ALASKA ENERGY AUTHORITY

July 1, 2013

Ms. Kimberly D. Bose
Secretary
Federal Energy Regulatory Commission
888 First Street, NE
Washington, DC 20426

Re: Susitna-Watana Hydroelectric Project, FERC Project No. 14241-000; Riparian Instream Flow, Groundwater, and Riparian Vegetation Studies FERC Determination Response Technical Memorandum

Dear Secretary Bose:

On April 1, 2013, the Federal Energy Regulatory Commission (Commission or FERC) issued its Study Plan Determination (April 1 SPD) for 14 of the 58 proposed individual studies in the Alaska Energy Authority's (AEA) Revised Study Plan (RSP) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241 (Project).

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 recommended that AEA file a technical memorandum that provides additional information on the methods for addressing several aspects of the study plan. The recommendations were:

Groundwater Study (RSP Section 7.5)

> *We recommend that AEA consult with the [Technical Workgroup (TWG)] on the construction of the necessary data sets for the MODFLOW RIP-ET package, and file no later than June 30, 2013, the following:*
>
> *1. A detailed description of the specific methods to be used to relate the data of Study 11.6 (riparian vegetation) to plant functional groups.*
> *2. A detailed description of the specific methods to be used to relate the rooting depth data from Study 8.6 (riparian instream flow) and the water level data from Study 7.5 (groundwater) to extinction and saturated extinction depths.*
> *3. A detailed description of the specific methods to be used to estimate the shape of the transpiration flux curves.*

813 West Northern Lights Boulevard Anchorage, Alaska 99503 T 907.771.3000 Toll Free (Alaska Only) 888.300.8534 F 907.771.3044

4. Documentation of consultation with the TWG, including how its comments were addressed.

<u>Riparian Instream Flow Study (RSP Section 8.6)</u>

[W]e recommend that AEA consult with the TWG on the sampling design for collecting plant xylem water; and file no later than June 30, 2013, the following:

1. A detailed description of the sampling sites, frequency, and schedule.
2. Documentation of consultation with the TWG, including how its comments were addressed.

<u>Riparian Vegetation Study (RSP Section 11.6)</u>

[W]e recommend that AEA consult with TWG on the sampling design for vegetation sampling within and outside the focus areas, and file no later than June 30, 2013, the following information:

1. A detailed sampling design, including a schematic of the sampling scheme for each focus area, the stratification factors, and basis for the number of plots within and outside the focus areas.
2. Documentation of consultation with the TWG, including how its comments were addressed.

Consistent with the Commission's recommendations within the April 1 SPD, AEA is filing the attached Riparian IFS, Groundwater and Riparian Vegetation Studies FERC Determination Response Technical Memorandum (attached as Attachment A).

The information supporting this technical memorandum was presented at a Technical Workgroup Meeting on June 25, 2013. A comment response table is included within the memorandum as Appendix 1.

As always, AEA appreciates the participation and commitment to this licensing process demonstrated by Commission Staff, federal and state resource agencies, and other licensing participants. AEA looks forward to working with licensing participants and Commission Staff in implementing the approved studies, which AEA believes will comprehensively investigate and evaluate the full range of resource issues associated with the proposed Project and support AEA's license application, scheduled to be filed with the Commission in 2015.

If you have questions concerning this submission please contact me at wdyok@aidea.org or (907) 771-3955.

Sincerely,

Wayne Dyok
Project Manager
Alaska Energy Authority

Attachment

cc: Distribution List (w/o Attachments)

Attachment A

Riparian Instream Flow, Groundwater, and Riparian Vegetation Studies
FERC Determination Response Technical Memorandum (June 2013)

Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Technical Memorandum:
Riparian Instream Flow, Groundwater, and Riparian Vegetation Studies FERC Determination Response

Prepared for

Alaska Energy Authority

Prepared by

R2 Resource Consultants, Inc., GW Scientific and ABR, Inc.

June 2013

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LIST OF ACRONYMS AND ABBREVIATIONS

Abbreviation	Definition
AEA	Alaska Energy Authority
ET	Evapotranspiration
FA	Focus Area
FERC	Federal Energy Regulatory Commission
ISR	Initial Study Report
RIFSTT	Riparian Instream Flow Study Technical Team
MODFLOW	U.S. Geological Survey's groundwater-flow model,
MR	Middle River
PFG	Plant Functional Group
Project	Susitna-Watana Hydroelectric Project, FERC Project No. 14241
RIP-ET	Riparian Evapotranspiration Package for MODFLOW
RSP	Revised Study Plan
SPD	Study Plan Determination
TWG	Technical Workgroup
USGS	United States Geological Survey
USFWS	United States Fish and Wildlife Service

1. INTRODUCTION

On April 1, 2013, the Federal Energy Regulatory Commission (FERC) issued its Study Plan Determination (April 1 SPD) for 14 of the 58 proposed individual studies in the Alaska Energy Authority's (AEA) Revised Study Plan (RSP) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241 (Project). When approving the Groundwater Study (Study 7.5), Riparian Instream Flow Study (Study 8.6), and Riparian Vegetation Study (Study 11.6), FERC's April 1 SPD made the following recommendations on the three interrelated study plans:

1.1. Groundwater Study (Study 7.5)

We recommend that AEA consult with the [Technical Workgroup (TWG)] on the construction of the necessary data sets for the MODFLOW RIP-ET package, and file no later than June 30, 2013, the following:

1. *A detailed description of the specific methods to be used to relate the data of Study 11.6 (riparian vegetation) to plant functional groups.*
2. *A detailed description of the specific methods to be used to relate the rooting depth data from Study 8.6 (riparian instream flow) and the water level data from Study 7.5 (groundwater) to extinction and saturated extinction depths.*
3. *A detailed description of the specific methods to be used to estimate the shape of the transpiration flux curves.*
4. *Documentation of consultation with the TWG, including how its comments were addressed.*

1.2. Riparian Instream Flow Study (Study 8.6)

[W]e recommend that AEA consult with the TWG on the sampling design for collecting plant xylem water; and file no later than June 30, 2013, the following:

1. *A detailed description of the sampling sites, frequency, and schedule.*
2. *Documentation of consultation with the TWG, including how its comments were addressed.*

1.3. Riparian Vegetation Study (Study 11.6)

[W]e recommend that AEA consult with TWG on the sampling design for vegetation sampling within and outside the focus areas, and file no later than June 30, 2013, the following information:

1. *A detailed sampling design, including a schematic of the sampling scheme for each focus area, the stratification factors, and basis for the number of plots within and outside the focus areas.*
2. *Documentation of consultation with the TWG, including how its comments were addressed.*

AEA has completed these recommended tasks. Consultation on the interrelated riparian vegetation, riparian instream flow and riparian groundwater/surface water (GW/SW) study plans was accomplished with TWG representatives in two Riparian Instream Flow Study Technical Team (RIFSTT) meetings. Meetings were held April 23, 2013 and June 6, 2013 to allow agency and AEA scientists to confer on technical details and to address agency comments and concerns regarding the study's technical approaches and methods (TWG meeting comments and AEA responses may be found in Appendix 1; April 23 and June 6 meeting notes are provided in Appendices 2 and 3).

This technical memorandum summarizes details concerning sampling design, proposed field protocols and analytical methodologies related to FERC Determination requests. The document is organized to address details for each of the three RSPs: Groundwater Study 7.5, Riparian Instream Flow Study 8.6, and Riparian Vegetation Study 11.6. For each study, we first present the FERC request followed by AEA's response. Additionally, riparian groundwater study *MetaData Standards for Cluster Well Stations including Sap Flow Sensors* are provided in Appendix 4.

2. STUDY PLAN DETAILS

2.1. Groundwater Study (Study 7.5)

The FERC April 1 SPD recommended consultation with the TWG on detailed methods for developing datasets for MODFLOW RIP-ET model. MODFLOW's function is to understand the larger scale GW/SW interactions to use in conjunction with field measurements and other analyses. Elements of these questions apply to both the Groundwater (7.5) and Riparian Instream Flow (8.6) studies. In the Riparian TWG Technical Team meetings (April 23 and June 6, 2013), AEA presented additional details and descriptions for the following:

1. Methods to determine plant functional groups.
2. Methods to determine extinction and saturated extinction depths for defining transpiration flux curves for plant functional groups using rooting depth and water level data.
3. Methods to estimate shape of transpiration flux curves.

2.1.1. FERC request: "A detailed description of the specific methods to be used to relate the data of Study 11.6 (riparian vegetation) to plant functional groups."

2.1.1.1. Determination of plant functional groups

Plant functional groups (PFGs) have been defined as non-phylogenic groups of plant species with similar functions or response to environmental conditions (Lavorel et al. 1997, Ajami et al. 2012). For purposes of this study, PFGs are defined as groups of plant species that access floodplain water compartments in a similar manner as defined by plant species root depth. Plant access to different floodplain water compartments (e.g., groundwater, surface water, precipitation, saturated soil) will be modeled for each PFG. Five provisional draft PFGs have been identified including Transitional, Wetland, Deep-rooted Trees, Shallow-rooted Trees, Shallow Rooted and Transition Groups following the RIP-ET modeling process proposed by Maddock et al. 2012 (Figure 1).

These PFGs have been defined based on expected rooting depths, water tolerance ranges gathered from literature reviews, and preliminary field studies using methods similar to Baird and Maddock (2005). PFGs will be used to model plant community responses to changes in water levels across floodplain surfaces. These PFGs are provisional and will be revised to reflect data gathered in 2013 on plant community composition and species distributions and rooting depth measurements made during the 2013 field studies. Final PFGs will be presented to the TWG for consideration in Q4 2013 and Q1 2014 meetings.

2.1.2. FERC request: "A detailed description of the specific methods to be used to relate the rooting depth data from Study 8.6 (riparian instream flow) and the water level data from Study 7.5 (groundwater) to extinction and saturated extinction depths."

