Susitna-Watana Hydroelectric Project (FERC No. 14241)

Riparian Instream Flow Study
Study Plan Section 8.6

Part D: Supplemental Information to June 2014 Initial Study Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

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1. INTRODUCTION

Section 1 (Part A) of the June 2014 ISR for the Riparian Instream Flow Study (Study Plan 8.6) details the development of this study from the Revised Study Plan (RSP) in 2012, through the end of the 2013 study season. Section 7 of the ISR (Part C), filed in June 2014, sets forth Alaska Energy Authority's (AEA) plan and schedule, at that time, for completing this study and meeting the objectives of the RSP.

As detailed in Section 2.2 of the ISR Part D Overview, various circumstances have required AEA to extend the original timeframe for completing the Commission-approved Study Plan. However, AEA has made meaningful progress with this Study 8.6 since the filing of the ISR in June 2014. As detailed below, AEA's recent activities for Study 8.6 have consisted of the following:

- Completion of literature review (RSP Section 8.6.3.1) in coordination with Fluvial Geomorphology Modeling (ISR Study 6.6).
- Completion of three-year longitudinal willow-cottonwood sexual reproduction seedling field surveys (RSP Section 8.6.3.3.2).
- Second season of aerial ice break-up observations and completion of river ice scar surveys in the Middle River Segment (RSP Section 8.6.3.4).
- Continuation of field data collection for the Floodplain Stratigraphy and Floodplain Development study (RSP Section 8.6.3.5) and Riparian GW/SW study (RSP Section 8.6.3.6).
- Participated in ISR meetings on October 17, 2014 to discuss the preliminary RIFS study results and the plans for completing the study. The emphasis for this meeting was on any modifications of the Study Plan in light of the progress of the Study Plan and data collected.
- Submitted a Study Implementation Report (SIR) on November 6, 2015 that summarized Study 8.5 activities since June 2014.

The primary purpose of this Part D Supplemental Information to the ISR is to report on the implementation of the Study Plan from the filing of the ISR in June 2014 through the filing of this ISR Part D. In light of this additional implementation, this Part D also identifies AEA's plans for completing Study 8.6 in a manner that meets the objectives of the Commission-approved Study Plan.

2. BACKGROUND

2.1. Purpose of Study

The goal of the Riparian Instream Flow Study (hereafter RIFS) is to provide a quantitative, spatially explicit model to predict potential impacts to downstream floodplain vegetation from

Project operational flow modification of natural Susitna River flow, sediment, and ice regimes. To meet this goal, AEA is applying a physical and vegetation process modeling approach. First, existing Susitna River groundwater and surface water (GW/SW) flow, sediment, and ice regimes are being measured and modeled relative to floodplain plant community establishment, recruitment, and maintenance requirements. Second, predictive models are being developed to assess potential Project operational impacts to floodplain plant communities and provide operational guidance to minimize these impacts. Third, the predictive models are being applied spatially in a Geographic Information System (GIS) to the riparian vegetation map produced by the Riparian Vegetation Study (Study 11.6) to produce a series of maps of predicted changes under alternative operational flow scenarios.

The study objectives are established in RSP Section 8.6.1:

- Synthesize historic physical and biological data for Susitna River floodplain vegetation, including 1980s studies, studies of hydro project impacts on downstream floodplain plant communities, and studies of un-impacted floodplain plant community successional processes.
- Delineate sections of the Susitna River with similar environments, vegetation, and riparian processes, termed riparian process domains (RPDs), and select representative areas within each riparian process domain, termed Focus Areas, for use in detailed 2013–2014 field studies.
- Characterize seed dispersal and seedling establishment groundwater and surface water hydroregime requirements. Develop a predictive model of potential Project operational impacts to seed dispersal and seedling establishment.
- Characterize the role of river ice in the establishment and recruitment of dominant floodplain vegetation. Develop a predictive model of potential Project operational impacts to ice process regimes and dominant floodplain vegetation establishment and recruitment.
- Characterize the role of erosion and sediment deposition in the formation of floodplain surfaces, soils, and vegetation. Develop a predictive model of Project operations changes to erosion and sediment deposition patterns and associated floodplain vegetation.
- Characterize natural floodplain vegetation groundwater and surface water maintenance hydroregime. Develop a predictive model to assess potential changes to natural hydroregime and potential floodplain vegetation.
- Develop floodplain vegetation study synthesis, scaling of Focus Areas to riparian process domains, and Project operations effects modeling**.**

