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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Riparian Instream Flow Study
Study Plan Section 8.6

Initial Study Report
Part C: Executive Summary and Section 7

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants

June 2014

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Riparian Instream Flow Study 8.6	
Purpose	The purpose of this study 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 process regimes.
Status	This is a multi-year study initiated in 2013. The first year of field data has been collected for all components of this study. The study team is analyzing data and preparing to continue data collection efforts to complete the study.
Study Components	Study components include the following activities: 1. Literature Review of Dam Effects on Downstream Vegetation 2. Focus Area Selection−Riparian Process Domain Delineation 3. Seed Dispersal and Seedling Establishment 4. River Ice Effects on Floodplain Vegetation 5. Floodplain Stratigraphy and Floodplain Development 6. Riparian GW/SW Hydroregime 7. Floodplain Vegetation Modeling Synthesis and Project Scaling
2013 Variances	AEA implemented the methods as described in the Study Plan with the exception of the variances listed below. • Completion of the literature review was scheduled for Q4 2013 and is now scheduled for 2014 (see Section 4.1). • The first year (0+) balsam poplar and willow establishment study was restricted to documenting the current cohort of seedlings less than 1 year old rather than all woody plants less than 1 meter in height. In response to this variance, AEA anticipates conducting a clonal reproduction study to characterize asexual recruitment patterns in 2015 field season (see Section 4.3.2).
Steps to Complete the Study	Steps to complete the Riparian IFS Study include: • 2014 field work: river ice break up aerial reconnaissance and field observations; Evapotranspiration (ET) study sap flow sensor installation, maintenance and data QA/QC; second year seedling establishment monitoring and sampling; sediment isotope sampling; tree ice scar mapping and sampling. • 2014 Combined Riparian IFS and Fluvial Geomorphology Dam Effects Literature Review Technical Memorandum.

Riparian Instream Flow Study 8.6	
	• 2015 field work: second year seed dispersal study field sampling and modeling; riparian vegetation study dendrology sampling; third year seedling establishment monitoring and sampling; ET study sap flow sensor installation, maintenance and data QA/QC; ET study porometer, isotope and root sampling; ice / floodplain vegetation interaction field sampling • 2015 modeling and statistical analyses.
Highlighted Results and Achievements	The Riparian IFS Study successfully accomplished all of the 2013 field objectives as described in the Study Plan. Accomplishments and key findings for each element of the study include the following: 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

Riparian Instream Flow Study 8.6	
	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

Riparian Instream Flow Study 8.6	
	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.

7. COMPLETING THE STUDY

7.1. Proposed Methodologies and Modifications

To complete this study, AEA will implement the methods in the Study Plan, except as described in Sections 7.1.2. Field data collections for the Updated Study Report (USR) will be completed by study section as described below. These activities include:

Literature Review of Dam Effects on Downstream Vegetation (RSP Section 8.6.3.1)

- Completion of literature review in coordination with Fluvial Geomorphology (Study 6.6)

Focus Area Selection−Riparian Process Domain Delineation (RSP Section 8.6.3.2)

- The final riparian process domain analysis will be completed for the Middle and Lower River Segments and will include ice mapping data and additional flow routing modeling.

Seed Dispersal Study (RSP Section 8.6.3.3.1)

- Female poplar trees and willow shrubs will be identified at four locations along the Middle and Lower River Segments for one additional field season.
- Weekly counts of open catkins until 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 2 years of data to link peak seed release to local climate and 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.

Seedling Establishment Study (RSP Section 8.6.3.3.2)

- To characterize seedling establishment hydrologic conditions, seedling transects will be revisited and seedlings counted twice to capture seedling mortality relative to bimodal peak flow patterns.
- Clonal poplar and willow surveys will be completed on the lateral channel margins.

- Additional channel margin and floodplain transects will survey 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 or 2-D hydraulic models.

Floodplain Stratigraphy and Floodplain Development (RSP Section 8.6.3.5)

- ITU plots surveyed by the Riparian Vegetation (Study 11.6) will be sampled. Tree and selected shrubs will be aged, and density and abundance will be measured.
- Tree core aging will continue to provide additional understanding of floodplain establishment patterns.

Ice Effects (RSP Section 8.6.3.4)

- The ice effects floodplain vegetation study will be developed based on results from 2013 field work.
- Additional select reaches in the Lower River Segment will be mapped.
- Refinement of mapping and further interpretation of ice scar zones will be done to determine intensive ice floodplain vegetation interaction survey locations.
- In addition to data and information obtained from previous technical studies and scientific literature, the task will also benefit from anecdotal information, knowledge, and insight provided by a number of local residents and people who have worked or recreated on the Susitna River. Local residents will be interviewed in regards to historic ice processes.
- Ice scar mapping will be completed for additional selected areas.

