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SUSITNA-WATANA HYDRO

2012 REVIEW OF EXISTING WATER TEMPERATURE MODEL RESULTS AND DATA COLLECTION

INTRODUCTION

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

Construction and operation of the Project as described in the Pre-Application Document (PAD, AEA 2011) will affect flow regimes and water temperatures downstream of the proposed dam site. This study plan outlines the objectives and methods for reviewing historical 1980s modeling results and collecting meteorological and stream temperature data that will provide a foundation for the 2013 and 2014 formal FERC licensing studies.

STUDY OBJECTIVES

The objective of this 2012 WQ-S1 Review of Existing Water Temperature Model Results and Data Collection Study is to provide a foundation for the 2013-2014 water temperature modeling study of reservoir and stream temperatures. The specific objectives are as follows:

- Evaluate the 1980s water temperature model results and determine the applicability of the past results to the currently proposed Project.
- Initiate collection of stream temperature and meteorological data that will be needed for the 2013 and 2014 studies.

STUDY AREA

The study area includes the Susitna River within the proposed Watana Reservoir and downstream of the proposed Watana Dam. Water quality studies will be conducted from river mile 10.1 (Susitna River above Alexander Creek) to river mile 233.4 (at Oshetna Creek, just above the upper extent of the proposed reservoir area). The proposed dam would be located at river mile 184.5. The dam would create a reservoir 39 miles long and up to 2 miles wide, with a normal reservoir surface area of approximately 22,500 acres and a normal maximum pool elevation of 2,000 feet.

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

The Project's operations will modify the flow and water temperature in the Susitna River downstream of the proposed reservoir. Reservoir operation and storage levels will affect water temperature in the reservoir and influence outflow water temperatures. Alteration of the water temperature in the Susitna River could modify river ice conditions, which in turn could impact channel morphology and riparian vegetation, as well as the suitability and productivity of aquatic

habitats. This could include the lower river, which is the habitat of forage fish for Cook Inlet beluga whales.

The results of the 2012 study will be used to further develop plans for additional studies in 2013-2014, assess effects of the proposed Project, and to identify protection, mitigation, and enhancement (PME) measures in the reservoir and in Project-affected river reaches downstream of the dam.

This study addresses some aspects of the following issues identified in the PAD (AEA 2011) for which existing information appears to be insufficient:

- WQ-S2: Potential effects of reservoir filling, Project operations, including reservoir surface elevation fluctuations, on temperature, turbidity, total dissolved/suspended solids, dissolved oxygen, pH, metals, and chemical/nutrient (fecal coliform, total phosphate, soluble reactive phosphorus, total nitrogen, ammonia nitrogen, nitrate+nitrite-nitrogen) characteristics within the reservoir.
- WQ-S3: Potential effect of Project operations on temperature, turbidity, total dissolved/suspended solids, dissolved oxygen, pH, metals, and chemical/nutrient (fecal coliform, total phosphate, soluble reactive phosphorus, total nitrogen, ammonia nitrogen, nitrate+nitrite-nitrogen) characteristics of the mainstem river downstream from the proposed Susitna-Watana Dam Site (RM 184).

EXISTING INFORMATION

Stream temperature data were collected in the mainstem Susitna River during the 1980s. These data were used both as input values and calibration data for the 1980s stream water temperature model (Stream Network Temperature Model [SNTEMP]; Theurer et al. 1984) and reservoir water temperature model (Dynamic Reservoir Simulation Model [DYRESM]); Imberger and Patterson 1981). SNTEMP is a one-dimensional river water temperature model. DYRESM is a one-dimensional hydrodynamics model used to predict the vertical distribution of temperature and density in lakes and reservoirs.

Results from the 1980s water temperature modeling studies are contained in the reports listed in Table 1. These reports are available digitally at the Alaska Resources Information and Library Service (ARLIS).