2.1.2.1. Defining extinction and saturated extinction depths

Input data for MODFLOW requires estimation of the extinction and saturated extinction depth (Figure 2) to assign transpiration flux curves. Extinction depth, or the depth at which the water table is far enough below the rooting zone that plants can no longer obtain water, will be approximated based on the maximum rooting depths observed in the field (Baird and Maddock 2005, Maddock et al. 2012). Root sampling will be done through the combination of random soil core sampling within each plant function group and deep soil trenches. Cores will be collected using a 7.62 cm diameter split-spoon soil core. Cores samples will be collected down to 150 cm. Observations of presence or absence of roots will be recorded at specific depths. Soil pits will be dug as part of the soil stratigraphic sampling for the Integrated Terrain Unit mapping (Riparian Vegetation Study 11.6) and sediment deposition sampling (Riparian Instream Flow Study 8.6). Within these trenches, horizontal soil cores will be taken at systematic depths in the soil profile using a 5 x 30 cm PVC corer. Root biomass will be measured by volume of the soil core.

Saturated extinction depths, or the water table elevation at which plants dies from O_2 deficiency through flooding of the root zone by groundwater, will be approximated through correlations between plant species occurrence and water-table elevations to describe upper and lower limits of species water tolerances (Baird and Maddock 2005).

2.1.3. FERC request: "A detailed description of the specific methods to be used to estimate the shape of the transpiration flux curves."

2.1.3.1. Transpiration flux curves

In many riparian plant communities, the rate in which water is transpired greatly varies with groundwater depth (Baird and Maddock 2005). In order to understand the interaction between groundwater and surface water to riparian vegetation, AEA will develop plant functional group specific transpiration curves. The shape of the curve is a function of transpiration flux (or the rate of transpiration per area) relative to the depth to groundwater. To develop the transpiration flux curve for the MODFLOW model, the average maximum evapotranspiration (ET) flux needs to be determined. Predicting the amount of water transpired by plants will be done using the Penmen-Monteith (PM) equation. The PM predicts the total ET, estimating the rate of total evaporation and transpiration from an ecosystem using the commonly measured meteorological measurements of solar radiation, air temperature, vapor content, and wind speed (Allen et al. 2005). The PM will be used to measure hourly estimates of ET across FAs 104, 115 and128. Direct measurements of woody plant species transpiration will be measured using Grainer's Thermal Dissipation Probe (TDP) methods using Dynamax Inc. TDP sap flow probes (Houston, TX). Sap flow techniques use a series of probes which are inserted into the xylem of a plant that measures the rate at which water flows through the xylem. The series is made up of two probes, one heater probe and the other a temperature sensor (thermocouple). A pulse of heat is released from the heater probe into the transpiration stream and the time it takes for that heat pulse to reach the temperature sensor is the flow rate of sap flow. Inference into herbaceous transpiration will be done by measuring leaf-level stomata conductance using hand-held porometers (SC-1, Decagon Device, Pullman, WA).

Depth to ground water will be measured using transects of wells through the Focus Areas. Wells will be located along important hydrological boundaries and within specific plant functional groups. Differential pressure transducers will be used in each well and adjacent surface-water body to record water levels throughout the year to develop an understanding of the annual hydrologic cycle. The depth to groundwater will be measured with both self-logging pressure transducers and pressure transducers logging in to data loggers in 15-minute intervals.

2.2. Riparian Instream Flow Study (Study 8.6)

2.2.1. FERC request: "A detailed description of plant xylem isotope sampling sites, frequency, and schedule."

2.2.1.1. Plant Xylem Isotopic Sampling

Details of the plant xylem water study including sampling sites, frequency and schedule were discussed in two Riparian TWG technical team meetings (April 23 and June 6, 2013). The discussion is summarized below. As described in RSP Section 8.6.3.6.3., a stable isotope experiment has been designed to determine the source from which dominant woody plant species obtain water. AEA proposes to collect isotope samples three times over the growing season in each sampling year to gain an understanding of how water sources may vary by species during the growing season and across meteorological conditions.

Due to inherent properties of isotopes (Lajtha and Marshall 1994), many biogeochemical processes have a specific isotopic signature measured as the ratio of heavy to light isotopes (Dawson 1993; Lajtha and Marshall 1994). Since plants do not discriminate against heavy isotopes during water uptake, xylem water in non transpiring plant tissues retain the isotopic signature of the water source from which it was derived (Flanagan and Ehleringer 1991). Isotopic abundance in xylem sap corresponds to the range of isotopic composition of all water taken up by the plant roots, and can be used to infer the source of a plant's water uptake (Dawson 1993; Dawson et al. 2002). By comparing the natural isotopic signature of O^{18} and H^2, it is possible to differentiate plant water use between surface water, ground water, and precipitation (Dawson et al. 2002).

Plant xylem samples will be collected through a combination of branch clipping and increment bore samples. Only non-transpiring tissues (Ehleringer and Dawson 1992) from target plants will be sampled and placed in a sealed 12 mm glass sample tube and kept frozen until sample extraction is completed. Large trees will be sampled with increment bore samples collected at breast height excluding bark tissue. Small shrubs and herbaceous species will be sampled by branch clipping. Sampling will be concentrated around midday (~1100 to 1400) to ensure the collection of data from actively transpiring plants. It will be assumed that transpiration of woody plants is at isotopic steady-state, such that the deuterium value of non-evaporated twig xylem water would be representative of that of transpiration vapor during the sample collection periods (Yakir and Sternberg 2000).

Plant xylem samples will be collected at two focus areas in 2013 (FA-104 and FA-128) with sampling periods in early June, mid-July and late August/early September. At least five samples will be processed for each dominant woody species selected for analysis including dominant trees: poplar (*Populus balsamifera* ssp. *trichocarpa*), white spruce (*Picea glauca*), and paper birch (*Betula papyrifera*), willows (Salix sp.) and dominant herbaceous species.

2.3. Riparian Vegetation Study (Study 11.6)

2.3.1. FERC request: "A detailed vegetation sampling design, including a schematic of the sampling scheme for each focus area, the stratification factors, and basis for the number of plots within and outside the focus areas."

2.3.1.1. Riparian Vegetation Sampling Design

Three sampling methods will be used for the riparian vegetation study, including Focus Area sampling, Non-Focus Area sampling, and Integrated Terrain Unit (ITU) mapping transect sampling. Focus Area sampling plots will be defined with stratified random sampling with the stratification unit being Ecotype. Ecotypes are local scale ecosystems and are represented in the ITU mapping as the mapping component which combines vegetation and environmental attributes including vegetation cover types, geomorphology including flood frequency, poplar successional status (size class), and soils.

A stratified random sample design was developed for each riparian Focus Area using ecotype as the stratification unit. The ITU mapping completed in Fall/Winter 2012 for the middle Susitna River was clipped using the boundary of each Focus Area. The total area of each Focus Area, the number of ecotypes within each Focus Area, and the total area (acres) of each ecotype within a Focus Area were calculated. The total number of random plots per Focus Area was determined using the following formula as a guide:

Focus Area plots = 1 plot/ 20 acres + 1.5* the total # of ecotypes in a Focus Area

The above formula accounts for both total area of a Focus Area and the total number of ecotypes such that a smaller Focus Area with a large number of ecotypes would be assigned a larger number of plots than it would based on area alone. The total area of each ecotype was then divided by the total area of the respective Focus Area to determine the percent area of each ecotype relative to the Focus Area. Ecotypes encompassing ≥ 2% of the total area within a Focus Area were assigned a number of random plots using the following formula as a guide:

Random Plots per Ecotype = % total ecotype area*# of Focus Area plots

The GENERATE RANDOM POINTS TOOL from Hawth's Analysis Tools for ArcGIS (http://www.spatialecology.com/htools/rndpnts.php) was used to generate the random plots by ecotype. For 2013 field studies, stratified random plots will be distributed across three (3) Focus Areas (FA-104, FA-115, FA-128) for a total of 118 plots.

The Non-Focus Area sampling design (satellite areas) will use a targeted/directed sampling scheme to select areas that will document underrepresented vegetation types such as some of the herbaceous communities which are not represented in the existing Focus Areas. A total of 94 Non-Focus Area plots will be targeted for sampling in 2013.

ITU transects will be focused in the Lower River study area to understand GIS aerial imagery signatures and resolve ITU mapping polygons. Approximately 60 transects which corresponds to about 300 plots are planned for the Lower River in 2013.