2.2. Study Components

The study consists of the following components:

- Literature Review of Dam Effects on Downstream Vegetation

- Focus Area Selection−Riparian Process Domain Delineation
- Seed Dispersal and Seedling Establishment
- River Ice Effects on Floodplain Vegetation
- Floodplain Stratigraphy and Floodplain Development
- Riparian GW/SW Hydroregime
- Floodplain Vegetation Modeling Synthesis and Project Scaling

3. STATUS, HIGHLIGHTED RESULTS, AND ACHIEVEMENTS

The following tasks were completed in 2013 and reported in Part A of the June 2014 ISR for Study 8.6:

Literature Review of Dam Effects on Downstream Vegetation

- More than 110 peer-reviewed articles were reviewed and searchable annotated bibliography was developed. A summary of findings will be presented in a combined Riparian and Fluvial Geomorphology Technical Memorandum literature review with the bibliography.

Focus Area Selection−Riparian Process Domain Delineation

- Riparian Process Domains (RPD) were identified for the entire Middle River Segment, and the TWG technical team was consulted to assist in selecting Focus Areas for riparian studies that are representative of each RPD.

Seed Dispersal and Seedling Establishment

- Catkins releasing seed from 6 female balsam poplar (*Populus balsamifera*) trees and 6 to 12 female willow (*Salix* spp.) shrubs were counted weekly at each of four seed release study sites distributed across the Middle and Lower River Segments.
- First year (0+) balsam poplar and willow seedling establishments were documented with 35 transects and 824 plots across five Focus Areas. Counts of established seedlings were completed in late July through early August and again in September 2013. To characterize white spruce establishment patterns, 12 8-meter-wide (26.25 feet wide) belt transects were surveyed covering approximately 3.5 hectares (8.7 acres) on seven mid-channel islands in the Middle River Segment.
- Significant mortality was observed as a result of the 2013 mid-August peak flow. Seedling survival occurred in sheltered terrain positions whereas high seedling mortality was observed resulting from both channel bed scour and sediment burial in exposed lateral channel margins.

- Seedling establishment study identified previously unreported white spruce establishment in tall alder seral stage. White spruce was shown to establish throughout early floodplain forest successional stages.

- Only balsam poplar and willow year 0+ seedlings were observed in woody seedling reconnaissance surveys.

- Clonal reproduction of balsam poplar appears to be a significant recruitment process in high ice flow disturbance zones. What appeared to be poplar sexual reproduction in these terrain areas is not. This finding has potential significance relative to assessment of Project operations effects on ice regime interactions with riparian vegetation, an assessment objective of the vegetation ice processes study.

River Ice Effects on Floodplain Vegetation

- The Riparian IFS team was able to aerially observe a significant 2013 river ice breakup over 2 days, providing observations of ice dam backwater flooding, floodplain sediment deposition, and extensive ice flow damage to floodplain vegetation. Identifying floodplain areas to study floodplain vegetation response to ice flow and sediment disturbances was an objective of 2013 fieldwork.

- A systematic riverbank survey of tree ice scars was conducted from PRM 102.2 through PRM 145.8 between September 15 and 29, 2013. A total of 222 ice-scarred trees, 190 locations with no visible ice-scars, and 29 locations with signs of ice damage that were not measurable were surveyed. In addition, 48 ice- scarred trees were sampled for dendrochronologic analysis of ice floodplain vegetation interaction frequency and magnitude.

- Ice dam backwater flooding was observed to deposit up to 20 to 30 cm of fine sand burying existing floodplain vegetation. Sediment deposition during ice dam backwater was observed to be a local phenomenon associated with ice dam backwater floods. Ice process generated floodplain sediment deposition is potentially a significant driver of local floodplain vegetation pattern.