Table 1

List of Arctic Environmental Information and Data Center (AEIDC)

Susitna Hydroelectric Project Stream Temperature Reports

Report Title	Date	APA Document Number
Methodological Approach to Quantitative Impact Assessment for the Proposed Susitna Hydroelectric Project	1983a	90
Stream Flow and Temperature Modeling in the Susitna Basin, Alaska	1983b	862
Effects of Project-Related Changes in Temperature, Turbidity and Stream Discharge on Upper Susitna Salmon Resources During June – Sept	1984a	454
Examination of Susitna River Discharge and Temperature Changes Due to the Proposed Susitna Hydroelectric Project	1984b	861
Assessment of the Effects of the Proposed SHP on Instream Temperature and Fishery Resources in the Watana to Talkeetna Reach Vol. 1 & 2	1984c,d	2330, 2331
Assessment of the Effects of the Proposed SHP on Instream Temperature and Fish Resources in the Watana to Talkeetna Reach	1985	2706

Additional data sources were reviewed prior to preparation of this study as part of the Water Quality and Sediment Transport Data Gap Analysis Report (URS 2011). The data gap analysis report focused on summarization and evaluation of existing data for use in the Susitna-Watana FERC license application. Technical information used for the evaluation was collected over the past 30 years, with most water quality information (e.g., conventional parameters and metals) being more than 20 years old. The results of the data gap analysis indicated that elevated surface water temperatures periodically occur in important salmonid spawning and migration habitat and that more current temperature data would be useful for verifying previous temperature exceedances and describing the extent of temperature issues.

METHODS

SAP and QAPP

A Sampling and Analysis Plan (SAP) and a Quality Assurance Project Plan (QAPP) will be prepared as part of implementation of this 2012 study plan. The SAP and QAPP are standard documents prepared before any water quality sampling and model development begins. These documents follow guidelines for the State of Alaska and U.S. Environmental Protection Agency Region 10 Credible Data Policy (ADEC 2005).

Evaluate 1980s Water Temperature Modeling Results

The 1980s SNTEMP and DYRESM model results will be evaluated to determine the applicability of the results to the current proposed Project for the purpose of guiding the development of the 2013-2014 study plans (e.g., water quality, fish, ice processes, instream flow, and productivity).

a. SNTEMP and DYRESM predictive capabilities and associated assumptions will be evaluated to determine if the model results are appropriate for application to current conditions and the proposed Project. Any critical limitations will be identified.

b. The models' general configurations, input parameters, and quality of calibration/validation will be evaluated. The accuracy of representation for current and proposed conditions will be ascertained.

c. 1980s river flows and release schedules will be analyzed and compared to recent records to determine the applicability of these historic flow and release data to the currently proposed Project.

d. If the existing temperature models and results are applicable to the currently proposed Project, results will be synthesized to evaluate the potential effects of the proposed Project on water temperature and guide the design of the 2013-2014 study plans.

e. Coordination with other resource studies (e.g., water quality, ice processes, fish, instream flow, productivity) will occur to assist in developing 2013-2014 study plans that appropriately anticipate potential water temperature effects of the proposed Project.

Water Temperature Data Collection

Overview

Water temperature data and monitoring locations from the 1980s (Figure 1) have been evaluated to determine which of the historic locations should be monitored for the 2012 study. Locations were evaluated based on (1) adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site; (2) preliminary consultation with AEA and licensing participants; and (3) anticipation of other studies and study sites (e.g., instream flow, ice processes). Characterization of water temperature will be completed in a variety of riverine locations. Fish habitat permit applications will be prepared for submittal to Alaska Department of Fish and Game (ADFG) that include temperature monitoring station design and will be reviewed by the Habitat Division in Palmer, AK.

Water temperature data loggers will be installed at 39 sites (Table 2, Figure 2). Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling (1980s). Thirty-one of the sites are mainstem, tributary, or slough locations, most of which were monitored in the 1980s. Locations for sites are suggested for several reasons: 1) they provide good coverage of the mainstem for temperature modeling, 2) they provide coverage in areas of important fish habitat, 3) sites represent the influence of major tributaries that may influence thermal refugia downstream, and 4) the sites extend an existing data record beginning from the 1980s to the present to determine if conditions have changed and how this impacts thermal refugia under current conditions.