Riparian GW/SW study (RSP Section 8.6.3.6)

- The groundwater and surface water data collection period began in July 2013 and will continue to document conditions in winter, spring, and summer in the next study year.
- 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.
- Sap flow sensors will be reinstalled prior to leaf-out to capture early spring transpiration.
- Three index weather stations at FA-128 (Slough 8A), FA-115 (Slough 6A) and FA-104 (Whisker Slough) will continue to collect soil and atmospheric measurements to be used in the evapotranspiration calculations for water budget characterizations and hydrologic modeling.
- 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.

- 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.

Floodplain Vegetation Modeling Synthesis and Project Scaling (RSP Section 8.6.3.7)

- Model development and continued coordination with 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

7.1.1. Decision Points from Study Plan

There were no decision points in the FERC-approved Study Plan to be evaluated for this study following the completion of 2013 work.

7.1.2. Modifications to Study Plan

AEA implemented the methods as described in the Study Plan with the exception of modifications listed below:

- Completion of the literature review was scheduled for Q4 2013 and is now scheduled for Q3 2014. (See discussion in RSP Section 8.6.3.1)
- 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 (RSP Section 8.6.3.3.2). For example, 2013 field investigations showed that Balsam poplar was found to establish and recruit not only from annual seed establishment (sexual reproduction) but also through clonal reproduction at floodplain margin sites that are repeatedly disturbed by ice flows and ice deposited sediment. Ice flows rafted onto the floodplain knock down Balsam poplar stems and ice dam flood associated sediment is often deposited burying the stems. The buried stems then send up new shoots (clonal reproduction). The 2013 field results indicate this

is a locally important style of Balsam poplar reproduction that will potentially be altered by Project operations alterations of ice process regime below the dam site.

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 in 2015. 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).

This study design modification also addresses the objectives of the river ice effects study design: "The objective of the ice effects vegetation study will be to quantitatively describe 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" (RSP Section 8.6.3.4). From the Ice Processes study methods (RSP Section 8.6.3.4.2.1): "1. Mapping of ice floodplain vegetation interactions and soil disturbance throughout the Study Area... 3. Comparative quantitative vegetation study of ice effects on identified ice floodplain impact and un-impacted zones. 4. Final ice vegetation field sampling methodology will be developed in Q2, Q3 2013 as tree ice-scar field data become available and ice effect domains are delineated. 5. Integration of ice process modeling results with empirical ice vegetation mapping and ice vegetation interaction studies."

Implementation of this seedling establishment and recruitment study modification will therefore achieve both the Seedling Establishment and Recruitment Study Objectives (RSP Section 8.6.3.3.2) as well as meet the Ice Processes Study Objectives (RSP Section 8.6.3.4). It should be noted that the Ice Processes final study was to be based upon 2013 field observations and results (RSP Section 8.6.3.4).

7.2. Schedule

In general, the schedule for completing the FERC-approved Study Plan is dependent upon several factors, including Project funding levels authorized by the Alaska State Legislature, availability of required data inputs from one individual study to another, unexpected weather delays, the short duration of the summer field season in Alaska, and other events outside the reasonable control of AEA. For these reasons, the Study Plan implementation schedule is subject to change, although at this time AEA expects to complete the FERC-approved Study Plan through the filing of the USR by February 1, 2016, in accordance with the ILP schedule issued by FERC on January 28, 2014.

With regard to this specific study, AEA expects to complete data collection in both the 2014 and 2015 study seasons, which will be reported in the USR.

2014 field activities will include: (1) two, late July/early August and late August/early September, 2nd year seedling establishment survival surveys at all 2013 seedling transects (FA-104 (Whisker Slough), FA-113 (Oxbow I), FA-128 (Slough 8A), 138 (Gold Creek) and 144 (Slough 21)); (2) completing tree ice scar surveying, mapping and sampling within the Middle River; (3) completing floodplain sediment core sampling at select FAs; and (4) monitoring, and removal October 2014, of installed tree sap-flow sensors at FA-104 (Whisker Slough) and FA-128 (Slough 8A),.

2014 office activities will include: (1) QA/QC of 2014 tree sap-flow data; (2) initial 1-D surface water modeling set-up for floodplain inundation frequency modeling throughout the Study Area; (3) initial statistical analyses of seedling establishment and groundwater/ surface water isotope laboratory data; (4) 2013 tree ice scar sample laboratory measurements; (5) development of final ice floodplain vegetation effects modeling approach with ice processes modeling team, and (6) development of a combined Riparian and Fluvial Geomorphology Technical Memorandum literature review with the bibliography.

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7.3. Conclusion

The Riparian IFS study accomplished all of the 2013 field objectives as described in the Study Plan. The riparian IFS team assisted and collaborated with Riparian Vegetation (Study 11.6), Fluvial Geomorphology Modeling (Study 6.6), Ice Processes (Study 7.6), and Groundwater (Study 7.5) teams in accomplishing targeted integrated efforts. Finally, the Riparian IFS team was able to aerially observe 2013 river ice break-up over 2 days, greatly informing the understanding of floodplain ice interaction processes, a critical objective of 2013 fieldwork.

Based on data collection completed in 2013, preliminary analyses, and plans for continued data collection in the next study year, the study is on track to meeting all Project objectives.