Floodplain Stratigraphy and Floodplain Development

- Sediment cores were collected during 2013 at 13 locations in the Middle River Segment, including 5 cores at FA-104 (Whiskers Slough) and 8 cores at FA-115 (Slough 6A).

- Tree and shrub composition and abundance were measured at 80 ITU and mid-channel island plots in the Middle and Lower River Segments. Tree core samples for dendrochronologic analysis were collected at all ITU plots.

- Analysis of sediment cores and aging of tree cores is in progress.

Riparian GW/SW Hydroregime

- Riparian Groundwater/Surface Water studies included collection of 659 plant samples, 545 soil samples, and 100 water samples for isotopic analysis of water source.

Transpiration of woody species was measured with TDP sensors installed at 21 trees at FA-104 (Whiskers Slough) and 27 trees at FA-128 (Slough 8A). Transpiration by herbaceous and small shrub species was measured through collection of 3,602 individual stomatal conductance measurements, including measurements from 1,747 herbaceous plants (11 species), 1,771 shrubs (11 species), and 79 trees (3 species).

- FA-138 (Gold Creek) river right floodplain wetlands were shown to not be strongly influenced by surface water fluctuations associated with the mid-August peak flow. This observation was made by measuring floodplain off-channel water body surface water elevations as compared to river stage fluctuations.

The study team has completed the following activities for Study 8.6 since the June 2014 filing of the ISR:

- Completion of literature review (RSP Section 4.1.1) in coordination with Fluvial Geomorphology Modeling (Study 6.6).
- Seedling transects were revisited in 2014 and 2015 and seedlings were counted twice each season to capture seedling mortality and establishment relative to hydrologic conditions. Field surveys for the three-year longitudinal willow-cottonwood sexual reproduction seedling study are complete (RSP Section 4.3.2).
- Ice scar mapping surveys were completed along the main channel and majority of side sloughs and channels from Project River Mile (PRM) 102 – PRM 151 and above Devils Canyon from PRM 167-186.
- Ice scar surveys were conducted in the Lower River Segment. The downstream extent of ice scars was mapped.
- The RIFS team was able to aerially observe 2013 and 2014 river ice-breakup to inform understanding of floodplain ice interaction processes.
- Preliminary tree aging was completed for tree core samples collected from the Middle River Segment Focus Areas.
- The Riparian GW/SW collected a full season of sap flow measurements from April through mid-October in 2014 to measure tree water use relative to groundwater elevation within the Susitna floodplain.
- Thirty-eight sediment stratigraphic descriptions and sediment isotope samples were collected for geochronological analysis in Focus Areas in coordination with Riparian Vegetation (Study 11.6).

4. SUMMARY OF STUDY 8.6 DOCUMENTS

Since filing of the RSP in 2012, AEA and FERC have prepared several documents pertaining to this study. To aid review by FERC staff and licensing participants, each of these documents is listed below. Each of these documents is accessible on AEA's Project licensing website

(http://www.susitna-watanahydro.org/type/documents/) by clicking on the entry in the "Link" column in the table. In addition, these documents are available on FERC's eLibrary system (http://www.ferc.gov/docs-filing/elibrary.asp), in Docket No. P-14241.