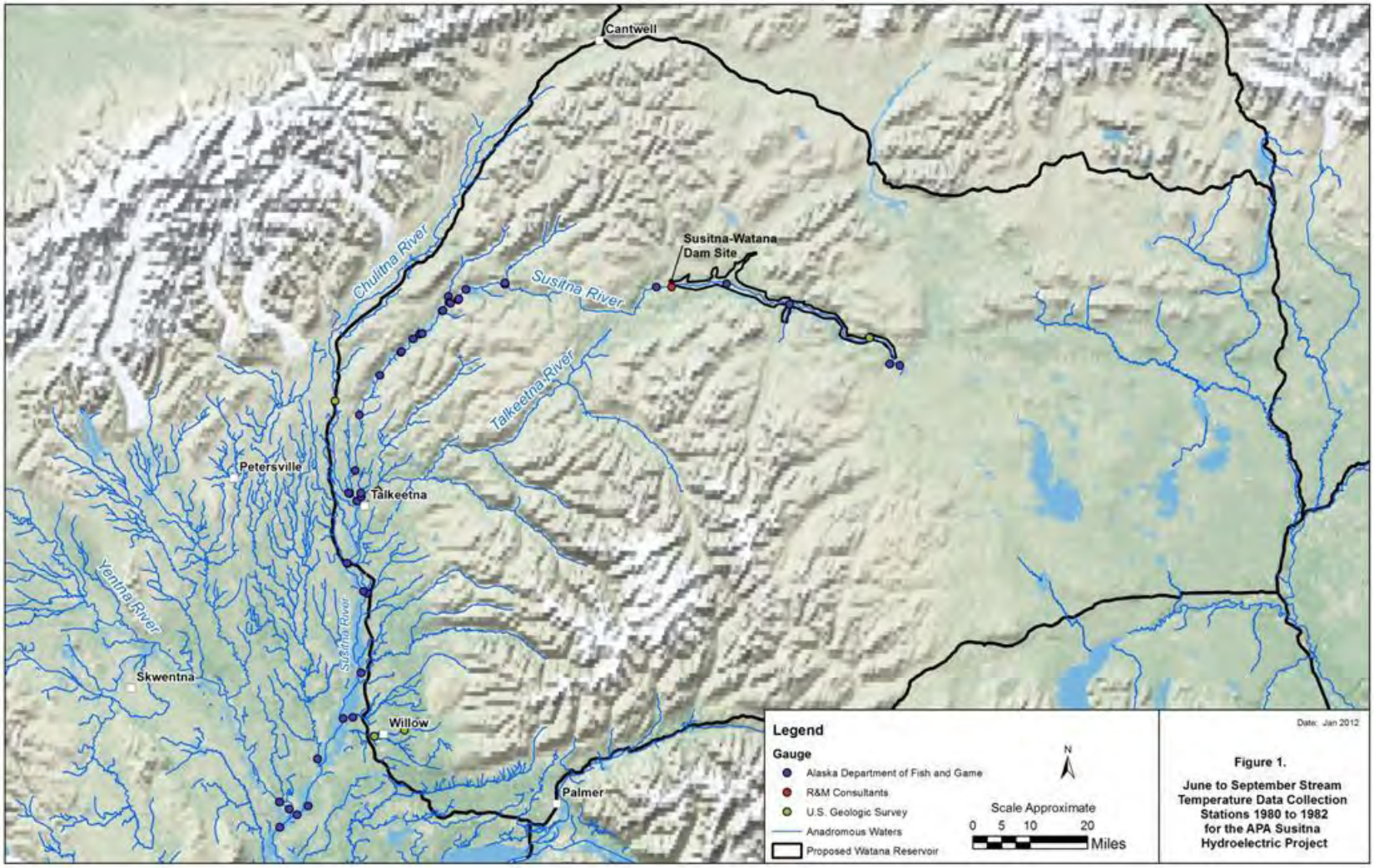

Figure 1 – June to September Stream temperature Data Collection Stations 1980 to 1982 for the APA Susitna Hydroelectric Project

