Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Baseline Water Quality Study
Study Plan Section 5.5

Initial Study Report
Part A: Sections 1-6, 8-10

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

URS Corporation/Tetra Tech, Inc.

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADEC	Alaska Department of Environmental Conservation
AEA	Alaska Energy Authority
AGL	above ground level
ANCSA	Alaska Native Claims Settlement Act
AOI	area of interest
BTEX	benzene, ethylbenzene, toluene, xylenes
°C	degrees Celsius
$CaCO_3$	calcium carbonate
CFR	Code of Federal Regulations
CIRWG	Cook Inlet Regional Working Group
cm	centimeter
CORS	Continuously Operating Reference Stations
DL	detection limit
DO	dissolved oxygen
DOC	dissolved organic carbon
EFDC	Environmental Fluid Dynamics Code
EPA	Environmental Protection Agency
°F	degrees Fahrenheit
FA	Focus Area
FERC	Federal Energy Regulatory Commission
ft.	feet
GIS	geographic information system
GPS	global positioning system
HDPE	high density polyethylene
HSC	habitat suitability criteria
ID	inner diameter
ILP	Integrated Licensing Process
ISR	Initial Study Report
lb.	pound
Hz	hertz
km	kilometer
m	meter
µg	microgram
µm	micrometer
µg/L	micrograms per liter
µmhos/cm	micromhos per centimeter

Abbreviation	Definition
mg/L	milligrams per liter
mV	millivolt
m/s	meters per second
NELAP	National Environmental Laboratory Accreditation Program
NOAA	National Oceanographic and Atmospheric Association
NTU	Nephelometric Turbidity Unit
OPUS	Online Positioning User Service
PAHs	polynuclear aromatic hydrocarbons
pH	potential hydrogen
PRM	Project River Mile
Project	Susitna-Watana Hydroelectric Project No. 14241
PVC	polyvinyl chloride
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
RF	radio frequency
RSP	Revised Study Plan
SAP	Sampling and Analysis Plan
SNTEMP	Stream Network Temperature
SOP	Standard Operating Procedure
SPD	study plan determination
SWE	snow water equivalency
TDS	total dissolved solids
TIR	thermal infrared remote
TKN	total Kjeldahl nitrogen
TMDL	total maximum daily load
TOC	total organic carbon
TP	total phosphorus
US	upland slough
USGS	United States Geological Survey
USR	Updated Study Report
WQ	water quality

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed its Revised Study Plan (RSP) with the Federal Energy Regulatory Commission (FERC or Commission) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241, which included 58 individual study plans (AEA 2012). Included within the RSP was the Baseline Water Quality Study (Section 5.5.). This section focuses on the methods for assessing the effects of the proposed Project and its operations on water quality in the Susitna River basin.

On April 1, 2013 FERC issued its study determination (April 1 SPD) for the RSP Section 5.5, approving the study with modifications. In its April 1 SPD, FERC recommended the following:

Standard Operating Procedures (SOP) and Quality Assurance Project Plan (QAPP)

- *We recommend that AEA employ EPA Method 1631E for laboratory analysis of total mercury in water, sediments, and fish tissue, and EPA Method 1630 for laboratory analysis of methylmercury in water and fish tissue. We recommend that AEA apply Method 1669 (Clean Hands/Dirty Hands) for all mercury field sampling.*
- *We recommend that AEA utilize the TRVs as an additional benchmark when evaluating the need for additional baseline water quality data collection.*

AEA included FERC's requested modifications in the QAPP.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule" (18 CFR 5.15(c)(1)). This Initial Study Report on the Baseline Water Quality Study has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP and as modified by FERC's April 1 SPD and the QAPP (collectively referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The objectives for this study are established by RSP Section 5.5.1. The goal of the overall water quality study efforts is to assess the effects of the proposed Project and its operations on water quality in the Susitna River basin, which informs development of any appropriate conditions for inclusion in the Project license. The Project is expected to change some of the water quality characteristics of the drainage as well as the inundated area that will become the reservoir.

The objectives of the Baseline Water Quality Study are as follows:

- Document historical water quality data and combine with data generated from this study. The combined dataset will be used in the Water Quality Modeling Study to predict Project impacts under various operations.

- Add current stream temperature and meteorological data to the existing data.
- Develop a monitoring program to adequately characterize surface water physical, chemical, and bacterial conditions in the Susitna River within and downstream of the proposed Project area.
- Measure baseline metals concentrations in sediment and fish tissue for comparison to state criteria.
- Perform Thermal Infrared Remote (TIR) sensing of the Susitna River from Susitna Station (Project River Mile [PRM] 29.9) to Deadman Creek (PRM 235.6), and use this data to map the groundwater discharge and possible extent of thermal refugia.

3. STUDY AREA

As established by RSP Section 5.5.3, the study area for water quality monitoring includes the Susitna River from PRM29.9 to PRM 235.2 (Oshetna River), and selected tributaries within the proposed transmission lines and access corridors. Water temperature monitoring began at PRM 19.9 and other water quality monitoring started at PRM 29.9.

4. METHODS AND VARIANCES IN 2013

The Baseline Water Quality Study methods were selected to satisfy the needs of:

- The water quality modeling efforts
- Consistency with historical data collection on the river (URS 2011)
- Requirements of the 401 Water Quality Certification Process

The frequency of sample collection varied by media, parameter being tested, potential for mobilization, and bioavailability. Most of the general water quality parameters and select metals were sampled on a monthly basis because each parameter had been demonstrated to be present in one or both of surface water and sediment (URS 2011).

Sixteen mainstem water quality monitoring sites were located below the proposed dam site and two were located above the dam site (Figure 4.1-1). Five sloughs were monitored, representing a combination of physical settings in the drainage and that are known to support important fish-rearing habitat. Tributaries to the Susitna River were monitored and include those contributing large portions of the lower river flow including the Talkeetna, Chulitna, Deshka, and Yentna rivers. Remaining tributaries where monitoring was planned for 2013, but not visited will be sampled in 2014. These sites represent important spawning and rearing habitat for anadromous and resident fisheries and include Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna River.

These sites were selected based on the following rationale:

- Adequate representation of locations throughout the Susitna River and tributaries above and below the proposed dam site for the purpose of a baseline water quality characterization.
- Location on tributaries where proposed access road-crossing impacts might occur during and after construction (upstream/downstream sampling points on each crossing).
- Preliminary consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Land access.
- Seven of the sites are mainstem monitoring sites that were previously used for Stream Network Temperature (SNTEMP) modeling (Table 4.1-1) in the 1980s. Thirty-seven of the sites are Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Baseline temperature monitoring sites were spaced at approximately 5-mile intervals so that the various factors that influence water temperature conditions were captured and support the development (and calibration) of the water quality model. The 2013 water quality monitoring effort resulted in fewer locations visited due to land access restrictions and so river mile intervals between sites were larger than originally stated in RSP Section 5.5.4. The water quality monitoring sites were co-located at a sub-set of the water temperature monitoring sites representing each type of riverine setting in the Lower-, Middle-, and Upper River. Frequency of sites along the length of the river is important for capturing localized effects from tributaries and from past and current human activity.

Sampling to characterize variability in water quality conditions was conducted along transects at the original 17 locations described in Table 5.5-1 of the RSP. An additional site was monitored for water quality conditions at PRM 152.2 Susitna River below Portage Creek. A total of 18 water quality monitoring locations were characterized for water quality conditions in 2013. The objective of this sampling strategy addresses the influence of channel complexity (multiple channels, braiding, etc.) on both the Susitna River and tributary water quality. These data also enable the Water Quality Modeling Study to predict conditions in 3-dimensions for the reservoir (longitudinally, vertically, and laterally) and in 2-dimensions (longitudinally and laterally) for the riverine portion of the project area.

4.1. Water Temperature Data Collection

4.1.1. Collection Sites

The 1980s water temperature data and monitoring locations were evaluated to determine which of the historic locations should be monitored in 2012. Replicating the 1980s monitoring locations helps to determine if conditions have changed and how this impacts thermal refugia. Locations were selected for monitoring based on:

- Adequate representation of locations throughout the Susitna River and tributaries;
- Preliminary consultation with licensing participants;
- Safety, and
- The needs of studies (e.g., fisheries, instream flow, ice processes).

A total of 37 sites were selected for installation of water temperature data loggers (Table 4.1-1 and Figure 4.1-1). Of these sites, 32 were replicates of sites monitored in the 1980s, and 5 of these sites represented new or relocated sites from the 1980s dataset.

Field reconnaissance of the 1980s sites was conducted by boat or viewed from the air during the 2012 field season. It was determined that four of the 1980s historical study sites were either no longer accessible due to changes in the river channel (two sites), or unsafe to access (two sites). Attempts were made to relocate these monitoring sites to accessible areas close to the original locations; however, conditions prohibited the final installation of the remaining four water temperature monitoring sites. Based upon this field reconnaissance, only 33 of the originally proposed 37 water temperature monitoring stations were installed.

4.1.2. Collection Protocols

The sensors were 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 would have affected data quality.

Collection of water temperature data began in July 2012, and continues through the winter of 2013/2014. Additional systems were installed during the 2013 field season, and some equipment was lost and replaced during routine site visits conducted during the ice free period (June through October). A summary of each site complete with photos, global positioning system (GPS) coordinates, aerial images, and installation/maintenance field notes are included in Appendix A with blue flags indicating 2012 installation locations and red flags indicating 2013 installation locations.

In September of 2012, 17 thermistors were redeployed as overwintering systems (Table 4.1-1). The locations were selected based on locations where ice forces might allow for their survival over the winter. Of the 17 overwinter systems, 11 thermistors were found following ice breakup and six thermistors could be downloaded during June 2013 site visits. There were five thermistors still intact as originally deployed, but were on restricted access lands.

The overwinter setups were removed from the river and replaced with anchor and buoy systems in June 2013, and replaced with overwinter systems in September 2013. A total of 27 sites of the proposed 37 sites were monitored in 2013. The remaining sites will be visited during 2014 field season.

Thermistors were generally retrieved on a monthly basis and redeployed after data were downloaded via a data shuttle.

Water temperatures were recorded in 15-minute intervals using Onset TidbiT v2 water temperature data loggers. The TidbiT v2 has a precision sensor for plus or minus 0.4 degrees Fahrenheit (°F) (0.2 degrees Celsius [°C]) accuracy over an operational range of -4°F to 158°F (-20°C to 70°C). Data readout is available in less than 30 seconds via an Optic USB interface.

The 2012 Fish and Aquatics Instream Flow Study installed water-level loggers with temperature recording capability at several study sites and are further described in Section 8.5.4.4 of the Fish and Aquatic Instream Flow Study Plan. Where these study sites overlapped with the water temperature monitoring sites, the water-level logger temperature sensors were used. However, a redundant TidbiT v2 was deployed at these sites for backup water temperature recording, especially for year-round temperature monitoring.

4.1.3. Thermistor Set-up Systems

AEA experimented with a variety of deployments for the thermistors, which are discussed below. Each of these set-ups had advantages and disadvantages.

4.1.3.1. Anchor-and-Buoy Thermistor System

The anchor-and-buoy system consisted of a cable attached to an anchor and floated by a buoy to record continuous bottom, middle, and surface water temperature conditions throughout the water column (Figure 4.1-2). An anchor line was attached from the temperature monitoring apparatus to the shore by running a cable along the river bottom. The anchor for each buoy was composed of a 2-foot section of steel rail (approximately 60 lbs. each). Due to approximately 2-foot to 5-foot daily fluctuations in water level at any one of the water temperature monitoring locations, a 1:2.5 or 1:3 ratio on the cable length was attached to the buoys so they could rise with water level. The anchor was placed at a channel location that was accessible during routine site visits and attached with a 1/4-inch galvanized steel cable wrapped around large tree or group of trees along the bank or bolted to a rock using anchor brackets. This installation design did not require substantial alterations to the sites. In cases of very slow moving or slack water (e.g., Deshka River), the temperature monitoring apparatus is solely held in place by the anchor. The anchor and buoy system was used during the summer.

The anchor and buoy system could be used virtually anywhere on the river, and provides vertical water temperature measurements in the water column, and is easy to locate, maintain, and download. Unfortunately this system is unable to survive the winter, and is vulnerable to damage from debris in the river.

4.1.3.2. Bank-Mounted Thermistor System

In 2012, eleven sites were equipped with a redundant set of thermistors in the form of bank mounted installations. This was done to reduce the possibility of data loss during the winter. The bank-mounted approach allowed for permanent structures during the data collection period as they needed to withstand the rigors of ice forces. The thermistor protection and mounting assembly included:

- A 2-inch inner diameter (ID) diameter schedule 40 galvanized pipe, 2.5 m (~8 ft.) in length, threaded at both ends with threaded end caps.

- A 1/4-inch hole was drilled into the bottom end cap to allow for fine sediment drainage.
- The pipe was perforated with a series of 1/4-inch holes (at approximate 20 cm (7-1/2-inch) spacing) running half the length of the pipe (the schematic shows holes up the entire pipe, however only one half will need to be perforated; Figure 4.1-3).