Title	Date	Description	Link
8.6. Riparian Instream Flow Study (Revised Study Plan	12/14/2012	This document presents the plan for this study, including goals, objectives, the study area, and proposed study methods for the Riparian Instream Flow Study.	RSP for Study 8.6
Draft Technical Memorandum, Selection of Focus Areas and Study Sites in the Middle and Lower Susitna River for Instream Flow and Joint Resource Studies – 2013 and 2014	1/31/2013	Summary of the evaluation process, habitat mapping analysis, and preliminary selection of Middle River Focus Areas and Lower River PHABSIM sites. This technical memorandum was prepared in response to the 1/17/2013 FERC Study Plan Determination Schedule that specified delivery of three IFS-related analyses.	Jan. 2013 Draft TM for Joint Resource Studies
Draft Initial Study Report for Study 8.6	2/3/2014	This draft of the ISR summarized the study methods and variances during the 2013 study season, and presented preliminary data collected for Study 8.5. This draft ISR was later republished as Part A of the final ISR.	Draft ISR for Study 8.6
Technical Memorandum, Selection of Focus Areas and Study Sites in the Middle and Lower Susitna River for Instream Flow and Joint Resource Studies – 2013 and 2014	3/1/2013	Supporting documentation of the Middle River Focus Areas and Lower River PHABSIM sites proposed in the Revised Study Plan. This technical memorandum was prepared in response to the 1/17/2013 FERC Study Plan Determination Schedule that specified delivery of three IFS-related analyses. Several adjustments to the Middle River Focus Areas were later implemented in response to the 4/1/ 2013 FERC Study Plan Determination.	Mar. 2013 TM for Joint Resource Studies
Technical Memorandum Riparian Physical Process Modeling	3/25/2013	This technical memorandum provides a summary overview of the various climatic, seed dispersal, ice process, geomorphologic, and groundwater physical process modeling studies conducted in support of the Riparian IFS. This TM was provided to illustrate the interrelationships between the various Riparian IFS modeling analyses and other supportive physical models.	Mar. 2013 TM for Study 8.6
FERC's Study Plan Determination for Study 8.6	4/01/2013	FERC SPD for Study 8.6, which approved the study with additional adjustments.	FERC SPD for Study 8.6
Adjustments to Middle River Focus Areas Technical Memorandum	5/31/2013	Detailed description of the final Middle River Focus Areas including changes developed in response to 4/01/2013 FERC Study Plan Determination.	May 2013 TM for Joint Resource Studies

Title	Date	Description	Link
Riparian Instream Flow, Groundwater, and Riparian Vegetation Studies FERC Determination Response Technical Memorandum	7/1/2013	When approving the Groundwater Study (RSP Section 7.5), the Riparian Instream Flow Study (RSP Section 8.6), and Riparian Vegetation Study (RSP Section 11.6), the Commission requested that AEA file a technical memorandum that provides additional information on the methods for addressing several aspects of the study plan. This technical memorandum summarizes details concerning sampling design, proposed field protocols and analytical methodologies related to the April 1, 2013 FERC Study Plan Determination.	July 2013 for Studies 7.5, 8.6, and 11.6
Initial Study Report for Study 8.6 and Appendices	6/3/2014	This document is the Initial Study Report (Parts A, B, and C) for Study 8.6. Part A republishes the Draft ISR. Part B identifies supplemental information and errata in Part A. Part C presents study modifications and plans for completing the study.	ISR Part A for Study 8.6 ISR Part B for Study 8.6 ISR Part C for Study 8.6
Riparian Instream Flow (Study 8.6) and Fluvial Geomorphology (Study 6.6) Dam Effects on Downstream Channel and Floodplain Geomorphology and Riparian Plant Communities and Ecosystems−Literature Review Technical Memorandum	11/14/2014	This literature review synthesizes historic physical and biologic data for the Susitna River floodplain vegetation (including 1980s studies), studies of hydro project impacts on downstream floodplain plant communities, and studies of un-impacted floodplain plant community successional processes.	November 2014 TM for Studies 6.6 and 8.6
Initial Study Report Meetings, October 17, 2014 (Parts A and B)	11/14/2014	Transcripts and AEA's agenda and PowerPoint presentations for the ISR meeting concerning the Project riparian instream flow study	Transcripts from ISR Meeting Materials from ISR Meeting
Riparian Instream Flow Study (8.6) -- 2014-2015 Study Implementation Report	11/5/2015	Study Implementation Report: a summary of 2014 study plan implementation.	2014-2015 SIR for Study 8.6 (File 1) 2014-2015 SIR for Study 8.6 (File 2) 2014-2015 SIR for Study 8.6 (File 3)

5. NEW STUDY DOCUMENTATION SUPPLEMENTING THE ISR

The following table identifies and describes additional reports and other documents that update, refine, or otherwise supplement certain sections of the ISR pertaining to Study 8.6, during AEA's continued implementation of the Study Plan through the filing of this ISR Part D.

ISR Reference	Description
Part A, Section 4	This section is supplemented by the Study Implementation Report for Study 8.6 (Section 4), describing 2014 and 2015 study plan implementation.
Part A, Section 5	This section is supplemented by the Study Implementation report for Study 8.6 (Section 5), describing the results of 2014 and 2015 study plan implementation.