Table 2. Proposed Susitna River Basin Temperature Monitoring Sites

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
10.1	Susitna above Alexander Creek	NA	61.4014	-150.519
25.8[3]	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6[3]	Deshka River	NA	61.7098	-150.324
55.0[1]	Susitna	NA	61.8589	-150.18
83.8[3]	Susitna at Parks Highway East	NA	62.175	-150.174
83.9[3]	Susitna at Parks Highway West	NA	62.1765	-150.177
97.0	LRX 1	NA	62.3223	-150.127
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0[2,3]	Talkeetna	NA	62.3943	-150.134
113.0[2]	LRX 18	NA	62.5243	-150.112
120.7[2,3]	Curry Fishwheel Camp	NA	62.6178	-150.012
126.0	--	8A	62.6707	-149.903
126.1[2]	LRX 29	NA	62.6718	-149.902
129.2[3]	--	9	62.7022	-149.843
130.8[2]	LRX 35	NA	62.714	-149.81
135.3	--	11	62.7555	-149.7111
136.5	Susitna near Gold Creek	NA	62.7672	-149.694
136.8[3]	Gold Creek	NA	62.7676	-149.691
138.0[1]	--	16B	62.7812	-149.674
138.6[3]	Indian River	NA	62.8009	-149.664
138.7[2]	Susitna above Indian River	NA	62.7857	-149.651
140.0	--	19	62.7929	-149.615
140.1[2]	LRX 53	NA	62.7948	-149.613
142.0	--	21	62.8163	-149.576
148.0	Susitna below Portage Creek	NA	62.8316	-149.406
148.8[2]	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
148.8[3]	Susitna above Portage Creek	NA	62.8279	-149.377
165.0[1]	Susitna	NA	62.7899	-148.997
180.3[1]	Susitna below Tsusena Creek	NA	62.8157	-148.652
181.3[3]	Tsusena Creek	NA	62.8224	-148.613
184.5[1]	Susitna at Watana Dam site	NA	62.8226	-148.533
194.1	Watana Creek	NA	62.8296	-148.259
206.8	Kosina Creek	NA	62.7822	-147.94
223.7[3]	Susitna near Cantwell	NA	62.7052	147.538
233.4	Oshetna Creek	NA	62.6402	-147.383

[1] Site not sampled for temperature in the 1980s or location moved slightly from original location.
[2] Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
[3] Overlap of temperature monitoring sites with other studies.

