selecting study sites, understanding flow versus habitat relationships, and assessing geomorphic conditions.

The study objectives are as follows:

- Identify the surface area of riverine habitat types (aquatic habitat and geomorphic features) over a range of stream flows;

- Compare existing and 1980s geomorphic feature/units and associated aquatic habitat types data to characterize the relative stability (proportionality of the various units) of the 1980s study sites and river morphology under unregulated flow conditions; and
- 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.

STUDY AREA

The study area includes the Middle Susitna River from Devils Canyon (RM ~150) downstream to the three rivers confluence (RM ~98), which matches the 1980s study area. Additionally, the bedrock-constrained reach from Devils Canyon to the Watana Dam site (RM ~150 to RM ~184) will be included in this study. Aquatic habitat and geomorphic mapping of the Lower River (RM 98 to RM 0) is addressed under a separate study plan.

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

Project operations have the potential to alter aquatic habitat and channel morphology because flow, sediment supply and sediment transport capacity will be altered. Understanding existing geomorphic conditions, how aquatic habitat changes over a range of stream flows, and how stable/unstable the geomorphic conditions have been over recent decades provides a baseline set of information needed to provide a context for predicting the likely extent and nature of potential changes that will occur due to the Project. Results of this study will also provide the basis for meso- and macro-habitat mapping to support the Instream Flow Study and will be used in the Ice Processes Study to provide the surface areas of bars likely to become vegetated in the absence of ice-cover formation.

The preliminary issues associated with geomorphic resources identified in the PAD (AEA 2011), for which the existing 1980s aerial photography assessment may not be adequate, include:

- G6: Potential effect of Project operations on the stability of tributary mouths and access to tributaries within the Middle River.
- WR2: Changes in timing and magnitude of flows from Project operations on the interconnection of side channel and side sloughs may affect fish habitat and productivity.
- F4: Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.
- F6: Influence of Project-induced changes to mainstem water surface elevations in July through September on adult salmon access to upland sloughs, side sloughs, and side channels.

EXISTING INFORMATION

An analysis of the Middle Susitna River reach geomorphology and how aquatic habitat conditions change over a range of stream flows was performed in the 1980s using aerial photographic analysis (Trihey & Associates 1985). 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-era morphological characteristics in each of the identified subreaches is required.

METHODS

Aerial Photography

New (2012) color aerial photography of the Middle River (RM 98 to RM 184) at stream flows corresponding to those analyzed in the Trihey & Associates study (1985) (stream flow at the Gold Creek gage [15292000]) will be obtained in order to provide the foundation for the geomorphic mapping and aquatic habitat of the Middle River, as well as to provide a resource for other studies.

Three sets of aerial photography will be obtained in 2012 at the following approximate discharges: 23,000 cfs, 12,500 cfs, and 5,100 cfs. (Note: seven sets of aerial photographs were flown and evaluated in the 1985 study at stream flows of 5,100 cfs, 7,400 cfs, 10,600 cfs, 12,500 cfs, 16,000 cfs, 18,000 cfs, and 23,000 cfs).

Determination of the scale of the aerial photography (i.e., flying elevation) and the digital scan resolution will be coordinated with AEA's Spatial Data Contractor, AEA, the Instream Flow Study Lead, and licensing participants.

The Geomorphology Study Lead will coordinate with the Spatial Data Contractor who will both obtain (fly) the aerial photography and orthorectify the aerial photography.

The flow record for the previous 10 years at the USGS Gold Creek gage will be reviewed. The river typically rises from about 2,000 cfs to over 15,000 cfs during the ice break-up period in late April to mid-May in a matter of a few days. Because of the influence of ice and ice break-up on water surface elevations during this period, it is unlikely that aerial photographs to make a valid comparison with the 1980s habitat mapping can be collected in the spring. The river does not recede to 12,500 cfs until mid-August to mid-September and to 5,100 cfs until sometime in October. The river is intermittently in the 23,000 cfs range in the June through August timeframe. For developing the schedule, it is assumed that the aerial photographs for 23,000 cfs will be available by August 1, 2012, aerials for 12,500 cfs will be available by October 15, 2012, and aerials for 5,100 cfs will be available by November 15, 2012. It should be noted that snowfall in the project area for 2012 is close to an all-time record, and this may influence the timing and magnitude of the discharges this year.

Digitize Geomorphic Features and Riverine Habitat Types

New aerial photography obtained in 2012 will be combined with historic and other information to create a digital, spatial representation (i.e., GIS database) of geomorphic features/units and meso- and macro- scale riverine habitat types.

Aerial Photography Analysis Study Reaches

The Geomorphology Study will coordinate with the Instream Flow Study, the Instream Flow Riparian Study, Ice Processes Study, and other pertinent studies to identify large-scale (typically many miles) aerial photography analysis study reaches for the riverine habitat and geomorphic feature digitizing (see below). For this initial work, the extent of the study sites to be analyzed is assumed to not exceed more than 50 percent of the river (RM 98 to RM 184). In addition to consideration of habitat and geomorphic characteristics of the reach, a visual qualitative side-by-side comparison of the aerials will be performed to ensure that the selected reaches are also representative of the degree of change that has occurred over the period of comparison. (Note: Aerial photography will be obtained for the entire reach so that additional areas may be digitized in the future if warranted.)

1980s Geomorphic Features/Units and Riverine Habitat Types (RM 98 to RM 150)

Within the aerial photography analysis study reaches) the riverine habitat and geomorphic features defined in the 1980s will be digitized from hard copy maps as found in the Middle River Assessment Report (Trihey & Associates 1985) will occur. Each feature must be a polygon (without slivers). The features were classified into the following categories: vegetated areas, exposed bars, and riverine habitat (main channel, side channel, side sloughs, upland sloughs, and tributary mouths).