3. REFERENCES

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4. FIGURES

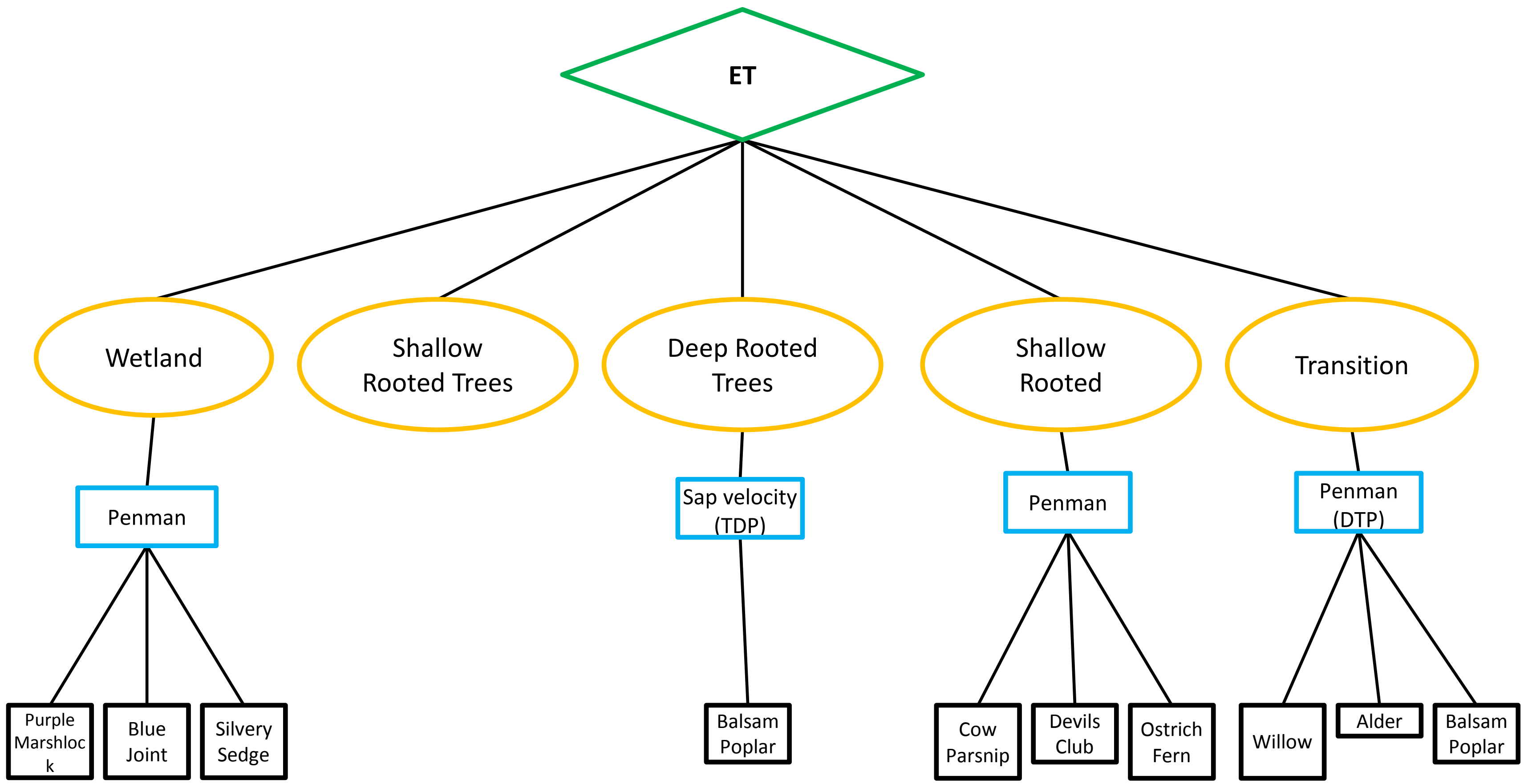

Figure 1. Provisional Plant Functional Groups (PFGs) (yellow ovals), proposed method to estimate ET (blue rectangles), and dominant plant species observed in the Susitna River floodplain (black squares).

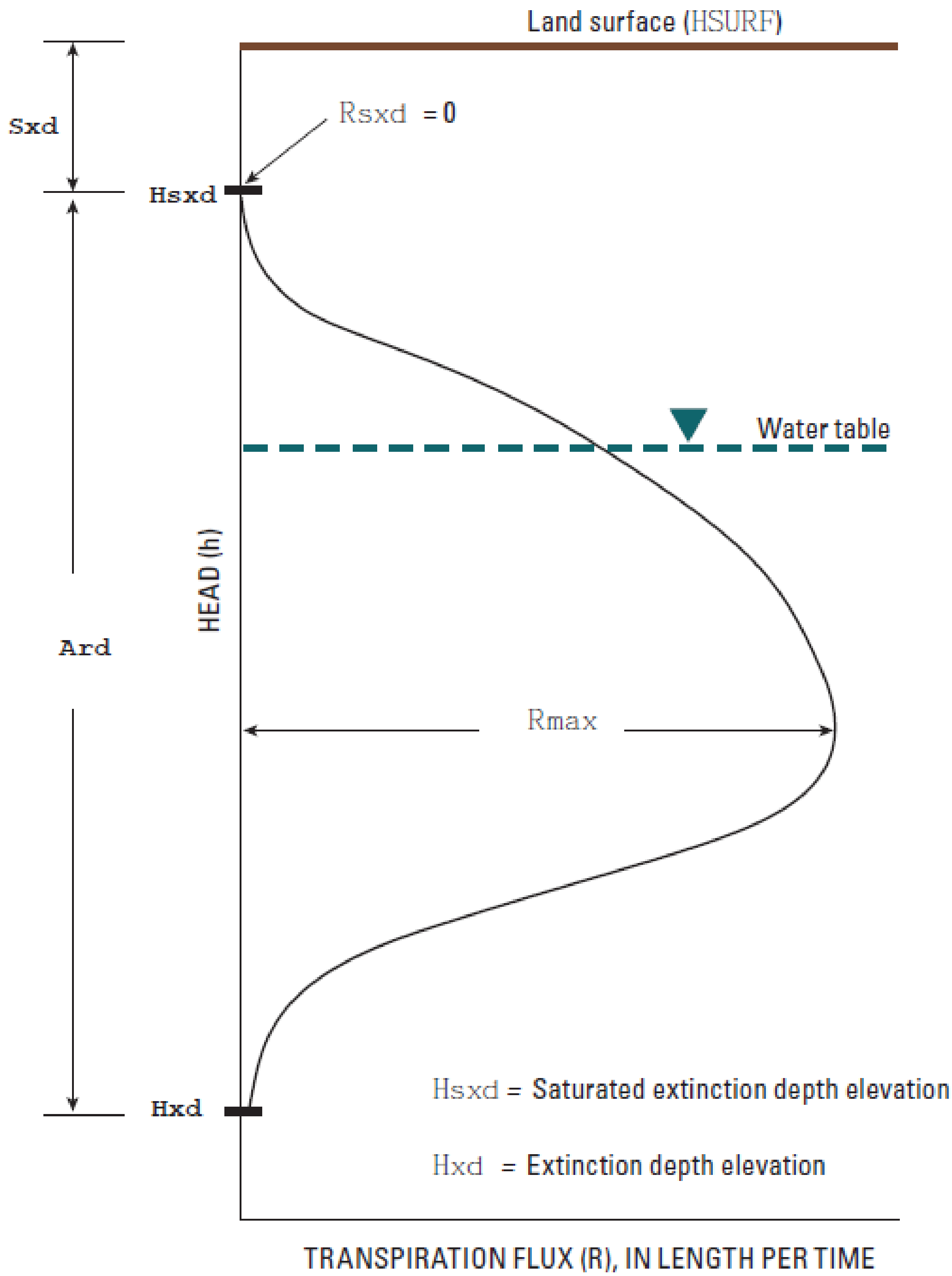

Figure 2. Generic transpiration flux curve (modified from Baird and Maddock 2005).

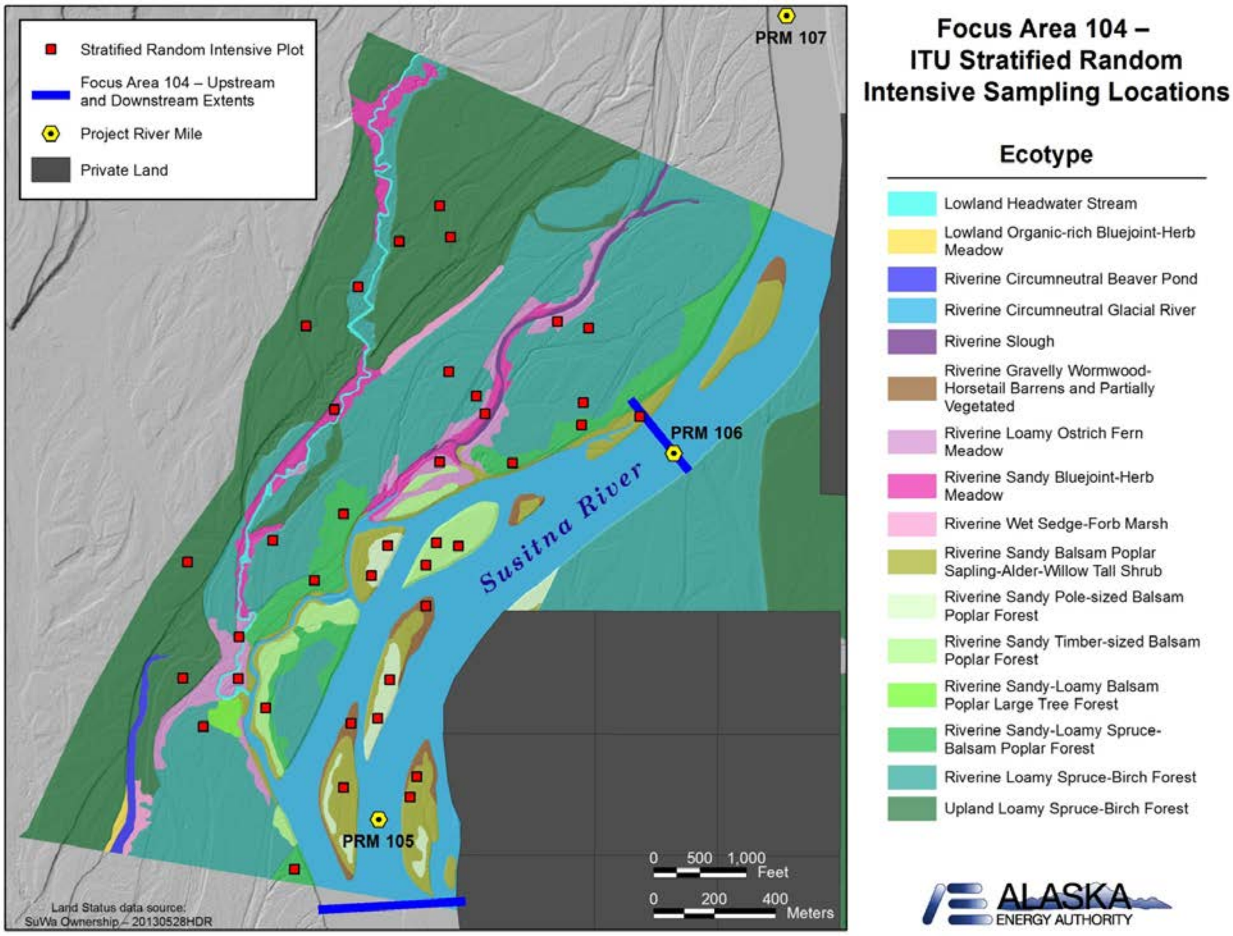

Figure 3. Proposed Focus Area riparian vegetation plot sampling strategy for FA-104 (Whiskers Slough).