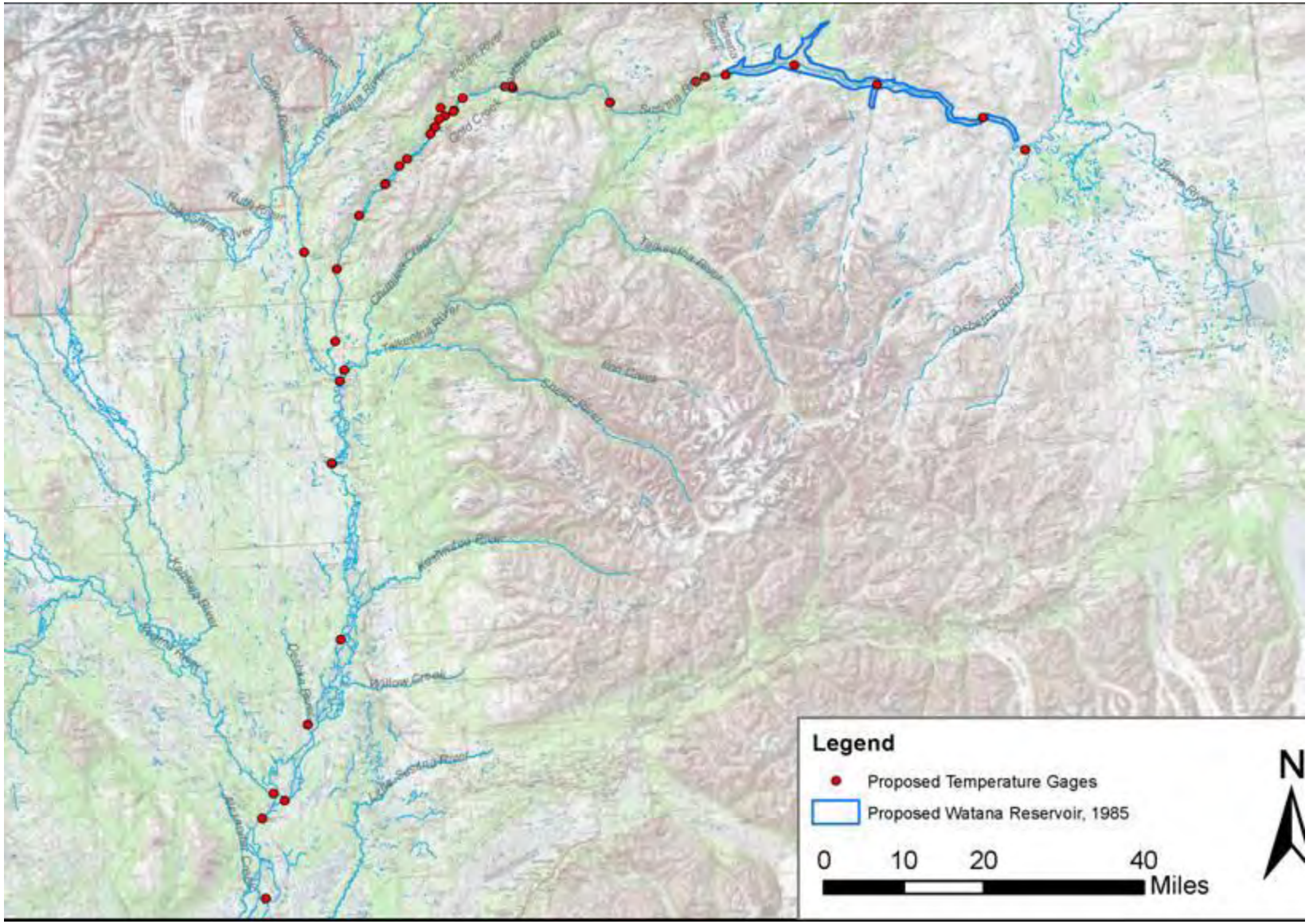

Figure 2 Proposed 2012 Stream Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project.

Installation and Monitoring Protocol

Water temperatures will be recorded at 15-minute intervals using Onset TidbiT® v2 water temperature data loggers (or equivalent instrumentation). The TidbiT v2 (or equivalent) has a precision sensor for ±0.2°C accuracy over an operational range of -20°C to 70°C (-4°F to 158°F). Data readout is available in less than 30 seconds via an Optic USB interface. Temperature probe calibration forms and field deployment forms are located in Appendix A.

To reduce the possibility of data loss, a redundant data logger will be used at each site. In general, two sets of sensors will be installed in different fashions (depending on site characteristics). One logger will be inserted into the bottom of a 2.5-meter (8.2-foot) length of perforated steel pipe housing fastened to a large bank structure via clamps and rock bolts. The TidbiT (or equivalent instrument) will be attached to a rope that will allow it to be easily retrieved for downloads. The top pipe cap will contain a locking mechanism, which can only be opened using the appropriate Allen key to prevent theft or vandalism. The second set of temperature loggers will be anchored to a concrete block and buoyed so that bottom, mid, and surface loggers record continuous temperature conditions throughout the water column (fewer temperature loggers may be deployed depending on site characteristics). The block will be placed in a location of the channel that is accessible and retrievable during routine site visits, and the apparatus will be attached with a steel cable to a post driven into the bank or to some other structure. The proposed installation procedures may require some alteration based on site specific conditions.