6. VARIANCES

6.1. 2013 Study Season

The following variances are reported in the June 2014 ISR:

- Completion of the literature review was originally scheduled for Q4 2013. The literature review was submitted in Q4 2014.
- The first year (0+) balsam poplar and willow establishment study was restricted to documenting current cohort of seedlings less than 1 year old rather than to all woody plants less than 1 meter in height. A clonal reproduction study will be done to characterize asexual recruitment patterns (see ISR Study 8.6, Section 4.3.2).

6.2. 2014 and 2015 Study Seasons

As noted in Section 4 of the Study Implementation Report for this study, AEA encountered no variances when implementing this study in 2014 or 2015.

7. STUDY PLAN MODIFICATIONS

7.1. Modifications Identified in the June 2014 ISR

Section 7 of the ISR (Part C) details modifications for this study following the 2013 study season. These modifications are generally summarized as follows:

- Seedling Establishment and Recruitment Study (RSP Section 8.6.3.3.2): First year field season's results (2013) indicate that the dominant riparian woody species seedlings establish under a wider range of conditions than foreseen during the study plan design. Therefore, based upon these 2013 findings, the study plan modification is to quantitatively capture where (floodplain terrain locations), and how Balsam poplar clonal establishment and recruitment is occurring. A transect sampling field design will be used to characterize this clonal reproduction process at select Focus Area mid-channel islands and lateral floodplain margins to be determined in the field. Transects will be run, as in the seedling establishment transect design, from gravel bar into the adjacent floodplain forest. Along each transect Balsam poplar stems will be excavated to identify whether they are recruiting from seedlings or from clonal stems arising from ice deposit buried shoots. The results of this additional seedling establishment and recruitment study approach will capture the newly identified clonal mode of Balsam poplar reproduction,

which is the intent of the original seedling establishment and recruitment study design (RSP Section 8.6.3.3.2).

7.2. Modifications Identified after the June 2014 ISR

As detailed in Section 7 of the Study Implementation Report for this study, AEA plans the following modification:

- A single modification is proposed for RIFS study related to ISR 8.6, Section 4.6. During the April 2014 RIFS TWG Meeting it was discussed that further evapotranspiration (ET) measurements were not warranted given that the Susitna Valley region is not precipitation limited region. Therefore, a second year of sap-flow and stomatal conductance ET measurements will not be conducted. ET modeling will use the results of 2013-2014 measurements.

8. STEPS TO COMPLETE THE STUDY

In light of the variances and modifications described above, the steps necessary for AEA to complete this study are summarized below. As necessary and appropriate, these steps have been updated from those appearing in Section 7 of the ISR (Part C):

- The final riparian process domain cluster analysis will be completed for the Middle and Lower River segments including ice mapping data and additional flow routing modeling results.
- One additional year of weekly poplar and willow seed dispersal and stand temperature measurements is needed to finalize the degree-day model of peak seed release. The seed dispersal and temperature monitoring field effort should start in early to mid-May to capture initial seed dispersal by some willow species. Female poplar trees and willow shrubs will be identified at four locations along the Middle and Lower River segments.
- Weekly counts of open catkins until following peak seed release will be performed.
- Temperature data from local sensors and the Talkeetna Airport will be obtained for the study period.
- Models will be developed with at least two years of data to link peak seed release to local climate and Susitna River discharge records. Models include:
- Degree-day model of peak seed release window using seed release observations and continuous temperature records from each floodplain sample site.
- Recruitment box model of balsam poplar and select willow species.
- Model of peak runoff/seed release temporal synchrony for operational flow guidelines.
- Model of critical summer flow regime necessary to support seedling establishment.
- Clonal poplar and willow surveys will be completed on the lateral channel margins.