2012 Geomorphic Features/Units and Riverine Habitat Types (RM 98 to RM 184)

Riverine habitat types and geomorphic features within the aerial photography study reaches from the 2012 aerial photographs will be delineated and digitized. The geomorphic features and riverine habitat types at each stream flow using the orthorectified photography and ArcGIS software will also be digitized (each feature/type must be a polygon without slivers). Habitat features types will be classified using the same classification categories used in the Trihey & Associates study (1985) (vegetated areas, exposed bars, and riverine habitat [main channel, side channel, side sloughs, upland sloughs, and tributary mouths]).

Riverine Habitat and Geomorphic Analysis

The information developed in the previous task will be used to analyze and compare the aquatic habitat and geomorphology for 1980s and current conditions.

RM 98 to RM 150

GIS software will be used to compare the 2012 versus 1980s total surface area associated with each delineated geomorphic feature/unit and associated riverine habitat type at each measured flow. Data results will be compiled into tables and graphs, as appropriate, to show the difference in surface area of the identified classification categories between 2012 and the 1980s photography and to show the change in riverine habitat types versus flow in the two periods. To ensure accurate comparison to the 1980s data set, not only will the same approximate flows be

compared, but the same definitions will be used for each of the riverine habitat features that are delineated (see above). The lead geomorphologist will provide training to ensure appropriate identification and application of the identified classification categories.

RM 150 to RM 184

Since the 34-mile river segment below the proposed Watana dam site was not analyzed in the 1980s, this portion of the river will be a new assessment (2012 photography only) that cannot be compared to past studies. However, the methods for analyzing riverine habitat and geomorphic features over the range of flows will remain the same as for the downstream reach (approximately 23,000 cfs, 12,500 cfs and 5,100 cfs). Since this is a bedrock controlled reach, the emphasis of the analysis will be the controls/reasons for the alluvial deposits present in the reach.

1980s Study Site Stability

Coordination with the Instream Flow Study to identify the locations of the 1980s study sites will occur. If riverine habitat types and geomorphic features have not been digitized and classified at these sites (see above) then identified classification categories/features will be digitized at the study sites in both the 1980s and 2012 aerial photography (at each flow). Geomorphic features and riverine habitat types will be compared and contrasted quantitatively and a qualitative assessment will be made of the similarity of the sites in 2012 compared to the 1980s.

Overall Geomorphic Analysis (RM 98 to RM 184)

The geomorphic change over the length of the river (bars, channel width, channel location) will be qualitatively assessed between the 1980s and 2012. Reaches will be identified that are relatively stable versus those that are more dynamic. Reaches that would be most susceptible to channel change (e.g., width or planform change) with changes in the flow or sediment regime resulting from the Project or Project operations will be qualitatively identified. Depending upon the results of the riverine habitat and geomorphic analysis, additional historical photographic analysis may be requested as part of future geomorphic studies, but this additional analysis is not included at this time. Additional analysis of historical aerial photographs and the corresponding flows that occurred between 1985 and 2012 could be pertinent if substantial changes in the riverine habitat types (surface area, locations, etc.) were identified during comparison of the 2012 and 1980s photography. This type of additional aerial photo analysis could provide more specific information on the flow magnitude(s) and other conditions (for example ice formation) that may cause substantial geomorphic channel adjustments.

Delineate Geomorphically Similar (Homogeneous) River Segments

The river (RM 98 to RM 184) 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 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 Middle 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 of the 1980s and current riverine habitat types will be created for each of the stream flows assessed. 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 must 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:

- ArcGIS shape files of all 1980s and current (2012) riverine habitat and geomorphic features at each of the stream flows.
- Tabulation of surface areas of riverine habitat and geomorphic features over each flow range assessed.
- Maps showing the existing riverine habitat delineations at each flow assessed.
- Maps comparing the existing and 1980s riverine habitat delineations at each flow assessed.
- Maps showing the delineated geomorphic reaches and written description of the reaches.
- Recommendations regarding additional study needs to be addressed in 2013 and 2014.

SCHEDULE

The following schedule for the 2012 scope of work is tentative, and depends on the availability and timing of the completion of the aerial photography products at the different target stream flows specified above. This study identifies work that will be started in early 2012 and be completed by November 2012. The first scheduled task will be to obtain the original 1980s photography. This will be followed by the collection of new aerial photography at the pre-determined target flows compatible with the 1980s data set, as discussed above. It will be necessary to schedule multiple flights over time to obtain the aerial photography at the target flows. Review of the hydrologic record indicates that obtaining the aerials at the appropriate flow levels will be the critical schedule item. The rising limb of the hydrograph is typically very steep and may occur while ice and snow limit the quality of the photos. In most years, the flow on the Susitna River at Gold Creek does not fall below 5,100 cfs until mid to late October. As aerial photographs are being obtained, the delineation of riverine habitat features and digitization can begin, so that the two tasks can be completed, to some extent, in parallel.

Performing the digitization of the 2012 aerial photography is dependent on the AEA SDC being able to fly the aerials at the appropriate discharge. The only portions of this effort that can be completed in 2012 are for flows for which the current aerial photographs are supplied in orthorectified format by November 15, 2012. The most critical discharge in regard to schedule is the 5,100 cfs since there are years when the Susitna at Gold Creek does not fall to this level until late October or early November.

Milestone	Date of Completion
Collect Aerial Data	mid-May to October 30, 2012 (depends on target flows and the hydrograph)
Summary of Interim Results	May 21, June 29, and October 30, 2012
Final ArcGIS Spatial Products	December 17, 2012
Final Technical Memorandum on 2012 Activity	December 17, 2012

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