The sensors will be situated in the river to record water temperatures that are representative of the mainstem or slough being monitored, avoiding areas of groundwater upwelling, unmixed tributary flow, direct sun exposure, and isolated pools that may affect the quality of the data.

The 2012 River Flow Routing Model Data Collection study will install water-level loggers with temperature recording capability at up to 12 of the temperature monitoring sites. A redundant string of TidbiT v2 temperature loggers (measuring bottom, mid, and surface conditions) will be deployed at these sites to complement the full deployment of equipment installed at all other temperature monitoring sites.

Meteorological Data Collection

Overview

Meteorological (MET) data collection will be initiated, and MET stations will be installed and/or upgraded at up to eight (8) locations between RM 224 and RM 25.6 during 2012. Table 3 lists the MET station locations. The exact spatial location will depend on access and suitability of an appropriate site for installing a MET station.

Table 3. Proposed Susitna-Watana Meteorological Stations

Susitna River Mile	Description	Station Status (New / Existing)	Latitude (Decimal degrees)	Longitude (Decimal degrees)
25.8	Susitna at Susitna Station	New	61.545399	-150.51601
44.3	Willow Creek	Existing (Talkeetna RWIS)	61.765	-150.0503
80.0	Susitna River near Sunshine Gage	Existing (Talkeetna RWIS)	62.1381	-150.1155
95.9	Susitna River at Talkeetna	Existing (Talkeetna Airport)	62.32	-150.095
136.8	Susitna River at Gold Creek	New	62.767601	-149.69099
184.1	Susitna River at Watana Dam (near river)	New	62.8240	-148.5636
184.1	Susitna River at Watana Dam Camp (upland on bench)	New	62.8226	-148.5330
224.0	Susitna River above Cantwell	New	62.7052	-147.53799

The two MET stations near the Watana Dam site need to be established at specific locations as requested by Project design engineers. The upland MET station will be established at about the 2,300 foot elevation on the north side of the river, in the area of the proposed field camp. The upland MET station will record snowfall data and precipitation. The near riversite MET station will be located on the north abutment just above river level, depending on suitability of location for establishing the structure.

Existing meteorological stations will be fitted with additional monitoring equipment and expand data collection to meet Project needs and to use historical information collected from each of these sites (Table 3). The linkage between historical records and continuing data records may be used in evaluating the utility of 1980s temperature data for modeling.

MET Station Parameters

MET stations are required to collect several types of parameters that will be used by the engineering design team for the proposed dam and will be used to provide inputs to the water quality model. The following is a comprehensive list of parameters required for use in this Project and will be measured continuously by each of the MET stations:

- Temperature – maximum, minimum, mean
- Relative humidity
- Barometric pressure
- Precipitation
- Wind speed – maximum, minimum, mean
- Wind direction

- Wind gust – maximum
- Wind gust direction
- Solar degree days

Installation and Monitoring Protocol

Each MET station will consist of, at a minimum, a 3-meter tripod with mounted monitoring instrumentation to measure and record wind speed and direction, air temperature, relative humidity, barometric pressure, incident solar radiation, and water-equivalent precipitation in 15-minute intervals (Figure 3). The station loggers will have sufficient ports and programming capacity to allow for the installation of instrumentation to collect additional meteorological parameters as required. Such installation and re-programming can occur at any time without disruption of the data collection program.

Figure 3. Example Meteorological Station Installation

MET station installation is intended to provide instrumentation that is sturdy enough to work continuously, with little maintenance, and produce high quality data through a telemetry system.