- Additional channel margin and floodplain transects will be surveyed to characterize spruce and birch seedlings recruitment and establishment patterns.
- Seedling year of establishment will be used, with the historic discharge record, to model the flood regime at the sample site using 1-D and/or 2-D hydraulic models.
- A 2-D model of local (transect plots) bed shear stress will be developed by Fluvial Geomorphology Modeling (Study 6.6) for use in the multivariate statistical analysis of the seedling response to modeled bed shear stress. A river bank erosion index will be developed, by the Fluvial Geomorphology Study, based on shear stress at different discharges and elevation locations along the transects.
- Using the three-year longitudinal study of seedling survival and mortality, a multivariate model of seedling establishment requirements will be developed. The model will be based on GW/SW interaction model results, local shear stress, soil texture, sediment transport, and alluvial terrain position.
- Integrated Terrain Unit (ITU) plots surveyed by the Riparian Vegetation Study (Study 11.6) will be sampled for woody plant species. Tree and selected shrubs will be aged, and density and abundance will be measured.
- Tree core aging will provide greater resolution to understanding of floodplain establishment patterns. Age at breast height will be estimated and preliminary tree age estimates will be revised.
- Complete sediment geochronology isotope sampling on sediment cores, data analysis, and final analysis report.
- Compile field data analyses for comparison of results with Fluvial Geomorphology Modeling (Study 6.6) historic aerial photographic channel change analyses. Compare measurements of the rates of channel migration, and floodplain vegetation disturbance or turnover, throughout the RIFS study area.
- Compile spatially explicit data including sediment isotope data to characterize rates of sediment deposition, and floodplain development, throughout the RIFS study area.
- In coordination with Fluvial Geomorphology Modeling (Study 6.6), analyze and model how Project operations will affect changes in the natural sediment regime, floodplain depositional patterns, and soil development throughout the RIFS study area.
- Assess/model how Project operation induced changes in sediment transport and soil development will affect floodplain development and plant community establishment and succession.
- Quantitatively describe and compare ice-influenced and non-ice-influenced floodplain plant community composition, abundance, age, and spatial pattern to assess the role and degree of influence ice processes have on Susitna River floodplain vegetation. For example, ice shearing of low elevation mid-channel islands generates and maintains forest stands in an early tall alder successional phase often dominated by felt-leaf willow.

- Refinement and interpretation of mapped ice scar zones will be done to determine intensive ice floodplain vegetation interaction survey locations

- Provide Project operational guidance on potential effects of operations flow on ice formation and floodplain vegetation development.

- Seedlings will be sampled for isotope analysis at several times during the growing season. Ground water and surface water samples will be collected for isotope analysis during the growing season.

- Excavation of trenches within each Focus Area floodplain plant community type in coordination with soil stratigraphic excavations and well-point soil pits will be used to characterize depth of dominant plant root systems.

- Additional root depth sampling using cut bank photography methodology (after Rood, S.B., S.G. Bigelow and A.A. Hall. 2011. Root architecture of riparian trees: river cut banks provide natural hydraulic excavation, revealing that cottonwoods are facultative phreatophytes. Trees 25: 907-917) and/or direct soil core around target species methodology needs to be completed in order to develop parameters for the RIPET MODFLOW model.

- Riparian GW/SW model construction will be developed.

- A physical process model of GW/SW interactions will be developed for select riparian Focus Area sites to model floodplain plant community GW/SW relationships. Developing conceptual model and numerical representations of the GW/SW interactions, coupled with important processes in the unsaturated zone, will help evaluate natural variability in the Susitna River riparian floodplain plant communities, and assesses how various Project operations may potentially result in alterations of floodplain plant community types, as well as improve the understanding of what controlled fluctuations of flow conditions would result in minimal riparian changes.

- Plant frequency water gradient analyses will result in multiple models each describing the frequency that a given plant species or community type occurs primarily as a function of estimated groundwater and surface water statistics (e.g., mean depth during growing season, growing season 7-day moving average high water level). An iterative statistical best-fit analysis will be conducted to create plant frequency response curve models.

- Model development and coordination with the Technical Workgroup (TWG).

- Continued coordination with Riparian Vegetation (Study 11.6), Groundwater (Study 7.5), Ice Processes (Study 7.6), and Fluvial Geomorphology Modeling (Study 6.6) to integrate effects modeling efforts for modeling synthesis and project scaling from Focus Areas to project reach will occur.