APPENDIX 1. TWG COMMENT, AEA RESPONSE TABLE

Licensing Participant	Comment	Response
Bob Henszey, USFWS	There may be additional herbaceous plant communities that warrant additional PFGs.	The 2012 study mapped only wet sedge meadow and wet forb herbaceous communities. Additional 2013 field work will cover a broader range of floodplain habitat. Additional functional groups, particularly herbaceous species, may be added to the study in 2014, as necessary. This topic will be revisited following summer 2013 field work and presented in Q4 2013 and Q1 2014 meetings TWG meetings.
Bob Henszey, USFWS	Requested information on the diameter soil core samples will be taken, and whether the team would do biomass estimates, volume, or presence/absence for the soil cores.	Three (3) inch soil cores will be obtained using a standard soil sampler. Soil cores for isotope studies will be done at systematic depths and presence/absence of roots will be noted. Root biomass will be sampled in soil stratigraphic pits with horizontal grab samples at taken systematic depths.
Bob Henszey, USFWS	How will it be determined whether each of the three sampling periods is occurring on a rising or falling limb?	All groundwater heights, sap flow, and meteorological data will be collected daily throughout the growing season, enabling the RIFS team to look at trends in regards to ET and groundwater elevations on a daily scale (e.g., rising and falling limb for groundwater). Porometer sampling periods were selected to coincide with seasonal leaf area and plant water use trends. Besides the seasonal rise and fall of the hydrograph, additional measurements will be made to capture any observed hydrograph flux.
Bob Henszey, USFWS	How will the presence of a perched water table be determined?	Perched water tables are not likely in the floodplain environment. The conductivities typical of high-energy fluvial sedimentary deposits (sands and gravels) typically result in well-connected aquifer conditions. Saturated soil conditions may exist at the top of a melting active layer (seasonally frozen soils), but these conditions typically referred to as a perched water table. If field conditions due indicate any perched water table conditions, then observational field hydrology methods, in combination with surveyed surface water features and terrain surface maps will be used to describe these conditions, if they are found.
Colin Kikuchi, USGS	Recommended that use of additional tracers (beyond ^{2}H and ^{18}O) may be necessary. Major ions such as chloride as a natural tracer in addition to the 2 tracers. He believes n-1 independent tracers are needed for a robust analysis of water source.	AEA will investigate feasibility of using additional natural occurring tracers based upon findings of 2013 field season. AEA will report back to TWG in Q4 2013, Q1 2014.
Jan Konigsberg, AK Hydro Reform	Requested clarification that only a single year of sampling will be conducted for this study	Riparian vegetation study is designed to describe vegetation succession (plant community change over time) by sampling the existing range of plant community stages. These stages will then be used to construct a model of plant community change over time. This study approach is a standard protocol in the field of forest ecology.

Colin Kikuchi, USGS	Requested detailed, integrated maps with proposed study plots.	Maps showing proposed transect and plot locations were provided at the June TWG meetings.

APPENDIX 2. RIFSTT MEETING NOTES, APRIL 23, 2013

Susitna Watana Hydro Project
Meeting Notes
Riparian Instream Flow and Groundwater Technical Team Meeting
April 23, 2013

LOCATION: **Webinar**

TIME: 9:00 AM - 1:00 PM AKST / 10:00 AM - 2:00 PM PST

SUBJECT: Review and discuss FERC Determination Riparian TWG Consultation Recommendations

Goal: 1) Review and discuss Riparian IFS and Groundwater Study Plan
2) Finalize Riparian Groundwater Study Implementation Plan

ON PHONE ATTENDEES: **Aaron Wells** ABR, **Kevin Fetherston** R2, **Michael Lilly** GWS, **Kate Knox** R2, **Michael Mazzacavallo** R2, **Bob Henszey** USFWS, **Chiska Derr** NMFS, **Colin Kikuchi** USGS, **Greg Auble** USGS, **Joe Klein** ADF&G, **Eric Rothwell** NMFS

This meeting serves as the first of two meetings to discuss details of the Groundwater/Surface Water interaction study as required in the April 1, 2013 FERC Study Plan Determination. A detailed agenda for this meeting is provided at the end of these notes. Goals for this meeting were to:

1) Review and discuss Riparian IFS and Groundwater Study Plan

2) Finalize Riparian Groundwater Studies Implementation Plan

Kevin Fetherston, R2, introduced the study plan design, described the concept of plant functional groups, and gave an overview of the ET study design. Michael Lilly, GW Scientific, provided photographs of current end of winter observations of seepage areas.

The proposed strategy to define plant functional groups (PFG's) was described. PFG's will be defined with rooting depths which characterize the relationship of the plant community to groundwater. To define this relationship, a literature review of rooting depth studies is underway and rooting depths will be measured in the field. Kevin responded that field work efforts will include gathering additional data on rooting depths which will be used to help to clarify PFGs. Preliminary assessment of plant community rooting depths assumes 4 PFGs (Transitional, Wetland, Deep-rooted Riparian, Shallow-rooted Riparian) following the RIP-ET modeling process proposed by Maddock et al 2012. Agency members generally agreed with this approach and expressed interest in a process for continued refinement of how Viereck plant communities will be aggregated into PFGs.

Aaron Wells, ABR, presented the ITU mapping process and provided a live web presentation of draft GIS maps for Lane Creek. This presentation showed how the ITU mapping process can be used to create preliminary PFG maps from original field mapping of Viereck vegetation classes. This mapping process will be further utilized to determine spatial distribution of ET study results. The relationship between groundwater and the plant functional groups will be determined through empirical field studies measuring water depths within PFG units.

Kevin Fetherston and Kate Knox presented data on plant community distribution within the five (5) Riparian Focus Areas presented in the RSP and subsequent Technical Memorandum, and developed rationale for selecting four (4) Focus Areas instead of five (5) Focus Areas for the groundwater/surface water interaction study. All agency members were generally in agreement that this may make sense based on a first look at the data. Bob Henszey asked to have additional time to review this information and respond.

Bob Henszey then gave a presentation about his work in developing plant response curves on floodplains along the Platte River. He summarized some of the difficulties encountered when defining plan response to hydrologic conditions. Bob used the 7-day moving average to correlate plant responses (frequency of distribution) to groundwater depth.

The difference between transpiration flux curves (groundwater system) and abundance curves (plant communities) was discussed. Abundance curves look at a longer time scale than transpiration response curves. Bob and Colin raised the point that measuring ET only 3 times during the season for the herbaceous species because the groundwater/soil moisture conditions may not result in a complete growing season model. All acknowledged that it may be possible that the magnitude of transpiration difference from trees/shrubs is higher than the possible error of measuring herbaceous transpiration.

The team discussed that the current proposal is to have four (4) Riparian Focus Areas with full groundwater instrumentation with supplemental wells. These additional wells would be used to characterize additional plant communities not found within the four (4) riparian focus areas.

Michael Lilly described his proposal for drilling shallow wells to map the water table. Details of the well layout and strategy to define boundary conditions were discussed. He presented an outline for using data in RIPET and MODFLOW.

Michael Mazzacavallo presented details of the vegetation physiological measurements for measuring ET (evapotranspiration). He described the proposed strategy for using Penman-Monteith equation to approximate ET and identify plant water source using stable isotopes was presented.

Michael Lilly asked agencies to identify important action items and take home messages from this meeting. No concerns were raised by any agency attendee. The meeting closed with a discussion of when the 2nd meeting could be held and what other important topics should be discussed. Tentative schedules indicated a meeting in the first week of June would be possible.

Action Items:

1. Further refinement of the purpose of the ET-flux curves and the plant suitability curves is needed. Bob Henszey was interested in knowing how the RIFS team will define whether the 3 sampling periods are occurring on a rising or falling limb. Defining the margin of error in assumptions will be necessary.

2. Bob Henszey will review and provide his response to the question of using four (4) Focus Areas instead of five (5) Focus Areas for the groundwater/surface water interaction field effort.

3. A second meeting may be scheduled in the first week of June.

4. A formal response to FERC to document results of this meeting and the 2nd meeting will be prepared for June 30 due date.