A Campbell Scientific CR1000 data logger will be used to record data. The archiving interval for all meteorological parameters will be 15 minutes, with a storage capacity to log up to two (2) years of data before filling the memory. The MET station will be powered by a 12 Vdc 8 amp-hour battery and a 20-watt solar panel with charge regulator.

To protect the stations from wildlife intrusion and to discourage any potential vandalism the stations will be protected by fencing as appropriate.

Satellite or Radio Telemetry Communications System

Real-time data will be downloaded from the data logger using satellite transmission or radio telemetry hardware. This will enable study staff to download, inspect, and archive data and monitor station operational parameters for signs of problems without visiting the site. The communication will ensure that problems, if they occur, are resolved promptly so that minimal data will be lost between service periods.

Conduct a Pilot Thermal Imaging Assessment of a Portion of the Susitna River

Aerial infrared photography and imagery have been used to locate areas of active groundwater discharge to surface waters (Robinove, 1965; Fischer and others, 1966; Robinove and Anderson, 1969; Taylor and Stingelin, 1969). This technique is effective only if the temperatures of surface water and groundwater differ by at least 2 °C (Pluhowski, 1972; Rundquist and others, 1985; Banks and others, 1996). Such a differential typically occurs on the Susitna River only during brief time periods in the fall and spring. The period for detecting this difference may be too small to exploit.

If areas of active groundwater recharge to surface water could be identified using aerial infrared imagery, it would provide valuable insights into evaluating water quality, and may help identify areas where salmon overwintering occurs. It would allow for rapid and accurate identification of gaining reaches over large areas that cannot be accomplished by stream surveys that measure temperature directly (Pluhowski, 1972). It may also allow AEA to obtain data for portions of the river where direct temperature measurements are impractical or access is dangerous.

Because of the potential value, AEA has decided to test this technique on a portion of the Susitna River, and if it works, to use it on other sections as well. Thermal imagery data from 10 miles of the Middle River will be collected. Data from the thermal imagery will be ground-truthed, and the applicability and resolution of the data will be evaluated in terms of identifying water temperatures and thermal refugia/upwelling. In coordination with the Instream Flow and fish studies, a determination will be made as to whether additional thermal imaging data will be applicable and whether or not additional thermal imaging will be collected during the 2013 field season to characterize river temperature conditions.

If the pilot study is successful, then a description of thermal refugia throughout the project vicinity can be mapped using aerial imagery calibrated with on-the-ground verification. The verification data will be collected at the same time as the aerial imagery (or nearly the same time) using the established continuous temperature monitoring network and additional grab sample temperature readings where there may be gaps, such as in select sloughs.

The following elements are important considerations for data collection, specifications for data quality, and strategy for relating digital imagery and actual river surface water temperatures.

Radiant Temperature

- Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river.
- Radiant temperature measurements are made only on the surface layer of the water (top 10 cm).
- Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water.

Spatial Resolution

- The key to good data quality is determining the pixel size of the TIR sensor and how that relates to the near-bank environment.

- Best practice is 3 pure-water pixels (ensures that the digital image represented by any 3 contiguous pixels identifies water versus land).
- Very fine resolution (0.2 - 1 m) imagery is best used to determine groundwater springs and cold-water seeps.
- Larger pixels can be useful for determining characteristic patterns of latitude and longitude thermal variation in riverine landscapes.

Calibrating Temperature

- Water temps change during the day; therefore collection should be measured near the same time daily and when water temp is most stable (early afternoon).
- Validation sampling site selections are determined where there is channel accessibility and where there are no known influences of tributaries or seeps in the area.
- Hand-held ground imaging radiometers can provide validation as long as the precision is at least as good as that expected from airborne TIR measurements.

Availability of historical imagery for thermal analysis will also be investigated.