The bottom cap was tightened using a pipe wrench as it is not to be removed except to clean out sediment (as required). The top cap was loosely hand tightened to allow access to the thermistors. The perforated side of the pipe, when installed, was face-down. The assembly was bolted to a rock surface by means of up to three pipe brackets and six 3/8-inch rock anchor bolts:

- The bracket was 3 cm (1-1/4-inch) wide and 1/4-inch thick to ensure integrity.
- The length of the bracket was constructed so as to mount the 2-inch ID pipe to a level surface.
- The two mounting bracket holes were drilled approximately 4 cm (1-1/2 inches) from each end and were able to accommodate the concrete anchor bolts which have a slightly wider expansion head (approximately 7/16-inch).
- The brackets were coated with anti-rust paint.

The TidbiT sensor(s) were attached near the bottom of a length of steel cable which was inserted into the galvanized pipe and withdrawn to download data. The bank-mounted system was used as a redundant system to supplement both the summer and winter deployments.

The bank-mounted system was more robust, however, it required attachment to a large rock or rock face on the bank, limiting where it could be deployed in the river. It also only recorded water temperature in the bottom of the river, and was found to be prone to silting in and damage from ice scour.

4.1.3.3. Overwinter Anchor and Buoy Thermistor System

The overwinter systems consisted of an anchor-and-buoy string set-up with single thermistor housed in a polyvinyl chloride (PVC)-housed protective casing suspended on a short cable (2.5 ft) and floated with one or two small buoys (Figure 4.1-4). These systems typically survived the winter; however, they only recorded data at the bottom of the water column. Prior to river freeze up in 2012 and again in 2013, overwinter anchor and buoy systems were installed at either selected (2012) or all (2013) of the water temperature monitoring stations (see Table 4.1-1).

4.1.4. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- Numbers and locations of water temperature monitoring sites were altered from the Study Plan. Establishment of temperature monitoring sensors was planned for 37 sites in 2013 (Table 4.1-1). Equipment deployment for water temperature monitoring was completed at 27 sites on the Susitna River mainstem and tributaries. This variances were due to 1) land access limitations preventing field crews from working on bankside private lands and 2) establishing monitoring apparatus at appropriate bank condition/anchor points (e.g., wide gravel bars, narrow canyons). Continuous water temperature monitoring was not conducted between PRM 152.2 and PRM 196.8 due to land access restrictions. In addition, one site (PRM 225.5 Susitna River near Cantwell) located between the dam site and the upper monitoring sites was not visited for deployment of water temperature monitoring probes. Land access restrictions prevented deployment of the water temperature monitoring probes at these sites. Absence of temperature monitoring data at eight sites between PRM 145.6 and PRM 209.2 may diminish the sensitivity of the riverine model. Existing water temperature conditions can be modeled by interpolating between these two river miles and by using available 1980s data and 2012 temperature monitoring data.

- Table 5.5-1 of Section 5.5 in the RSP lists a total of 39 site names. However, two of the site names in this table are duplicates (e.g., Susitna River above Portage Creek) and Slough 11 was monitored as part of the Focus Area studies. More detailed data collection effort was completed for this portion of the river than was described in the RSP Section 5.5.4.4. This variance represents a benefit to the riverine modeling effort by predicting water quality conditions at a higher resolution than originally planned.
- The QAPP called for redundant data loggers at each site. The team found it impractical, and in some cases unsafe, to deploy the bank-mounted pipe systems at many locations. Following the winter of 2012/2013, many pipe systems were lost due to ice and flooding and therefore this type of system was deemed impractical. Further, it was found that the overwinter anchor and buoy systems could be installed at more of the monitoring locations, and that the survival rate of the overwinter anchor and buoy systems was higher than the bank-mounted thermistor systems.

4.2. Meteorological Data Collection

Six meteorological stations were identified in the Study Plan that could be used in constructing the (3D and 2D) Reservoir and River Water Quality Models. The Study Plan (Section 5.5.4.3 of the RSP) indicated that the ability to upgrade existing stations was currently being evaluated. The 2013 field effort identified three existing stations that would be used in the reservoir and riverine model construction and a need for establishing three new stations (EMS-1, EMS-2, and EMS-3). One station was established near the Watana Dam site, at an elevation of approximately 2,300 feet on the north side of the river. This station is above the projected elevation of the reservoir and proposed dam height. The second station was installed slightly upriver of the proposed reservoir footprint, at an elevation of approximately 2,100 feet near the confluence of Oshetna River and the Susitna River. The third station was installed 40 miles downriver of the proposed dam near the confluence with Indian River and the Susitna River at an elevation of approximately 720 feet. Meteorological data is also available from the National Oceanographic and Atmospheric Association (NOAA) station located at the Talkeetna Airport (Table 4.2-1). Existing information from the Willow Creek and Susitna River near Sunshine gage stations is a partial list of parameters and will be included in the database.

The stations with usable data for constructing the water quality models are spatially distributed on the Susitna River and represent a range of distinct physical settings throughout the Project area (Figure 4.2-1). The data recorded by the stations installed in 2012 is uploaded every hour via radio frequency (RF) telemetry and stored on a digital server in Talkeetna, Alaska. All recorded meteorological data undergoes QA/QC protocols and noise in the data is removed using a low pass filter.

4.2.1. Meteorological Station Installation and Monitoring Protocol

In late-September 2013, rain gauges were installed on ESM2 and ESM3 as well as a snow-water equivalency sensor on ESM2 and a sonic snow depth sensor on ESM3. ESM1 has excellent exposure to winds in all directions. ESM2 and ESM3 are located within the Susitna River valley and are subjected to valley-induced wind steering. ESM2 has a large occurrence of low wind speeds that may be the natural result of more open terrain in the area, but may also be due to the influence of sparse tree cover in the area. ESM3 is subject to an earlier cessation of direct sunlight as the sun drops below the ridge on the south side of the river in the late afternoon.

A Campbell Scientific CR1000 data logger is used to record and store the data. The archiving interval for all meteorological parameters is 15 minutes. The stations are powered by an enclosed battery pack consisting of four external 12 Vdc batteries and a 65-watt solar panel. The station loggers have sufficient ports and programming capacity to allow for the installation of instrumentation to collect additional parameters as required. Such installation and re-programming can occur at any time without disruption of the data collection program.

Real-time data is uploaded from the stations to an internal server via the RF Susitna-Watana Internal Data Network which allows communication with the data loggers from various studies. This approach enables study staff to download, inspect, and archive the data as well as monitor station operational parameters for signs of problems without visiting the site. The communication also ensures that problems are resolved promptly to minimize data loss between service periods.

4.2.2. Meteorological Station Parameters

All three stations are equipped with instrumentation to measure wind speed and direction (at 3 meters), air temperature, relative humidity, barometric pressure, and incident solar radiation (and beginning in September 2013, water-equivalent precipitation). The data being collected supports the activities of the engineering design team and the development of the hydrodynamic and water quality temperature model.

4.2.3. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- The 2013 RSP identified potential for MET Station data sources from RM 25.8 to RM 224.0. Three new MET Stations were established from between PRM 142.2 to PRM 235.2. An additional existing MET Station was identified for use in constructing the riverine model at PRM 99.6 (Talkeetna Airport). The existing MET Station extends the meteorological monitoring effort near the boundary between the Lower River and Middle River reaches. Since the meteorological data is not expected to have as large an influence on water conditions in the riverine model as it will for construction of the reservoir model, the current collection of MET Stations is expected to satisfy modeling needs.
- To record precipitation, in addition to a tipping bucket rain gauge, a CS725 snow water equivalency (SWE) sensor was installed on ESM2 in 2013. The SWE sensor is a new technology, developed in part by Hydro Quebec for the purpose of collecting higher accuracy and time variant SWE data in remote areas for reservoir modeling. The instrument records the amount of water contained in the snowpack as a function of degradation of potassium and thallium radiating from the soil below the snow.
- The rain gauge installed at ESM3 was coupled with a sonic level sensor which will record the depth of snow. This data will be used to estimate the SWE contained in the snowpack using the meteorological standard of 10%.
- The intention was to install a rain gauge and CS725 at ESM1 as well; however, site access was restricted. It will be installed if site access is allowed.

4.3. Baseline Water Quality Monitoring

The purpose of the Baseline Water Quality Study was to collect information to support an assessment of the effects of the proposed Project operations on water quality in the Susitna River basin.

Effects of the proposed Project operations will be determined by using baseline water quality monitoring data in the reservoir and riverine model described in the Water Quality Modeling Study ISR (Section 4.2). There were two types of monitoring programs used to characterize surface water conditions: Baseline Water Quality Monitoring (Section 5.5.4.4 of the RSP) and Focus Area Monitoring (Section 5.5.4.5 of the RSP). These programs were distinguished by the frequency of water sampling and the density of sampling effort in a localized area. The Focus Area Monitoring method is described in Section 4.4 of this ISR.

Baseline water quality collection was broken into two components: in situ water quality sampling and general water quality sampling. In situ water quality sampling consisted of on-site monthly measurements of physical parameters at monitoring locations using field equipment. General water quality sampling consisted of monthly grab samples that were sent to an off-site laboratory for analysis. The laboratory, SGS in Anchorage, is National Environmental Laboratory Accreditation Program (NELAP) certified which allows credible data for use by state, federal, and tribal regulatory programs for evaluating current and future water quality conditions. As part of the Data Quality Objectives described in Section B.5.2 of the QAPP, a laboratory split sample from two sites (PRM 87.8 and PRM 118.6) was sent to each of SGS Laboratory in Anchorage, AK and Aquatic Research, Inc. in Seattle, WA (both NELAP and State-Certified laboratories). Results from analysis of a full set of water quality parameters was compared for agreement and where substantial differences occurred between laboratory results further investigation of analytical methods was implemented. In general, these samples represented water quality components that cannot be easily measured in situ, such as metals concentrations, nitrates, etc.

4.3.1. Baseline Parameters Monitored

Surface water, sediment, and pore water samples were collected on a variety of schedules from baseline water quality monitoring locations and analyzed for organics, metals, nutrients, and conventional/other analyses (Table 4.3-1). The frequency of monitoring was based on the ease at which the data could be collected, and the variability expected in the concentrations over time. For example, water temperature was thought to vary daily or even hourly, while the radionuclide flux in the river is expected to be fairly constant from year to year. Some parameters are best analyzed in situ (for example, pH) while others require fixed laboratories to obtain high quality results. The parameters selected for analyses as part of the baseline water quality monitoring correspond to the Alaska Water Quality Standards water quality criteria (18 ACC 70.020(b)) for protecting designated uses in fresh water, when available. Specific analysis methods are detailed in the QAPP.

4.3.2. Baseline Sampling Protocol

Water quality data collection occurred on average at 5 mile intervals (Figure 4.1-1). This spacing follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Sampling during winter months of 2013/2014 will focus on locations where flow data is currently collected (or was historically collected by the U.S. Geological Survey [USGS]) and will be used in the Water Quality Modeling Study.

Monthly water quality samples were collected during each site visit in a representative portion of the stream channel/water body, using methods consistent with Alaska Department of Environmental Conservation (ADEC) and U.S. Environmental Protection Agency (EPA) protocols and regulatory requirements for sampling ambient water and trace metal water quality criteria. Monthly samples were planned for collection from 17 locations from June 2013 to September 2013 (Table 4.3-2). An additional sampling location was added to this monitoring effort at PRM 152.2 (Susitna River below Portage Creek) to make a total of 18 locations visited during 2013. One-time sampling occurred for a limited number of analytes (benzene, ethylbenzene, toluene, xylenes [BETX], polynuclear aromatic hydrocarbons [PAHs], radionuclides, aluminum, chromium, selenium, fecal coliform, and total organic carbon [TOC]).

Variation of water quality in a river cross-section can be significant and is most likely to occur because of incomplete mixing of upstream tributary inflows, point-source discharges, or variations in velocity and channel geometry. Water quality field measurements were collected in a manner to determine the extent of vertical and lateral mixing. Samples were collected at three equi-distant locations along each transect at each monitoring location (i.e., 25% from left bank, 50% from left bank, and 75% from left bank). Samples were collected from a depth of 1.5 ft. below the surface as well as 1.5 ft. above the bottom, if total water depth was 5 ft. or greater. This ensured that variations in concentrations, especially metals, were captured and adequately characterized throughout the study area. Samples collected at 25% from left bank were referred to as the left bank sample, samples collected at 50% from left bank were referred to as the middle sample, and samples collected at 75% from the left bank were referred to as the right bank sample.

4.3.2.1. In Situ Water Quality Sampling

During each site visit, in situ measurements of dissolved oxygen (DO), pH, specific conductance, redox potential, turbidity, and water temperature were collected at depths corresponding to grab sample locations (1.5 ft. below the surface and 1.5 ft. above the bottom if total water depth was 5 ft. or greater). A Hach 2100 IS Portable Turbidity Meter was used to measure turbidity during the June sampling event along with a YSI multi-parameter sonde to measure the remaining field parameters. Beginning in July, a Hydrolab® datasonde (MS5) was used to measure all field parameters during each site visit, including turbidity. Color was measured in the field using a Hanna Instruments HI 727 Colorimeter.

Standard techniques for pre- and post-sampling calibration of in situ instrumentation were used to ensure quality of data generation and followed accepted practice.

4.3.2.2. General Water Quality Sampling

Surface water grab samples were collected using one of two methods dependent upon field conditions. Field personnel were equipped to perform either method and/or make modifications based on site conditions, water velocity, and flow. Water quality sample containers were filled using a high capacity peristaltic pump and non-reactive high density polyethylene (HDPE) tubing system. The sample tubing was cable tied to a davit cable attached to a 50 to 75 lb. weight and lowered into the water column. Once the tubing was positioned at the right depth the pump was turned on and flushed for 3 minutes. Samples were collected from the tubing and into the proper sample containers and labeled accordingly. Filtered samples were collected after a 0.45 µm filter was attached to the tubing and flushed for one minute. Some sample locations were located in water depths less than 3 ft. (<1 m) deep and were not accessible by boat. In this case field personnel collected samples by wading into the river, and using the HDPE tubing and peristaltic pump to collect the sample. The HDPE tubing was secured to an extendable aluminum boat pole and placed along the bottom of the river such that with the tubing opening was facing upstream at approximately mid-water column depth.

All sample collection avoided pools and slack water. Sampling methods also avoided unnecessary collection of sediments in water samples, and touching the inside or lip of the sample container. Samples were delivered to a State-Certified laboratory using EPA-approved analytical methods including a separate completed chain of custody sheet. Field duplicates were collected for 10 percent of samples (i.e., 1 for every 10 water grab samples). Laboratory quality control samples including duplicate, samples between laboratories, spiked, and blank samples were prepared and processed by the laboratory. Further details on field sample protocols, including chlorophyll *a*, may be found in the QAPP.

4.3.3. Baseline Sample Handling and QA/QC

QA/QC samples included laboratory sample splits, field duplicates, matrix spikes, duplicate matrix spikes, and rinsate blanks for non-dedicated field sampling equipment. The results of the analyses were used in data validation to determine the quality, bias, and usability of the data generated.

Sample numbers were recorded on field data sheets immediately after collection. Samples intended for the laboratory were stored in a dedicated sample refrigerator and kept under the custody of the field team at all times. Samples were transported to the laboratory in coolers with ice the following day by a member of the field team. Chain of custody records and other sampling documentation were kept in sealed plastic bags (Ziploc®) and taped inside the lid of the coolers prior to transport. A temperature blank accompanied each cooler. Packaging, marking, labeling, and shipping of samples was in compliance with all regulations promulgated by the U.S. Department of Transportation in the Code of Federal Regulations, 49 CFR 171-177.

Water quality samples were labeled with the date and time that the sample was collected and filtered/preserved (as appropriate), then stored and delivered to a state-certified water quality laboratory (laboratory) for analyses using EPA-approved methods in accordance with maximum holding periods. A chain of custody record was maintained with the samples at all times.

The laboratory reported data electronically (Excel, Access database, PDF) results for each chemical parameter analyzed with the laboratory method detection limit, reporting limit, and practical quantification limit. The laboratory attained method detection limits specified in the QAPP that were at the applicable regulatory criteria and provided all laboratory QA/QC documentation. However, the method detection limit should be lower for estimating total phosphorus concentrations (MDL ≤ 2.0 µg/L) than was achieved for analysis of surface water samples collected during 2013. Future sampling results will use the lower detection limit for determining total phosphorus concentrations in surface water.

The procedures used for collection of water quality samples followed protocols from ADEC and EPA Region 10 (Pacific Northwest). Water quality data were summarized with appropriate graphics and tables

Additional details of the sampling procedures and laboratory protocols are included in the QAPP.

4.3.4. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- During the 2013 field effort, monitoring was required at PRM 225.5 for water quality samples. The collection effort differed from the original monitoring plan by relocating this site from PRM 225.5 (Susitna near Cantwell) to PRM 235.2 (Susitna River adjacent to Oshetna Creek) due to limited site access by helicopter. The new location of this site is used to generate input concentrations of water quality parameters to the proposed reservoir area for purpose of calibrating the reservoir model (RSP Section 5.6). No further information needs to be generated with future monitoring from this new site location.

- Tsusena Creek was not sampled in 2013, but was planned as reported in Table 5.1-1 of the Revised Study Plan Section 5.5. The site was not accessible due to land access restrictions during the 2013 sampling season. This tributary represents the first large tributary to the Susitna River below the dam site and will influence water quality conditions under some flows. Water quality data from this site is important to know so that predicted water quality conditions from the model will incorporate this influence. Water quality sampling is planned for this site in in the next study year in order to adequately characterize all inputs into the water quality model and improve accuracy for predictions under several flow scenarios. Samples were required for collection at PRM 168.1 and PRM 183.1. Two point samples (including field measurements and laboratory sampled) were collected at PRM 174.0 (below Watana Dam Site; above PRM 168.1 and below PRM 183.1) as this was the upper most location accessible from a boat that was deployed on the upper river. Access to PRM 168.1 was restricted in 2013 as well as access by helicopter so the next site upstream that could be visited was at PRM 174.0. The distance between the PRM 168.1 and PRM 174.0 is not expected to have any effect on characterizing water quality conditions in this part of the river. The revised location corresponds with one of the Focus Areas that benefited modeling at a finer resolution. Future monitoring will be conducted at the proposed sites reported in RSP Section 5.5.

- The QAPP (RSP Section 5.5) indicated that a Hydrolab® datasonde (MS5) would be used to measure pH, specific conductance, dissolved oxygen, and redox potential during the baseline water quality monitoring. A YSI datasonde was used during June 2013 and part of July 2013 sampling events during the baseline water quality sampling. This equipment served as an alternate backup for one of the water quality study teams, but experienced technical issues with the pH probe. This equipment failure resulted in loss of pH data as described above. There are no expected significant impacts to study objectives as pH collected on succeeding months show little to no variation from within a narrow range of measurements. Water quality model calibration (reservoir and riverine) will able to use existing data as well as new field data measurements when re-sampling for Total Phosphorus is conducted as described below.

- The detection limit (DL) for total phosphorus was higher (3.1 µg/L) and was consistent with both method and DL specified in the RSP (Table B1-3; Attachment 5-1 of the RSP) than what is achievable for low-level detection limits (2.0 µg/L). The laboratory detection limit was higher due to batch analysis of samples within the laboratory. Study objectives remain unaffected as any concentrations below the specified DL were reported as non-detected. New results from sites visited in 2013 will be generated during the next year of study.

4.4. Focus Area Water Quality Monitoring

The second type of water quality monitoring is distinguished from the large-scale program by a higher density of sampling within a pre-defined reach length and a higher frequency of sample collection (greater than once per month). The purpose for the intensive water quality monitoring in select Focus Areas of the proposed Project area was to evaluate potential effects from Project operations on resident and anadromous fisheries.

4.4.1. Focus Area Parameters Monitored

Similar to baseline water quality monitoring, Focus Area samples were analyzed for organics, metals, nutrients, and conventional/ other analyses; however, only surface water and ground water samples were collected (Table 4.3-1). Specific analysis methods are detailed in the QAPP.

4.4.2. Focus Area Sampling Protocol

The Focus Areas had a higher density of sampling locations, in contrast to the mainstem network, so that prediction of change in water quality conditions from Project operations could be made with a higher degree of resolution. The resolution expected for predicting conditions were as short as 100-meter (m) longitudinal distances within the Focus Areas. Depending on the length of the Focus Area, transects were spaced every 100 m to 500 m and water quality samples collected at three or more locations along each transect. The collection locations along a transect were in open water areas and had three to six collection points. These were discrete samples taken at each collection point. The density of monitoring locations within the Focus Areas was used as a grid to detect and describe groundwater input. Plumes of groundwater input to a Focus Area were traceable using thermal data or conductivity. The area of groundwater input was described using the monitoring grid network represented by the transects, and sampling points along each transect. The locations of open water transects and groundwater monitoring wells were coordinated with the Instream Flow Study and the Groundwater Study to efficiently implement common elements in each of the studies. Groundwater wells were installed as part of the Water Quality Monitoring Study so that surface water and groundwater samples were collected at the same time for determination of influence of groundwater on surface water. Surface water samples and parameters were taken at representative points in sloughs and side channels within each Focus Area, with the location of each point determined by potential fisheries habitat and current fish rearing habitat. Water quality parameters were also taken 40 m downstream and 50 m upstream at 10 m intervals from the surface water sampling point.

The ten Focus Areas were selected in consultation with the water resources leads. The locations of the Focus Areas are shown on Figure 4.4-1. The Water Quality Study sampling transects and sampling locations for the Focus Areas shown on Figures 4.4-2 through 4.4-8.

Collection of groundwater and surface water during each site visit was used to evaluate the influence of groundwater on surface water quality. Frequency of sampling was every two weeks for a total duration of six weeks and coordinated with the Instream Flow and Groundwater studies (Table 4.4-1). Two groundwater monitoring wells were installed at four Focus Area monitoring locations.

Water quality parameters measured in Focus Areas from PRM 104 to PRM 144 will be used to calibrate the (2D) River Water Quality Model with Enhanced Resolution Focus Areas , but at a higher level of resolution than used for the main channel in the Susitna River. The focus for (2D) River Water Quality Model with Enhanced Resolution Focus Area predictions was on the parameters listed in Table 4.3-1 that could affect habitat used by anadromous and resident fish in this drainage.

The water quality parameter list was divided further into two categories: (1) constituents of concern (e.g., metals), and (2) general water quality conditions that may adversely affect fish species (RSP Section 5.5.4.5). These parameters were selected for comparison against ADEC water quality criteria and to Screening Quick Reference Tables (SQuiRT) as reported in RSP Section 5.5.4.8.

Inclusion of the nutrient parameters was used to inform the productivity studies and potentially be used to develop habitat suitability criteria (HSC) curves for select aquatic communities. Response of biological communities such as periphyton and benthic macroinvertebrates to nutrient concentrations will be predicted for alternative operational scenarios.

4.4.3. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- Ten Focus Areas were described in RSP Section 5.5 for water quality sampling during 2013. Seven Focus Areas instead of ten Focus Areas were monitored in 2013 due to access limitations. Sampling at Focus Areas was restricted to areas in the drainage where permission of access was obtained. The remaining Focus Areas are scheduled for sampling in the next year of study in order to incorporate into the modeling effort and that benefits the productivity studies.
- Three to five sampling points were proposed in the RSP Section 5.5.4.5 along each transect. A greater number of sampling points along each transect within a Focus Area was collected to improve resolution of outputs from the model. In several cases, up to six sample points were placed along individual transects as well as the addition of point samples that were beyond the proposed effort in RSP Section 5.5. Wherever point samples were located within side channels or sloughs, a longitudinal profile of field measurements were made that included water temperature, pH, dissolved oxygen, and specific conductance. Each of the longitudinal observations was spaced 10 meters apart in a 100-meter reach that was centered on the point sample. This sampling strategy was intended to describe the spatial extent of water quality conditions that could be detrimental for fish use and habitat rearing. Remaining Focus Areas will be sampled in order to complete the proposed detailed modeling with higher resolution in these areas.

4.5. Sediment Samples for Mercury/Metals in the Reservoir Area

This task is designed to gather specific information on the distribution of metals within potential source areas along the Susitna River. In general, all sediment samples were taken from sheltered backwater areas, downstream of islands, and in similar riverine locations in which water currents are slowed, favoring accumulation of finer sediment along the channel bottom. Samples were analyzed for total metals, including arsenic, cadmium, copper, iron, lead, mercury, nickel, selenium, and zinc.

In addition, sediment size and total organic carbon (TOC) was included to evaluate whether these parameters are predictors for elevated metal concentrations. Samples were collected near the mouths of tributaries near the proposed dam site, including Goose, Jay, and Kosina, Creeks, and the Oshetna River (Figure 4.5-1 through Figure 5.4-4). The purpose of this sampling was to determine where metals, if found in the water or sediment, originate in the drainage. Toxics modeling will be conducted to address potential for bioavailability in resident aquatic life. Comparison of bioaccumulation of metals in tissue analysis with results from sediment samples will inform on potential for transfer mechanisms between source and fate.

Two types of modeling analysis are being completed: (1) pathway model analysis, and (2) numerical modeling using the(3D) Reservoir Water Quality Model. First, pathway models were constructed for preliminary evaluation of potential for transfer between media (e.g., sediment-pore water, pore water-surface water, surface water-fish tissue). Exposure concentrations were estimated for each constituent within the medium sampled (e.g., sediment, pore water, surface water) and companion parameters (e.g., hardness and pH) were collected to enable calculation of applicable chronic and acute aquatic life criteria. Potential for transfer of metals between media can be facilitated by surrounding physicochemical conditions like low dissolved oxygen conditions, low pH resulting from low dissolved oxygen concentrations, or low redox potential. These companion field measurements were made along with all media sampled at each site.

Most of the metals of interest are typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling was to obtain sediments with at least 5 percent fines (i.e., particle size less than 0.0025 inches [63 µm], or passing through a #230 sieve).

The sediment samples were collected using a hand auger of stainless steel spoon. All samples were collected by wading into shallow nearshore areas. To the extent possible, samples consisted of the top 6 inches (15 cm) of sediment.

4.5.1. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- Visits to eight sites for collection of sediment samples were proposed in the RSP Section 5.5.4.6. Four sites were not visited in 2013 (Fog, Deadman, Watana, and Tsusena Creeks). The reason for omission of this sampling as planned in 2013 was due to land access restrictions. These sediment samples will be collected in the next year of study in order to acquire an adequate representation of sediment constituent conditions in and around the dam site. This information is important for calibrating presence and rates of mercury cycling that will be incorporated into the reservoir water quality model.
- The RSP Section 5.5 proposed use of an Ekman Dredge or a modified Van Veen grab sampler. Due to sampling site conditions, all sediment samples were collected using either a hand auger or stainless steel spoon by wading into shallow nearshore areas. Site access was by helicopter and so heavy equipment deployed from a boat was not possible.

The data collected meets study objectives and will be further used for model construction and in pathway analysis. There are no proposed changes in future monitoring effort as quality of the data and sample representativeness of deposition areas along the river had been maintained.

4.6. Baseline Metals Levels in Fish Tissue

Methods to assess the baseline metals in fish tissue are provided in the Study 5.7 Mercury ISR.

4.7. Thermal Infrared Remote Sensing

Airborne TIR sensing is an effective method for mapping spatial temperature patterns in rivers and streams. These data are used to establish baseline conditions and direct future ground level monitoring. The TIR imagery illustrates the location and thermal influence of point sources, tributaries, and surface springs. When combined with other spatial datasets, TIR data also illustrate reach-scale thermal responses to changes in morphology, vegetation, and land use.

The thermal differential between bulk water temperatures in the Susitna and subsurface discharges is approximately 3°C during the fall months, with the groundwater discharge typically being warmer than instream temperatures. While many studies have successfully used this type of work to delineate groundwater contributions to surface water, the temperature differential between surface water and groundwater in Alaska is not as large as in other areas of the United States, making this type of study difficult to perform.

TIR data for the middle and upper Susitna River was successfully acquired in 2012 as part of a pilot program described in the RSP (AEA 2012). This pilot program identified numerous areas where groundwater was significantly contributing to surface water, and based on the success of this program a decision was made to expand this study to the rest of the river. Two separate missions were performed in 2013:

- **Focus Area reshoot** – The Focus Areas, along with the middle and upper river, were imaged in 2012. The results of the 2012 study were excellent; however, it was felt that additional data acquisition would allow for a better correlation between site conditions on the ground and the thermal imagery, including an evaluation of year to year variations in groundwater flow. In addition, the use of a fixed-wing plane and some slightly different equipment would allow the resolution to be reduced from 0.7 m to 0.5 m.
- **Lower River** – Collect thermal images for the lower river.

The scope of the 2013 fieldwork for the Focus Areas can be seen on Table 4.7-1, and Figure 4.7-1. AEA collected airborne TIR imagery over a 4-day period in October 2012, and again between October 21 and November 8, 2013.

To maximize thermal contrast between warmer ground water discharge and colder river temperatures of the mainstem Susitna, the TIR sensor was flown during early morning hours. On flight days bulk water temperatures were at or near freezing, while groundwater temperatures remained at a constant 2 to 4°C.

Unfortunately the weather during the study period was largely rainy, foggy, or windy, limiting flight times. While the Focus Areas were successfully re-imaged on good days, only 73% of the lower river imaging was completed before freeze-up.

Images were collected with a FLIR system's SC6000 sensor (8 to 9.2 µm) mounted in a Cessna T310Q. The aircraft was flown in parallel flight lines in order to capture the entire requested area. The TIR sensor was set to acquire images at a rate of 1 image every second resulting in an image forward-overlap of approximately 60% and side-lap of 40%. The TIR data acquisition was conducted at a flight altitude of 1,000 meters above ground level (AGL) resulting in a native pixel resolution of 0.5 meters (1.6 feet) for the middle river.

Ground survey data are used to aid in geospatially correcting the aircraft positional coordinate data and to perform quality assurance checks on final data. The monument location was selected with consideration for satellite visibility and field crew safety. To correct the continuous onboard measurements of the aircraft position recorded throughout the missions, AEA conducted multiple static GPS ground surveys (1 Hz recording frequency) over the monument using a Trimble 5700 receiver with a Zephyr antenna. After the airborne survey, the static GPS data were triangulated with nearby Continuously Operating Reference Stations (CORS) using the Online Positioning User Service (OPUS) for precise positioning. Multiple independent sessions over the same monument were processed to confirm antenna height measurements and to refine position accuracy.

Instream data from 24 sensors was utilized to calibrate and verify the thermal accuracy of the TIR imagery. All sensors were recording data at 15 minute intervals. Data logger locations are illustrated in Figure 4.7-2.

Thermal infrared images were recorded directly from the sensor to an on-board computer as raw counts, which were converted to radiance values. The individual images were referenced with time, GPS position data, and aircraft attitude. After acquisition, the radiant temperatures are adjusted based on the kinetic temperatures recorded at each instream sensor. This adjustment is performed to correct for path length attenuation, atmospheric temperature, humidity, and the emissivity of natural water. Because the imagery is calibrated for stream temperatures, terrestrial temperatures should not be considered absolute.

Once calibrated, the images were integrated into a geographic information system (GIS) where an analyst sampled interpreted stream temperatures. Sampling consisted of querying radiant temperatures (pixel values) from the center of the stream channel and saving the median value of a ten-point sample to a GIS database file. The temperatures of detectable surface inflows (i.e., surface springs, tributaries) were also sampled at their mouths. During sampling, the analyst provided interpretations of the spatial variations in surface temperatures observed in the images.

The TIR image mosaic was visually inspected to determine spatial variability in surface temperatures within the study area. A trained analyst identified thermal features within the study area and identified areas of ground water discharge either through direct detection of a spring or inferred from bulk temperature patterns.

The TIR images collected during this survey consist of a single band. As a result, visual representation of the imagery requires the application of a custom classification scale to the pixel values. The selection of the scale was made to highlight features most relevant to analysis of the spatial variability of stream temperatures. An example of how the data were processed is presented in Figure 4.7-3.

Once calibrated and geo-rectified, the final TIR images are integrated into GIS where an analyst interprets the stream temperatures. A polygon shape file was digitized (at a scale of 1:500) to highlight areas of increased groundwater activity. An example is provided for a specific area of interest (AOI) in Figure 4.7-4.

Several conditions can cause variation in the accuracy of the thermal imaging:

- Thermal infrared data only records the temperature of the water at the surface. It only represents bulk water temperatures where the water column is thoroughly mixed.
- Variable water surface conditions (i.e., riffle versus pool), slight changes in viewing aspect, and variable background terrestrial temperatures (i.e., shaded vs. not) can result in differences in the calculated radiant temperatures within the same image or between consecutive images. The apparent temperature variability is generally typically less than 0.5°C (Torgersen et al. 2001). The occurrence of reflections as an artifact (or noise) in the TIR images is a consideration during image interpretation and analysis.
- A small stream width logically translates to fewer pixels and greater integration with nearby non-water features such as rocks and vegetation. Consequently, a narrow channel (relative to the pixel size) can result in higher variability and inaccuracies in the measured radiant temperatures as more 'mixed pixels' are sampled.
- The TIR sensor used for this study uses a focal plane array of detectors to sample incoming radiation. A challenge when using this technology is to achieve uniformity across the detector array. The sensor has a correction scheme which reduces non-uniformity across the image frame; however, differences in temperature (typically <0.5°C) may be observed near the edges of the image frame and can be recognized in large open water areas as striping in the mosaic datasets.

4.7.1. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variance explained below:

- Due to adverse weather conditions, not all the data could be collected from the lower river. Acquisition of the data requires that the air temperature be cold (near freezing), with no wind, no ice on the river, and no precipitation. Despite six weeks of effort during October and November of 2013, only around 5 days of usable data were recovered. These data include all the Focus Areas, and 73% of the lower river. The remaining portions of the lower river will be collected in the next study year.

4.8. Groundwater Quality in Selected Habitats

The purpose of studying groundwater quality was to characterize the differences between a set of key productive aquatic habitat types and a set of non-productive habitat types that are related to the absence or presence of groundwater upwelling, so as to improve the understanding of the water quality differences and related groundwater/surface water processes. Concern for sensitive fisheries habitat in floodplain shallow alluvial aquifers and changes to this habitat from Project operations is the focus for identifying environmental conditions that may affect food-chain elements (e.g., periphyton and benthic macroinvertebrates). The groundwater/surface water exchange is expected to influence the energy flow from primary producers (periphyton) to consumers at an intermediate level in the trophic food web. An estimate of density and mass for each of these trophic food web components in target habitats represents production of the food base and can be compared against production necessary to support current fisheries populations. These sites were co-located within the Focus Areas (Table 4.4-1) in order to measure groundwater input and influence on surface water chemistry.

Basic water chemistry information (water temperature, DO, specific conductance, pH, turbidity, redox potential) was collected at selected instream flow, fish population, and riparian study sites. These data will be used to characterize groundwater and surface water interactions. Groundwater monitoring site wells are identified in Appendix F: Figure F-2, Figure F-3, and Figure F-5.

4.8.1. Variances from the Study Plan

AEA implemented the methods as described in the Study Plan with the exception of variances explained below:

- Groundwater sampling piezometers were originally described for placement at the end of each mainstem transect within each Focus Area. However, wells had to be moved to areas where they could be successfully installed and where more applicable in support of the Instream Flow Study (Section 8.5 of the ISR). Alignment of groundwater wells with the groundwater study (RSP Section 7.5) improved likelihood of measuring known groundwater interaction with surface water. There is no change from suggested monitoring site placement strategy described in RSP Section 5.5.4.12. Monitoring completed in 2013 will satisfy the information needs for determining influence on sensitive fisheries habitat in floodplain shallow alluvial aquifers examined in more detail in RSP Section 8.5.
- A groundwater monitoring well was planned for installation at the downstream end of Focus Area 138. The groundwater monitoring well ESGF138 MW-1 was eventually installed at the downstream end of Focus Area 138, but did not have sufficient recharge to be able to sample due to slow recharge. Past mapping of this area for groundwater recharge informed placement of this well, but at the time of sampling in 2013 the slow recharge rate indicated little contribution of groundwater to surface water. Since groundwater recharge is so low at this location and past identification as a groundwater source was to be confirmed, information generated from this effort shows that there will be no effect of groundwater to surface water at this location.

5. 2013 RESULTS

This section reports and summarizes the water quality data from the 2013 study season collected pursuant to this Study Plan (Baseline Water Quality) that has undergone validation and verification. During 2013, AEA collected data from June 2013 through the end of October 2013. AEA has complete validation and verification of the 2013 data through September 30, 2013. The October 2013 data will be reported after AEA completes validation and verification of this data.

5.1. Data Validation/Verification

Laboratory results are being reviewed for verification and validation according to ADECs Analytical Data Validation Checklist (Appendix B; QAPP) in preparation of an Analytical Data Validation Memoranda. Laboratory data that have not undergone quality assurance review are provisional and are not reported in the ISR.

Subsets of quality reviewed data are provided as appropriate graphics and tables in the ISR with larger datasets provided in Appendices.

5.2. Continuous Water Temperature Monitoring

Results from the continuous water temperature monitoring program have undergone quality assurance review and are presented as a final dataset. Thermistor temperature loggers were deployed at 28 different locations throughout the project area from PRM 29.2 on the Susitna River to PRM 235.2 on the Oshetna River (Figure 4.1-1). Water temperature monitoring stations during 2013 are found in Table 4.1-1. Appendix A contains detailed maps of each continuous water temperature monitoring site, as well as, site photos and logger information (deployment dates, logger numbers, depth, and maintenance notes).

Appendix B contains average daily water temperature results, in graphical form, for all continuous monitoring locations. Water temperature results for six monitoring locations, representing the lower, middle, and upper reaches of the Susitna as well as major tributaries, are discussed in further detail below.

All continuous temperature monitoring data can be found on the GINA website at the following location:

ftp://ftp.gina.alaska.edu/isr/5/5.5/ISR_5.5_WQ_AppendixA_Continuous_Temp_Mon/

- Thermistor Data
  Filename: ISR_WQ_5.5_Thermistor_Data.xlsx

In the lower river, the thermistors recorded a decline and rise in water temperature of about the same magnitude and times at locations like PRM 29.9 in the Susitna River, Deshka River (PRM 45.1), and Indian River (PRM 142.2) (Figure 5.1-1 through Figure 5.1-5). This change in water temperature patterns was recorded at other tributaries throughout the length of the project area as recorded on the Chulitna and Oshetna Rivers (Figure 5.1-3 and Figure 5.1-6). One of the deeper sites monitored on the Susitna River was at PRM 29.9 and showed little difference in variation water temperature in the water column. The loggers at PRM 45.1 on tributaries like the Deshka River recorded a wider variation of water temperatures than those at PRM 29.9 on the Susitna, ranging from 14.5°C up to 22.5°C from mid-June to mid-August. The Deshka River thermistors also recorded a noticeable temperature gradient relative to depth from mid-to-late June and from mid-July to early-August as seen in Figure 5.1-2. water The water temperatures recorded in the Chulitna River were both colder and more stable for the duration of the 2013 monitoring period than those on the Susitna River, with water temperatures ranging between 4 and 8°C from mid-June to mid-September. Water temperatures showed a noticeable decline towards the end of September at all locations the water Timing for fluctuation in water temperature at locations from the Lower River to Upper River were synchronous and appeared to respond to ambient air temperature.

5.3. Meteorological Characterization

Results summarized below include the low pass filtered, quality assurance reviewed meteorological observations recorded at the three stations over the period September 2012 to October 2013. Diminished wind data were not removed as further analysis of more data is required before a conclusive decision to omit it can be made. ESM2 wind data, particularly during winter, should be used with discretion at this point. These results also include quality assurance reviewed data recorded by the NOAA station at Talkeetna Airport. Precipitation data is not described in this report as gauges were only installed in late-September. Obvious ice-affected wind data has been removed (ESM2).

Data is presented for each of the new stations in three figures: a period of record wind rose, monthly wind roses and a time series of wind and weather conditions (Appendix C). Meteorological summary tables are also presented for the three non-government stations which describe average and extreme meteorological observations by month based on the period of recorded data. All MET data is located on the GINA website at the following location:

ftp://ftp.gina.alaska.edu/isr/5/5.5/

- Station MET data
  Filename: ISR_5.5_WQ_StationName_MET_Data.xlt

5.3.1. Wind Roses

Wind rose diagrams help visualize direction and speed of wind at the dam and upper extent of the reservoir. This information is encoded in the original form so is not easily interpreted by a reviewer. Code transformed into numerical values is used, in part, to calibrate the reservoir model and establish wind-related cycling patterns in each of the seasons. Two wind rose figures are presented for each station in Appendix C. The first, which graphically displays the predominant wind directions at the site, plots the frequency of occurrence of hourly-averaged winds blowing *from* each of 16 directional bins and the percent occurrence of these winds in terms of wind speeds (light blue: 1 to 3 m/s, navy: 3 to 6 m/s, green: 6 to 9 m/s, etc.). The frequency distribution of the data is shown in the table at the lower right of the figure. For example, winds at the Watana Dam site came predominantly from the northeast and southwest (Figure 5.2-1) with northeast winds occurring more frequently.

The second wind rose figure illustrates the same data, analyzed by month and describes seasonal patterns to wind speed and direction. For example, Figure 5.2-2 shows that northeasterly winds at the Watana Dam site are strongly predominant throughout the winter months (October to May) while southwesterly winds become much more predominant during summer (June to August). It also shows that stronger winds (navy blue, green) occur more often between November and February and that southwesterly winds during the summer are typically lighter (less than 3 m/s on average).

5.3.2. Winds and Weather Time Series

The time series plots in Appendix C display the hourly meteorological observations recorded at each station and illustrates seasonal and synoptic patterns. The top panel contains wind vector stick plots, which show the direction *to* which the wind was blowing in each hour. In Figure 5.2-3, the aforementioned predominance of strong northeasterly winds is apparent, along with a shift in wind pattern towards late May. The next four panels illustrate: air temperature (red), relative humidity (blue), sea-level adjusted barometric pressure (green) and incident solar radiation (black), respectively. Cloud cover persisted over much of late-June to mid-July, late-August and most of September 2012 and 2013, as evidenced by the diminished incident solar radiation signal over this period.

5.3.3. Meteorological Summary Tables

Tables 5.2-1 through 5.2-3 summarize average meteorological observations by month based on the period of recorded data (August [ESM1] or September 2012 – October 2013). The tables serve to replicate the information provided by meteorological agencies in 30-year climate normal; however, the data contained in these tables represents a summary of meteorological data recorded over a period of one year only and is not intended to represent ‘normal’ conditions at each site. It should also be noted that low end of the operating range of the air temperature probe is -40°C (-40°F); thus, extreme temperatures below this will not be recorded.

5.4. Overview of Water Quality Conditions

Baseline and Focus Area (FA) water quality data includes data collected in situ and field collected samples analyzed by an accredited laboratory. Samples analyzed by a laboratory are being reviewed for verification and validation according to ADECs Analytical Data Validation Checklist (Appendix B; QAPP) in preparation of an Analytical Data Validation Memoranda. Laboratory data is considered provisional at this time pending the completion of the Data Validation Memoranda. This provisional water quality data will be reported in the Updated Study Report (USR) following completed data QA/QC.

Baseline and Focus Area laboratory data were also reviewed for accuracy and meeting concentrations in an expected range. Additional data review was completed using laboratory split sample results and by comparing current results with the historic range of concentrations. This secondary validation review ensured that expected range of concentrations for individual analytes was proportionate to expectations for riverine environments in the region. As a result of this assessment, some of the water quality data analyzed by the laboratory are considered overestimates of actual concentrations and not included at this time in the ISR. These water quality parameters include: total phosphorus (TP), total Kjeldahl nitrogen (TKN), and total metals concentrations in surface water. Since the validation and verification review are part of the monitoring program as stated in the RSP Section 5.5 (Attachment 5-1), this does not constitute a variance. Response to this review is to recommend one of three approaches: accept current results, perform additional split samples and identify a correction factor for the 2013 sample concentrations, and/or re-sample all sites for the select water quality parameters.

5.4.1. Baseline Water Quality Characterization

Field parameter data collected at each site during baseline monthly water quality sampling events are summarized in Table 4.3-1 and Table 4.3-2. For parameters with completed QA/QC, example results are provided in two graphical forms in the ISR: 1) by PRM and date to illustrate changes at depth across the Project, and 2) using scatter plots for each site to illustrate horizontal changes across each transect. Complete in situ baseline water quality parameters collected throughout the Project area from June 2013 through September 2013 are reported in Appendix D. All baseline water quality field data can be found on the GINA website at:

ftp://ftp.gina.alaska.edu/isr/5/5.5/ISR_5.5_WQ_AppendixD_Baseline_WQ_FieldData/

- Baseline water quality field data
  Filename: ISR_5.5_WQ_BaselineFieldData.xlsx

Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.1. Water Temperature

Water temperature measurements tended to be the highest during the July sampling event with site averages around 14°C. The lowest temperatures were reported in September and averaged around 8°C. Figure 5.3-1 illustrates water temperatures for each baseline monthly sampling site during the August 2013 sampling event, and is an example for all other field parameter graphs that were created, which are included in Appendix D. Figure 5.3-2 and Figure 5.3-3 are examples of temperature scatter plots that were created for each site.

5.4.1.2. Dissolved Oxygen

5.4.1.3. DO concentrations were collected in situ. Results were similar from July to September throughout the river and tributaries except for the Chulitna River. The Chulitna River had an average DO concentration of 13 mg/L while the mainstem Susitna averaged 11 mg/L. Figures 5.3-4 and Figure 5.3-5 are examples of DO scatter plots that were created for each site.pH

Measurements for pH were collected in situ. Average pH values ranged from 8 for the mainstem while tributary sites had lower pH values (around 7) which were observed at PRM 45.1 (Deshka River). During the June sampling event, pH values were rejected due to equipment malfunction and therefore not included in the ISR. The faulty equipment was replaced with a HydroLab® MS5 datasonde and generated field data measurements without failure for the remainder of the monitoring effort in 2013.

5.4.1.4. Nutrients

Water samples were collected in the field for nutrient analysis by a laboratory. Specific nutrients analyzed as part of the baseline water quality program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.5. Chlorophyll a

Water samples were collected for chlorophyll *a* samples at all baseline water quality monitoring locations in June, July, August, and September 2013 per the RSP. Chlorophyll *a* samples were filtered and frozen at the end of each day. Chlorophyll *a* concentrations in the mainstem of the Susitna River ranged from 0 to 2.5 µg/L. Lower concentrations were measured in June and July with only a few locations having concentrations above 0 µg/L (Figure 5.3-6 and Figure 5.3-7). Higher chlorophyll *a* concentrations occurred in August and September (Figures 5.3-8 and 5.3-9). Overall, chlorophyll *a* concentrations were highest in the Deshka River, the Chulitna River, and in mainstem stations PRM 87.8 (Susitna at Parks Highway East) and PRM 59.9 (Susitna Station). Figure 5.3-10 and Figure 5.3-11 illustrate chlorophyll *a* concentrations at PRM 45.1 (Deshka River) and PRM 124.2 (Curry Fishwheel Camp), respectively. Appendix E contains chlorophyll *a* data for all baseline monitoring locations. All baseline water quality data can be found on the GINA website at the following location:

ftp://ftp.gina.alaska.edu/isr/5/5.5/ISR_5.5_WQ_AppendixE_Basline_WQ_Chla/

- Baseline water quality chlorophyll *a* data set
  Filename: ISR_5.5_WQ_Baseline_Chl_Dataset.xlsx

5.4.1.6. Turbidity

Water samples were collected in the field for turbidity analysis by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.7. Metals

Water samples were collected in the field for metals analysis by a laboratory. Specific metals analyzed as part of the baseline water quality program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.8. Total Dissolved Solids

Water samples were collected in the field for total dissolved solids (TDS) analysis by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.9. Specific Conductance

Specific conductance was collected in situ. Values were uniform throughout the sampling period, averaging 140 µmhos/cm. Tributaries tended to have lower specific conductance values than mainstem Susitna River sites. Examples of specific conductance scatter plots developed for each monitoring location are shown in Figure 5.3-12 and Figure 5.3-13.

5.4.1.10. Significant Ions

Water samples were collected in the field for ion analysis by a laboratory. Specific ions analyzed as part of the baseline water quality program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.11. Total Hardness

Water samples were collected in the field for analysis of total hardness by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.12. Total Alkalinity

Water samples were collected in the field for analysis of total alkalinity by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.13. Organic Carbon

Water samples were collected in the field for analysis of organic carbon by a laboratory. The sampling frequency for total and dissolved organic carbon (TOC and DOC, respectively) is presented in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.1.14. Color

Apparent color (i.e., not filtered) was collected in situ. Results were near or greater than 500 for all sites except for the Deshka River, which was around 25. Apparent color values decreased in September and became varied from site to site. True color (i.e., filtered) values generally ranged from 0 to 50 for all sampling locations. Results are provided in Appendix D.

5.4.1.15. Redox Potential

Redox potential, or ORP, was collected in situ. Results averaged 350 mV, and were consistent throughout sampling sites and sampling events. Redox data from the June sampling event was rejected due to equipment malfunction and therefore not included in the ISR. The faulty equipment was replaced with a HydroLab® MS5 Datasonde and generated field data measurements without failure for the remainder of the monitoring effort in 2013.

5.4.1.16. Other Water Quality Parameters

One-time sampling occurred for a limited number of analytes (BETX, PAHs, radionuclides, aluminum, chromium, selenium, fecal coliform, and TOC). Samples were collected in the field for analysis by a laboratory. Specific parameters analyzed as part of the baseline water quality program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2. Focus Area Water Quality Characterization

Field parameter data collected at each site during the Focus Area water quality sample events are summarized in Table 4.3-1 and Table 4.4-1. Specifically, Table 4.1-1 lists the seven locations where water quality data were collected during the 2013 monitoring year. As described in Section 6 of the ISR, the remaining three FAs will be sampled during the next year of study.

For parameters with completed QA/QC, example results are provided in the ISR and are presented by FA and date from upstream to downstream. Point sample field data were graphed by parameter and distance from the point sample taken. A depth profile for all parameters was taken at FA-115 (Slough 6A). Complete in situ FA water quality parameters collected throughout the Project area from July 2013 through August 2013 are reported in Appendix G. All Focus Area in-situ field data that was collected is available on the GINA website at:

ftp://ftp.gina.alaska.edu/isr/5/5.5/ISR_5.5_WQ_AppendixG_FocusArea_FieldData/

- Focus Area field data spreadsheet

  Filename: ISR_5.5_WQ_FAFieldData.xlsx

As previously mentioned, laboratory data have not yet undergone complete QA/QC review and will therefore be provided in the USR.

5.4.2.1. Water Temperature

Water temperature measurements were collected in situ. Values tended to be the highest during the end of July sampling event with site averages around 14°C. The lowest temperatures were reported during the end of August sampling event and averaged around 9°C. Point sample temperatures were slightly more extreme, either higher or lower than transect samples, depending on the date sampled. Figure 5.4-1 illustrates temperature for FA104 (Whiskers Slough), and is an example for all other FA field parameter graphs that were created which are included in Appendix G. Figure 5.4-2 through Figure 5.5-4 are examples of point sample scatter plots that were created for each site, Figure 5.4-5 is an example of the temperature depth profile taken for FA-115 (Slough 6A).

5.4.2.2. Dissolved Oxygen

DO concentrations were collected in situ. On average, measurements were around 11 mg/L. Sloughs such as FA-144 (Slough 21) had lower concentrations with an average of 8 mg/L. The last sampling event at the end of August had the highest DO concentrations near 12 mg/L.

5.4.2.3. pH

Measurements for pH were collected in situ. During all sampling events, pH values tended to be uniform around pH 8. Point sample slough sites were often slightly lower (near pH 7), depending on location.

5.4.2.4. Nutrients

Water samples were collected in the field for nutrient analysis by a laboratory. Specific nutrients analyzed as part of the FA water quality monitoring program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2.5. Chlorophyll a

Water samples were collected for chlorophyll *a* samples in Focus Areas at all surface water transect locations as well as point sample locations, per the RSP. Chlorophyll *a* concentrations ranged from 0 to 3.5 µg/L in the Focus Areas for all three sampling events. The maximum concentration was observed at FA-144 (Slough 21) in the upstream transect of the mainstem on August 21, 2013. Chlorophyll *a* concentrations varied in all FAs between mainstem surface water transects and point samples with concentrations in sloughs, side channels, and side sloughs being generally higher than mainstem. Figure 5.4-6 illustrates mean chlorophyll *a* concentrations for FA-104 (Whiskers Slough). Mean chlorophyll *a* graphs for the remaining FAs can be found in Appendix G. All chlorophyll *a* Focus Area lab results can be found on the GINA website at:

ftp://ftp.gina.alaska.edu/isr/5/5.5/ISR_5.5_WQ_AppendixH_FocusArea_Chl/

- Focus Area chlorophyll data set

  Filename: ISR_5.5_WQ_FocusArea_Chl_Dataset.xlsx

5.4.2.6. Turbidity

Water samples were collected in the field for turbidity analysis by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2.7. Metals

Water samples were collected in the field for metals analysis by a laboratory. Specific metals analyzed as part of the FA water quality program are outlined in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2.8. Specific Conductance

Specific conductance was collected in situ. Values averaged 150 µmhos/cm for most transect sites. Point samples were either lower or higher depending on location. For example, the side slough in FA-104 (Whiskers Slough) averaged 25 µmhos/cm.

5.4.2.9. Total Hardness

Water samples were collected in the field for analysis of total hardness by a laboratory. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2.10. Organic Carbon

Water samples were collected in the field for analysis of organic carbon by a laboratory. The sampling frequency for TOC and DOC are presented in Table 4.3-1. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.4.2.11. Redox Potential

Redox potential was measured for groundwater in situ. Values were uniform throughout samples, with an average range of 300 to 350 mV.

5.5. Sediment Samples for Mercury/Metals in the Reservoir Area

Sediment and porewater samples were collected from four sampling locations in 2013: Mouth of Oshetna Creek, Mouth of Kosina Creek, Mouth of Goose Creek, and the Mouth of Jay Creek. Laboratory results for these samples were not received from the laboratory prior to the September 30, 2013, cut-off date so are not included in this ISR. Laboratory analyzed data will be available once the Quality Assurance review is complete and reported in the USR.

5.6. Baseline Metals in Fish Tissue

Results assessing the baseline metals in fish tissue are provided in Section 5.6 in the ISR Study 5.7.

5.7. Thermal Infrared Remote Sensing

Thermal infrared imagery was collected and analyzed for 10 Focus Areas and 9 additional areas of interest (AOI) along the Middle Susitna River over a 3-day period in late October 2013 (Table

4.7-1). During data collection conditions were ideal with cold atmospheric temperatures and river temperatures near freezing.

Minimal groundwater activity was seen in the upper Focus Areas (FA-151 [Portage Creek], FA-173 [Stephan Lake Complex]), and FA-184 [Watana Dam]). Nine individual locations of groundwater activity were located for the three areas, but all were very small and on the lower end of the temperature spectrum for groundwater (~2.0°C). This is similar to the results reported in 2012.

Numerous areas of groundwater activity were seen in the remaining Focus Areas with the highest concentration along the lower reach of Indian River in FA-141 and along Slough 21 within FA-144. Numerous areas of groundwater activity were also seen in FA-104 (107 unique point sources). Activity was concentrated along Whiskers Slough and the side channel networks to the west of Whiskers Creek.

Some of the instream sensors fell outside of the target accuracy of ±0.5°C for the study. The reason for this varies between locations:

- Sensors located in small side channels may have a "mixed pixel" effect, resulting from the blending of water pixels with cold terrestrial pixels (exposed rocks and logs), resulting in reduced radiant temperatures. This typically results in colder water temperatures being recorded by the TIR than measured in situ. For example, sensors ESGFA113-1 'Oxbow 1' and 'Unnamed' are located in a channel that is only 3 feet wide, which translates into only two TIR pixels at the camera's resolution. This type of narrow channel will result in mixed pixel temperatures and also makes it difficult to get a clean sample for comparison.
- Water reaches its maximum density at 4°C; therefore, under the right conditions, "warmer" water (4°C) will sink below colder water (0°C), and the surface (and subsequent radiant) temperatures will be colder than what may be measured in situ. This may happen in quiet side channels and sloughs. ESGFA138-1is a likely example of this effect. Radiant values just upstream from the sensor show surface temperatures of 3.3°C. Depending on the depth of the sensor and given the mixing seen at the surface, the subsurface temperatures are likely warmer than the surface temperatures as reflected in the accuracy offset of -1.2°C (Table 5.8-1).
- Some sensors (such as ESGFA 128-1, 2, 6, and 7) are located in groundwater mixing zones. As such, the small deviation from the target accuracy is not considered a concern since the temperature varies greatly over short distances. For example, the subsurface temperature seen at the instream sensor at ESGFA 128-1 (2.8°C) was detected in the TIR imagery within 30 feet of the sensor location.

A comparison of the surface temperatures recorded and the in stream temperature sensors is presented on Table 5.8-1. A complete dataset is provided in Appendix J.

The TIR data for the lower river has not yet been processed, given that formal data collection ended November 13, 2013. Due to adverse weather conditions in the fall, data acquisition only included approximately 76% of the lower river. It is anticipated that the 2013 lower river data obtained will be processed and ready by the end of January, and the remaining, un-imaged sections of the river will be imaged in the next year of study.

5.8. Groundwater Quality in Selected Habitats

Groundwater samples were collected from wells located in Focus Areas 104, 113, 128, and 138. Table 4.4-1 summarizes groundwater samples by Focus Area and date. Results for samples collected in late August and early September have not be fully reviewed and are not included in this report.

Field and laboratory data results for groundwater samples received prior to September 30, 2013 are summarized in Table 5.8-2 through Table 5.8-5. Groundwater samples were analyzed for TP, TKN, total Aluminum, total Iron, and total Mercury in addition to analytes listed in Table 4.3-1; however, as described in 5.5.1 above, provisional laboratory data are under review and not presented in this report.

Groundwater well field data taken between August and September 2013 are considered final. The highest groundwater temperatures were found in Focus Area 104 with an average of 8.63°C. The lowest groundwater well temperatures were found at Focus Area 113 with an average temperature of 6.15°C. The lowest DO concentrations were found at Focus Area 104 with an average of 0.3 mg/L. The pH values between Focus Area groundwater wells are relatively similar, and averages range from 6.32 to 7.10. Specific conductance values were also highest at FA-104 (Whiskers Slough) with an average of 269 µmhos/cm. Redox potential was highest at FA- 128 (Slough 8A) with an average of 276 mV.

6. DISCUSSION

Data interpretation and analysis will follow a complete and quality reviewed dataset.

A substantial portion of the water quality monitoring work was completed during 2013. However, there were several issues identified that precluded generation of complete monitoring datasets for: (1) Focus Area Monitoring, (2) Sediment/Pore Water Monitoring, and (3) Continuous Temperature Monitoring. In all cases, some of the proposed sites in Section 5.5 of the RSP have not been accessible due to site access restrictions. Of site visits during the 2013 monitoring effort, all data proposed for collection had been completed and the remainder of sites will be visited in subsequent monitoring years.

Volume of data generated during the Baseline Water Quality Monitoring effort was greater than 17,000 records for laboratory results and more than 2,000 records for field measurements. There were approximately 1.3 million continuous temperature data records generated between June 2013 and beginning of October 2013. Meteorological station monitoring operated from between August 2012 and October 2013 generating almost 2 million combined data records from three sites. Focus Area monitoring was completed over three monitoring intervals that generated over 2,000 data records; this included transect samples, point samples, and groundwater samples.

As part of the water quality evaluation, results will be compared to the Alaska Water Quality Standards water quality criteria (18 ACC 70.020(b)) for protecting designated uses in fresh water. Results from the baseline water quality monitoring program, the Focus Area monitoring program, and pore water in sediment monitoring will be interpreted using the Alaska Department of Environmental Conservation (ADEC) water quality criteria and the SQuiRT (NOAA) tables for preliminary screening for effects to aquatic life (ISR Section 5.5.4.8).

Construction of the water quality models (reservoir and riverine) is progressing at the same time as the data review and finalization process (Section 5.6 of the ISR) as part of the Baseline Water Quality Study. Calibration of the model using the finalized 2012 continuous temperature data is currently in progress and will be confirmed using the 2013 continuous temperature data generated by the baseline water quality program. Water quality data generated during 2013 will be finalized prior to preparation of the water quality models that will use this information for calibration.

Historic field data were compared with current monitoring results using 1970s/1980s data and 2013 data (Table 6.0-1). Data records from historic monitoring at select sites were chosen by determining similarity with current monitoring methods at 2013 sites; based on frequency of data logging or collection of grab samples and proximity to current monitoring sites. The set of in situ field parameters (water temperature, specific conductance, dissolved oxygen, and pH) collected during the summer months (June through September) were from 1970 through 1980 and compared with 2013 field season results from six Project sites (PRM 29.9, PRM 107, PRM 124.2, PRM 140.1, PRM 152.7,and PRM 187.2). In general, water temperature in 2013 had similar maximum temperatures, but the same sites from the 1970s and 1980s dataset showed lower minimum temperatures except at the Watana Dam site (PRM 187.2). Historic water samples were collected at the beginning of June nearer ice breakup, while 2013 sample collection did not begin until the third week of the month (June 21, 2013). Specific conductance was variable between historic and current conditions; however, historic minimum values were more than half that of current, while maximum values were generally within the range of historic results. Dissolved oxygen (DO) and of pH were similar between datasets for sites where comparable data were available.

Data review and management has been on-going as results are received from the laboratory. Data validation and verification have been the first phase in the review process. The second phase of review included evaluation of data for accuracy; comparing against historic data collected from the basin and with response indicators (e.g., high total phosphorus concentrations should correspond with high chlorophyll *a* concentrations). Suspect data were re-evaluated using laboratory split sample results and further monitoring needs identified to ensure systematic error in laboratory analytical methods produced accurate results.

Groundwater monitoring information was completed in conjunction with effort from the Groundwater Study (Section 7.5 of the RSP). Information generated for groundwater conditions from Focus Area monitoring will be used by the Groundwater Study (Section 7.5 of the RSP).

Water quality data generated in Focus Areas will be used to describe the chemical habitat encountered by fish species (and life stages). Water quality conditions will be projected by modeling using the (2D) River Water Quality Model with Enhanced Focus Areas (Section 5.6 of the RSP) for multiple operational scenarios. These results will be included for interpretation of results in Section 8.5 of the RSP (Instream Flow).

7. COMPLETING THE APPROVED STUDY PLAN

[Section 7 appears in the Part C section of this ISR.]

8. LITERATURE CITED

AEA (Alaska Energy Authority). 2012. Revised Study Plan: Susitna-Watana Hydroelectric Project FERC Project No. 14241. December 2012. Prepared for the Federal Energy Regulatory Commission by the Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/study-plan.

Torgersen, C.E., R. Faux, B.A. McIntosh, N. Poage, and D.J. Norton. 2001. Airborne thermal remote sensing for water temperature assessment in rivers and streams. Remote Sensing of Environment 76(3): 386-398.

URS. 2011. AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report. Prepared by Tetra Tech, URS, and Arctic Hydrologic Consultants. Anchorage, Alaska. 62p.+Appendixes

9. TABLES

Table 4.1 -1. Susitna River Basin Temperature and Water Quality Monitoring Sites

Project River Mile (PRM)	Description	Lat.	Long.	Water Temp. Summer 2012	Water Temp. Winter 2012/2013	Water Temp. 2013	Water Quality Monitoring 2013	Location Rationale
19.9	Susitna above Alexander Creek	61.439030	-150.48456	X	X	X		Outer Project area site (above the “Beluga Line”)
29.9	Susitna Station	61.544280	-150.515560			X	X	Influence of upstream tributary
32.5	Yentna River	61.587604	-150.483017	X	X	X	X	Major tributary
33.6	Susitna above Yentna	61.575950	-150.427410	X	X	X	X	Above major tributary
45.1	Deshka River	61.710142	-150.324700	X	X	X	X	Major tributary
59.9	Susitna	61.862200	-150.184630	X	X	X	X	Above major tributary
87.8	Susitna at Parks Highway East	62.174531	-150.173677	X	X	X	X	Mainstem river site
88.3	Susitna at Parks Highway West	62.181096	-150.167877	X	X	X		Side channel habitat connected with the mainstem
99.2	LRX 1	62.306018	-150.108764	X	X	X		Below confluence of major tributary
102.8	Talkeetna River	62.342430	-150.112660	X	X	X	X	Major tributary
118.6	Chulitna River	62.567703	-150.237828	X	X	X	X	Major tributary
107[1]	Talkeetna	62.397240	-150.137280	X		X	X	Downstream of existing townsite; Historic (1980s) monitoring site
116.69[1]	LRX 18	62.526527	-150.114671	X		X		Upstream of existing townsite
124.2[1]	Curry Fishwheel Camp	62.617830	-150.013730	X		X	X	Important side channel habitat
129.6	Slough 8A	62.670479	-149.903241	X		X		Important side channel habitat
129.9[1]	LRX 29	62.673914	-149.899025	X		X		Historic (1980s) monitoring site
132.7	Slough 9	62.702358	-149.841895	X		X		Important side channel habitat

Project River Mile (PRM)	Description	Lat.	Long.	Water Temp. Summer 2012	Water Temp. Winter 2012/2013	Water Temp. 2013	Water Quality Monitoring 2013	Location Rationale
134.1[1]	LRX 35	62.713854	-149.808926	X		X		Historic (1980s) monitoring site
140.0	Susitna near Gold Creek	62.767054	-149.693532	X		X		Below confluence of major tributary
140.1	Gold Creek	62.767892	-149.689781	X		X	X	Major tributary
141.0	Slough 16B	62.780204	-149.685360	X		X		Important side channel habitat
142.2	Indian River	62.78635	-149.658780			X	X	Major tributary
142.3[1]	Susitna above Indian River	62.785776	-149.648900	X	X	X	X	Historic (1980s) monitoring site
143.6	Slough 19	62.793819	-149.614255	X		X		Important side channel habitat
143.6[1]	LRX 53	62.79427	-149.613270	X		X		Historic (1980s) monitoring site
145.6	Slough 21	62.814667	-149.575329	X		X		Important side channel habitat
152.2	Susitna below Portage Creek	62.830397	-149.382743	X	X		X	Downstream of major tributary
152.3	Portage Creek	62.830379	-149.380289	X	X		X	Major tributary
152.7	Susitna above Portage Creek	62.827002	-149. 827002	X	X		X	Historic (1980s) monitoring site
168.1	Susitna	62.791696	-148.993825		X			Mid-point between neighboring sites
183.1	Susitna below Tsusena Creek	62.813480	-148.656868	X				Downstream of major tributary
184.8	Tsusena Creek	62.821783	-148.606809		X			Major tributary
187.2	Susitna at Watana Dam site	62.822600	-148.553000		X		X	Boundary condition between the reservoir and riverine models
196.8	Watana Creek	62.829600	-148.259000					Major tributary stream to the proposed reservoir
209.2	Kosina Creek	62.782200	-147.940000	X	X	X		Major tributary stream to the proposed reservoir
225.5	Susitna near Cantwell	62.705200	-147.538000					Uppermost mainstem site in the proposed reservoir
235.2	Oshetna Creek	62.639610	-147.383109	X	X	X	X	Uppermost tributary in the Project area

1 Susitna River temperature monitoring sites used in 1980s SNTEMP model evaluation.

Table 4.2-1. Identification and Location of 2013 Meteorological Stations

Project River Mile	Station ID	Description	Station Status (New / Existing)	Elevation (feet)	Latitude (Decimal degrees)	Longitude (Decimal degrees)
6.85 miles (36,195 ft) Due east of PRM 51.0	N/A	Willow Creek	Existing (Talkeetna RWIS)	Not Available	61.7650	-150.0503
83.8	N/A	Susitna River near Sunshine Gage	Existing (Talkeetna RWIS)	Not Available	62.1381	-150.1155
99.6	26528	Susitna River at Talkeetna	Existing (Talkeetna Airport)	350	62.3200	-150.0950
142.2	ESM3	Susitna River at Indian River	New	720	62.7842	-149.6633
187.1	ESM1	Susitna River at Watana Dam Camp (upland on bench)	New	2330	62.8295	-148.5518
235.2	ESM2	Susitna River above Cantwell	New	2100	62.6388	-147.3781

Table 4.3-1. Water Quality Study Sampling Parameters and Schedule

Parameter	Baseline Water Quality (collected monthly)	Focus Areas (collected every 2 weeks; 3 events)		Mercury Assessment (one-time survey)[2]		
		Surface Water	Ground Water	Sediment (Total)	Porewater (Dissolved)	Tissue (Total)
In Situ Water Quality Parameters						
Water Temperature	X	X	X		X	
Dissolved Oxygen (DO)	X	X	X			
pH	X	X	X		X	
Specific Conductance	X	X	X			
Turbidity	X	X	X			
Redox Potential	X	X	X			
Color	X		X			
Residues	X[1]					
Other Water Quality Parameters (grab samples for laboratory analysis)						
Hardness	X	X	X		X	
Alkalinity	X				X	
Nitrate/Nitrite	X	X	X			
Ammonia as N	X					
Total Kjeldahl Nitrogen	X	X	X			
Total Phosphorus	X	X	X			
Ortho-phosphate	X	X	X			
Chlorophyll-a	X	X	X			
Total Dissolved Solids	X					
Total Suspended Solids	X					
TOC	X[1]	X	X	X		
DOC	X	X			X	
Fecal Coliform	X[1]					
Petroleum Hydrocarbons	X[1]					
Radioactivity	X[1]					
Metals						
Aluminum	X[1]	X	X		X	
Arsenic	X			X	X	X
Barium	X					
Beryllium	X					
Cadmium	X			X	X	X
Calcium	X				X	
Chromium (Total)	X[1]					
Cobalt	X					

Parameter	Baseline Water Quality (collected monthly)	Focus Areas (collected every 2 weeks; 3 events)		Mercury Assessment (one-time survey)[2]		
		Surface Water	**Ground Water**	**Sediment (Total)**	**Porewater (Dissolved)**	**Tissue (Total)**
Copper	X			X	X	
Iron	X	X	X	X	X	
Lead	X			X	X	
Manganese	X					
Magnesium	X		X		X	
Mercury	X	X (total)	X (total)	X	X	X
Methyl mercury		X (dissolved)	X (dissolved)			X
Molybdenum	X					
Nickel	X			X	X	
Selenium	X[1]			X	X	X
Thallium	X					
Vanadium	X					
Zinc	X			X	X	
Sediment Size				X		

Notes:
1 One-time survey
2 Refer to ISR Section 5.7 for details
Metals in surface water were analyzed for dissolved and total.

Table 5.8-2. Sample Location and Frequency for Monthly Baseline Water Quality Sampling

Project River Mile (PRM)	Description	Sample Date(s)[1]	Total No. Samples Collected
29.9	Susitna Station	6/25/2013	6
		7/19/2013	6
		8/19/2013	6
		9/15/2013	6
32.5	Yentna River	6/26/2013	4
		8/18/2013	6
		7/19/2013	6
		9/15/2013	6
33.6	Susitna above Yentna	6/27/2013	6
		8/19/2013	6
		7/20/2013	6
		9/16/2013	6
45.1	Deshka River	6/28/2013	6
		8/19/2013	5
		7/19/2013	5
		9/16/2013	5
59.9	Susitna	6/29/2013	5
		7/19/2013	5
		8/19/2013	5
		9/17/2013	5
87.8	Susitna at Parks Highway East	6/21/2013	5
		7/17/2013	5
		8/17/2013	5
		9/14/2013	6
102.8	Talkeetna River	6/22/2013	5
		7/15/2013	3
		8/16/2013	3
		9/9/2013	4
107	Talkeetna	6/21/2013	6
		7/18/2013	5
		8/16/2013	5
		9/9/2013	6
118.6	Chulitna River	6/24/2013	6
		7/16/2013	6
		8/17/2013	6
		9/13/2013	6

Project River Mile (PRM)	Description	Sample Date(s)[1]	Total No. Samples Collected
124.2	Curry Fishwheel Camp	6/22/2013	6
		7/18/2013	6
		8/15/2013	6
		9/10/2013	6
140.1	Gold Creek	6/23/2013	6
		7/17/2013	5
		8/17/2013	6
		9/10/2013	6
142.2	Indian River	6/23/2013	6
		7/16/2013	5
		8/14/2013	5
		9/11/2013	6
142.3	Susitna above Indian River	6/24/2013	5
		7/15/2013	4
		8/13/2013	5
		9/11/2013	5
152.3[1]	Portage Creek	7/30/2013	6
		8/14/2013	5
		9/12/2013	6
152.7	Susitna above Portage Creek	7/30/2013	6
		8/14/2013	6
		9/12/2013	6
174	Above Dam Point Sample	8/18/2013	1
		8/31/2013	1
		9/20/2013	1
187.2/187.7[1]	Susitna at Watana Dam Site	7/2/2013	1
		7/22/2013	1
		8/18/2013	4
		8/31/2013	1
		9/20/2013	1
235/235.2[1]	Oshetna Creek	7/2/2013	1
		7/22/2013	1
		8/31/2013	1
		9/20/2013	1

Notes:
1 Sites slightly modified due to helicopter landing access with no expected differences in water quality parameters.

Table 5.8-1. Sample Location and Frequency for Focus Area Sampling during the 2013 Monitoring Year

Focus Area (FA)	Description	Water Quality Sample Date(s)	Groundwater Sample Date(s)
FA-104	Whiskers Slough	7/27/2013 to 7/28/2013	
		8/11/2013	
		8/23/2013 to 8/25/2013)	8/23/2013
		9/4/2013	9/4/2013
FA-113	Oxbow I	7/27/2013	
		8/10/2013	
		8/20/2013	8/20/2013
FA-115	Lane Creek (Slough 6A)	7/26/2013	
		8/9/2013	
		8/24/2013 to 8/25/2013	
FA-128	Skull Creek Complex	8/8/2013	8/8/2013
		8/25/2013	8/25/2013
		9/5/2013	9/5/2013
FA-138	Gold Creek (Slough 11)	7/24/2013	
		8/7/2013	8/7/2013
		8/26/2013	8/26/2013 (one well only)
			9/4/2013
FA-141	Indian River	7/23/2013	
		8/6/2013 to 8/7/2013	
		8/22/2013	
FA-144	Slough 21	7/22/2013	
		8/5/2013	
		8/21/2013	

Table 4.7-1. Acquisition Locations and Dates for the Susitna River TIR Project

Area	Data Acquisition Dates	Resolution (feet)
Middle River from Chulitna River to Deadman Creek	10/12/2012	2.3
	10/13/2012	2.3
	10/17/2012	2.3
	10/18/2012	2.3
Middle River Focus Areas and 9 additional areas of interest	10/23/2013	1.6
	10/24/2013	1.6
	10/31/2013	1.6
Lower River Maid Lake to Chulitna River	10/30/2013	2.3
	10/31/2013	2.3
	11/05/2013	2.3
	11/06/2013	2.3
	11/07/2013	2.3
	11/08/2013	2.3

Table 5.2-1. Summary of ESM1: Watana Dam Meteorological Station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind													
Average Wind Speed (m/s)	4.58	4.48	4.03	4.00	3.28	2.77	2.37	2.18	2.87	3.39	5.13	4.59	3.64
Average Daily Maximum Wind Gust (m/s)	11.28	10.40	9.23	9.68	8.51	9.79	8.05	7.70	9.46	9.04	11.30	10.48	9.58
Extreme Wind Gust (m/s)	17.67	15.65	17.12	15.06	11.27	16.24	12.09	12.51	20.61	17.18	16.27	17.54	20.61
Air Temperature													
Extreme Daily Maximum Temperature (°C)	0.27	0.00	1.88	3.35	24.26	31.72	28.81	27.47	17.54	19.11	-2.44	2.50	31.7
Average Daily Maximum (°C)	-7.75	-6.12	-5.73	-3.05	7.42	22.23	19.47	17.18	9.47	2.83	-10.11	-13.24	2.7
Average Daily Mean (°C)	-10.79	-8.97	-10.67	-8.04	2.64	14.81	13.74	11.50	5.36	-2.04	-13.25	-16.30	-1.8
Average Daily Minimum (°C)	-14.20	-12.45	-15.87	-14.07	-2.83	7.88	9.12	7.24	2.04	-5.53	-16.56	-19.43	-6.2
Extreme Daily Minimum Temperature (°C)	-33.78	-22.87	-26.96	-21.50	-10.77	2.28	5.32	-0.62	-7.19	-16.35	-22.26	-30.09	-33.8
Relative Humidity													
Average Daily Maximum (%)	85.4	87.7	78.6	74.2	79.9	75.9	91.1	96.2	91.9	86.3	75.4	73.3	96.2
Average Daily Mean (%)	75.5	77.3	63.5	55.5	58.8	52.9	71.6	79.4	76.0	71.9	65.5	65.7	67.8
Average Daily Minimum (%)	64.4	67.0	46.7	39.0	42.1	27.5	48.0	52.8	55.4	53.9	56.1	56.0	27.5
Barometric Pressure													
Average Daily Mean (hPa)	922	915	928	930	929	932	934	926	919	924	923	916	925
Incident Solar Radiation													
Average Instantaneous (W/m^2)	10	37	110	218	258	269	211	137	81	44	18	6	117
Average Daily Radiation (kWh/m^2/d)	0.2	0.9	2.7	5.2	6.2	6.5	5.1	3.3	1.9	1.1	0.4	0.1	2.8

Notes:
Averages based on 24-hour summary data between August 30, 2012 and October 21, 2013
Average wind speed and average instantaneous solar insolation calculated using 15-minute data

Table 5.2-2. Summary of ESM2: Susitna at Oshetna Station Meteorological Station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind													
Average Wind Speed (m/s)	0.14	0.23	0.38	0.84	0.89	1.43	1.33	0.81	0.74	0.33	0.06	0.08	0.61
Average Daily Maximum Wind Gust (m/s)	0.93	2.5	3.61	5.34	5.35	7.6	7.28	5.35	5.35	3.33	0.86	0.82	4.03
Extreme Wind Gust (m/s)	9.67	8.46	9.51	11.11	9.73	11.5	9.93	9.57	10.42	8.1	2.58	5.78	11.5
Air Temperature													
Extreme Daily Maximum Temperature (°C)	-0.4	2.1	5.7	5.7	23.2	31.8	28.3	26.7	19.7	9.0	-3.6	-1.5	31.8
Average Daily Maximum (°C)	-13.1	-7.5	-4.3	-0.8	9.5	22.4	20.8	17.7	10.5	2.5	-15.7	-22.5	1.6
Average Daily Mean (°C)	-18.0	-13.8	-15.8	-10.4	2.9	14.8	14.3	11.4	4.7	-3.8	-21.2	-27.4	-5.2
Average Daily Minimum (°C)	-23.2	-20.6	-25.8	-22.3	-5.4	5.0	7.3	5.0	-0.2	-8.9	-25.8	-31.2	-12.2
Extreme Daily Minimum Temperature (°C)	-39.6	-34.9	-37.0	-33.8	-14.8	-1.4	0.5	-3.6	-7.2	-24.3	-35.3	-39.6	-39.6
Relative Humidity													
Average Daily Maximum (%)	85.7	89.5	82.7	82.5	92.4	89.2	91.6	95.0	94.6	92.9	82.1	75.0	95.0
Average Daily Mean (%)	79.8	80.4	65.6	57.4	60.3	53.8	65.8	76.7	76.6	81.7	75.6	70.2	70.3
Average Daily Minimum (%)	72.8	66.1	41.3	34.1	36.1	26.5	38.9	48.8	50.4	58.9	68.3	65.0	26.5
Barometric Pressure													
Average Daily Mean (hPa)	931	924	937	938	936	938	941	934	926	935	933	927	933
Incident Solar Radiation													
Average Instantaneous (W/m^2)	6	20	122	219	260	272	216	143	82	47	10	2	117
Average Daily Radiation (kWh/m^2/d)	0.2	0.5	2.9	5.2	6.2	6.5	5.2	3.4	2.0	1.1	0.2	0.1	2.8

Notes:
*Possible diminished winter wind speeds. Use with discretion.
Averages based on 24-hour summary data between August 30, 2012 and October 21, 2013
Average wind speed and average instantaneous solar insolation calculated using 15-minute data

Table 5.2-3. Summary of ESM3: Susitna at Indian River Meteorological Station

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Wind													
Average Wind Speed (m/s)	1.59	1.36	1.38	1.89	1.37	0.96	0.75	0.6	0.97	1.06	1.78	2.06	1.31
Average Daily Maximum Wind Gust (m/s)	7.23	6.25	6.69	8.21	6.63	7.06	5.48	5.08	5.34	5.58	8.06	7.92	6.63
Extreme Wind Gust (m/s)	17.18	11.63	12.58	18.98	12.67	12.67	10.22	11.89	11.79	15.16	14.47	18.49	18.98
Air Temperature													
Extreme Daily Maximum Temperature (°C)	3.58	2.7	5.87	8.28	26	33.8	29.62	26.05	19.06	13.68	2.49	5.61	33.8
Average Daily Maximum (°C)	-4.21	-1.92	-0.74	2.57	11.62	23.65	20.91	18.8	10.97	5.24	-4.2	-8.27	6.2
Average Daily Mean (°C)	-7.98	-5.51	-7.79	-4.43	4.86	15.02	14.92	13.08	6.79	0.96	-7.97	-11.82	0.8
Average Daily Minimum (°C)	-12.5	-10.4	-15.53	-13.24	-1.66	6.6	9.85	8.92	3.31	-2.18	-11.98	-16.12	-4.6
Extreme Daily Minimum Temperature (°C)	-34.46	-21.99	-32.28	-24.92	-6.78	-0.61	5.32	0.6	-5.29	-11.86	-19.61	-34.6	-34.6
Relative Humidity													
Average Daily Maximum (%)	87.1	89.8	83.4	78.9	89.0	91.7	96.9	97.2	92.7	90.3	72.2	74.2	97.2
Average Daily Mean (%)	74.0	76.8	64.0	52.8	58.6	61.8	78.5	84.0	79.4	77.1	55.9	62.5	68.8
Average Daily Minimum (%)	58.4	62.6	40.5	28.3	32.9	29.1	50.6	56.6	58.9	58.0	42.2	49.0	28.3
Barometric Pressure													
Average Daily Mean (hPa)	982	974	989	990	987	989	991	984	976	986	982	976	984
Incident Solar Radiation													
Average Instantaneous (W/m^2)	5	21	88	183	209	141	83	62	44	30	9	2	73
Average Daily Radiation (kWh/m^2/d)	0.1	0.5	2.1	4.4	5.0	3.4	2.0	1.5	1.1	0.7	0.2	0.05	1.8

Notes:
Averages based on 24-hour summary data between September 28, 2012 and October 21, 2013
Average wind speed and average instantaneous solar insolation calculated using 15-minute data

Table 5.8-1. Comparison of Radiant Temperatures Derived from the TIR Images and In Situ Temperatures

Sensor	In stream Water Temperature (°C)	TIR Temp (°C)	Difference
PRM 142.3	0.273	0.3	0.0
ESS60	0.035	0.2	0.2
ESGFA138-2	1.580	1.4	-0.2
ESGFA138-1	3.300	2.1	-1.2
ESS45	-0.013 (CS451) 0.000 (CS109)	0.1	0.1 0.1
ESGFA115-5 (Slough 6A)	0.100	-0.2	-0.3
ESGFA113-1 (Unnamed)	1.231	0.7 (highly variable)	-0.5
ESGFA113-1 (Oxbow1)	3.697	0.9	-2.8
ESGFA 128-12	0.921	0.7	-0.2
ESGFA 128-1	2.848	2.2	-0.6
ESGFA 128-2	1.900	1.7	-0.2
ESGFA 128-6	1.680	1.6	-0.1
ESGFA 128-7	1.560	1.9	0.3
ESS50	0.009	0.7	-0.7
PRM 124.2	0.051	0.7	-0.7
PRM 107.0	1.208	1.3	0.1
ESS40	1.184	1.4	0.2
ESSFA 104-1	2.684	2.8	0.1
ESSFA 104-5 WS	2.7	0.9	-1.8
ESSFA 104-5 WC	4.1	2.8	-1.3
ESSFA-104-8	1.2	1.5 (mid-river) 2.1 (near shore)	0.3 0.9
ESSFA 104-9	2.758	2.8	0.0
ESSFA 104-10	3.555	2.3	-1.3

Table 5.8-2. Groundwater Laboratory and Field Data for Focus Area 104 (Whiskers Slough)

Analyte	Sample ID/Well: ESGFA104-WQ1	Sample ID/Well: ESGFA104-MW-2
	8/23/2013	**9/4/2013**
Water Temperature (°C)	8.69	8.57
Dissolved Oxygen (mg/L)	0.20	0.41
pH	6.14	6.50
Specific Conductance (µS/cm)	189.3	349
ORP (mV)	272	206
Aluminum, Dissolved (µg/L)	19.4	Results under review
Hardness, as $CaCO_3$ (mg/L)	85.7	Results under review
Iron, Dissolved (µg/L)	4570	Results under review
Soluble Reactive Phosphorus (mg/L)	0.0032	Results under review
Total Nitrate/Nitrite-N (mg/L)	ND	Results under review
Total Organic Carbon (mg/L)	7.01	Results under review
Total Organic Carbon, Dissolved (mg/L)	6.31	Results under review
Turbidity (NTU)	24	Results under review

Table 5.8-3. Groundwater Laboratory and Field Data for Focus Area 113 (Oxbow I)

Analyte	Sample ID/Well: ESGFA113-1MW-2
	8/20/2013
Water Temperature (°C)	6.15
Dissolved Oxygen (mg/L)	10.2
pH	7.10
Specific Conductance (µS/cm)	140.4
ORP (mV)	155
Aluminum, Dissolved (µg/L)	20.9
Hardness, as $CaCO_3$ (mg/L)	40.7
Iron, Dissolved (µg/L)	20,100
Soluble Reactive Phosphorus (mg/L)	0.0647
Total Nitrate/Nitrite-N (mg/L)	ND
Total Organic Carbon (mg/L)	3.52
Total Organic Carbon, Dissolved (mg/L)	3.4
Turbidity (NTU)	22

Table 5.8-4. Groundwater Laboratory and Field Data for Focus Area 128 (Slough 8A)

Analyte	Sample ID/Well: ESGFA128-13-MW-1			Sample ID/Well: ESGFA128-18-MW-1		
	8/8/2013	8/25/2013	9/5/2013	8/8/2013	8/25/2013	9/5/2013
Water Temperature (°C)	9.41	8.84	6.74	6.97	6.90	6.99
Dissolved Oxygen (mg/L)	0.49	6.16	9.91	5.38	6.21	7.02
pH	6.89	6.85	6.66	7.05	7.13	6.73
Specific Conductance (µS/cm)	120.5	104.6	69.7	153.6	108.6	126.2
ORP (mV)	263	269	329	258	248	291
Aluminum, Dissolved (µg/L)	37	Results under review		21	Results under review	
Hardness, as $CaCO_3$ (mg/L)	49.7	Results under review		54.8	Results under review	
Iron, Dissolved (µg/L)	63.6	Results under review		35.9	Results under review	
Soluble Reactive Phosphorus (mg/L)	0.004	Results under review		0.0041	Results under review	
Total Nitrate/Nitrite-N (mg/L)	0.423	Results under review		0.841	Results under review	
Total Organic Carbon (mg/L)	Results under review			Results under review		
Total Organic Carbon, Dissolved (mg/L)	Results under review			Results under review		
Turbidity (NTU)	No data	Results under review		No data	Results under review	

Table 5.8-5. Groundwater Laboratory and Field Data for Focus Area 138 (Gold Creek)

Analyte	Sample ID/Well: ESGFA138-MW-2	
	8/26/2013	9/4/2013
Water Temperature (°C)	7.43	7.52
Dissolved Oxygen (mg/L)	2.12	1.79
pH	6.95	6.97
Specific Conductance (µS/cm)	152.9	164.8
ORP (mV)	272	243
Aluminum, Dissolved (µg/L)	Results under review	
Hardness, as $CaCO_3$ (mg/L)	Results under review	
Iron, Dissolved (µg/L)	Results under review	
Soluble Reactive Phosphorus (mg/L)	Results under review	
Total Nitrate/Nitrite-N (mg/L)	Results under review	
Total Organic Carbon (mg/L)	Results under review	
Total Organic Carbon, Dissolved (mg/L)	Results under review	
Turbidity (NTU)	Results under review	

Table 6.0-1. Range of in situ water temperature, specific conductance, dissolved oxygen, and pH collected during the summer (June 1 to September 30) from historic (1970s and 1980s) and current (2013) years at select sites.

Location	RM	PRM	Source for Historic Data	Water Temperature (⁰C)		Specific Conductance (µS/cm)		Dissolved Oxygen (mg/L)		pH	
				Historic	Current	Historic	Current	Historic	Current	Historic	Current[1]
Susitna River	25.8	29.9	USGS 15294350	2.9 to 14.8	7.1 to 15.6	90 to 154	145.9 to 170.0	9.0 to 12.4	10.9 to 12.5	7.7 to 8.5	8.1 to 8.5
Talkeetna River	97.0	107	USGS 15292700	0 to 13	5.3 to 17.8	50 to 198	122.0 to 168.8	9.9 to 13.8	10.2 to 11.7	6.0 to 8.7	8.1 to 8.3
Curry Fishwheel Camp	120.7	124.2	APA and ADF&G	2.7 to 15.3	5.2 to 16.7	N/A	131.0 to 166.6	10.1 o 13.9	10.0 to 12.5	6.8 to 8.0	8.1 to 8.1
			USGS 623948149543400	3.3 to 15.5		114 to 148		10.8 to 12.2		7.0 to 7.6	
Gold Greek	136.8	140.1	USGS 15292000	0.3 to 14.1	5.9 to 16.3	79 to 181	116.0 to 161.5	8.5 to 13.3	10.5 to 12.5	6.4 to 8.6	6.7 to 8.6
Susitna above Portage Creek	149.4	152.7	APA and ADF&G	N/A	7.3 to 14.8**	N/A	130.7 to 158.5	10.9 to 14.8	10.4 to 12.7	6.8 to 8.2	8.0 to 8.5
			USGS 624941149221500	8*		80*		12.8*		7.2*	
Susitna River at Watana Dam Site	184.2	187.2	APA and ADF&G	1.9 to 14.4	2.6 to 11.9**	N/A	137.8 to 168.5	N/A	10.5 to 12.5	N/A	6.4 to 8.5

Notes:

1 Reflects data collected August through September only

* one-time sample event only

** current water temperature based on field one-time grab sample from a Hydrolab (all other current temperature data based on continuously monitored sites using thermistors).

N/A not available

10. FIGURES

[See separate file for figures.]

PART A - APPENDIX A: CONTINUOUS TEMPERATURE MONITORING

[See separate file for Appendix.]

PART A - APPENDIX B: THERMISTOR FIGURES

[See separate file for Appendix.]

PART A - APPENDIX C: WATER QUALITY METEOROLOGICAL STATION DATA

[See separate file for Appendix.]

PART A - APPENDIX D: BASELINE WATER QUALITY DATA

[See separate file for Appendix.]

PART A - APPENDIX E: BASELINE WATER QUALITY CHLOROPHYLL DATA

[See separate file for Appendix.]

PART A - APPENDIX F: FOCUS AREA LOCATION MAPS

[See separate file for Appendix.]

PART A - APPENDIX G: FOCUS AREA WATER QUALITY DATA

[See separate file for Appendix.]

PART A - APPENDIX H: FOCUS AREA WATER QUALITY CHLOROPHYLL DATA

[See separate file for Appendix.]

PART A - APPENDIX I: INTERIM STUDY REPORT WATER QUALITY PHOTOGRAPHS

[See separate file for Appendix.]

PART A - APPENDIX J: TIR IMAGES

[See separate file for Appendix.]