Riparian Instream Flow and Groundwater Study

Technical Meeting Agenda

Tuesday April 23, 2013

LOCATION: **WEBINAR**

TIME: 9:00 AM - 1:00 PM AKST / 10:00 AM - 2:00 PM PST

OBJECTIVES: 1) Review and discuss Riparian IFS and Groundwater Study Plan

2) Finalize Riparian Groundwater Studies Implementation Plan

GoTo Meeting: https://www4.gotomeeting.com/register/407369839

1-800-315-6338 Code 3957#

9:00 – 9:10 Introductions

- **Kevin Fetherston**

9:10 – 9:30 Overview of Riparian Groundwater Study Plan

- **Kevin Fetherston**
- **Combined studies – R-IFS, GW-R, Rip-Veg**

9:30 – 10:45 Plant Functional Groups, Viereck Level IV Classes, Mapping and Analysis

- **Fetherston: Plant functional groups: overview of functional groups and modeling approach**
- **Aaron Wells: plant functional group mapping and relationship to Integrated Terrain Unit mapping, field sampling, Viereck Level vegetation classes, ArcMap live presentation**
- **Kate Knox - Focus Areas analysis: Change from 5 to 4 Focus Areas**
- **Short break**

10:45 – 11:30 Robert Henszey, USFW, presentation of Platte River Floodplain Groundwater Study and plant response curve analyses

- **Fetherston intro to Bob's presentation and how it relates to the R-GW Study**
- **Bob Henszey presentation**

11:30 – 1:00pm Riparian Groundwater Study Approach and operational details (working lunch)

- **Fetherston Overview Groundwater operational study approach**
- **Michael Lilly – Hydrologic Cycle, GW/SW Study Approach**
- **Michael Mazzacavallo – Evapotranspiration: theory and field operational measurement, Stable isotope analyses for water source identification of fluxes/source of plant water**

- **General Group Discussion**
- **Follow-Up Key Points,**
- **Action Items Review**
- **Next Meeting**

1:00 pm Adjourn

APPENDIX 3. RIFSTT MEETING NOTES, JUNE 6, 2013

SUSITNA-WATANA HYDRO

Meeting Notes
Riparian Instream Flow and Groundwater Technical Team Meeting
June 6, 2013

LOCATION: **Conference Call**

TIME: 8:00 AM - 10:00 AM AKST / 9:00 AM - 11:00 AM PST

SUBJECT: Review and discuss FERC Determination Riparian TWG Consultation Recommendations

Goal: 1) Review and discuss Riparian IFS and Groundwater Study Plan
2) Finalize Riparian Groundwater Study Implementation Plan

ON PHONE ATTENDEES: **Aaron Wells** ABR, **Kathryn Peltier** McMillen, **Kevin Fetherston** R2, **Michael Lilly** GWS, **Justin Crowther** AEA, **Kate Knox** R2, **Michael Mazzacavallo** R2, **Bob Henszey** USFWS, **Chiska Derr** NMFS, **Colin Kikuchi** USGS, **Greg Auble** USGS, **Wayne Dyok** AEA, **Matt Love** VNF, **Dara Glass** CIRI, **Becky Long** Coalition for Susitna Dam Alternatives, **Hal Shepard** Center for Water Advocacy, **Kim Sager** DNR, **Jan Konigsberg** AK Hydro Reform, **Eric Rothwell** NMFS

Today's meeting was scheduled to discuss details of the Riparian Instream Flow and Groundwater Study plans. This meeting is the second of two meetings to address April 1 FERC Study Plan Determination recommendations. A previous meeting was held on April 23, 2013. The meeting notes from the April 23, 2012 meeting are included as an attachment to this document. All attendance was by telephone conference. The agenda and meeting materials are available on the Project website (http://www.susitna-watanahydro.org/) under today's meeting date on the "Past Meetings" tab.

MAJOR TOPICS AND DISCUSSION POINTS

Today's meeting addressed FERC requests and recommendations listed in the April 1, 2013 FERC Study Plan Determination. The meeting was organized to provide detailed discussion and methodology for the study plan associated with interrelated parts of the Riparian IFS, Groundwater, and Riparian Vegetation studies. Main topics included development of the vegetation sampling design, review of methods for functional group determination, measurement and estimation of rooting depths, calculation of extinction depths, development of transpiration flux curves, and clarification of xylem isotope study protocols. Kevin Fetherston initiated the presentation with a brief review of topics presented in the previous April 23, 2013 Riparian Technical Team meeting.

Riparian Vegetation Sampling Design

Aaron Wells described the riparian vegetation sampling strategy based on three sampling methods: Focus Area sampling, Non-Focus Area sampling, and Integrated Terrain Unit (ITU) transect sampling. Focus Area sampling plots will be defined with stratified random sampling with the stratification unit being Ecotype. Kevin F. asked Aaron to clarify the definition of Ecotype. Aaron responded that ecotype is considered the ITU mapping component which combines vegetation and environmental attributes including vegetation cover types, geomorphology including flood frequency, poplar successional status (size class), and soils. Aaron stated that the RSP designated that the total number of plots would be determined based on size of the Focus Areas. The RSP was completed before the Focus Areas were fully defined. The number of Focus Areas was assigned to be 1 plot per 10 acres of Focus Area if the

Focus Area was less than 250 acres. All Focus Areas are greater than 250 acres and thus the protocols were modified slightly.

A stratified random sample design was developed for each riparian Focus Area using ecotype as the stratification unit. The ITU mapping completed by ABR, Inc. in Fall/Winter 2012 for the middle Susitna River was clipped using the boundary of each Focus Area. The total area of each Focus Area, the number of ecotypes within each Focus Area, and the total area (acres) of each ecotype within each Focus Area was calculated. The total number of random plots per Focus Area was determined using the following formula as a guide:

Focus Area Plots = 1 plot/20 acres + 1.5*the total # of ecotypes in a Focus Area

The above formula accounted for both total area of a Focus Area and the total number of ecotypes such that a smaller Focus Area with a large number of ecotypes would be assigned a larger number of plots than it would based on area alone. The total area of each ecotype was then divided by the total area of the respective Focus Area to determine the percent area of each ecotype relative to the Focus Area. Ecotypes encompassing ≥2% of the total area within a Focus Area were assigned a number of random plots using the following formula as a guide:

Random Plots per Ecotype = % total ecotype area*# of Focus Area plots

The GENERATE RANDOM POINTS TOOL from Hawth's Analysis Tools for ArcGIS (http://www.spatialecology.com/htools/rndpnts.php) was used to generate the random plots by ecotype. Aaron clarified that plots have only been distributed across 3 Focus Areas to date (FA-104, FA-115, FA-128) with a total of 118 plots. Plots in other Focus Areas (e.g., Gold Creek and Stephans Slough) have not yet been assigned.

Aaron described Non-Focus Area sampling design (satellite areas) as targeted/directed sampling to select areas that will document underrepresented vegetation types such as some of the herbaceous communities which are not represented in the existing Focus Areas. A total of 94 non-Focus Area plots have been defined to date.

ITU transects will be focused in the Lower River study area to understand GIS aerial imagery signatures and resolve ITU mapping polygons. Approximately 60 transects which corresponds to about 300 plots are planned for the Lower River.

Dana Glass asked for confirmation that no work is proposed on CIRI lands. Wayne Dyok responded that no work is planned until mutual agreements have been reached.

Aaron ended the presentation by showing a map of proposed plots for Whiskers Slough (FA-104) and indicated he will present maps showing proposed plots for other Focus Areas and non-Focus Area sites in the June 25 TWG meeting.

Jan asked for clarification that only a single year of sampling will be conducted for this study. Aaron indicated that they will use space instead of time sampling to describe community succession. They will install magnetic markers buried in the plot center and sub-meter GPS accuracy to prepare repeatable sampling in case someone wants to revisit these plots at a later time.

In the transition to the next topic, Kevin presented a slide with images of break-up photos from last week.

Plant Functional Group Determination, Rooting Depths, Extinction Depths

Kevin F. updated the strategy to use 5 plant functional groups (PFGs) which he described as a group of plants that are defined by similar functions and life history traits such as rooting depth. Root zone access to different water compartments (e.g., groundwater, surface water, precipitation, etc.) will be modeled for PFGs. The riparian groundwater study will assess whether different PFGs in this system are accessing different water compartments. Water use will be measured and modeled for the existing flow regime and then for projected flows from the project. Bob H. suggested that there may actually be additional herbaceous plant communities that warrant additional PFGs. Aaron Wells responded that the 2012 study mapped only wet sedge meadow and wet forb herbaceous communities. Additional field work to occur in 2013 will cover a broader range of habitat types and additional herbaceous types may be added to the study in 2014 as necessary. This topic will be revisited following summer 2013 field work.

Michael L. provided context for the interaction between the riparian, aquatic, and groundwater studies. He described slides showing the relationship between surface water, groundwater and evapotranspiration and gave schematic examples of groundwater monitoring well locations for a cross-section of the river.

Colin K. asked Michael L. to comment on the accuracy of the schematic relative to locations of wells shown in another meeting for the HSC plan. He also asked whether the team would be doing transects across the whole river to define boundary conditions on either side of the river. Michael L. responded that this diagram is only a schematic example. Eric R. asked whether there are or would be maps showing specific locations of instrumentation for all the various study elements that would be available for agency members. Michael L. responded that these sites are being refined this month as staff is now in the field and additional information and maps will be available at the June 25 TWG meeting.

Michael M. described details of the riparian groundwater study design to measure rooting depth by a combination of soil cores and soil pit observations and extinction depths. Bob H. asked what diameter soil core samples will be taken, and asked whether the team would do biomass estimates, volume, or presence/absence for the soil cores. Michael L. responded that 3" cores would be used. Michael M. responded that soil cores for isotope studies would be done at systematic depths and presence/absence of roots would be noted. Root biomass will be sampled in soil stratigraphic pits with grab samples. Bob H. noted that volume of collection is critical.

Plant Xylem Water

Michael M. presented the major questions for the plant xylem study by describing what water source plant species are utilizing and how changes in groundwater and surface water elevation will affect how these plants access and utilize these water sources. Plant xylem water will be measured by collecting non-transpiring tissue (branch clippings or core samples) collected at mid-day. Samples will be collected in 2013 at FA-104 and FA-128 in June, July, and late-August or September. Bob H. asked how the team will determine presence of perched water table. Michael L. and Michael M. responded that precipitation records will be kept and timing recent of precipitation events will be used to interpret results. Colin asked whether additional tracers (beyond ^{2}H and ^{18}O) have been considered. He suggested using major ions such as chloride as a natural tracer in addition to the 2 tracers, as he believes n-1 independent tracers are needed for a robust analysis of water sources. If there are potentially 5 water sources (surface water-main stem, surface water-slough, precipitation, groundwater, shallow groundwater), then 4 tracers may be needed. Michael L. indicated that the WQ study will likely have information on major ion concentrations in these water sources.

Michael M. described how ET MODFLOW flux curves will be bounded at the high and low end of the curve. The extinction depth can be determined by approximation through the maximum rooting depth. The saturated extinction depth can be measured by timing field efforts to coincide with high water table.

Other Topics

Kevin F. wrapped up the meeting by asking if there were any remaining questions or concerns anyone would like to address. He relayed that any additional questions that come up after the meeting could be forwarded to AEA directly. Information presented and discussions resulting from this meeting will be compiled for a Technical Memorandum that will be submitted by June 30, 2013.

Colin reiterated a request for a technical site layout that is as detailed as possible to help them prepare for site visits they have planned following the June TWG meeting.

A point of information was requested regarding deployment of soil moisture sensors. Michael M. responded that the current plan is to install 4 soil moisture sensors at 4 locations.

Hal Shepard asked for confirmation that his comments have been received by AEA regarding the fluvial geomorphology Draft TM. AEA responded that the comments have been received.

Action Item	Date	Responsibility
Develop detailed maps of Focus Areas showing plot layouts, equipment installation sites, and transects for agency review at June 25 TWG meeting.	6/25/13	Kevin Fetherston and Michael Lilly
For 2014 field effort vegetation sampling, assess full range of herbaceous plant communities and add plots and ET study species as necessary to represent additional herbaceous communities as warranted by data collected in 2013.	Ongoing	RIFS study team
For isotope tissue analysis study, RIFS team will consider feasibility and need to increase tracers beyond ^{2}H and ^{18}O to also use major ions (e.g., chloride). Independent tracers should total n-1 with n being the number of potential water sources. Some ion data may be available from WQ study.	Ongoing	RIFS study team
Acquire and review tracer study papers from Colin Kikuchi.	6/15/13	
A formal response to FERC to document results of the April 23 and June 6 meeting will be presented to FERC by June 30 due date.	6/30/13	Kevin Fetherston, Michael Lilly, Aaron Wells

APPENDIX 4. GROUNDWATER STUDY METADATA STANDARDS FOR CLUSTER WELL STATIONS INCLUDING SAP FLOW SENSORS

Susitna Hydrology Project
ESMFA104-2 Focus Area Clearing Met Station
Data Measurement and Recording Standards
Last Update: 06/21/2013
Last Update By: R Paetzold

Focus Area Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

- Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
- Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
- Instantaneous readings are taken at the time specified by the time stamp.
- A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Images

Camera: Moultrie Game camera; not connected to data logger.
Memory Card: 16GB SD Flash Memory Card
Flash Card Capacity: ~20,000 Images or over 1 year
Images Taken: On camera's internal time interval.
Images Saved on Camera Memory Card: Half-hourly Lo-Resolution
Images Saved on Datalogger: Not connected to data logger.
Image Trigger Interval: 30-minutes
Data Retrieval: Manually, during station visits.

Air Temperature

Sensor: HC2S3 AT/RH sensor (PT100 RTD, IEC 751 1/3 Class B, with calibrated signal conditioning).
Measurement Range: -40°C to +60°C.
Accuracy: ±0.1°C @23°C (~±0.3°C at -40°C).
Installation: In 10-plate radiation shield, non-aspirated.
Height: 2 meters.
Output Units: °C.
Scan Interval: 60 seconds.
Output to Tables:

- Hourly Table:
    - Hourly Sample Air Temperature: Recorded at the top of each hour.

  - Hourly Average Air Temperature: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
  - Hourly Maximum Air Temperature: The highest reading from the previous hour.
  - Hourly Minimum Air Temperature: The lowest reading from the previous hour.
- Hourly Climate Table:
  - Hourly Minimum Air Temperature: Recorded at the top of each hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Air Temperature: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Air Temperature: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Air Temperature: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Air Temperature: The lowest reading from the previous fifteen minutes.
- Daily Table:
  - Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST.
  - Daily Maximum Air Temperature: The highest reading taken during the previous day.
  - Daily Minimum Air Temperature: The lowest reading taken during the previous day.

Relative Humidity

Sensor: HC2S3 AT/RH sensor (ROTRONIC Hygromer® IN1.
Operating Range: 0 to 100% RH.
Accuracy: ±0.8% @23°C (~±0.3% at -40°C).
Installation: In 12-gill radiation shield, non-aspirated.
Height: 2 meters
Output Units: % Relative Humidity
Scan Interval: 60 seconds
Output to Tables:

- Hourly Atmospheric Table:
  - Hourly Sample Relative Humidity: Recorded at the top of each hour.
  - Hourly Average Relative Humidity: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
  - Hourly Maximum Relative Humidity: The highest reading from the previous hour.
  - Hourly Minimum Relative Humidity: The lowest reading from the previous hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Relative Humidity: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Relative Humidity: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Relative Humidity: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Relative Humidity: The lowest reading from the previous fifteen minutes.
- Hourly Climate Table:

  - Hourly Sample Relative Humidity: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Relative Humidity: the highest reading taken during the previous day.
  - Daily Minimum Relative Humidity: the lowest reading taken during the previous day.

Dew Point Temperature
Sensor: Calculated value from AT/RH
Scan Interval: N/A, calculated
Output to Tables:

- Hourly Table:
  - Hourly Sample Dew Point: Calculated from the Sample Air Temperature and Relative Humidity values at the top of each hour.
  - Hourly Average Dew Point: Average of the 60 values calculated from the 60-second Air Temperature and Relative Humidity values.
  - Hourly Maximum Dew Point: The highest reading from the previous hour.
  - Hourly Minimum Dew Point: The lowest reading from the previous hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Dew Point: Fifteen-minute sample (point) calculation recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Dew Point: Fifteen-minute average of all 15 calculations recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Dew Point: The highest reading from the previous fifteen minutes.
  - Fifteen-Minute Minimum Dew Point: The lowest reading from the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Dew Point: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Dew Point: The highest calculated value during the previous day.
  - Daily Minimum Dew Point: The lowest calculated value during the previous day.

Wind Speed
Sensor: RM Young 05103-45 Wind Monitor (Alpine).
Operating Range: 0 to 100 m/s (0 to 224 mph).
Accuracy: ± 0.3 m/s (±0.6 mph) or 1% of reading.
Starting Threshold: 1 m/s (2.2 mph).
Installation: 30 m from nearest obstruction.
Height: 3 m.
Output Units: meters per second.
Scan Interval: 3s.
Output to Tables:

- Hourly Met Table:
  - Instantaneous Wind Speed: The 3-second wind speed sampled at the top of the hour.
  - Hourly Average Wind Speed: Hourly average of 1200 three-second wind speed readings for the previous hour.

  - Hourly Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past hour (max wind).
- Fifteen-Minute Met Table:
  - Instantaneous Wind Speed: The 3-second wind speed sampled at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Wind Speed: Fifteen-minute average of all three hundred 3-second readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past fifteen minutes (max wind).
- Two-Minute Wind Table:
  - Two-Minute Average Wind Speed: 2-minute average of 3-second wind speeds.
  - Two-Minute Peak Wind Speed: the highest recorded 3-second wind observation from the reporting interval of the past 2 minutes (max wind).
- Hourly Climate Table:
  - Hourly Sample Wind Speed: Recorded at the top of each hour.
- Daily Table:
  - Daily Average Wind Speed: The daily average of all 5-second wind speeds for the previous day.
  - Daily Peak Wind Speed: The highest recorded 5-sec wind speed for the previous day.

Wind Direction

Sensor: RM Young 05103-45 Wind Monitor (Alpine).
Operating Range: 0 to 360 deg (mechanical) True North (0 to 355 electrical, 5 deg open).
Accuracy: ±5°.
Starting Threshold: 1.1 m/s (2.4 mph) 10 deg displacement.
Installation: Align true north.
Height: 3 meters.
Output Units: degrees true north.
Scan Interval: 3s.
Output to Tables:

- Hourly Atmospheric Table:
  - Instantaneous Wind Direction: Wind direction sample at the top of the hour.
  - Hourly Average Wind Direction: Hourly average of 3-second wind direction vector for the previous hour.
- Fifteen-Minute Met Table:
  - Instantaneous Wind Direction: The 3-second wind direction vector sampled at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Wind Direction: Fifteen-minute average of all three hundred 3-second readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Two-Minute Wind Table:
  - Two-Minute Average Wind Direction: 2-minute average of 3-second wind direction vector.
- Hourly Climate Table:
  - Hourly Sample Wind Direction: Recorded at the top of each hour.
- Daily Table:

  - Daily Wind Direction: Vector mean of all wind direction readings for the previous day.

Wind Direction Standard Deviation
Sensor: Calculated.
Scan Interval: 3s.
Output to Tables:

- Hourly Atmospheric Table:
  - Hourly Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the one hour recording period.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the fifteen-minute recording period.
- Two-Minute Wind Table:
  - Two-Minute Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction over the 2-minute recording period)
- Daily Table:
  - Daily Wind Direction Standard Deviation: The standard deviation (computed by the datalogger) of the wind direction for the previous 24 hours.

Wind Chill Temperature
Sensor: Calculated from Air Temperature & Wind Speed. Wind Sensor
Output Units: °C.
Scan Interval: N/A, calculated.
Algorithms: $WC = 35.74 + 0.6215\,T - 35.75(V^{0.16}) + 0.4275T(V^{0.16})$

where:

WC = Wind Chill (°F)
T = Air Temperature (°F)
V = Wind Speed (mph)

Source: Alaska Safety Handbook. 2006. p180.

$WC\,(°C) = (WC - 32) * 5/9$

where:

WC (°C) = Wind Chill (°C)

Output to Tables:

- Hourly Atmospheric Table:
  - Instantaneous Wind Chill: Calculated from the Instantaneous Air Temperature and Wind Speed values sampled at the top of the hour.
  - Hourly Average Wind Chill: Average of the 60 values calculated from the 60-second sample Air Temperature and the average of the 60 corresponding 3-second sample wind speed values.
  - Hourly Maximum Wind Chill: The highest reading from the previous hour.
  - Hourly Minimum Wind Chill: The lowest reading from the previous hour.
- Fifteen-Minute Met Table:

- Instantaneous Wind Chill: Calculated from the Instantaneous Air Temperature and Wind Speed values sampled at the top of the hour, 15, 30, and 45 minutes past the hour.
- Fifteen-Minute Average Wind Chill: Average of the 15 values calculated from the 60-second sample Air Temperature and the average of the 15 corresponding 3-second sample wind speed values.
- Fifteen-Minute Maximum Wind Chill: The highest reading from the previous fifteen minutes.
- Fifteen-Minute Minimum Wind Chill: The lowest reading from the previous fifteen minutes.

- Hourly Climate Table:
  - Hourly Sample Wind Chill: Recorded at the top of each hour.
- Daily Table:
  - Daily Maximum Wind Chill: The highest calculated value during the previous day.
  - Daily Minimum Wind Chill: The lowest calculated value during the previous day.

Solar Radiation
Sensor: Campbell Scientific LI200X, LiCor LI200 pyranometer.
Height: 2 meters.
Output Units: mV, converted by datalogger to W/m^2.
Scan Interval: 60 seconds.
Output to Tables:

- Hourly Met Table:
  - Hourly Average Solar Radiation: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
  - Hourly Average Solar Radiation: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Average Solar Radiation: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
  - Hourly Sample Solar Radiation: Recorded at the top of each hour.
- Daily Table:
  - Daily Average Solar Radiation: The daily average of all solar radiation measurements for the previous day.

Barometric Pressure
Sensor: Campbell Scientific CS100, Setra 278
Height: 2 meters.
Range: 600 to 1100mBar
Output Units: mBar, Not Corrected to sea level
Scan Interval: 60 seconds.
Output to Tables:

- Hourly Atmospheric Table:
  - Hourly Sample Barometric Pressure: Recorded at the top of each hour.
- Fifteen-Minute Met Table:

- Fifteen-Minute Sample Barometric Pressure: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
  - Hourly Sample Barometric Pressure: Recorded at the top of each hour.

Net Radiation
Sensor: Kipp and Zonen NR Lite2 Net Radiometer
Height: 2 meters.
Output Units: mV converted by datalogger to W/m^2, Wind Corrected W/m2
Scan Interval: 60 seconds.
Output to Tables:

- Hourly Met Table:
  - Hourly Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.
  - Hourly Average Net Radiation, Net Radiation w/ Wind Correction: 60 readings from the beginning of the hour to the end of the hour, averaged and recorded at the end of the hour.
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.
  - Fifteen-Minute Average Net Radiation, Net Radiation w/ Wind Correction: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
  - Hourly Sample Net Radiation, Net Radiation w/ Wind Correction: Recorded at the top of each hour.
- Hourly Raw Table:
  - Hourly Sample Sensor mV: Recorded at the top of each hour. "Raw" data in mV.
  - Hourly Average Sensor mV: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV.

Air Temperature - Back Up
Sensor: Triplicate YSI Series 44033 thermistors
Operating Range: -80°C to +75°C
Installation: In 6-gill radiation shield, non-aspirated.
Height: 2 meters
Output Units: kΩ, °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Atmospheric Table:
  - Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).
  - Hourly Average Air Temperature: Average of the 60 one-minute readings for the previous hour. (three values, one for each thermistor).
- Hourly Climate Table:

  - Hourly Sample Air Temperature: Recorded at the top of each hour. (three values, one for each thermistor).
- Fifteen-Minute Met Table:
  - Fifteen-Minute Sample Air Temperature: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Air Temperature: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Raw Table:
  - Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (three values, one for each thermistor)
  - Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (three values, one for each thermistor).
- Daily Table:
  - Daily Average Air Temperature: Average of all temperature readings for the previous day ending at midnight AST. (three values, one for each thermistor).
  - Daily Maximum Air Temperature: The highest reading from the previous day. (three values, one for each thermistor).
  - Daily Minimum Air Temperature: The lowest reading from the previous day. (three values, one for each thermistor).

Water Height

Sensor: One CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensor or one INW PT12 (Instruments North West) pressure transducer, SDI-12 type sensor.
Pressure Measurement Range: 0-7.25 psig
Output Units: cm, ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Height Table:
  - Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
  - Hourly Sample Water Height: Sample at the top of each hour.
- Daily Table:
  - Daily Average Water Height: Average of all readings for the previous day.
  - Daily Maximum Water Height: Maximum water height for the previous day.
  - Daily Minimum Water Height: Minimum water height for the previous day.

Water Temperature

Sensor: One CS451 (Campbell Scientific, inc) SDI-12 sensor or one INW PT12 (Instruments North West) SDI-12 type sensor.

Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Level Table:
  - Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
  - Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Water Temperature: Sample at the top of each hour.
- Daily Table:
  - Daily Average Water Temperature: Average of all readings for the previous day.
  - Daily Maximum Water Temperature: the highest reading taken during the previous day.
  - Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Soil Temperature Profile
Sensor: Twelve YSI Series 44033 thermistors
Operating Range: -80°C to +75°C
Installation: In back-filled bored hole.
Depths: 0, 5, 10, 15, 20, 30, 40, 60, 80, 100, 120, 150 cm, 1-12 thermistors (based on actual depth of bored drill hole)
Output Units: kΩ, °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Subsurface Table:
  - Hourly Sample Soil Temperature: Recorded at the top of each hour. (twelve values, one for each thermistor).
  - Hourly Average Soil Temperature: Average of the 60 one-minute readings for the previous hour. (twelve values, one for each thermistor).
- Hourly Raw Table:
  - Hourly Sample Sensor Resistance: Recorded at the top of each hour. "Raw" data in kΩ. (twelve values, one for each thermistor)
  - Hourly Average Sensor Resistance: Average of the 60 one-minute readings for the previous hour. "Raw" data in kΩ. (twelve values, one for each thermistor).
- Hourly Climate Table:
  - Hourly Sample Soil Temperature: Recorded at the top of each hour. (twelve values, one for each thermistor).
- Daily Table:

- Daily Average Soil Temperature: Average of all temperature readings for the previous day ending at midnight AST. (twelve values, one for each thermistor).

Soil Moisture Profile
Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes
Installation: Horizontal orientation in back-filled hole
Depths: 10, 20, 30, 40 cm
Output Units: µs, volumetric soil water content (v/v). Electrical Conductivity
Scan Interval: Hourly
Output to Tables:

- Hourly subsurface Table:
  - Hourly Instantaneous Soil Moisture: Hourly volumetric soil water content taken at the top of the hour (four values). Unitless volume ratio (water volume/soil volume).
- Hourly Raw Table:
  - Hourly Instantaneous Soil Moisture: Hourly "raw" volumetric soil water content taken at the top of the hour (four values). Units are µs.
- Hourly Climate Table:
  - Hourly Sample Soil Moisture: Recorded at the top of each hour(four values). Unitless volume ratio (water volume/soil volume).
- Daily Table:
  - Daily Average Soil Moisture: Average of all readings for the previous day ending at midnight AST (four values).
- Hourly Raw Table:
  - Hourly Sample Sensor Period: Recorded at the top of each hour. "Raw" data in µSec

Soil Temperature Profile 2
Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes
Installation: Horizontal orientation in back-filled hole
Depths: 10, 20, 30, 40 cm
Output Units: °C.
Scan Interval: Hourly
Output to Tables:

- Hourly subsurface Table:
  - Hourly Instantaneous Soil Temperature: Hourly volumetric soil water content taken at the top of the hour (four values). Unitless volume ratio (water volume/soil volume).
- Hourly Climate Table:
  - Hourly Sample Soil Temperature: Recorded at the top of each hour. (four values).
- Daily Table:
  - Daily Average Soil Temperature: Average of all temperature readings for the previous day ending at midnight AST (four values).

Soil Moisture Electrical Conductivity
Sensor: Four sensors: CSI 650 Unfrozen Soil-Moisture/Soil Temperature Probes
Installation: Horizontal orientation in back-filled hole
Depths: 10, 20, 30, 40 cm
Output Units: dS/m

Scan Interval: Hourly
Output to Tables:

- Hourly subsurface Table:
  - Hourly Instantaneous Soil Moisture Electrical Conductivity: Hourly soil water electrical conductivity taken at the top of the hour (four values).
- Hourly Climate Table:
  - Hourly Sample Soil Moisture Electrical Conductivity: Recorded at the top of each hour(four values). Unitless volume ratio (water volume/soil volume).
- Daily Table:
  - Daily Average Soil Moisture Electrical Conductivity: Average of all readings for the previous day ending at midnight AST (four values).

Soil Heat Flux
Sensor: HFP01-L Hukseflux Soil heat Flux Plate
Operating Range: -2000 W/m^2 to +2000 W/m^2
Installation: Horizontally in back-filled bored hole.
Depth: 8 cm
Output Units: W/m^2, mV
Scan Interval: 60 seconds
Output to Tables:

- Hourly Subsurface Table:
  - Hourly Average Soil Heat Flux: Average of the 60 one-minute readings for the previous hour.
  - Hourly Sample Soil Heat Flux: Recorded at the top of each hour.
- Hourly Climate Table:
  - Hourly Sample Soil Heat Flux: Recorded at the top of each hour.
- Daily Table:
  - Daily Average Soil Heat Flux: Average of all readings for the previous day ending at midnight AST.
- Hourly Raw Table:
  - Hourly Sample Sensor mV: Recorded at the top of each hour. "Raw" data in mV.
  - Hourly Average Sensor mV: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV.

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.

- Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

Battery Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Current: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Load Current: Measured at the top of the hour.
  - Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Load Current: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds

Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
    - Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
    - Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
    - Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
    - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes
Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Susitna Hydrology Project
ESGFA104-6 Focus Area Well Head with Sap Flow Station
Data Measurement and Recording Standards
Last Update: 06/21/2013
Last Update By: R Paetzold

Focus Area Station

Data-Collection Objectives: Meteorological data to evaluate the potential for hydro-electric power generation in the Susitna River region.
Time Recording Standard: **Always** Alaska Standard Time (UTC – 9).
Datalogger Scan Interval Standard: 60 seconds.
Time Measurement Standards:

- Hourly readings are recorded at the end of the hour; therefore, the hourly average water temperature, for example, with a 60-second scan interval and a time stamp of 14:00 is measured from 13:01 to 14:00:00. For a 60-second scan interval, the hourly average would be the average of 60 min = 60 values.
- Quarter-hourly readings are recorded every fifteen minutes starting at the top of the hour.
- Instantaneous readings are taken at the time specified by the time stamp.
- A day begins at midnight (00:00:00) and ends at midnight (23:59:55). All daily data are from the day prior to the date of the time stamp. For example, if the time stamp reads 09/09/2007 00:00 or 09/09/2007 12:00:00 AM, the data are from 09/08/2007.

Data Retrieval Interval: Data will be retrieved hourly.
Data Reporting Interval: Hourly

Sap Flow 1
Sensor: TDP30 Thermal Dissipation Probe Sensors
Installation: Two thermocouples and heater inserted in tree.
Height: TBD meters
Output Units: mV, cm^3/cm^2/hr.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Table:
  - Hourly Sample Sap Flow: Recorded at the top of each hour. (one value for each sensor).
  - Hourly Average Sap Flow: Average of the 60 one-minute readings for the previous hour. (one value for each sensor).
  - Hourly Maximum Sap Flow: Hourly maximum of all 60 readings recorded at the top of the hour. (one value for each sensor)
  - Hourly Minimum Sap Flow: Hourly minimum of all 60 readings recorded at the top of the hour. (one value for each sensor)
- QuarterHrlyMet Table:
  - Fifteen-Minute Sample Sap Flow: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
  - Fifteen-Minute Average Sap Flow: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)

  - Fifteen-Minute Maximum Sap Flow: Fifteen-minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
  - Fifteen-Minute Minimum Sap Flow: Fifteen-minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
- HalfHrSap Table:
  - Thirty-Minute Sample Sap Flow: Thirty-minute sample (point) reading recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Average Sap Flow: Thirty-minute average of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Maximum Sap Flow: Thirty-minute maximum of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Minimum Sap Flow: Thirty-minute minimum of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
- Hourly Climate Table:
  - Hourly Sample Sap Flow: Recorded at the top of each hour. (one value for each sensor). This table is for the Current Conditions page on the Diag Site only.
- Hourly Raw Table:
  - Hourly Sample Sensor Voltage: Recorded at the top of each hour. "Raw" data in mV. (one value for each sensor)
  - Hourly Average Sensor Voltage: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV. (one value for each sensor).
  - Hourly Maximum Sensor Voltage: Hourly maximum of all 60 readings recorded at the top of the hour. (one value for each sensor)
  - Hourly Minimum Sensor Voltage: Hourly minimum of all 60 readings recorded at the top of the hour. (one value for each sensor).
- Daily Table:
  - Daily Average Sap Flow: Average of all temperature readings for the previous day ending at midnight AST. (one value for each sensor).
  - Daily Maximum Sap Flow: The highest reading from the previous day. (one value for each sensor).
  - Daily Minimum Sap Flow: The lowest reading from the previous day. (one value for each sensor r).

Sap Flow 2

Sensor: TDP50 Thermal Dissipation Probe Sensors
Installation: Two thermocouples and heater inserted in tree.
Height: TBD meters
Output Units: mV, cm^3/cm^2/hr.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Table:

- Hourly Sample Sap Flow: Recorded at the top of each hour. (one value for each sensor).
- Hourly Average Sap Flow: Average of the 60 one-minute readings for the previous hour. (one value for each sensor).
- Hourly Maximum Sap Flow: Hourly maximum of all 60 readings recorded at the top of the hour. (one value for each sensor)
- Hourly Minimum Sap Flow: Hourly minimum of all 60 readings recorded at the top of the hour. (one value for each sensor)

- QuarterHrlyMet Table:
  - Fifteen-Minute Sample Sap Flow: Fifteen-minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
  - Fifteen-Minute Average Sap Flow: Fifteen-minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
  - Fifteen-Minute Maximum Sap Flow: Fifteen-minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
  - Fifteen-Minute Minimum Sap Flow: Fifteen-minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour. (one value for each sensor)
- HalfHrSap Table:
  - Thirty-Minute Sample Sap Flow: Thirty-minute sample (point) reading recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Average Sap Flow: Thirty-minute average of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Maximum Sap Flow: Thirty-minute maximum of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
  - Thirty -Minute Minimum Sap Flow: Thirty-minute minimum of all 30 readings recorded at the top of the hour and 30 minutes past the hour. (one value for each sensor)
- Hourly Climate Table:
  - Hourly Sample Sap Flow: Recorded at the top of each hour. (one value for each sensor). This table is for the Current Conditions page on the Diag Site only.
- Hourly Raw Table:
  - Hourly Sample Sensor Voltage: Recorded at the top of each hour. "Raw" data in mV. (one value for each sensor)
  - Hourly Average Sensor Voltage: Average of the 60 one-minute readings for the previous hour. "Raw" data in mV. (one value for each sensor).
  - Hourly Maximum Sensor Voltage: Hourly maximum of all 60 readings recorded at the top of the hour. (one value for each sensor)
  - Hourly Minimum Sensor Voltage: Hourly minimum of all 60 readings recorded at the top of the hour. (one value for each sensor
- Daily Table:
  - Daily Average Sap Flow: Average of all temperature readings for the previous day ending at midnight AST. (one value for each sensor).

- Daily Maximum Sap Flow: The highest reading from the previous day. (one value for each sensor).
- Daily Minimum Sap Flow: The lowest reading from the previous day. (one value for each sensor).

Water Height

Sensor: One CS451 (Campbell Scientific, inc) pressure transducer, SDI-12 type sensors
Pressure Measurement Range: 0-7.25 psig
Output Units: cm, ft (water height above sensor), psig
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Height Table:
  - Fifteen-Minute Sample Water Height: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Water Height: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Height: Fifteen minute maximum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Minimum Water Height: Fifteen minute minimum of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
- Hourly Climate Table:
  - Hourly Sample Water Height: Sample at the top of each hour. This table is for the Current Conditions page on the Diag Site only.
- Daily Table:
  - Daily Average Water Height: Average of all readings for the previous day.
  - Daily Maximum Water Height: Maximum water height for the previous day.
  - Daily Minimum Water Height: Minimum water height for the previous day.

Water Temperature

Sensor: One CS451 (Campbell Scientific, inc) SDI-12 Sensors
Operating Range: -10°C to 80°C
Output Units: °C
Scan Interval: 60 seconds
Output to Tables:

- Fifteen-Minute Water Level Table:
  - Fifteen-Minute Sample Water Temperature: Fifteen minute sample (point) reading recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Average Water Temperature: Fifteen minute average of all 15 readings recorded at the top of the hour, 15, 30, and 45 minutes past the hour.
  - Fifteen-Minute Maximum Water Temperature: The highest reading taken during the previous fifteen minutes.
  - Fifteen-Minute Minimum Water Temperature: The lowest reading taken during the previous fifteen minutes.
- Hourly Climate Table:
  - Hourly Sample Water Temperature: Sample at the top of each hour. This table is for the Current Conditions page on the Diag Site only.

- Daily Table:
  - Daily Average Water Temperature: Average of all readings for the previous day.
  - Daily Maximum Water Temperature: the highest reading taken during the previous day.
  - Daily Minimum Water Temperature: the lowest reading taken during the previous day.

Battery Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Voltage: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Voltage: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Voltage: The lowest reading from the previous hour.

- **Battery Current**

Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample CR1000 Battery Current: Measured at the top of the hour.
  - Hourly Average CR1000 Battery Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum CR1000 Battery Current: The highest reading from the previous hour.
  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Load Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Load Current: Measured at the top of the hour.
  - Hourly Average Load Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Load Current: The highest reading from the previous hour.

  - Hourly Minimum CR1000 Battery Current: The lowest reading from the previous hour.

Solar Panel Voltage
Sensor: CH200
Output Units: V.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Solar Panel Voltage: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Voltage: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Voltage: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Voltage: The lowest reading from the previous hour.

Solar Panel Current
Sensor: CH200
Output Units: A.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Sample Solar Panel Current: Hourly reading at the top of the hour.
  - Hourly Average Solar Panel Current: Average of the 60 one-minute readings for the previous hour.
  - Hourly Maximum Solar Panel Current: The highest reading from the previous hour.
  - Hourly Minimum Solar Panel Current: The lowest reading from the previous hour.

Datalogger (CR1000) Panel Temperature
Sensor: CR1000 Internal thermistor
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Voltage Regulator (CH200) Temperature
Sensor: CH200
Output Units: °C.
Scan Interval: 60 seconds
Output to Tables:

- Hourly Diagnostics Table:
  - Hourly Average CR1000 Panel Temperature: Average of the 60 one-minute readings for the previous hour.

Resulting Final Storage Data Tables:
See Datalogger Output Files Excel Document

Notes

Definitions:
Scan interval = sampling duration = scan rate
Time of maximum or minimum values is not recorded
Sample reading = instantaneous reading
Beginning of the hour = top of the hour

Document Content(s)

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