STUDY PRODUCTS

Study products to be delivered in 2012, at a minimum, will include:

Interim Technical Memorandum. An interim report describing the 1980s data, models, and reports that were recoverable; a statement regarding the applicability of the recovered work to the current project; and recommendations regarding additional study needs to be addressed in 2013 - 2014 will be prepared. Locations of meteorological stations and thermographs installed in 2012 will be reported in ArcGIS. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection, and North American Datum of 1983 (NAD 83) horizontal datum, consistent with Alaska Department of Natural Resources (ADNR) standards.

Geo-spatially Referenced Relational Database. All historic data used in the analysis and data collected during the 2012 field season, including links to photographs, will be checked for quality and delivered in a geospatially-referenced relational database to AEA. This database will form the basis for additional data collection in 2013 - 2014. All field data must be associated with location information collected using a Global Positioning System (GPS) receiver in unprojected geographic coordinates (latitude/longitude) and the WGS84 datum. Naming conventions of files and data fields, spatial resolution, and metadata descriptions must meet the ADNR standards established for the Susitna-Watana Hydroelectric Project.

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

SCHEDULE

The following schedule is for the 2012 scope of work:

Table 4. Schedule for Implementation of WQ-S1: Review of Existing Water Temperature Model Results and Data Collection, 2012 and Production of Associated Deliverables

Milestone	Date of Completion
Deployment of thermographs and meteorological stations	June 15, 2012
Interim Technical Memorandum	June 29, 2012
Original Data (quality assured)	November 9, 2012
Geospatially-referenced relational database (quality assured)	November 9, 2012
Final Technical Memorandum on 2012 Activity	November 9, 2012

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APPENDIX A: Temperature Probe Field Data Forms

a. Temperature Logger Calibration Check Form

b. Field Deployment Form

Temperature Logger Calibration Check Form

Date: _____

Temperature Logger Calibration Check Form

Technicians:

_____

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

Notes:
SN = Serial Number

Field Deployment Form

Continuous Temperature Survey Form

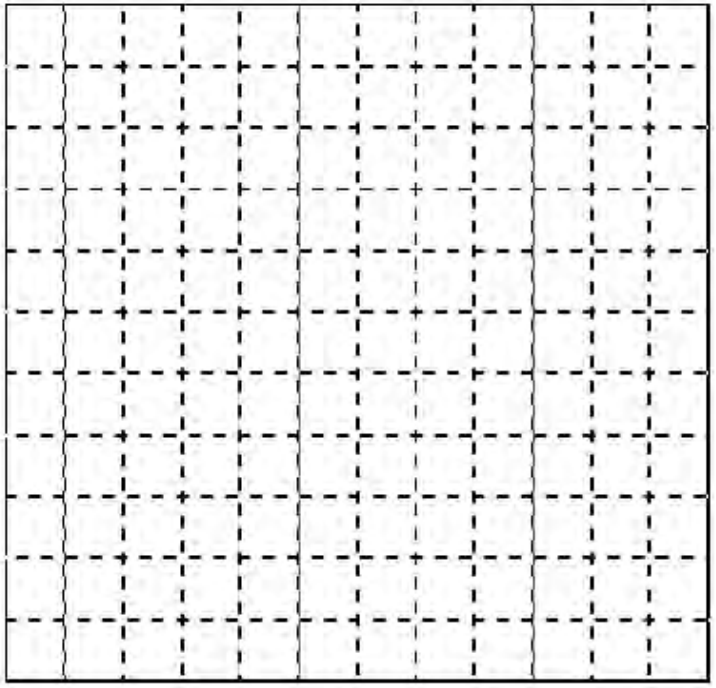
Station #: _____ **Station Name:** _____ **Samplers:** _____

Interval Frequency _____

Water Temperature Logger
I.D. # _____
Water Depth _____ ft Deployment Depth _____ ft
Height (Abv Bottom) _____ ft Retrieval Depth _____ ft

Air Temperature Logger
I.D. # _____
Height (Abv Stream) _____ ft

Date	Time	Water Temp	Air Temp	Weather/ Comments



Air Temperature Logger Location:

Water Temperature Logger Location: