5. WATER QUALITY

5.1. Introduction

Construction and operation of the Susitna-Watana Project (Project) will change the Susitna River reach inundated by the Project reservoir, as well as portions of the drainage down-gradient. Changes will include flow, water depth, surface water elevation, water chemistry, channel characteristics, and sediment deposition. The potential effects of the Project need to be carefully evaluated as part of the licensing process because changes to these parameters may adversely affect aquatic and riparian habitat quality, which can in turn affect fish populations, riparian-dependent species, and recreation opportunities along the river corridor.

This section of the RSP describes the water quality studies that will be conducted to characterize and evaluate these effects. These studies will be subject to revision and refinements in consultation with licensing participants as part of the continuing study program identified in the (Integrated Licensing Process (ILP). The impact assessments will inform development of any necessary protection, mitigation, and enhancement measures to be presented in the draft and final License Applications.

Water quality studies each generate data that will be used to assess current conditions, calibrate a predictive water quality model, and assess presence and potential impact of toxics (e.g., mercury) on aquatic life. The three water quality studies are integrated by using products from each (e.g., water quality data, predicted water quality conditions under various operational scenarios, and evaluation of potential toxics effects on aquatic life) and then combined to assess potential for water quality impacts from an ecosystem perspective. Objectives described for Study Plan 5.5 (Baseline Water Quality Monitoring), Study Plan 5.6 (Water Quality Modeling), and Study Plan 5.7 (Mercury Assessment and Potential for Bioaccumulation) reflect the focus on establishing a baseline description of pre-dam water quality and projects water quality conditions and impacts during a post-dam period.

5.2. Nexus Between Project Construction / Existence / Operations and Effects on Resources to be Studied

As discussed above, the Project will change elements of the physical environment, which in turn will affect other resources (riparian communities, biological resources, recreational opportunities). Having a clear understanding of Project effects on water quality allow a better analyses of impacts to the physical environment within the Susitna River corridor, which will be critical to the environmental analysis of the Project.

5.3. Resource Management Goals and Objectives

Water quality in Alaska is regulated by a number of state and federal regulations. This includes the federal Clean Water Act (CWA), and the State of Alaska Title 18, Chapter 70, of the Alaska Administrative Code (18 AAC 70). Aquatic resources including fish and their habitats, and wildlife resources, are generally protected by a variety of state and federal mandates. In addition, various land management agencies, local jurisdictions, and non-governmental interest groups have specific goals related to their land management responsibilities or special interests. These goals are expressed in various statutes, plans, and directives.

In addition to providing information needed to characterize the potential Project effects, these water resources studies will inform the evaluation of possible conditions for inclusion in the Project license. These studies are designed to meet Federal Energy Regulatory Commission (FERC) licensing requirements and also to be relevant to recent, ongoing, and/or planned resource management activities by other agencies.

5.4. Summary of Consultation with Agencies, Alaska Native Entities, and Other Licensing Participants

These study plans have been modified in response to comments from various agency reviewers, including the National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS); the Alaska Department of Environmental Conservation (ADEC); and the U.S. Fish and Wildlife Service (USFWS). Consultation on the study plan occurred during licensing participant meetings on April 6, 2012, and during the June 14, 2012 Water Resources Technical Work Group (TWG) meeting. At the June 2012 TWG meeting, study requests and comments from the various licensing participants were presented and discussed, and refinements were determined to address agreed-upon modifications to the draft study plans. Additional comments were received during the August 17 and Ocotber 23, 2012 TWG meetings.

A summary of consultations relevant to water quality resources is provided in Table 5.4-1.

Table 5.4-1. Summary of consultation on Water Quality study plans.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
General					
Email	08/23/2012	Joseph Klein	ADF&G	Information on availability of the Sampling and Analysis Plan (SAP) and Quality Assurance Project Plan (QAPP) is needed.	AEA will include in the SAP and QAPP in the RSP as an attachment.
Baseline Water Quality Study (Section 5.5)					
Email	08/23/2012	Joseph Klein	ADF&G	5.5.4.3.2 **In-Situ Water Quality Sampling** The sampling protocol currently calls for monthly in-situ water quality monitoring for the 4 summer months. It should be revised to include continuous (hourly or so) water quality measurements for basic parameters (pH, DO, conductivity, turbidity), year-round if possible using in-situ semi-permanent sensors (e.g. sondes). The technology is readily available and would provide very useful baseline information to assess any post project impacts.	Grab sampling of surface water has been proposed at approximately every 5 river miles (39 sites). Grab sampling of water for physical parameters allows for better quality control, especially regarding calibration of parameters such as DO and pH. The use of multi-parameter probes would be appropriate for the focus study areas where monitoring of conditions is required to detect changes in water quality that may affect aquatic life stages. This will be performed in the Focus Areas selected for intensive in-stream flow studies. (Section 5.5.4.5)
Email	08/23/2012	Joseph Klein	ADF&G	Any monitors should be calibrated pre- and post-monitoring along with multiple field measurements for post monitoring calibration.	Agreed. The RSP's QAPP will include this detail.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Email	08/23/2012	Joseph Klein	ADF&G	GW Quality in Selected Habitats (Section 5.5.4.7) - need more information on study. For example, sampling intensity/number of site measurements per slough or criteria for how they will be determined. Will ground water level monitors be installed if so, what is the sampling intensity (numbers per habitat type) and duration of monitoring (e.g. continuous year-round/ point samples during field visits, etc.). If not, it is strongly recommended groundwater monitoring be performed concurrently with water quality monitoring in this study.	This comment will be addressed more thoroughly when the Focus Area intensive study site selection is complete. The RSP will include a process, criteria, and schedule for selection of Focus Area. See RSP Section 5.5.4.5t. For each Focus Area, the sampling methodology will be described, including sampling intensity/number of site measurements per slough; whether ground water level monitors will be installed, and sampling intensity and duration of monitoring.
Water Quality Modeling Study (Section 5.6)					
				No Comments.	

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Mercury Assessment/Potential For Bioaccumulation Study (Section 5.7)					
Letter	08/17/2012	Lori Verbrugge	USFWS	1) Mercury modeling aspect is absent in all studies. We need them to model mercury inputs into the reservoir, amounts of mercury methylation, uptake and biomagnification of methylmercury in reservoir organisms including concentrations at each trophic level, and transport of mercury downstream from the reservoir, from date of initial flooding until 20 years post-impoundment. 2) Avian piscivores - need to analyze feathers for mercury content to determine baseline. This objective is absent from the bird studies. 3) Actual risk assessment step is missing. We need them to perform an ecological risk assessment for each piscivorous species. Estimate the amount of mercury ingested by individuals of each piscivorous species, based upon dietary information and modeled mercury levels in food items post-impoundment. Compare ingested mercury amounts to toxic levels, based on species-specific data from the scientific literature. Note: this step is missing in the study plans for avian species and aquatic furbearers.	Mercury modeling is being addressed in both the water quality modeling (Section 5.6.4.8) and the Mercury Assessment and Bioaccumulation study plan (Section 5.7). Studies have shown that the occurrence of mercury in newly formed reservoirs is a relatively predictable phenomenon, and that such predictions do not require the degree of modeling requested. The proposed mercury study plan will predict mercury concentrations in water and sediment within the reservoir, as well as predict mercury concentrations in piscivorous and non piscivorous fish. We believe that the proposed study is actually more protective of the environment than the agency request, as it proposes to mitigate methylmercury if the potential for environmental impact exists, as opposed to a more uncertain modeling of the scale of such impacts on individual species.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-164, first paragraph: discussion does not make sense. The State of Alaska (SOA) measured total mercury in salmon and other freshwater fish species from the Susitna River drainage. Contrary to the discussion, the SOA does not compare fish mercury concentrations to water quality standards. Unlike some other states such as Oregon, SOA does not base mercury water quality standards on fish concentrations. Table 5.12-1 reveals mean concentrations of mercury in several species of fish (arctic char, northern pike, pink salmon and lake trout) that are above levels deemed safe for unlimited consumption by women of childbearing age, as determined by the Alaska Division of Public Health.	The text has been changed and clarified. See section 5.5.4.7. The text has been changed to reference SQuiRT tables.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-163, paragraph 5: The report states "At Costello Creek only 0.02 percent of the mercury detected (in what- sediments?) was found to be methylated. This study suggests, based on limited data, that mercury concentration varies significantly between separate drainages, and that methylation is also tributary specific". a. This may be true for sediments, but is very unlikely to be true for fish. As a general rule, mercury in fish tissue is nearly 100% methyl mercury.	This text has been clarified (Section 5.5.2); however, several studies have shown that both metallic and methylated mercury concentrations and ratios in water, sediment, and fish can vary considerably between drainages and tributaries of the same drainage. In the case of the Frenzel study, significant differences were noted in mercury speciation in sediment between Costello Creek and the Deshka River, and the report attempted to explain those differences based on tributary specific physical conditions. It can be assumed that tributaries with higher methylmercury concentrations in sediment and water will also display higher methylmercury concentrations in fish, particularly those (ex. Slimy sculpin) that spend a majority of their time confined to specific tributaries. The Frenzel study also reported inorganic mercury in both Slimy sculpin and Dolly Varden. This data has been added to the text.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-168, Section 5.12.4.3.2 "Fish Tissue": The report states, "Body size targeted for collection will represent the non-anadromous phase of each species life cycle (e.g., Dolly Varden; 90 mm- 125 mm total length to represent the resident portion of the life cycle.) a. This makes some sense, in order to understand the amount of mercury in the fish that is clearly attributed to the local environment. However, for risk assessment purposes it is also important to sample fish that are representative of those taken for consumption by humans and wildlife receptors. Specifically, large adult fish that are targeted by anglers (and bears) should also be sampled, to determine how much additional mercury can "safely" be added from the project before consumption advisories are warranted.	The goal is not to determine the current mercury concentration in all species and model their connections, rather it is to determine whether the conditions for mercury methylation will be enhanced or diminished by the dam (described in Section 5.7.1). Target fish species in the vicinity of the Susitna-Watana Reservoir will include adult Dolly Varden, arctic grayling, whitefish species, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-170, Section 5.12.4.5, "Pathway assessment of mercury into the reservoir..." a. The water quality modeling this section refers to (from Section 5.6) does not have the capacity to predict mercury inputs from inundated bedrock, soils and vegetation, mercury fate and transport, mercury methylation, or mercury uptake by biota. Studies 5.6 and 5.12 point to each other, but neither actually does this critical mercury modeling work. A concerted, specific mercury modeling component is essential and must be added.	The differences seem to be between the use of the words “model” and “assessment”, and not in the functional result. Since we understand that a source of inorganic mercury already exists (the atmosphere and inundated organic soils), and that inorganic mercury is not a significant issue, and we know the receptors are and will be present in the inundation area (macro invertebrates, fish, birds, etc.), the only questions remaining are whether conditions within the reservoir will cause mercury methylation, and whether this mercury is bioavailable. The Water Quality Modeling Study (Section 5.6) will generate a three-dimensional model of the proposed reservoir. This model will allow us to evaluate the potential for conditions conducive to mercury methylation in the reservoir. If conditions for mercury methylation are created, mitigation may be necessary.
Letter	08/17/2012	Lori Verbrugge	USFWS	Section 5.12.6 Schedule: Two additional monitoring activities needs to be added to this table and scheduled. a. Quantitative modeling of mercury inputs, rates of methylation, and uptake by biota; and b. Ecological risk assessment for mercury exposure to avian and mammalian piscivores in the study area. I don't have the expertise to opine on the discussion regarding the choice of model to use.	The planned modeling will generate predictions regarding methylmercury concentrations in water, sediment, and fish within the reservoir. The source of inorganic mercury and receptors of methylmercury are assumed to be present and don’t have to be quantified.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-17, paragraph 2 in total: the report states, "Body size targeted for collection will represent the non-anadromous phase of each species life cycle (e.g., Dolly Varden; 90 mm- 125 mm total length to represent the resident portion of the life cycle.) a. This makes some sense, in order to understand the amount of mercury in the fish that is clearly attributed to the local environment. However, for risk assessment purposes it is also important to sample fish that are representative of those taken for consumption by humans and wildlife receptors. Specifically, large adult fish that are targeted by anglers (and bears) should also be sampled, to determine how much additional mercury can "safely" be added from the project before consumption advisories are warranted. Similarly, for ecological risk assessment purposes it is important to sample fish representative of those in the diet of avian and mammalian piscivores in the project area. Our study request (Page 19 paragraph 3) contains a more robust description of the types and sizes of fish that should be sampled.	The RSP has been modified (See Section 5.7.4.2.5). Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, arctic grayling, stickleback, whitefish species, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. The larger number of samples from existing fish species will allow for some statistical control over the results. All fish species present in the inundation zone will be sampled.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-17, paragraph 4: the report states "Results will be reported with respect to applicable Alaska State and federal standards". The comparison values must be specified and agreed to up front. For human risk assessment purposes, US EPA guidance for fish consumption advisories is most appropriate. For ecological risk assessment purposes, risks should be interpreted using published scientific literature, based on both field observational studies and controlled laboratory experiments, using the same or comparable piscivorous avian and mammalian species.	The study plan does not intend to perform a risk assessment for various species. Even if this were done, published literature is unlikely to have usable data for appropriate mercury concentrations for all piscivorous species in the study area.
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-17, paragraph 5: the report states "Results from fish tissue analysis will also be used as a baseline for determining how the proposed Project may increase the potential of current metals concentrations to become bioavailable". This doesn't make sense. Results from fish tissue analysis will be used as a baseline for fish metal concentrations prior to development. In order to understand how the Project may increase the potential for current metal concentrations to become bioavailable, you need to predict how mercury methylation rates may change in response to the Project. This would entail prediction of organic carbon stores, amount of wetland or peat surface this context, because water levels do not relate directly to fish levels.	This will be taken care of by mercury modeling under EFDC. The model will predict if the conditions in the reservoir will be conducive to mercury methylation. Fish tissue mercury concentrations will be modeled using Harris and Hutchison and Hydro Quebec methods, which predict mercury concentration against background.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
TWG meeting	08/17/2012	Lori Verbrugge	USFWS	Explain the absence of macroinvertebrate sampling in the PSP.	The RSP has included the possible addition of macroinvertebrate sampling. See Section 5.5.4.7.
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-17, paragraph 5: the report states, "Detection of mercury in fish tissue and sediment will prompt further study of naturally occurring concentrations in soils and plants and how parent geology contributes to concentrations of this toxic (sic) in both compartments of the landscape". The study of "naturally occurring concentrations of mercury in soil and plants and how parent geology contributes to concentrations of this toxicant" must be undertaken, regardless of whether it is currently present in fish and sediment. Vast surface areas and vegetation will be inundated, that are not currently part of the system. There is not the need to prove current presence before proceeding to predict the addition from the project. In any case, if adequate detection limits are used it is a given that fish and sediments will contain mercury; unfortunately they do everywhere. There is no reason to delay this "further study", particularly as the ILP process is so compressed. This study needs to be planned and implemented now. Likewise, macroinvertebrates need to be added to the current study plan.	Many studies have shown the principal source of mercury is atmospheric, not from the soil, rocks, or plants. We agree that there is no need for additional studies if mercury is found, and that current studies are for documentation purposes only. This statement will be removed. The RSP has included the possible addition of macroinvertebrate sampling. See Section 5.5.4.7.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-19, section 5.5.6 Schedule: Several needed elements are missing, including the collection of geomorphology, geology, vegetative type and quantity, etc. needed to estimate mercury inputs to the reservoir. Then modeling is needed to incorporate baseline conditions, estimate new mercury inputs and rates of methylation, and predict mercury levels in biota post-impoundment. Several study plans point to each other regarding this topic, but none actually undertake these tasks.	Soil and vegetation sampling have been added, and a geologic survey will be done for mineral deposits. However, this information is not necessary for estimating methylmercury impacts to fish. The proposed study will provide mercury modeling for methylmercury in water, sediment and fish. The schedule can be found in Section 5.7.6
Letter	08/17/2012	Lori Verbrugge	USFWS	Objectives Analysis: Two objectives contained in our study request are not included in the AEA study plan. These are: 1) Model mercury inputs into the reservoir, amounts of mercury methylation, uptake and biomagnification of methylmercury in reservoir organisms including concentrations at each trophic level, and transport of mercury downstream from the reservoir, from date of initial flooding until 20 years post-impoundment.	The study will be limited to predicting mercury impacts to water, sediment, and fish.

Comment Format	Comment Date	Licensing Participant Name	Licensing Participant Affiliation	Comment	Response
Letter	08/17/2012	Lori Verbrugge	USFWS	Page 5-37, paragraph 4: the report reads, "Organic carbon content from inflow sources will be correlated with mercury concentrations determined from the Baseline Water Quality Study discussed in Section 5.5. Predicted water quality conditions established by Project operations and that promote methylation of mercury will be identified by location and intensity in both riverine and reservoir habitats." a. Nowhere in Section 5.5 or elsewhere does it indicate how mercury inputs will be estimated based on the specific vegetation, bedrock and soils in the area to be inundated. Likewise, a specific model has not been proposed to predict mercury inputs, concentrations, or rates of methylation in the reservoir. Neither the underlying data collection nor the modeling activity necessary to quantify future mercury levels in biota are contained within any of the current study plans. This includes the area inundated, and the pH, calcium concentration and water hardness of the reservoir ... among other factors	Hydro Québec (2003) has studied these phenomena extensively, and found the increase in fish mercury levels after reservoir impoundment does not depend on the mercury content of soil, rock, or vegetation, but rather on the conditions within the reservoir after filling. Numerous studies have shown that mercury inputs to reservoirs are fairly consistent across North America, and are for the most part not drainage specific. The variability in methylmercury concentrations within reservoirs and drainages is based on the methylation rate, not on the mercury source, which is largely atmospheric. Samples of vegetation and soil will be analyzed for mercury as part of this study; however, this information does not directly input calculations for methylmercury concentrations in fish and wildlife. It will be used as part of potential mitigation strategies.

5.5. Baseline Water Quality Study

5.5.1. General Description of the Proposed Study

The collective goal of the water quality studies is to assess the effects of the proposed Project and its operations on water quality in the Susitna River basin, which will inform 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 resulting riverine portion of the drainage once the dam is in place 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 data set will be used in the water quality modeling study to predict Project impacts under various operations (Section 5.6 in the Revised Study Plan).
- Add three years of current stream temperature and meteorological data to the existing data. An effort will be made to collect continuous water temperature data year-round, with the understanding that records may be interrupted by equipment damage during river floods, ice formation around the monitoring devices, ice break-up and physical damage to the anchoring devices, or removal by unauthorized visitors to a site.
- 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 a pilot thermal imaging assessment of a portion (between Talkeetna and Devil's Canyon) of the Susitna River. If the pilot assessment is successful, it may be expanded to other thermal refugia in the Project area.

5.5.2. Existing Information and Need for Additional Information

Historical water quality data available for the study area includes water temperature data, some general water quality data, and limited metals data primarily collected during the 1980s (URS 2011). Additional data has been recently collected by the U.S. Geological Survey (USGS) at limited mainstem Susitna sites describing flow, in situ, general, and metals parameters. The following is a summary of existing water quality data:

Lower Susitna from Cook Inlet to the Susitna – Chulitna –Talkeetna confluence (River Mile 0-99)

- Large amounts of data were collected in this reach during the 1980s. Very little data are available that describe current water quality conditions.
- Metals data are not available for the mouth of the Chulitna River. The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.
- Metals data are not available for the Skwentna River or the Yentna River.

- Continuous temperature data, general water quality data, and metals data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

Middle Susitna River and tributaries from the Susitna – Chulitna–Talkeetna confluence to the mouth of Devil's Canyon (River Mile 99-150)

- The source(s) for metals detected at high concentrations in the mainstem Susitna River is unknown.
- Current data reflects large spatial data gaps between the upper river and the mid to lower portions of the river.
- Continuous temperature data are not available for the Susitna River mainstem, tributary, and sloughs potentially used for spawning and rearing.

Middle Susitna River from Devil's Canyon to the proposed Susitna-Watana Dam site (River Mile 150-184)

- Temperature data are not available above and below most tributaries on the mainstem Susitna River.
- Overall, very limited surface water data are available for this reach.
- Metals monitoring data do not exist or are limited.
- Concentrations of metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation.
- Monitoring of Susitna River mainstem and sloughs (ambient conditions and metals) is needed for determining the potential for metal bioaccumulation in fishes.

Upper Susitna River including headwaters and tributaries above the proposed Susitna-Watana Dam site (River Mile 184-313)

- Surface water and sediment analysis for metals are not available for the Susitna River mainstem, only for one tributary.
- Information on concentrations of metals in media and current water quality conditions is needed to predict if toxics can be released in a reservoir environment.
- Continuous temperature data are not available for Susitna River mainstem, tributary, and sloughs potentially used for spawning and rearing.

Overall

- Limited fish tissue sampling has been performed in the Susitna River by ADEC and USGS (ADEC 2012; Frenzel 2000).

A large-scale assessment of water quality conditions throughout the Susitna River drainage has not been completed. The proposed overall assessment will be used to establish background water quality parameters. This need was identified in the Data Gap Analysis for Water Quality (URS 2011).

Water temperature monitoring was primarily done in the middle river portion of the Project area during the 1980s. The purpose for collection of this data was to model post-dam temperature conditions and to predict the potential for impact on thermal refugia for fish downstream of the proposed dam site. An expanded network of continuous temperature monitoring data and water quality data (including sediment, surface water, potentially pore water) collection is required for the Project because of the following:

- More information is needed to define existing thermal refugia throughout the Susitna drainage.
- Limited information is available on natural, background conditions for water quality.
- It is unknown if seasonal patterns exist for select water quality parameters.
- Additional information is required for calibrating the water quality model to be used (Section 5.6 in the Revised Study Plan). More recent water quality data will be used for predicting reservoir conditions and predicting riverine conditions downstream of the proposed dam.

The current proposal includes expansion of the temperature monitoring effort from river mile (RM) 10.1 to 233.4, encompassing both the lower end of the riverine portion of the Project area and above the proposed area of inundation by the reservoir. Monitoring sites are located at the same sites characterized during the 1980s studies, as well as at additional sites. Monitoring of areas of the mainstem Susitna River or tributaries with high metals concentrations or temperature measurements (based on the Data Gap Analysis for Water Quality (URS 2011) will confirm previous observations and will describe the persistence of any water quality exceedances that might exist.

Locations in the mainstem Susitna River and tributaries where high metals concentrations were historically identified in surface water lack sediment analysis data to determine potential sources that can be mobilized. The linkage between sediment sources, mobilization into the water column (dissolved form), and the potential for bioaccumulation in fish tissue presents a potential human health concern with respect to mercury contamination. The consumption of mercury in fish tissue will be addressed by co-locating a limited number of surface water, sediment, and fish tissue monitoring sites (and sampling events) where there is the greatest likelihood for bioaccumulation. The proposed Project may have the potential to exacerbate bioaccumulation of toxics beyond that occurring under current conditions. The initial monitoring will identify select monitoring locations and media (e.g., surface water, pore water, and sediment) for sampling and suggest the need for more detailed, site-specific sampling if a potential risk from bioaccumulation is found.

The available historical data are not continuous over time or over spatial areas of the Susitna drainage. The discontinuities in the data record limit the opportunity for conducting a complete assessment of current water quality conditions that define natural background, the spatial extent of higher than expected concentrations of metals (and select parameters), and identification of source and timing of pollutant entry into the Susitna drainage. The expanded data record beyond existing information will be used to develop a model of the proposed reservoir and for projecting water quality changes in the existing riverine system resulting from reservoir operations.

5.5.3. Study Area

The study area for water quality monitoring includes the Susitna River from RM 10.1 to RM 233.4, and select tributaries within the proposed transmission lines and access corridors. Water quality and water temperature data loggers were installed at 39 sites identified in Table 5.5-1 and Figure 5.5-1 as part of the 2012 Baseline Water Quality Study. The lowermost boundary of the monitoring activity is above the area protected for beluga whale activity.

5.5.4. Study Methods

The Baseline Water Quality Study has several components that address needs for water quality modeling and for detecting the location and magnitude of water quality issues. The proposed water quality monitoring locations and water quality parameter list fill in substantial data gaps throughout the project area from historical data collected beginning 1975 through 2003 (URS 2011). Besides the utility of water quality data in calibrating the water quality model, establishment of a comprehensive baseline of water quality descriptions will be useful for comparison to historical water quality data and future scenarios based on model predictions and with future data collection.

Data will be collected from multiple aquatic media including surface water, sediment, and fish tissue. Continuous temperature monitoring will inform the predictive model on how the mainstem river and tributaries will respond to Project operations and if changes in water quality conditions could affect aquatic life use and survival in the Project area. In addition, several other requirements of the 401 Water Quality Certification Process will be addressed with collection and description of additional data, including the following:

- Conducting a water quality baseline assessment
- Describing how existing and designated uses are met
- Using appropriate field methods and models
- Using acceptable data quality assurance methods
- Scheduling of technical work to meet deadlines
- Deriving load calculations of potential pollutants (pre-Project conditions)

Two types of water quality monitoring activities will be implemented: (1) routine monitoring for characterizing water quality baseline conditions, and (2) a single, comprehensive survey for a larger array of parameters (Section 5.5.4.5 in the Revised Study Plan). Frequency of sampling water quality parameters varies by category and potential for mobilization and bioavailability. Most of the general water quality parameters and select metals will be sampled on a monthly basis because each parameter has been demonstrated to be present in one or both of surface water and sediment (URS 2011). An initial screening survey has been proposed for several other toxics that might be detected in sediment and tissue samples (Table 5.5-4). The single surveys for toxics in sediment, tissue, or water will trigger additional study for extent of contamination and potential timing of exposure if results exceed criteria or thresholds (e.g., LAETs, LC_{50}s, etc.). The general list of water quality parameters and metals will be used in calibrating the water quality model (Section 5.6 in the Revised Study Plan) in both a riverine and reservoir environment.

Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location. Six sloughs will be monitored that represent a combination of physical settings in the drainage and that are known to support important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow including the Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be monitored represent important spawning and rearing habitat for anadromous and resident fisheries and include Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek. The operation of temperature monitoring sites will continue as part of water quality monitoring activities in 2013/2014. 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).
- Access and land ownership issues.
- Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling (see Section 5.6) in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Monitoring sites are spaced at approximately five-mile intervals so that the various factors that influence water quality conditions are captured and support the development (and calibration) of the water quality model. Frequency of sites along the length of the river is important for capturing localized effects from tributaries and from past and current human activity. Additional sampling to characterize variability in water quality conditions on six cross sections of the river will be completed. This objective for this sampling strategy will address potential influence of channel complexity (multiple channels, braiding, etc.) on both the Susitna River and tributary water quality. These data will also enable the water quality model (Section 5.6 in the Revised Study Plan) to predict conditions in 3-dimensions (longitudinally, vertically, and laterally).

5.5.4.1. Water Temperature Data Collection

Water temperatures are being recorded in 15-minute intervals using Onset TidbiT v2 water temperature data loggers (or equivalent instrumentation). Data collection began in late June 2012 and will continue through the winter of 2012/2013. At this time it is unclear if the equipment will survive physical damage or interruption of temperature logging from ice break-up and sedimentation during the winter. Temperature data has been retrieved from 39 sites representing a partial or whole record from third week in July 2012 through end of September 2012. Deployment and continuous temperature data logging will continue for each of the two following years (2013 and 2014) using the same apparatus and deployment strategy at all 39 sites. The TidbiT v2 (or equivalent) 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.

To reduce the possibility of data loss, a redundant set of data loggers will be used at each site (where possible). In general, the two sets of sensors will be installed differently (depending on site characteristics). One logger will be inserted into the bottom of an 8.2-foot (2.5-meter) length of perforated steel pipe housing that is fastened to a large bank structure via clamps and rock bolts. A shorter or longer perforated steel pipe may be used depending on location of suitable anchoring places. The logger will be attached to a rope that allows it to be easily retrieved for downloads. To prevent theft or vandalism, the top pipe cap will contain a locking mechanism that can only be opened using the appropriate Allen key. The second set of temperature loggers will be anchored to a 2-foot section of a steel rail and buoyed to record continuous bottom, mid, and surface temperature conditions throughout the water column. The anchor rail will be placed at a channel location that is accessible during routine site visits and will be attached with a steel cable to a post that is driven into the bank or to some other structure. The proposed installation procedures may require some alteration based on site-specific conditions.

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

The 2012 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.

WILL BE UPDATED SHORTLY

Where these study sites overlap the water temperature monitoring study sites (Figure 5.5-1), the water-level logger temperature sensors may be used. However, a redundant TidbiT v2 would be deployed at these sites for backup temperature recording, especially for year-round temperature monitoring.

5.5.4.2. Meteorological Data Collection

Meteorological (MET) data collection stations were installed three new locations during 2012 between RM 136.8 and RM 224.0. Table 5.5-2 lists the MET station locations including the potential for 3 updated MET stations to be installed if needed by the water quality model (Study Plan 5.6).

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

Existing MET stations were fitted with additional monitoring equipment to expand data collection that meets project needs and to use historical information collected from each of these sites (Table 5.5-2). Data records from other studies will be used, wherever available, to help generate information for the required parameters needed for construction of the water quality models (Section 5.6). The linkage between historical records and continuing data records may be used in evaluating the utility of 1980s temperature data for modeling.

MET stations are spatially distributed on the Susitna River from RM 25.8 to RM 224.0 and represent a range of distinct physical settings throughout the Project area. The current array of three MET stations are located from RM 136.8 to 224.0 and transfer data generated at 15 minute intervals by a telemetry system and stored on a digital server in Talkeetna, AK. Data from these MET stations will be combined with data from three MET stations that were installed in the upper Susitna basin by the Glacier and Runoff Changes Study (Section 7.7). Additional MET station sites may be necessary if current site placement is inadequate to represent the needs of water quality model development. This determination will be made in the spring of 2013.

Parameters measured by each of the MET stations will be compared with the nearest down-gradient site and evaluated for adequacy of representation of weather conditions in that reach. If data recorded between successive sites are distinctly different, then additional sites will be proposed so that weather descriptions for use in the water quality model calibration phase (Section 5.6) will be improved with greater detail.

5.5.4.3. MET Station Parameters

MET stations will collect parameters that support the activities of the engineering design team and the development of the water quality temperature model. Snow depth will be estimated from the precipitation gage with the onset of the winter season. Evapotranspiration is measurable within deciduous canopies; however, the MET station placement will not be under vegetation canopies so that parameters (like wind speed, etc.) necessary for establishing conditions on the reservoir can be measured. Precipitation will be an added parameter to each station beginning in 2013 and estimated as snow depth as the season progresses following October 2013. Solar radiation will be measured using proposed meteorological instruments and solar degree days derived from these measurements. The following is a comprehensive list of parameters required for use in this Project and will be measured by each of the MET stations:

- Temperature (maximum, minimum, mean)
- Relative humidity
- Barometric pressure
- Precipitation
- Wind speed (maximum, minimum, mean)
- Wind direction
- Wind gust (maximum)
- Wind gust direction
- Solar degree days (from solar radiation)

5.5.4.3.1 MET Station Installation and Monitoring Protocol

Each MET station will consist of, at a minimum, a 10-foot (3-meter) tripod with mounted monitoring instrumentation to measure the parameters identified above (Figure 5.5-2). The station loggers will have sufficient ports and programming capacity to allow for the installation of instrumentation to collect additional MET parameters as required. Such installation and re-programming can occur at any time without disruption of the data collection program.

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

A Campbell Scientific CR1000 data logger will be used to record data. The archiving interval for all MET parameters will be 15 minutes, with a 2-year storage capacity. The MET station will be powered by a 12 Vdc 8 amp-hour battery and a 20-watt solar panel complete with charge regulator.

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

5.5.4.3.2 Satellite or Radio Telemetry Communications System

Real-time data will be downloaded from MET stations using satellite transmission or radio telemetry hardware. This will enable 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 will ensure that problems, if they occur, are resolved promptly to minimize data loss between service periods.

5.5.4.4. **Baseline Water Quality Monitoring**

The purpose of the Baseline Water Quality Study is to collect baseline water quality information that will 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 EFDC (Environmental Fluid Dynamics Code) model described in Section 5.6, Water Quality Modeling Study. There are two types of monitoring programs proposed for characterizing surface water conditions that are distinguished by the frequency of water sampling and the density of sampling effort in a localized area (Baseline Water Quality Monitoring and Focus Area Monitoring). The large-scale monitoring program (at sites from RM 10.1 to RM 233.4) will be used to calibrate the Susitna River water quality model.

Baseline water quality collection can be broken into two components: in situ water quality sampling and general water quality sampling. In situ water quality sampling consists of on-site monthly measurements of physical parameters at fixed locations using field equipment. General water quality sampling will consist of monthly grab samples that will be sent to an off-site laboratory for analysis. The laboratory will have at a minimum, National Environmental Laboratory Accreditation Program (NELAP) certification in order to generate credible data for use by state, federal, and tribal regulatory programs for evaluating current and future water quality conditions. In general, these samples represent water quality components that cannot be easily measured in situ, such as metals concentrations, nitrates, etc.

Water quality data collection will be at the locations in bold in Table 5.5-1. The initial sampling will be expanded if general water quality, metals in surface water, or metals in fish tissue exceed criteria or thresholds. Additional contiguous sample sites will be visited on this list beginning the following sampling month wherever criteria or thresholds have been exceeded by individual parameters. This proposed spacing follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Sampling during winter months will be focused on locations where flow data is currently collected (or was historically collected by USGS) and will be used for water quality modeling (Section 5.6 in the Revised Study Plan).

5.5.4.4.1 Monitoring Parameters

Water quality samples will be analyzed for several parameters reported in Table 5.5-3. Metals monitoring for total and dissolved fractions in surface water include the full set of parameters used by ADEC in fish health consumption screening. The creation of a reservoir and potential alteration of surface water downstream of the proposed dam site may change characteristics of groundwater in the upper and middle Susitna basin. The water quality parameters identified in Table 5.5-3 will address the influence surface water may have on adjoining groundwater supplies in the vicinity of each sampling site. Changes to groundwater quality may have an effect on drinking water supplies, so several parameters included on the inorganic chemical contaminants list have been included as part of this sampling program (ADEC 2003). The criteria that will be used for comparison with sampling results are the drinking water primary maximum contaminant levels.

Additional parameters will be measured from all sites in a single survey that occurs during low water conditions (e.g., August/September) in the Susitna basin. The following is a list of pollutants for which Alaska Water Quality Standards have established water quality criteria (18 ACC 70.020(b)) for protecting designated uses in fresh water:

- Continuous temperature monitoring program
  - — Temperature, already included as part of the continuous temperature monitoring program.
- In situ monitoring program
  - — pH, included as part of the monthly water quality sampling routine.
  - — Color, categorical observation.
  - — Residues, categorical assessment (floating solids, debris, sludge, deposits, foam, or scum).
- General water quality program
  - — Dissolved gas, included in the monitoring program (dissolved oxygen).
  - — Dissolved inorganic substances (total dissolved solids), included in monthly monitoring.
  - — Turbidity, already included as part of the monthly water quality sampling routine.
  - — Toxic and other deleterious organic and inorganic, already included in monitoring for metals and mercury/methylmercury (organometals).
- One-time survey
  - — Fecal coliform bacteria, included in monthly monitoring.
  - — Sediment, already included in assessing mercury and other metals from sediments.
  - — Petroleum hydrocarbons, oil, and grease, included in a one-time survey.
  - — Radioactivity; radionuclide concentrations to be generated from surface water samples.
  - — Toxic and other deleterious organic and inorganic, already included in monitoring for metals and mercury/methylmercury (organometals).

Water quality parameters listed above that do not exceed Alaska Water Quality Standards will not be collected in succeeding months; the exception are those parameters listed in Table 5.5-4 associated with monthly sample collection from surface water.

5.5.4.4.2 Sampling Protocol

Water quality grab samples will be collected during each site visit in a representative portion of the stream channel/water body, using methods consistent with Alaska state and U.S.

Environmental Protection Agency (EPA) protocols for sampling ambient water and trace metal water quality criteria.

Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single grab sample. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or are well-mixed with the mainstem will be characterized by collecting samples at two locations: in the tributary and in the mainstem upstream of the tributary confluence. All samples will be collected from a well-mixed portion of the river/tributary.

These samples will be collected on approximately a monthly basis (four samples from June to September) and used for calibrating the same model framework used for predicting temperature. The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located. Review of existing data (URS 2011) indicated that few criteria exceedances occur with metals concentrations during the winter months. Existing data show that conventional water quality parameters do not change during the winter months and appear to be mediated by constancy in flow and by water temperature. Initial assessment of this existing data suggests that samples be collected twice during the winter months for analysis of early and late season conditions when the hydrograph declines (near the beginning of winter) and when the hydrograph begins to increase (near the beginning of spring). If the 2013 data sets suggest that metals and other general water quality parameters exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Water quality indicators like conductivity (specific conductance) have been suggested as a surrogate measure for transfer of metals from groundwater to surface water or in mobilization of metals within the river channel. Should the one-time survey for metals at each of the sampling sites show elevated concentrations of select parameters, then a full list of metals sampling will be conducted one time that analyzes groundwater concentrations in order to adequately characterize current conditions. Available USGS data from select continuous gaging stations will be reviewed for increases in specific conductance during monthly and seasonal intervals, and these results will be used to determine if further metals sampling is warranted during additional winter months.

Water samples will be collected using an appropriate sample container upstream of any agitated water that has been mixed either by a boat or walking.

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. Cross-section profiles will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing. If conditions show that mixing is not nearly complete at a representative cross-section, then a flow-integrated sampling technique employed by USGS known as the *equal width increment/equal transit rate* (EWI) method (Edwards and Glysson 1988; Ward and Harr 1990) will be used. In this method, an isokinetic sampling device (a sampler that allows water to enter without changing its velocity relative to the stream) is lowered and raised at a uniform transit rate through equally-spaced vertical increments in the river cross-section. This can be done either by wading with hand-held samplers or from a boat using a winch-mounted sampler, depending on river stage and flow conditions. The number of vertical increments used will differ between sites depending upon site-specific conditions. The river conditions at most water quality monitoring locations prohibit wading, even though the USGS method cites this procedure. Application of transect measurements at many of the sites will only be applied where river conditions are safe enough to do so and may not be at ideal locations and times.

Additional details of the sampling methods will be provided in a combined Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP) for this study. More detail describing study design, field sampling procedures, and evaluation of data quality will be provided in the Baseline Water Quality Monitoring QAPP (Attachment 5-1).

In Situ Water Quality Sampling. During each site visit, in situ measurements of dissolved oxygen, pH, specific conductance, redox potential, turbidity, and water temperature will be made. A Hanna Instruments HI 98703 Portable Turbidity Meter will be used to measure turbidity, while a Hydrolab® datasonde (MS5) will be used to measure the remaining field parameters during each site visit. Continuous turbidity measurement may be conducted with the Hydrolab datasonde at select locations (e.g., former/current USGS sites where turbidity data are available from the 1980s) and operated during summer and winter conditions. The following list of former and current USGS mainstem Susitna River monitoring sites will be considered for continuous turbidity monitoring: Susitna Station, Sunshine, Gold Creek, Tsusena Creek, and near Cantwell. These locations have historic and current flow data that will be used in water quality modeling (Section 5.6) of effects on turbidity from Project operations. Continuous logging of water quality parameters using a multi-parameter probe (e.g., temperature, pH, dissolved oxygen, and conductivity) may be placed at focus area locations (identified in Section 5.5.4.5. The period of deployment will be focused on summer months June through September (four months) as water conditions permit deployment and routine download of data. Maintenance of a multi-parameter probe and risk from damage is high during winter months. Also, freezing conditions will damage sensor apparatus and the logging unit if enclosed by formation of ice.

Standard techniques for pre- and post-sampling calibration of in situ instrumentation will be used to ensure quality of data generation and will follow accepted practice. If calibration failure is observed during a site visit, field data will be corrected according to equipment manufacturer's instructions.

General Water Quality Sampling. Sampling will avoid eddies, pools, and deadwater. Sampling will avoid unnecessary collection of sediments in water samples, and touching the inside or lip of the sample container. Samples will be delivered to EPA-approved laboratories within the holding time frame. Each batch of samples will have a separate completed chain of custody sheet. A field duplicate will be collected for 10 percent of samples (i.e., 1 for every 10 water grab samples). Laboratory quality control samples including duplicate, spiked, and blank samples will be prepared and processed by the laboratory.

Quality Assurance/Quality Control (QA/QC) samples will include field duplicates, matrix spikes, duplicate matrix spikes, and rinsate blanks for non-dedicated field sampling equipment. The results of the analyses will be used in data validation to determine the quality, bias, and usability of the data generated.

Sample numbers will be recorded on field data sheets immediately after collection. Samples intended for the laboratory will be stored in coolers and kept under the custody of the field team at all times. Samples will be shipped to the laboratory in coolers with ice and cooled to approximately 4°C. Chain of custody records and other sampling documentation will be kept in sealed plastic bags (Ziploc®) and taped inside the lid of the coolers prior to shipment. A temperature blank will accompany each cooler shipped. Packaging, marking, labeling, and shipping of samples will be 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 will be labeled with the date and time that the sample is collected and preserved/filtered (as appropriate), then stored and delivered to a state-certified water quality laboratory for analyses in accordance with maximum holding periods. A chain of custody record will be maintained with the samples at all times.

The state-certified laboratory will report (electronically and in hard copy) each chemical parameter analyzed with the laboratory method detection limit, reporting limit, and practical quantification limit. The laboratory will attempt to attain reporting detection limits that are at or below the applicable regulatory criteria and will provide all laboratory QA/QC documentation.

The procedures used for collection of water quality samples will follow protocols from ADEC and EPA Region 10 (Pacific Northwest). Water samples will be analyzed by a laboratory accredited by ADEC or recognized under NELAP. Water quality data will be summarized in a report with appropriate graphics and tables with respect to Alaska State Water Quality Standards (ADEC 2005) and any applicable federal standards.

Additional details of the sampling procedures and laboratory protocols will be included in the SAP and QAPP.

5.5.4.5. Water Quality Characterization in Focus Areas

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 smaple collection (greater than once per month). The purpose for the intensive water quality monitoring in select focus areas of the proposed Project area is to evaluate effects from dam operations on resident and anadromous fisheries. Potential focus areas in the middle river portion of the Susitna drainage have been selected in consultation with the water resources leads and will serve as examples for potential effects in other similar channel and slough areas. The focus area sites are fully discussed in the Instream Flow Study Plan in Section 8.5.4.2.

Changes in water quality conditions from Project operations may influence usable habitat by individual species of fish and the life stages. Water quality conditions influence usability of areas within the river and sloughs by supporting required physicochemical characteristics that range from metabolic needs to predator avoidance. Adequate temperature and dissolved oxygen concentrations are required to sustain basic metabolic needs and these can differ for life stages of a species. Successful predator avoidance improves survivability of a population and this is commonly achieved by using physical structures in the aquatic environment. In the case of water quality, early life stages of a species may benefit from increased turbidity in the water column. Changes to turbidity in the water column may result in increased predation on certain life stages of fish and present a negative impact to a population.

The focus areas will have a higher density of sampling locations, in contrast to the mainstem network, so that prediction of change in water quality conditions from Project operations can be made with a higher degree of resolution. The resolution expected for predicting conditions will be as short as 100-meter (m) longitudinal distances within the focus areas. Depending on the length of the focus area, transects will be spaced every 100 m to 500 m and water quality samples collected at three locations along each transect. The collection points along a transect will be in open water areas and have 3 to 5 collection points. These will be discrete samples taken at each collection point. The density of monitoring locations within the focus areas will be used as a grid to detect and describe groundwater input. Plumes of groundwater input to a focus area will be traceable using thermal data or conductivity. The area of groundwater input will be described using the the monitoring grid network represented by the transects and sampling points along each transect. The location of open water transects and piezometers will be coordinated with the Instream Flow Study (Section 8 in the Revised Study Plan) and the Groundwater Study (Section 7.5 in the Revised Study Plan) to efficiently implement common elements in each of the studies. Piezometers will be installed as part of the Water Quality Monitoring Study so that surface water and groundwater samples are collected at the same time for determination of influence of groundwater on surface water. Collection of groundwater and surface water during each site visit will be used to evaluate the influence of groundwater on surface water quality. Frequency of sampling will be every 2 weeks for a total duration of 6 weeks and coordinated with the Instream Flow and Groundwater studies.

Water quality parameters measured in focus areas will be used to calibrate the EFDC model, but at a higher level of resolution than used for the main channel beginning from RM 10.1 and ending at RM 233.4 in the Susitna River. The focus for EFDC model predictions will be on the following parameters that could affect habitat used by anadromous and resident fish in this drainage:

Field Parameters

- Water temperature
- Dissolved oxygen
- Conductivity
- pH

General Chemistry

- Turbidity
- Hardness
- Total nitrogen
- Nitrate+nitrite-nitrogen
- Total phosphorus
- Soluble reactive phosphorus

Metals

- Mercury (total)
- Methylmercury (dissolved)

- Aluminum (dissolved and total)
- Iron (dissolved and total)

The water quality parameter list is divided further into two categories: (1) contaminants of concern (e.g., metals), and (2) general water quality conditions that may adversely affect fish species.

Inclusion of the nutrient parameters will be 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 like periphyton and benthic macroinvertebrates to nutrient concentrations will be predicted for a variety of operational scenarios.

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

This task was designed to gather specific information on the distribution of Susitna River sediment contaminants of concern in potential source areas. In general, all sediment samples will be 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 will be analyzed for total metals, including aluminum, arsenic, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc. In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated metal concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouths of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be 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 will be completed: (1) pathway model analysis, and (2) numerical modeling using EFDC (Section 5.6). First, pathway models will be 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 will be estimated for each toxic within the medium sampled (e.g., sediment, pore water, surface water) and companion parameters (e.g., hardness and pH) will be collected that enable calculation of chronic and acute toxics concentrations to aquatic life. Potential for transfer of toxics between media will 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 will be made along with all media sampled at each site. Transfer potential of toxics between media will be identified under two conditions: (1) when field parameters listed above are at levels that result in mobilization of toxics between media, and (2) when toxics mobilize along a concentration gradient and transfer from high concentration to media with a lower concentration. Potential for bioaccumulation in aquatic life is determined when chronic thresholds for toxics exposure in a medium are identified. Potential for mortality is determined when acute criteria for toxics in a medium are exceeded.

Most of the contaminants of interest are typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size less than 0.0025 inches [63 micrometers], or passing through a #230 sieve). At some locations, however, larger-sized sediments may be all that are available.

The sediment samples will be collected using an Ekman dredge or a modified Van Veen grab sampler. Sampling devices will be deployed from a boat. Samples may also be collected by wading into shallow nearshore areas. To the extent possible, samples will consist of the top 6 inches (15 centimeters) of sediment. Comparison of results from the Susitna drainage will be made with other studies for Blue Lake, Eklutna Lake, and Bradley Lake when similar data are available and where physical settings are comparable.

5.5.4.7. Baseline Metals Levels in Fish Tissue

Two screening level tasks will be conducted. The first will be for methylmercury in sport fish. Methylmercury bioaccumulates and the highest concentrations are typically in the muscle tissue of adult predatory fish. Final determination of tissue type(s) for analysis will be coordinated with ADEC's Division of Environmental Health and guidance on fish tissue sampling. Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, Arctic grayling, whitefish species, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. Body size targeted for collection will represent the non-anadromous phase of each species life cycle (e.g., Dolly Varden will be 3.5 to 5 inches [90 to 125 millimeters] total length to represent the resident portion of the life cycle). Adult fish from each of the species will be collected in order to estimate the metals concentrations in fish tissue (metals to be analyzed in fish tissue are listed in Table 5.5-3). Collection times for fish samples will occur in late August and early September. Filet samples will be analyzed for methyl and total mercury.

Liver samples will also be collected from burbot and analyzed for mercury, methylmercury, arsenic, cadmium, and selenium.

Field procedures will be consistent with those outlined in applicable Alaska state and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene gloves will be used during fish tissue collection. The species, fork length, and weight of each fish will be recorded. Fish will be placed in Teflon® sheets and into zipper-closure bags and placed immediately on ice. Fish samples will be submitted to a state-certified analytical laboratory for individual fish muscle tissue analysis. Results will be reported with respect to applicable Alaska state and federal standards.

Results from fish tissue analysis will also be used as a description of bioaccumulative baseline toxics prior to the proposed Project. Results from the toxics pathways model and from the numeric model will be used to determine how the proposed Project may increase the potential of current metals concentrations to become bioavailable. The projected water conditions in the reservoir will be estimated and current results for metals concentrations re-evaluated for determining potential toxicities to resident and anadromous fish species. Detection of mercury in fish tissue and sediment will prompt further study of naturally occurring concentrations in soils and plants and how parent geology contributes to concentrations of this toxic in both compartments of the landscape. The focused study will estimate the extent and magnitude of mercury contamination so that an estimate of increased bioavailability might be made once the reservoir inundates areas where high concentrations of mercury are sequestered. Detectable concentrations of mercury may prompt additional sampling and analysis of tissues in the benthic macroinvertebrate community. The biomagnification of mercury contamination from sediments and plants to the fish community may be facilitated through consumption of contaminated food sources like the benthic macroinvertebrates. Contamination of this component of a trophic level may also be a conduit for mercury biomagnification in waterfowl and other wildlife that consume this food source.

5.5.4.8. **Technical Report on Results**

The technical report will include a description of the study goals and objectives, assumptions made, sample methods, analytical results, models used, and other background information. Field data, laboratory report, and quality assurance information will be attached.

A summary data report will be constructed that includes a description of patterns and an explanation for field parameters and general chemistry conditions. The origin of patterns in water quality data sets collected as part of this study may be due to seasonal influence (e.g., changes mediated by climate patterns), influence of tributary water chemistry on mainstem conditions, or in the case of sloughs may be moderated by groundwater influence.

The intensity of sampling effort is expected to be greater at focus areas and so resolution of changes in field parameters, general chemistry, and metals chemistry is expected to be described in finer detail. Spatial water quality conditions will be described in greater detail at these focus areas (Section 5.5.4.5), but descriptions over shorter time intervals will not be possible for general chemistry and metals conditions because site visits and sample collection will be limited to monthly sampling due to the remoteness of focus areas. However, select field parameters will collect continuous data that will be downloaded during each of the monthly focus area visits and will be able to describe daily diurnal patterns from these data.

Comparison of data will be made with existing and appropriate water quality criteria, sediment thresholds, and fish tissue screening levels. Surface water results will be compared to Alaska Water Quality Standards (18 ACC 70.020(b)) for protection of beneficial uses in fresh water. Sediment and fish tissue results will be compared to the Screening Quick Reference Tables (SQuiRTs) used by the National Oceanic and Atmospheric Administration (NOAA) to determine if thresholds for toxicity to aquatic life have been exceeded.

The focused effort in characterizing current mercury conditions through monitoring and modeling in the vicinity of the proposed dam site is described further in Study Plan 5.6 and Study Plan 5.7 in the Revised Study Plan. A general description of the approach and reporting of results for the mercury study is summarized here.

Mercury will be modeled using two methods:

1. Water quality modeling of the reservoir will predict whether the conditions for the formation of methylmercury will be present, and where in the reservoir this may occur.
2. The linear model of Harris and Hutchinson (2008) will provide an initial prediction of peak mercury concentrations in fish.

The phosphorous release model may be used if there is a need to evaluate when peak methylmercury production may occur.

The report will include a conceptual model showing mercury inputs to the reservoir, mercury methylation, mercury circulation among different media (fish, air, water, sediment, etc.), and bioabsorption and transfer. Strategies to manage mercury methylation, bioaccumulation, and biomagnification will be reviewed (Mailman et al. 2006).

Sediment, water, and tissue results from toxics analysis will use the federal NOAA Screening Quick Reference Tables (SQuiRTs). These are thresholds used as screening values for evaluation of toxics and potential effect to aquatic life in several media and will be implemented where ADEC water quality, sediment, or tissue criteria are not available.

An example for SQuiRT values can be found at the following web site:

http://mapping2.orr.noaa.gov/portal/sanfranciscobay/sfb_html/pdfs/otherreports/squirt.pdf

Specific thresholds and criteria for toxics in each of the media will be included in a QAPP. The Water Resources Technical Workgroup will be consulted before final criteria and thresholds are agreed upon and used to interpret toxics monitoring results from sediment, water, and fish tissue.

5.5.4.9. Pilot Thermal Imaging Assessment of a Portion of the Susitna River

Thermal imagery using Forward Looking Infra-Red (FLIR) technology of the entire middle portion of the Susitna River will be collected in October 2012. Data from the thermal imaging will be ground-truthed and the applicability and resolution of the data will be determined in terms of identifying water temperatures and thermal refugia/upwelling. Ground-truthing will occur by using the existing continuous temperature monitoring data from buoy systems and bank installation equipment for the 2012 Temperature Monitoring Study. In coordination with the instream flow and fish studies, a determination will be made as to whether thermal imaging data will be applicable and whether or not additional thermal imagery will be collected during the 2013 field season to characterize river temperature conditions.

If the pilot study is successful, then a description of thermal refugia throughout the Project area can be mapped using aerial imagery calibrated with on-the-ground verification. The verification data used will be collected at the same time as the aerial imagery (or nearly the same time) using the established continuous temperature monitoring network and additional grab sample temperature readings where there may be gaps, such as in select sloughs. The elements described in the following sections are important considerations for data collection, specifications for data quality, and strategy for relating digital imagery and actual river surface water temperatures.

5.5.4.9.1. Radiant Temperature

Remotely sensed thermal images allow for spatially distributed measurements of radiant temperatures in the river. Radiant temperature measurements are made only on the surface layer of the water (top 4 inches [10 centimeters]). Temperature readings can vary depending on the amount of suspended sediment in the water and the turbidity of the water. Collection of data will occur near the end of October when the freeze begins and the contrast between cold surface water and warmer groundwater influence is accentuated. The suspended sediment and turbidity will be diminished during this period of the year when the glacial flour content in the water column is reduced from glacial meltwater.

Spatial Resolution

The key to good data quality is determining the pixel size of the thermal infra-red (TIR) sensor and how that relates to the near-bank environment. Best practice is three pure-water pixels (ensures that the digital image represented by any three contiguous pixels discriminates water from land). Very fine resolution (0.7 to 3.3 feet [0.2 to 1 meter]) imagery is best used to determine groundwater springs and cold water seeps. Larger pixels can be useful for determining characteristic patterns of latitude and longitude thermal variation in riverine landscapes.

5.5.4.9.2. Calibrating Temperature

Water temperatures change during the day; therefore, measurements should occur near the same time each day and when water temperature is most stable (early afternoon). Data used from the continuous temperature probes throughout the middle reach will be the same time interval as thermal imaging collected at each location. Site selection for validation sampling will be determined by channel accessibility and where there is not known influences of tributaries or seeps in the area. Hand-held ground imaging radiometers can provide validation as long as the precision is at least as good as that expected from airborne TIR measurements. Availability of historical satellite imagery for thermal analysis will be investigated. Historical thermal imagery may enable exploration of potential trends in water temperature both spatially and temporally.

5.5.4.10. **Groundwater Quality in Selected Habitats**

The purpose of studying groundwater quality will be to characterize the water quality differences between a set of key productive aquatic habitat types (three to five sites) and a set of non-productive habitat types (three to five) that are related to the absence or presence of groundwater upwelling 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 will affect food-chain elements (e.g., periphyton and benthic macroinvertebrates). The groundwater/surface water exchange (Section 7.5 in the Revised Study Plan) is expected to influence the energy flow from primary producers (periphyton) to consumers at an intermediate level in the trophic food web (Section 9.8 in the Revised Study Plan, River Productivity Study). An estimate of density and mass for each of these trophic food web components in target habitats will represent production of the food base and be compared against production necessary to support current fisheries populations. These sites will be co-located within the focus areas (Section 5.5.4.5) in order to measure groundwater input and influence on surface water chemistry.

Basic water chemistry information (temperature, dissolved oxygen [DO], conductivity, pH, turbidity, redox potential) that defines habitat conditions will be collected at selected instream flow, fish population, and riparian study sites. These data will be used to characterize groundwater and surface water interactions.

5.5.5. Consistency with Generally Accepted Scientific Practice

Studies, field investigations, laboratory testing, engineering analysis, etc. will be performed in accordance with general industry accepted scientific and engineering practices. The methods and work efforts outlined in this study plan are the same or consistent with analyses used by applicants and licensees and relied upon by FERC in other hydroelectric licensing proceedings.

The process for developing and implementing a water quality monitoring program ensures that high quality data is generated for use in regulatory decision-making and management of aquatic resources. Products like the: Quality Assurance Project Plan, use of NELAP Certified laboratory to analyze water samples, and sampling design for appropriate chacterization of current water quality will ensure that complete documentation imporves performance in implementing the Study Design.

5.5.6. Schedule

Baseline Water Quality Study elements will be completed in several stages and based on the following timeline:

Table 5.6-5. Schedule for Implementation of the Baseline Water Quality Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Thermal Imaging (one survey)				—									
MET Station Installation and Data Collection			—	—	—	—	—	—	—	—	—		
QAPP/SAP Preparation and Review			—	—									
Deployment of Temperature Monitoring Apparatus			—	—	—	—	—	—	—	—	—		
Water Quality Monitoring (monthly)						—	—	—	—				
Sediment Sampling							—	—					
Fish Tissue Sampling							—	—					
Data Analysis and Management				—	—	—	—	—	—	—	—		
Initial Study Report									Δ				
Updated Study Report													▲

Legend:

—— Planned Activity

Δ Initial Study Report

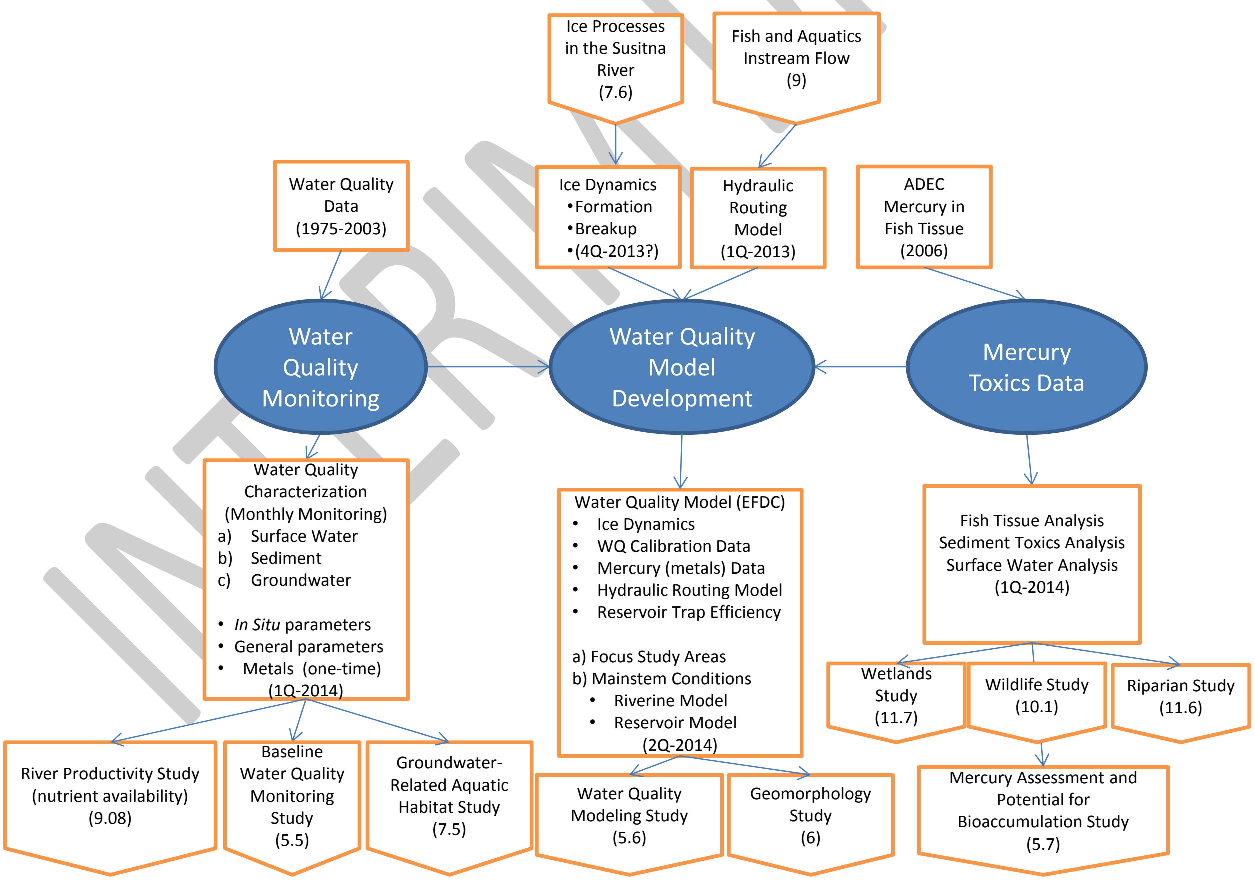
▲ Updated Study Report

A flow chart describing interdependencies (below) outlines origin of existing data and related historical studies, specific output for each element of the Water Resources studies, and where the output information generated in the Water Resources studies will be directed. This chart provides detail describing flow of information related to the Water Resources studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis the previous year (URS 2011), and this information was used, in part, to assist in making decisions about the current design for the Baseline Water Quality Monitoring Study and for ensuring that current modeling effort would be able to compare the 1980s study results with current modeling results.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Study Plan 5.6) with information about timing and conditions for ice formation and ice break-up. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

[Additional detail describing the Interdependency Chart will be provided in the RSP]

INTERDEPENDENCIES FOR WATER RESOURCES STUDIES



5.5.7. Level of Effort and Cost

The estimated cost for the water quality baseline monitoring in the Susitna basin in 2013 and 2014 is approximately $2,000,000, not including the cost of the thermal imaging.

5.5.8. Literature Cited

Alaska Department of Environmental Conservation (ADEC). 2003. Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances. Alaska Department of Environmental Conservation: Division of Water. Juneau, Alaska. 51p.

ADEC. 2005. Water Quality Assessment and Monitoring Program. Alaska Department of Environmental Conservation: Division of Water. Juneau, Alaska. 58p.

ADEC. 2012. Mercury concentration in fresh water fish Southcentral Susitna Watershed. Personal communication with Bob Gerlach, VMD, State Veterinarian. June 2012.

Edwards, T.K., and D.G. Glysson. 1988. Field methods for measurement of fluvial sediment. U.S. Geological Survey Open-File Report 86-531, 118p.

Frenzel, S.A. 2000. Selected Organic Compounds and Trace Elements in Streambed Sediments and Fish Tissues, Cook Inlet Basin, Alaska. USGS Water-Resources Investigations Report 00-4004. Prepared as part of the National Water-Quality Assessment Program.

Mailman, M., Stepnuk L., Cicek N., Bodaly R.A. 2006. Strategies to lower methylmercury concentrations in hydroelectric reservoirs and lakes: A review. Science of the Total Environment 368:224-235.

Harris, R., and Hutchinson, D., 2008. Lower Churchill Hydroelectric Generation Project Environmental Baseline Report: Assessment of the Potential for Increased Mercury Concentrations. Prepared by Tetra Tech Inc. March 4, 2008.

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.

U.S. Environmental Protection Agency (USEPA). 2000. Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories: Volume 1 Fish Sampling and Analysis, 3rd Edition. EPA-823-B-00-007. United States Environmental Protection Agency, Office of Water. Washington, D.C. 485p.

Ward, J.C., and C.A. Harr (eds.). 1990. Methods for collection and processing of surface-water and bed-material samples for physical and chemical analyses. U.S. Geological Survey Open-File Report 90-140, 71p.

5.5.9. Tables

Table 5.5-1. Proposed Susitna River Basin Temperature and Water Quality Monitoring Sites.

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

1 Site not sampled for water quality or temperature in the 1980s or location moved slightly from original location.

2 Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
3 Locations with overlap of water quality temperature monitoring sites with other studies.

Locations in bold font represent that both temperature and water quality samples are collected from a site.

Table 5.5-2. Proposed Susitna-Watana Meteorological Stations.

Susitna River Mile	Description	Station Status (New / Existing)	Latitude (Decimal degrees)	Longitude (Decimal degrees)
44.3	Willow Creek	Existing (Talkeetna RWIS)	61.765	-150.0503
80.0	Susitna River near Sunshine Gage	Existing (Talkeetna RWIS)	62.1381	-150.1155
95.9	Susitna River at Talkeetna	Existing (Talkeetna Airport)	62.32	-150.095
136.8	Susitna River at Indian River	New	62.8009	-149.664
184.1	Susitna River at Watana Dam Camp (upland on bench)	New	62.8226	-148.5330
224.0	Susitna River above Cantwell	New	62.7052	-147.53799

Table 5.5-3. Parameters for water quality monitoring and laboratory analysis (Baseline Water Quality Monitoring and Focus Area monitoring).

Parameter	Analysis Method	Sample Holding Times
In-Situ Water Quality Parameters		
Dissolved Oxygen (DO)	Water Quality Meter	Not Applicable
pH	Water Quality Meter	Not Applicable
Water Temperature	Water Quality Meter	Not Applicable
Specific Conductance	Water Quality Meter	Not Applicable
Turbidity	Water Quality Meter	Not Applicable
Redox Potential	Water Quality Meter	Not Applicable
Color	Platinum-Cobalt Scale (SM)	Not Applicable
Residues	Defined in 18 ACC 70	Not Applicable
General Water Quality Parameters (grab samples for laboratory analysis)		
Hardness	EPA - 130.2	180 days
Nitrate/Nitrite	EPA - 353.2	48 hours
Alkalinity	EPA - 2320	14 days
Ammonia as N	EPA - 350.1	28 days
Total Kjeldahl Nitrogen	EPA - 351.2	28 days
Total Phosphorus	EPA - 365.3	28 days

Ortho-phosphate	EPA - 365.3	48 hours
Chlorophyll-a	SM 10300	28 days
Total Dissolved Solids	EPA - 160.1	7 days
Total Suspended Solids	EPA - 160.2	7 days
Turbidity	EPA - 180.1	48 hours
TOC	EPA - 415.1	28 days
DOC	EPA – 415.1	28 days
Fecal Coliform	EPA 1604	30 hours
Petroleum Hydrocarbons	EPA 602/624 (TAqH) EPA 610/625 (TAH)	14 days
Radionuclides[1]	EPA 900.0, 901.1, 903.1, 904.0, 905.0, Alpha Spectroscopy	5 days
Metals – (Water) Dissolved and Total		
Aluminum	EPA – 6010B/6020A	48 hours
Arsenic	EPA – 6010B/6020A	48 hours
Barium	EPA – 6010B/6020A	48 hours
Beryllium	EPA – 6010B/6020A	48 hours
Cadmium	EPA – 6010B/6020A	48 hours
Chromium (III & IV)	EPA – 6010B/6020A	48 hours
Cobalt	EPA – 6010B/6020A	48 hours
Copper	EPA – 6010B/6020A	48 hours
Iron	EPA – 6010B/6020A	48 hours
Lead	EPA – 6010B/6020A	48 hours
Magnesium	EPA – 6010B/6020A	48 hours
Manganese	EPA – 6010B/6020A	48 hours
Mercury (Total and methylmercury)	EPA – 7470A	48 hours
Molybdenum	EPA – 6010B/6020A	48 hours
Nickel	EPA – 6010B/6020A	48 hours
Selenium	EPA – 6010B/6020A	48 hours
Thallium	EPA – 6010B/6020A	48 hours
Vanadium	EPA – 6010B/6020A	48 hours
Zinc	EPA – 6010B/6020A	48 hours
Metals –Sediment (Total)		
Aluminum	EPA - 200.7	180 days

Arsenic	EPA - 200.7	180 days
Cadmium	EPA - 200.7	180 days
Copper	EPA - 200.7	180 days
Iron	EPA - 200.7	180 days
Lead	EPA - 200.7	180 days
Mercury	EPA – 245.5 / 7470A	28 days
Zinc	EPA - 200.7	180 days
Metals – Fish Tissue (Use EPA Sampling Method 1669) (Mercury Assessment Study Plan 5.7 only)		
Total Mercury	EPA – 1631	7 days
Methylmercury	EPA – 1631	7 days
Arsenic	EPA - 1632, Revision A	7 days
Cadmium	EPA - 1632	7 days
Selenium	EPA - 1632	7 days

Note: List of Radionuclides suggested for analysis includes the following: Americium-241; Cesium-137; Lead-210; Plutonium-238, 239, 240; Potassium-40; Radium-226; Radium-228; Strontium-90; Thorium-230, 232; Uranium-234, 235, 238; Tritium Gross Alpha, Gross Beta

Table 5.5-4. List of water quality parameters and frequency of collection.

Parameter	Task	Frequency of Collection
In-Situ Water Quality Parameters		
Dissolved Oxygen (DO)	Baseline WQ and Sediment	Each Sampling Event
pH	Baseline WQ and Sediment	Each Sampling Event
Water Temperature	Baseline WQ and Sediment	Each Sampling Event
Specific Conductance	Baseline WQ and Sediment	Each Sampling Event
Turbidity	Baseline WQ and Sediment	Each Sampling Event
Redox Potential	Baseline WQ and Sediment	Each Sampling Event
Color	Baseline WQ (Visual)	Monthly
Residues	Baseline WQ (Visual)	One Survey-summer
General Water Quality Parameters (grab samples for laboratory analysis)		
Hardness	Baseline WQ	Monthly
Alkalinity	Baseline WQ	Monthly
Nitrate/Nitrite	Baseline WQ	Monthly
Ammonia as N	Baseline WQ	Monthly
Total Kjeldahl Nitrogen	Baseline WQ	Monthly
Total Phosphorus	Baseline WQ	Monthly
Ortho-phosphate	Baseline WQ	Monthly

Chlorophyll-a	Baseline WQ	Monthly
Total Dissolved Solids	Baseline WQ	Monthly
Total Suspended Solids	Baseline WQ	Monthly
Turbidity	Baseline WQ	Monthly
TOC	Baseline WQ	One Survey-summer
DOC	Baseline WQ	One Survey-summer
Fecal Coliform	Baseline WQ	One Survey-summer
Petroleum Hydrocarbons	Baseline WQ	One Survey-summer
Radioactivity	Baseline WQ	One Survey-summer
Metals – (Water) Dissolved and Total		
Aluminum	Baseline WQ (Total & Dissolved)	One Survey-summer
Arsenic	Baseline WQ (Total & Dissolved)	Monthly
Barium	Baseline WQ (Total & Dissolved)	Monthly
Beryllium	Baseline WQ (Total & Dissolved)	Monthly
Cadmium	Baseline WQ (Total & Dissolved)	Monthly
Chromium (III & IV)	Baseline WQ (Total & Dissolved)	One Survey-summer
Cobalt	Baseline WQ (Total & Dissolved)	Monthly
Copper	Baseline WQ (Total & Dissolved)	Monthly
Iron	Baseline WQ (Total & Dissolved)	Monthly
Lead	Baseline WQ (Total & Dissolved)	Monthly
Manganese	Baseline WQ (Total & Dissolved)	Monthly
Magnesium	Baseline WQ (Total & Dissolved)	Monthly
Mercury	Baseline WQ (Total & Dissolved)	Monthly
Molybdenum	Baseline WQ (Total & Dissolved)	Monthly
Nickel	Baseline WQ (Total & Dissolved)	Monthly
Selenium	Baseline WQ (Total & Dissolved)	One Survey-summer
Thallium	Baseline WQ (Total & Dissolved)	Monthly
Vanadium	Baseline WQ (Total & Dissolved)	Monthly
Zinc	Baseline WQ (Total & Dissolved)	Monthly
Metals –Sediment (Total)		
Aluminum	Sediment Samples	One Survey-summer
Arsenic	Sediment Samples	One Survey-summer
Cadmium	Sediment Samples	One Survey-summer
Copper	Sediment Samples	One Survey-summer
Iron	Sediment Samples	One Survey-summer
Lead	Sediment Samples	One Survey-summer

Mercury	Sediment Samples	One Survey-summer
Zinc	Sediment Samples	One Survey-summer
Metals – Fish Tissue (Use EPA Sampling Method 1669)		
Total Mercury	Fish Tissue Screening	One Survey-late summer
Methylmercury	Fish Tissue Screening	One Survey-late summer
Arsenic	Fish Tissue Screening	One Survey-late summer
Cadmium	Fish Tissue Screening	One Survey-late summer
Selenium	Fish Tissue Screening	One Survey-late summer

5.5.10. Figures

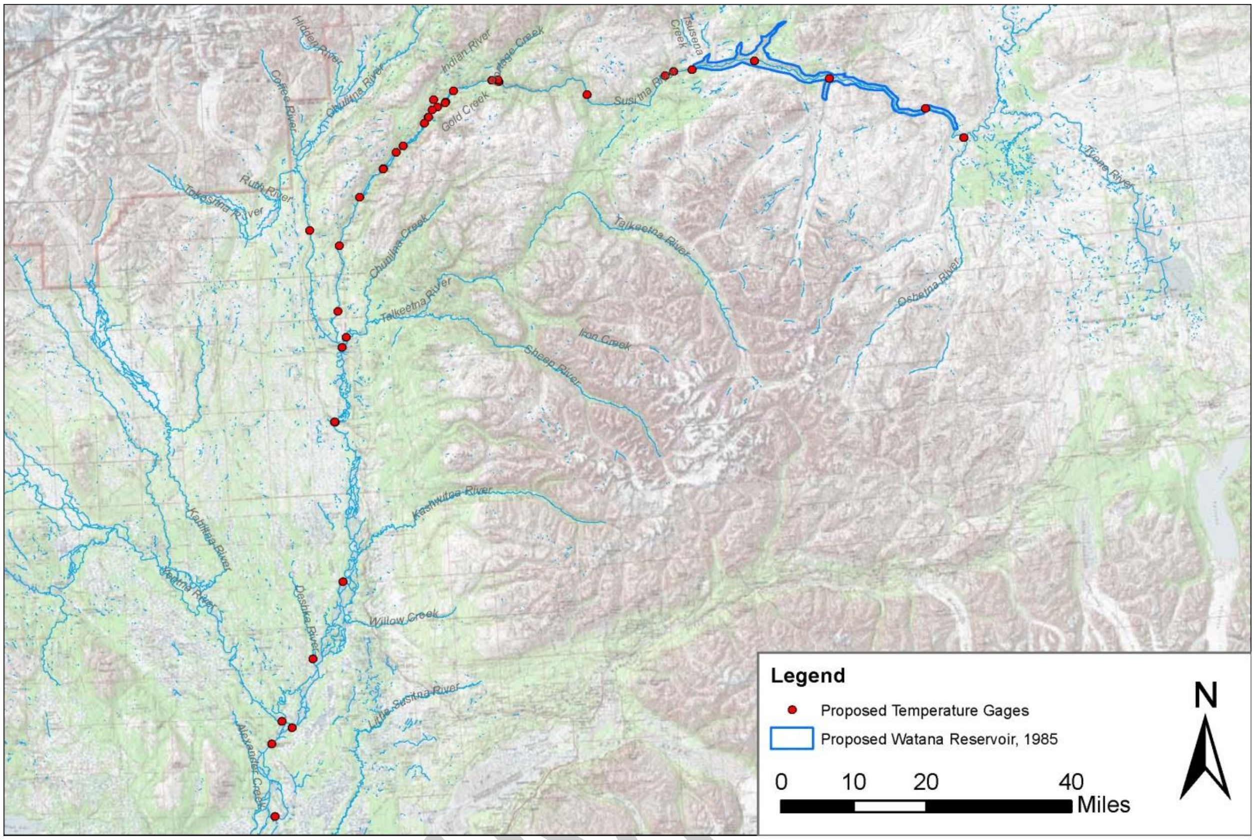


Figure 5.5-1. Proposed 2012 Stream Water Quality and Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project.

Figure 5.5-2. Example of a 10-foot (3-meter) tripod MET station installed above the proposed Watana Dam site.

5.6. Water Quality Modeling Study

5.6.1. General Description of the Proposed Study

The collective goal of the water quality studies is to assess the impacts of the proposed Project operations on water quality in the Susitna River basin with particular reference to state water quality standards. Predicting the potential impacts of the dam and its proposed operations on water quality will require the development of a water quality model. The goal of the Water Quality Modeling Study will be to utilize the extensive information collected from the Baseline Water Quality Study to develop a model(s) to evaluate the potential impacts of the proposed Project and operations on various physical parameters within the Susitna River watershed.

A large number of water quality models are available for use on the Susitna-Watana Project. Selection of the appropriate model is based on a variety of factors, including cost, data inputs, model availability, time, licensing participant familiarity, ease of use, and available documentation. Under the current study, a multi-dimensional model capable of representing reservoir flow circulation, temperature stratification, and dam operations among other parameters is necessary. The proposed model must account for water quality conditions in the proposed Susitna-Watana Reservoir, including temperature, dissolved oxygen (DO), suspended sediment and turbidity, chlorophyll-a, nutrients, and metals, as well as water quality conditions in the Susitna River downstream of the proposed dam. The model must also simulate current Susitna River baseline conditions (in the absence of the dam) for comparison to conditions in the presence of the dam and reservoir.

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

- In consultation with licensing participants, identify an appropriate reservoir and river water temperature model for use with past and current monitoring data.
- Using the data developed in Sections 5.5 (Baseline Water Quality Study) and 7.6 (Ice Precesses Study) in the Revised Study Plan, model water quality conditions in the proposed Susitna-Watana Reservoir, including (but not necessarily limited to), temperature, DO, suspended sediment and turbidity, chlorophyll-a, nutrients, ice, and metals.
- Model water quality conditions in the Susitna River from the proposed site of the Susitna-Watana Dam downstream, including (but not necessarily limited to) temperature, suspended sediment and turbidity, and ice processes (in coordination with the Ice Processes Study).

5.6.2. Existing Information and Need for Additional Information

In the 1980s, hydrologic and temperature modeling was conducted in the Susitna River basin to predict the effects of one or more dams on downstream temperatures and flows. The modeling suite used was called H2OBAL/SNTEMP/DYRESM. The modeling suite addressed temperature and had some limited hydrodynamic representation, but it lacked the ability to predict vertical stratification or local effects. In addition, the modeling suite lacked a water quality modeling component.

Review of existing water quality and sediment transport data revealed several gaps that present challenges for calibrating a water quality model (URS 2011). Analysis of existing data was used to identify future studies needed to develop the riverine and reservoir water quality models and to eventually predict pre-Project water quality conditions throughout the drainage. Some general observations based on existing data are as follows:

- Large amounts of data were collected during the 1980s. A comprehensive data set for the Susitna River and tributaries is not available.
- The influence of major tributaries (Chulitna and Talkeetna rivers) on Susitna River water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations.
- Continuous temperature data and seasonal water quality data are not available for the Susitna River mainstem and sloughs potentially used for spawning and rearing habitat.

Concentrations of water quality parameters including metals in sediment immediately below the proposed Project are unknown. Metals in these sediments may become mobile once the Project begins operation. Monitoring information in the immediate vicinity of the reservoir and riverine habitat will be important for developing two models (reservoir and riverine) and coupled for predicting expected water quality conditions below the proposed dam.

5.6.3. Study Area

Water quality samples will be collected at the same locations where temperature data loggers were installed in (Table 5.6-1 and Figure 5.6-1) as part of the 2012 Baseline Water Quality Study. The study area begins at RM 10.1 and extends past the proposed dam site to RM 233.4. The lowermost boundary of the monitoring that will be used for developing and calibrating models is above the area protected for beluga whale activity. Twelve mainstem Susitna River monitoring sites are located below the proposed dam site and two mainstem sites above this location for calibration of the models. Six sloughs will be included in the models and represent important fish-rearing habitat. Tributaries to the Susitna River will be monitored and include those contributing large portions of the lower river flow like the Talkeetna, Chulitna, Deshka, and Yentna rivers. A partial list of the remaining tributaries that will be included in modeling and that represent important spawning and rearing habitat for anadromous and resident fisheries include Gold Creek, Portage Creek, Tsusena Creek, Watana Creek, and Oshetna Creek. 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.
- Preliminary consultation with licensing participants including co-location with other study sites (e.g., instream flow, ice processes).
- Access and land ownership issues.

Eight of the sites are mainstem monitoring sites that were previously used for SNTEMP modeling in the 1980s. Thirty-one of the sites are Susitna River mainstem, tributary, or slough locations, most of which were also monitored in the 1980s.

5.6.4. Study Methods

This section provides a justification for selection of the water quality model that will be used for this project. For the current project, the model will need to be capable of simulating both river and reservoir environments. It will also be a multi-dimensional dynamic model that includes hydrodynamics, water temperature, water quality, and sediment transport modules and considers ice formation and break-up. Ice dynamics evaluated in the Ice Processes Study will be used to inform the water quality model. Ice formation and break-up will have a profound impact on hydrodynamics and water quality conditions in the reservoir and riverine sections of the basin. Ice cover affects transfer of oxygen to and from the atmosphere and this directly affects the dissolved oxygen concentration at points along the water column. The output from the Ice Processes Study (Section 7.6) will provide boundary conditions for the water quality model.

The model will be configured for the reservoir and internally coupled with the downstream river model. This will form a holistic modeling framework that can accurately simulate changes in the hydrodynamic, temperature, and water quality regime within the reservoir and downstream. A model for use in this study should feature an advanced turbulence closure scheme to represent vertical mixing in reservoirs, and be able to predict future conditions. Thus, it will be capable of representing the temperature regime within the reservoir without resorting to arbitrary assumptions about vertical mixing coefficients.

The model will need to have the ability to simulate an entire suite of water quality parameters, and the capacity for internal coupling with the hydrodynamic and temperature modeling processes. The model will be configured to simulate the impact of the proposed Project on temperature as well as DO, nutrients, algae, turbidity, total suspended solids (TSS), and other key water quality features both within the reservoir and for the downstream river. This avoids the added complexity associated with transferring information among multiple models and increases the efficiency of model application.

Other important factors used for selecting a water quality model included the following:

- The model and code easily accessible and are part of the public domain.
- The model is commonly used and accepted by EPA and other public regulatory agencies.
- The water quality model will be available for current and future use and remain available for the life of the project and beyond (including upgraded versions).
- Model output can be compared to relevant ADEC water quality criteria (18 ACC 70.020(b)).

The following sections summarize the capabilities of models considered for use on this project and outline characteristics of those previously used with historical data from the Susitna River drainage and others commonly used for water quality modeling for regulatory decision-making.

5.6.4.1. H2OBAL/SNTEMP/DYRESM Model Review

The existing H2OBAL/SNTEMP/DYRESM model of the Susitna River basin is perhaps the most obvious candidate model to implement when assessing the effects of the originally proposed Project. The existing model was expressly configured to represent the unique conditions in the Susitna River basin. However, the modeling suite is limited to flow and temperature predictions. Hydrodynamics are simplified, and water quality is not addressed.

The Arctic Environmental Information and Data Center (AEIDC) previously completed a study that examined the temperature and discharge effects if the proposed Project was completed and compared the effects to the natural stream conditions, without a dam and reservoir system (AEIDC 1983a). The study also assessed the downstream point at which post-Project flows would be statistically the same as natural flows. Multiple models were used in the assessment: SNTEMP, a riverine temperature model; H2OBAL, a water balance program; and DYRESM, a reservoir hydrodynamic model.

The simulation period covered the years 1968 through 1982. Only the summer period was simulated, using historical meteorological and hydrological data to represent normal, maximum, and minimum stream temperature conditions, represented by the years 1980, 1977, and 1970, respectively (AEIDC 1983a). Post-project modifications were applied to these summer periods to compare natural conditions to post-Project stream temperatures. Due to a lack of data, a monthly time-step was used in these summer condition simulations.

Mainstem discharges from the Susitna-Watana Dam site were estimated from statistically-filled streamflow data and the H2OBAL program, which computes tributary inflow on a watershed area-weighted basis. Post-Project flows were predicted for both a one-dam scenario and a two-dam scenario using release discharge estimates from a reservoir operation schedule scenario in the FERC license application. Flows derived from H2OBAL were input into SNTEMP.

SNTEMP is a riverine temperature simulation model that can predict temperature on a daily basis and for longer time periods. This allows for the analysis of both critical river reaches at a fine scale and the full river system over a longer averaging period (AEIDC 1983b). SNTEMP was selected because it contains a regression model that can fill in data gaps in temperature records. This is useful because data records in the Susitna River watershed are sparse. SNTEMP can also be calibrated to adjust for low-confidence input parameters. SNTEMP outputs include average daily water temperatures and daily maximum and minimum temperatures.

SNTEMP contains several sub-models, including a solar radiation model that predicts solar radiation based on stream latitude, time of year, topography, and meteorological conditions (AEIDC 1983b). SNTEMP was modified to include the extreme shading conditions that occur in the basin by developing a monthly topographic shading parameter. Modifications were also made to represent the winter air temperature inversions that occur in the basin. Sub-models are also included for heat flux, heat transport, and flow mixing.

SNTEMP validation indicated that upper tributary temperatures were under-predicted (AEIDC 1983b). Most of the data for the tributaries were assumed or estimated, leading to uncertainty. Five key poorly defined variables were identified as possible contributors to the under-prediction of temperatures: stream flow, initial stream temperature, stream length, stream width and distributed flow temperatures. Distributed flow temperatures were highlighted as the most important of the five variables. During calibration, groundwater temperature parameters were adjusted to modify distributed flow and improve tributary temperature prediction.

Water temperatures are derived from USGS gages, but when data were lacking, SNTEMP computed equilibrium temperatures and then estimated initial temperatures from a regression model. AEIDC noted that the reliability of the regression models "restricts the accuracy of the physical process temperature simulations" (1983a). The level of confidence in the regression model varies by the amount of gage data available. Continuous data yielded higher confidence, while years with only grab sample data notably decreased the confidence in the predicted temperatures.

The DYRESM model is a one-dimensional, hydrodynamic model designed specifically for medium size reservoirs (Patterson et al. 1977). The size limitation ensures that the assumptions of the model algorithm remain valid. DYRESM predicts daily temperature and salinity variations with depth and the temperature and salinity of off-take supply. The reservoir is modeled as horizontal layers with variable vertical location, volume, temperature and salinity. Mixing between layers is through amalgamation. Inflow and withdrawal are modeled by changes in the horizontal layer thickness and insertion or removal of layers, as appropriate. The model incorporates up to two submerged off-takes and one overflow outlet. Model output is on a daily time-step.

The DYRESM model was run to simulate the reservoir scenario for 1981 conditions (AEIDC 1983a). Other reservoir release temperature estimates were not available. The AEIDC report cautions that the results from 1981 may not be representative of other years due to annual variations in meteorology, hydrology, reservoir storage, and power requirements. The lack of reservoir release temperature data limited the simulation of downstream temperatures under operational conditions to one year. AEIDC noted that the "effort to delineate river reaches where post-project flows differ significantly from natural flows has been unsuccessful" (AEIDC 1983a). This was attributed in large part to the lack of estimates for the reservoir release temperatures. Additional data were needed to increase the predictive ability of SNTEMP.

Perhaps the biggest limitations of the existing H2OBAL/SNTEMP/DYRESM modeling suite are the lack of suitable data, simplified hydrology, and the lack of a water quality component. Modeling is limited to discharge and temperature. Other issues that limit the suitability of the modeling suite for the Water Quality Modeling Study are the chronic under-prediction of upper tributary temperatures, and the inability to predict vertical stratification within the reservoir.

5.6.4.2. Other Modeling Approaches

Two other modeling approaches may provide better results than the previously used H2OBAL/SNTEMP/DYRESM model. These are discussed below.

5.6.4.3. Two-Dimensional Approach (CE-Qual-W2)

The U.S. Army Corps of Engineers' CE-QUAL-W2 model is a two-dimensional, longitudinal/vertical (laterally averaged), hydrodynamic and water quality model (Cole et al. 2000). The model can be applied to streams, rivers, lakes, reservoirs, and estuaries with variable grid spacing, time-variable boundary conditions, and multiple inflows and outflows from point/nonpoint sources and precipitation.

The two major components of the model include hydrodynamics and water quality kinetics. Both of these components are coupled (i.e., the hydrodynamic output is used to drive the water quality output at every time-step). The hydrodynamic portion of the model predicts water surface elevations, velocities, and temperature. The water quality portion of the model can simulate 21 constituents including DO, suspended sediment, chlorophyll-a, nutrients, and metals. A dynamic shading algorithm is incorporated to represent topographic and vegetative cover effects on solar radiation.

5.6.4.4. Three-Dimensional Approach (EFDC)

The Environmental Fluid Dynamics Code (EFDC) model was originally developed at the Virginia Institute of Marine Science and is considered public domain software (Hamrick 1992).

This model is now being supported by EPA. EFDC is a dynamic, three-dimensional, coupled water quality and hydrodynamic model. In addition to hydrodynamic, salinity, and temperature transport simulation capabilities, EFDC is capable of simulating cohesive and non-cohesive sediment transport, near field and far field discharge dilution from multiple sources, eutrophication processes, the transport and fate of toxic contaminants in the water and sediment phases, and the transport and fate of various life stages of finfish and shellfish. The EFDC model has been extensively tested, documented, and applied to environmental studies world-wide by universities, governmental agencies, and environmental consulting firms.

The structure of the EFDC model includes four major modules: (1) a hydrodynamic model, (2) a water quality model, (3) a sediment transport model, and (4) a toxics model. The water quality portion of the model simulates the spatial and temporal distributions of 22 water quality parameters including DO, suspended algae (three groups), periphyton, various components of carbon, nitrogen, phosphorus and silica cycles, and fecal coliform bacteria. Salinity, water temperature, and total suspended solids are needed for computation of the 22 state variables, and they are provided by the hydrodynamic model. EFDC incorporates solar radiation using the algorithms from the CE-QUAL-W2 model.

5.6.4.5. Qualitative Comparison of Models

Table 5.6-2 presents an evaluation of the models' applicability to a range of important technical, regulatory, and management considerations. Technical criteria refer to the ability to simulate the physical system in question, including physical characteristics/processes and constituents of interest. Regulatory criteria make up the constraints imposed by regulations, such as water quality standards or procedural protocol. Management criteria comprise the operational or economic constraints imposed by the end-user and include factors such as financial and technical resources. The relative importance of each consideration, as it pertains to the Project, are presented alongside the models' applicability ratings. Although the evaluation is qualitative, it is useful in selecting a model based on the factors that are most critical to this Project.

5.6.4.6. Technical Considerations

The following discussion highlights some of the key technical considerations for modeling associated with the Project and compares the ability of CE-QUAL- W2 and EFDC to address these considerations. For informational purposes, the H2OBAL/SYNTEMP/DYRESM modeling suite is also discussed in the technical considerations. Based on a review of the literature, some key factors that will likely be important in the modeling effort include the following:

1. Prediction of vertical stratification in the reservoir when the dam is present
2. Nutrient and algae representation
3. Sediment transport
4. Ability to represent metals concentrations
5. Integration between temperature and ice dynamics models
6. Capability of representing local effects (i.e., focus areas)

5.6.4.6.1. Predicting Vertical Stratification

Both EFDC and CE-QUAL-W2 are equipped with turbulence closure schemes that allow prediction of temporally/spatially variable vertical mixing strength based on time, weather condition, and reservoir operations. Therefore, both are capable of evaluating the impact of dam/reservoir operations/climate change on reservoir stratification. In contrast, the existing H2OBAL/SYNTEMP/DYRESM model does not have the necessary predictive capability because vertical stratification is represented based on parameterization through calibration. Therefore, it cannot represent the response of vertical mixing features to the changes in external forces.

5.6.4.6.2. Nutrient and Algae Representation

Both EFDC and CE-QUAL-W2 are capable of simulating dynamic interactions between nutrients and algae in reservoirs and interactions between nutrients and periphyton in riverine sections. This is very important for addressing the potential impact of the proposed Project on water quality and ecology in the river. EFDC has better nutrient predictive capabilities due to its sediment diagenesis module, which simulates interactions between external nutrient loading and bed-water fluxes. EFDC is thus capable of predicting long-term effects of the proposed Project. CE-QUAL-W2 does not have such a predictive capability. The existing H2OBAL/SNTEMP/DYRESM modeling suite is not capable of representing nutrient and algae interactions.

5.6.4.6.3. Sediment Transport

EFDC is fully capable of predicting sediment erosion, transport, and settling/deposition processes. CE-QUAL-W2 has limited sediment transport simulation capabilities. It handles water column transport and settling; however, it is not capable of fully predicting sediment bed re-suspension and deposition processes. H2OBAL/SNTEMP/DYRESM is not capable of simulating sediment transport. Reservoir trap efficiency will be simulated using EFDC and will use estimates for sediment inflow determined by the Geomorphology Study (Section 6.5 in the Revised Study Plan).

5.6.4.6.4. Ability to Represent Metals Concentrations

EFDC is fully capable of simulating fate and transport of metals in association with sediments in both rivers and reservoirs. CE-QUAL-W2 does not have a module to simulate metals; however, a simplified representation can be implemented using the phosphorus slot in the model and simple partitioning (to couple with its basic sediment transport representation). The H2OBAL/SNTEMP/DYRESM is not capable of addressing metals issues.

5.6.4.6.5. Integration between Temperature and Ice Dynamics Models

The CE-QUAL-W2 model has a coupled temperature-ice simulation module, which is of moderate complexity and predictive capability. EFDC has a slightly simpler ice representation that was previously applied to a number of Canadian rivers (e.g., Lower Athabasca River and the North Saskatchewan River in Alberta, Canada). Both models, however, can be coupled to external ice models with a properly designed interface to communicate temperature results. Fully predictive simulation within either model would require code modification to handle the interaction between temperature simulation, ice formation and transport, hydrodynamics simulation, and water quality simulation.

5.6.4.6.6. Capability of Representing Local Effects

CE-QUAL-W2 is a longitudinal-vertical two-dimensional model; therefore, it is capable of resolving spatial variability in the longitudinal and vertical directions. It is not capable of representing high-resolution local effects such as lateral discharge, areas affected by secondary circulation, or certain habitat characteristic changes. EFDC is a three-dimensional model that can be configured at nearly any spatial resolution to represent local effects. H2OBAL/SNTEMP/DYRESM is a one-dimensional modeling suite and therefore has limited capability representing local effects.

5.6.4.7. **Conclusion**

Based on the evaluation of each model presented in Section 5.6.4.6, the EFDC model has been selected for further use in this study.

A Quality Assurance project Plan will be developed that provides greater detail for model capabilities, calibration procedures, and performance expectations. This information will be included in Attachment 5-2.

5.6.4.8. Reservoir and River Downstream of Reservoir Modeling Approach

Reservoir modeling will focus on the length of the river from above the expected area of reservoir inundation to the proposed dam location. It will involve first running the initial reservoir condition. This initial condition represents current baseline conditions in the absence of the dam. Subsequently, the model will represent the proposed reservoir condition when the dam is in place. The reservoir representation will be developed based on the local bathymetry and dimensions of the proposed dam. It is recommended that a three-dimensional model be developed for the proposed reservoir to represent the spatial variability in hydrodynamics and water quality in longitudinal, vertical, and lateral directions. The model will be able to simulate flow circulation in the reservoir, turbulence mixing, temperature dynamics, nutrient fate and transport, interaction between nutrients and algae, sediment transport, and metals transport. The key feature that needs to be captured is water column stratification during the warm season and the de-stratification when air temperatures cool down. The capability of predictively representing the stratification/de-stratification period is of critical importance for evaluating the impact of the dam because this is the critical water quality process in the reservoir.

With the dam in place, the original river will be converted into a slow flowing reservoir; therefore, any sediment previously mobilized will likely settle in the reservoir, disrupting the natural sediment transport processes. Before the construction of the dam, primary production is likely driven by periphyton. After construction of the dam, periphyton will be largely driven out of existence due to deep water conditions typical of a reservoir environment. In lieu of periphyton, phytoplankton will likely be the dominant source of primary production of the ecological system with the dam in place. Nutrients from upstream will have longer retention in the reservoir, providing nutrient sources to fuel phytoplankton growth. All processes would need to be predictively simulated by both the reservoir model and the pre-reservoir river model for the same river segment.

Because the dam is not in place when the model is constructed, proper calibration of the model using actual reservoir data is not possible. To achieve reasonable predictions of water quality conditions in the proposed reservoir, a literature survey will be conducted to acquire parameterization schemes of the model. An uncertainty analysis approach will also be developed to account for the lack of data for calibration, therefore enhancing the reliability of reservoir model predictions.

Downstream of the proposed dam location, a river model will also be developed to evaluate the effects of the proposed Project. It is anticipated that the same model platform used for the reservoir model will be implemented for the river model (at a minimum the two models will be tightly coupled). The river model will be capable of representing conditions in both the absence and presence of the dam. The downstream spatial extent of this model will be the lowermost monitoring site on the Susitna River mainstem (RM 15.1) extending downstream of the Susitna-Talkeetna-Chulitna confluence. Water quality modeling will extend into the lower river and will use channel topography and flow data at select locations in order to develop a model for predicting water quality conditions under various Project operational scenarios.

Flow, temperature, TSS, DO, nutrients, turbidity (continuous at USGS sites and bi-weekly at additional locations required for calibrating the model), and chlorophyll-a output from the reservoir model will be directly input into the downstream river model. This will enable downstream evaluation of potential impacts of the proposed Project on hydrodynamic, temperature, and water quality conditions.

The river model will be calibrated and validated using available data concurrently with the initial reservoir condition model (representing absence of the dam). Output from the models will be used directly in other studies (e.g., Ice Processes, Productivity, and Instream Flow studies).

The EFDC model will be calibrated in order to simulate water quality conditions for load following analysis. Organic carbon content from inflow sources will be correlated with mercury concentrations determined from the Baseline Water Quality Study discussed in Section 5.5. Predicted water quality conditions established by Project operations and that promote methylation of mercury in the bioaccumulative form will be identified by location and intensity in both riverine and reservoir habitats. Water temperature modeling and routing of fluctuating flows immediately prior to and during ice cover development may be conducted with a separate thermodynamics-based ice process model River 1D ice-processes model; the Susitna Hydraulic and Thermal Processes Model (Revised Study Plan Section 7.6.3.2).

Modeling of mercury concentrations in dissolved and in methylated form will be done by updating the EFDC model to simulate three sorptive toxic variables representing mercury (Hg) states. Algorithms have been successfully used with EFDC in other studies and will be modified to account for potential sources of Hg as the reservoir is filled (e.g., soils, vegetation, air deposition). Other metals parameters will be modeled if significant concentrations are identified from surface water and sediment. However, cumulative impacts of multiple metals on aquatic life are difficult to predict using the proposed modeling strategy because there are associated uncertainties. Measuring additivity or synergism of toxics effects from multiple stressors is simplistic and is determined by identifying the single, worst, or dominant stressor (simple comparative effect model).

5.6.4.8.1 Focus Areas

The EFDC model will be used to predict water quality conditions at a finer scale of resolution for intensive study reaches. The increased intensity of sampling at transects 100 m apart and at three locations across each transect will improve resolution for predictions at approximately 100 m longitudinally and a smaller distance laterally. This model will be embedded within the larger-scale EFDC model used for the entire riverine component of the Project area. An embedded model can be used for predicting conditions in sloughs and selected braided areas of the mainstem Susitna River.

Some of the water quality parameters listed in Section 5.5.4.4 will be used to predict conditions within the focus areas to determine if suitability of habitat for life stages of select fish species is maintained or changes under each of the operational scenarios. The EFDC model calibrated for each of the focus areas will have a time-step component so that conditions and areal extent are described for each of the water quality parameters and are associated with load following.

5.6.4.8.2 Scales for Modeling and Resolution of the Output

The large-scale EFDC model calibrated using the mainstem water quality monitoring data will have a longitudinal predictive resolution between 250 m and 1 kilometer (km) depending on lateral variability of conditions and the run-time selected. Single channel areas of the mainstem Susitna River and sloughs may not require higher resolution predictions if water quality conditions are uniform. The uniformity of conditions will be evaluated by measuring across transects at a few locations in the drainage to determine if lateral variability is low.

Grid size in the model determines spatial resolution of predicted water quality conditions. The riverine (and reservoir) areas of the Project are divided into equal-sized grids and the center of each represents the predicted water quality condition. The grid size is dependent on a number of characteristics of the Project area. These characteristics include elevation changes throughout the length of the drainage, length of the water body that will be modeled, surrounding terrain, and length of time the model is run for predicting temporal changes. Each of the factors ultimately determines the resolution of the predictive capability of the EFDC model.

5.6.5. Consistency with Generally Accepted Scientific Practice

Models will be the primary method used for predicting potential impacts to water quality conditions in both the proposed reservoir and the riverine portion of the Susitna basin. The models will be developed for each of the reservoir and riverine sections of the Susitna River and will be used to predict conditions resulting from Project operations under several operational scenarios. In the absence of a dam and data describing actual water quality conditions in the proposed reservoir, models are the only way to predict potential changes that may occur in the Susitna River from the presence of a dam. The 401 Water Quality Certification process includes the use of baseline assessment information and the use of models. The use of models is a scientifically accepted practice for predicting impacts to water quality and generating operational scenario outputs to inform the Project certification. The selection process developed and implemented in this Revised Study Plan Section 5.6 outlined features of a model required for use in a river setting with braided channels, glacial water source, and ability to predict conditions in more than two-dimensions. The evaluation and proposed documentation describing performance and use of the model are accepted scientific practice for generating defensible and high quality data. The output from model calibration and predictions are consistent with recommended steps in generating high quality data as guided by a Credible Data Policy.

5.6.6. Schedule

The planned schedule for the study plan is presented below:

Table 5.6-7. Schedule for Implementation of the Modeling Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Coordination with water quality data collection and analysis				—	—	—	—	—	—				
Model Evaluation/Selection			—										
Model Calibration (Water Quality)							—	—					
Initial Study Report									Δ				
Re-calibration adjustments										—	—		
Verification runs											—		
Generate Results for Operational Scenarios										—	—	—	
Updated Study Report													▲

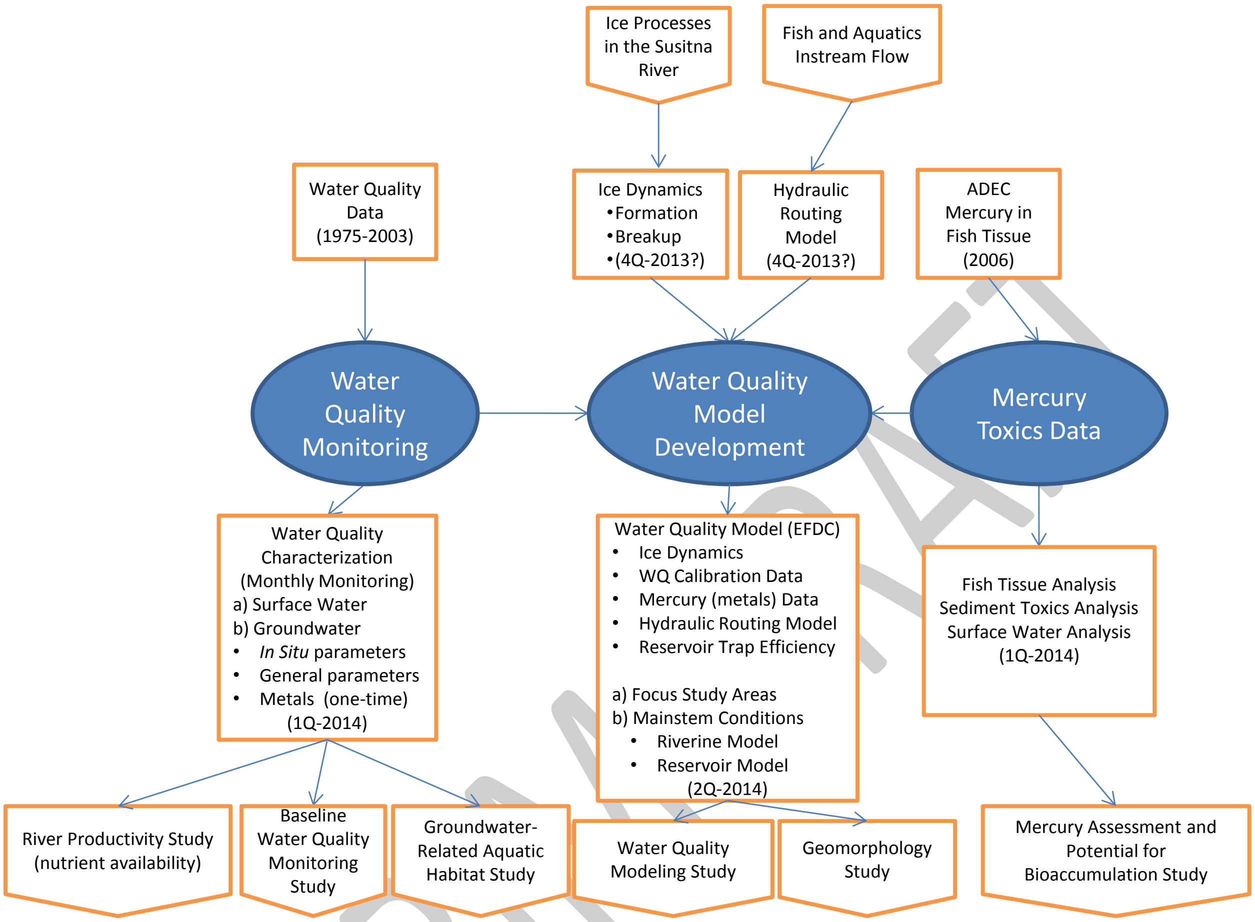
Legend:

—— Planned Activity
Δ Initial Study Report
▲ Updated Study Report

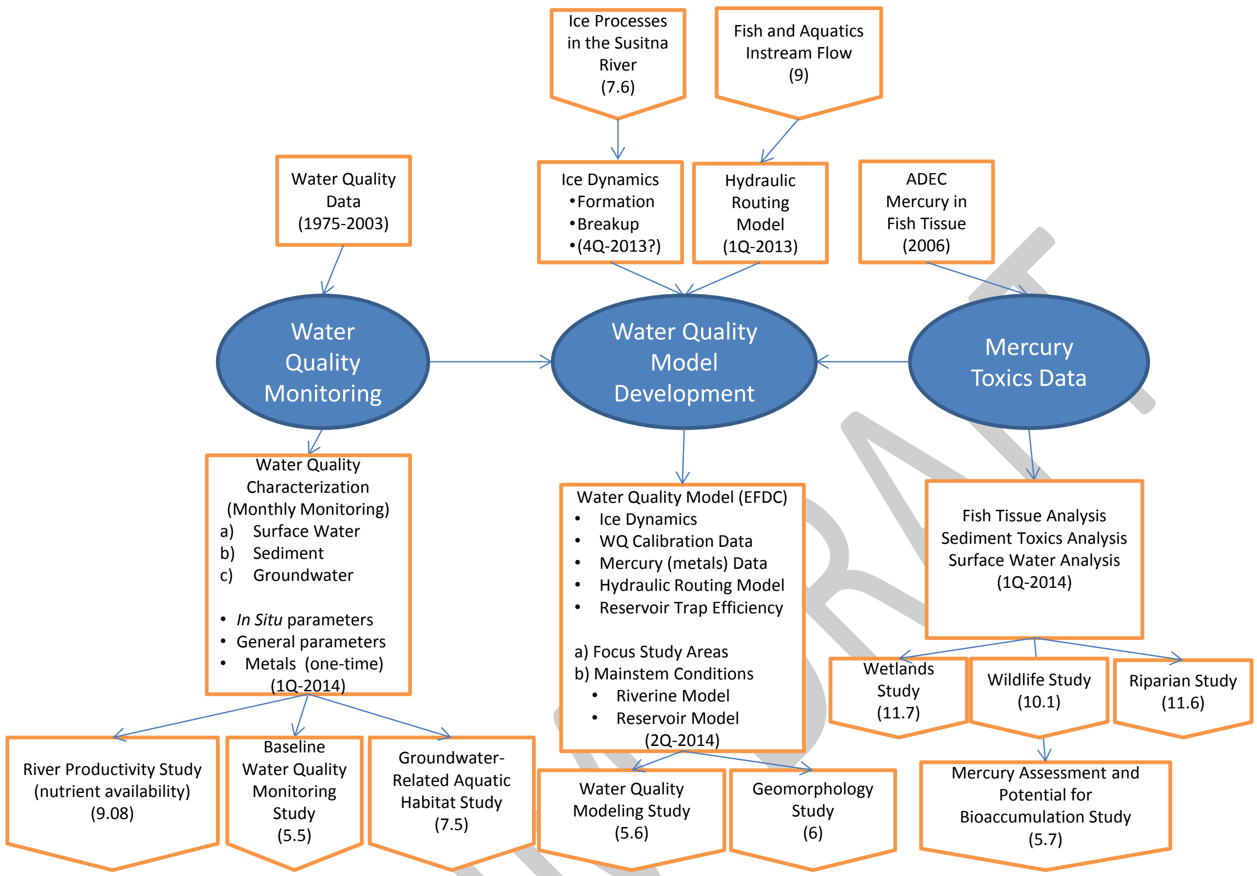
The flow chart below describe the interdependencies between existing data and related historical studies, specific output for each element of the Water Resources studies, and where the output information generated in the Water Resources studies will be directed. This chart provides details describing the flow of information related to the Water Resources studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis the previous year (URS 2011) and this information was used, in part, to assist in making decisions about the current design for the Baseline Water Quality Monitoring Study and for ensuring that current modeling efforts would be able to compare the 1980s study results with current modeling results.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Section 5.6 in the Revised Study Plan) with information about timing and conditions for ice formation and ice breakup. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

INTERDEPENDENCIES FOR WATER RESOURCES STUDIES



INTERDEPENDENCIES FOR WATER RESOURCES STUDIES



5.6.7. Level of Effort and Cost

The estimated cost for the proposed water quality modeling effort in 2013 and 2014, including planning, model calibration and development, modeling various operational scenarios, and reporting is approximately $1,050,000.

5.6.8. Literature Cited

Arctic Environmental Information and Data Center (AEIDC), 1983a. *Examination of Susitna River Discharge and Temperature Changes Due to the Proposed Susitna Hydroelectric Project – Final Report*. Prepared by Arctic Environmental Information and Data Center Anchorage, AK. Submitted to Harza-Ebasco Susitna Joint Venture Anchorage, AK. Prepared for the Alaska Power Authority, Anchorage, AK.

AEIDC. 1983b. *Stream Flow and Temperature Modeling in the Susitna Basin, Alaska*. Prepared by Arctic Environmental Information and Data Center Anchorage, AK. Submitted to Harza-Ebasco Susitna Joint Venture Anchorage, AK. Prepared for the Alaska Power Authority, Anchorage, AK.

Cole, T.M. and S. A. Wells. 2000. *CE-QUAL-W2: A two-dimensional, laterally averaged, Hydrodynamic and Water Quality Model, Version 3.0, Instruction Report EL-2000*. US Army Engineering and Research Development Center, Vicksburg, MS.

Hamrick, J.M. 1992. *A Three-Dimensional Environmental Fluid Dynamics Computer Code: Theoretical and Computational Aspects*, *Special Report 317*. The College of William and Mary, Virginia Institute of Marine Science. 63 pp.

Patterson, John, J. Imberger, B. Hebbert, and I. Loh. 1977. *Users Guide to DYRESM – A Simulation Model for Reservoirs of Medium Size*. University of Western Australia, Nedlands, Western Australia.

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.

5.6.9. Tables

Table 5.6-1. Proposed Susitna River Basin Water Quality and Temperature Monitoring Sites.

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

1 Site not sampled for water quality or temperature in the 1980s or location moved slightly from original location.

2 Proposed mainstem Susitna River temperature monitoring sites for purposes of 1980s SNTEMP model evaluation.
3 Locations with overlap of water quality temperature monitoring sites with other studies.

Locations in bold font represent that both temperature and water quality samples are collected from a site.

Table 5.6-2. Evaluation of models based on technical, regulatory, and management criteria.

●High Suitability ◐ Medium Suitability ○ Low Suitability

Considerations	Relative Importance	H2OBAL/SNTEMP/ DYRESM	CE QUAL W2	EFDC
Technical Criteria				
Physical Processes:				
• advection, dispersion	High	◐	●	●
• momentum	High	○	●	●
• compatible with external ice simulation models	High	○	●	●
• reservoir operations	High	◐	●	●
• predictive temperature simulation (high latitude shading)	High	◐	●	●
Water Quality:				
• total nutrient concentrations	High	○	●	●
• dissolved/particulate partitioning	Medium	○	●	●
• predictive sediment diagenesis	Medium	○	○	●
• sediment transport	High	○	◐	●
• algae	High	○	●	●
• dissolved oxygen	High	○	●	●
• metals	High	○	◐	●
Temporal Scale and Representation:				
• long term trends and averages	Medium	◐	◐	●
• continuous – ability to predict small time-step variability	High	○	●	●
Spatial Scale and Representation:				
• multi-dimensional representation	High	○	◐	●
• grid complexity - allows predictions at numerous locations throughout model domain	High	○	◐	●
• suitability for local scale analyses, including local discharge evaluation	Medium	○	◐	●
Regulatory Criteria				
Enables comparison to AK criteria	High	○	●	●

●High Suitability ◐ Medium Suitability ○ Low Suitability				
Considerations	**Relative Importance**	**H2OBAL/SNTEMP/ DYRESM**	**CE QUAL W2**	**EFDC**
Flexibility for analysis of scenarios, including climate change	High	◐	●	●
Technically defensible (previous use/validation, thoroughly tested, results in peer-reviewed literature, TMDL studies)	High	◐	●	●
Management Criteria				
Existing model availability	High	●	●	●
Data needs	High	●	●	●
Public domain (non-proprietary)	High	●	●	●
Cost	Medium	●	◐	◐
Time needed for application	Medium	N/A	◐	◐
Licensing participant community familiarity	Low	●	◐	◐
Level of expertise required	Low	●	●	●
User interface	Low	◐	◐	◐
Model documentation	Medium	◐	●	●

5.6.10. Figures

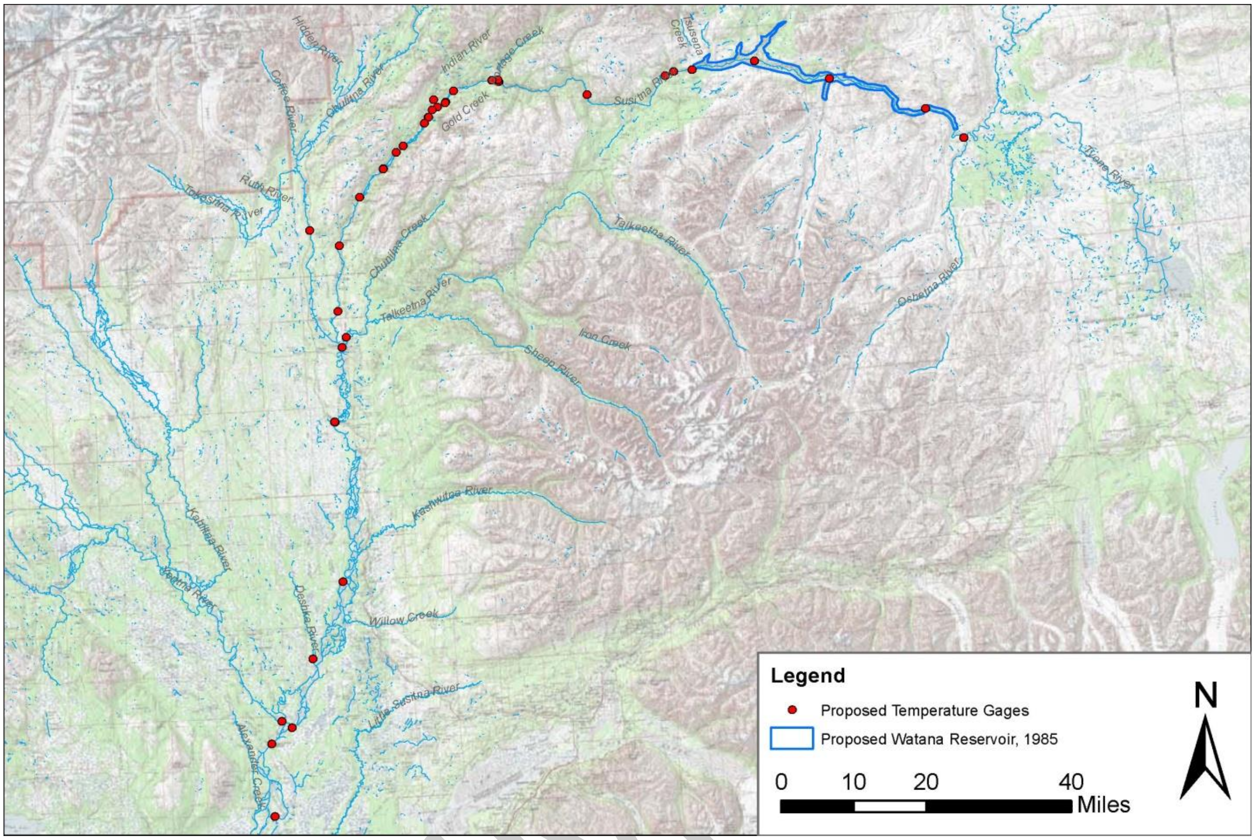


Figure 5.6-1. Proposed 2012 Stream Water Quality and Temperature Data Collection Sites for the Susitna-Watana Hydroelectric Project.

5.7. Mercury Assessment and Potential for Bioaccumulation Study

5.7.1. General Description of the Proposed Study

Many studies have documented increased mercury concentrations in wildlife following the flooding of terrestrial areas to create hydroelectric reservoirs. The purpose of this study is to assess the potential for such an occurrence in the proposed Project area.

Based on several studies, the mercury that is found in newly formed reservoirs originates predominantly from inundation of organic soils. Receptors are and will be present in the inundation area (macroinvertebrates, fish, birds, etc.). Mercury methylation in reservoirs is a fairly well understood process, and numerous models exist to predict the occurrence and magnitude of the phenomena.

Given these known factors, key questions that need to be answered by this study include the following:

1) Whether conditions within the reservoir will cause mercury methylation from this source.
2) The concentrations of methylmercury that might occur.
3) Whether a mechanism exists (fish and small invertebrates living in the methylation zone) to transfer that methylmercury to wildlife, resulting in detrimental impacts.

Based on these questions, specific objectives of this study are as follows:

- Summarize available and historic water quality information for the Susitna River basin, including data collection from the 1980s Alaska Power Authority (APA) Susitna Hydroelectric Project.
- Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, avian, terrestrial furbearers, and fish tissue samples for mercury.
- Utilize available geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- Map mercury concentrations of soils and vegetation within the proposed inundation area. This information will be used to develop maps of where mercury methylation may occur.
- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation.
- Use modeling to estimate methylmercury concentrations in fish.
- Assess potential pathways for methylmercury to migrate to the surrounding environment.

- Coordinate study results with other study areas, including fish, instream flow, and other piscivorous bird and mammal studies.

5.7.2. Existing Information and Need for Additional Information

The process by which mercury enters ecosystems is fairly well understood:

1) Organic material is decayed by bacteria in water.
2) The process utilizes the available oxygen in the water, creating anoxic conditions.
3) Under anoxic conditions, inorganic mercury is utilized by the bacteria to continue the decay process.
4) The utilization of inorganic mercury by bacteria creates methylmercury.
5) Methylmercury is significantly more toxic than inorganic mercury, and unlike inorganic mercury, bioaccumulates in the ecosystem.
6) Larger predators consume the bacteria, and the methylmercury biomagnifies each step up the food chain to fish and macroinvertebrates.
7) Fish and macroinvertebrates are consumed, spreading the methylmercury to humans and other piscivorous terrestrial wildlife.
8) Fish-eating birds and mammals are known to suffer a range of toxic effects from consumption of methylmercury, including behavioral, neurochemical, hormonal, and reproductive effects.

While this process occurs all over the world in natural wetlands, it can be especially acute in newly formed reservoirs. This is because organic-rich soils can absorb mercury from the atmosphere over decades, and their degradation at the bottom of the reservoir will generate methylmercury (Hydro-Quebec 2003). Many studies have documented increased mercury levels in fish following the flooding of terrestrial areas to create hydroelectric reservoirs (Bodaly et al. 1984; Bodaly et al 1997; Bodaly et al 2004; Bodaly et al. 2007; Rylander et al. 2006; Lockhart et al 2005; Johnston et al. 1991; Kelly et al. 1997; Morrison 1991b). Increased mercury concentrations have also been noted at other trophic levels within aquatic food chains of reservoirs, such as aquatic invertebrates (Hall et al. 1998). These problems have been particularly acute in hydropower projects from northern climates including Canada and Finland (Rosenberg et al. 1997). When boreal forests with large surface-area-to-volume ratios are flooded, substantial quantities of organic carbon and mercury stored in vegetation biomass and soils become inputs to the newly formed reservoir (Bodaly et al. 1984; Grigal 2003; Kelly et al. 1997). This flooding accelerates microbial decomposition, causing high rates of microbial methylation of mercury. Studies have shown this increase is temporary, lasting between 10 and 35 years (Hydro-Quebec 2003; Bodaly et al. 2007), whereupon methylmercury concentrations return to background levels.

Mercury in organic soils is common. Background concentrations in organic soils of the Kuskokwim area of Alaska were found to be 0.10 to 1.2 parts per million (ppm) (Bailey and Gray 1997; Gray et al 2000); however, this area is well known to have large ore bodies of cinnabar, a mercury ore. Soils in Norway and Sweden were found to have mercury concentrations only as high as 0.24 ppm (Lindqvist 1991). In the United States, the mean concentrations reported from organic soils and loamy soils are 0.28 ppm and 0.13 ppm, respectively (Kabata-Pendias and Pendias 1992). Background levels for organic soils in Canada as high as 0.40 ppm have been reported (Kabata-Pendias and Pendias 1992). Shacklette and Boerngen (1984) report an average value of 0.058 ppm in all soil types in the continguous United States.

In organic soils, mercury is mainly present in its inorganic form; the methylated form usually represents less than 1 percent of the total. Mercury does not appear to be mobile in soils, where it is firmly bound to the humus (Hydro-Quebec 2003).

Methylmercury can be detected in nearly every fish analyzed, from nearly any water body in the world. This is because the primary source of mercury to most aquatic ecosystems is deposition from the atmosphere. Mercury deposition worldwide has been steadily increasing due to the widespread burning of coal. In 2007, an international panel of experts concluded, "remote sites in both the Northern and Southern hemispheres demonstrate about a threefold increase in Hg deposition since preindustrial times" (Lindberg et al. 2007). Lakes at Glacier Bay, Alaska, have shown that current rates of atmospheric mercury deposition are about double what was observed in pre-industrial times (Engstrom and Swain 1997).

Mercury of non-atmospheric origin has been occasionally found in water bodies. The source can be industrial processes, mercury mining, or simply the presence of sulfate-rich mercury ores, which occur in very limited areas. In the study area, no mining has occurred, and there are no industrial sources. Point sources have been documented on the Kuskokwim River in Alaska, but are relatively rare, and are associated with known sulfate-rich ore bodies (Saiki and Martin 2010; Gray et al 2000). Based on the available geologic information, the inundation area consists largely of diorite and granodiorite, which are not typically associated with massive sulfide mineral deposits. For this reason, such a point source appears to be unlikely in the inundation area for the dam.

In areas that lack the necessary mercury mineralization, the mercury concentration in parent geologic materials is typically very low, and cannot explain the mercury concentrations observed in sediment in aquatic ecosystems (Fitzgerald et al. 1998; Swain et al. 1992; Wiener et al. 2006).

Historical mercury data from the study area are limited. Some samples were collected during previous studies of the APA Susitna Hydroelectric Project in the 1980s (AEA, 2011). This consisted of the collection of water samples at Gold Creek (RM 136) in 1982. Total mercury was found to be 0.12 micrograms per liter (µg/L) in turbid, summer water, and 0.04 µg/L in the clear, winter water (AEA, 2011). The same results were found downriver at Susitna Station (RM 26).

Frenzel (2000) collected sediment samples from the Deshka River and Talkeetna River, as well as from Colorado Creek and Costello Creek, which are tributaries to the Chulitna River (Table 5.7-1). Based on these results, mercury concentrations in the drainage appear to be elevated over the national median, and appear to vary significantly by drainage. The report indicated that both Colorado and Costello Creeks appear to drain a portion of Denali National Park and Preserve that is highly mineralized, which likely causes the higher than background mercury concentrations. Previous studies (St. Louis et al. 1994) have shown that methylmercury occurrence is positively correlated with wetland density, and the Deshka River has significantly more wetlands in the drainage than other tributaries to the Susitna River.

Additional samples were collected by Frenzel (2000) of slimy sculpin from the Deshka River, Talkeetna River, and Costello Creek (Table 5.7-2). Whole fish samples tend to underestimate the presence of methylmercury, given that this compound concentrates in muscle tissue.

Samples of fish tissue and sediment from the Deshka River and Costello Creek were speciated for metallic mercury and methylmercury (Table 5.7-3). As anticipated, the ratio of methylmercury to inorganic mercury in the Deshka River is relatively high due to extensive wetlands in the drainage area. Costello Creek was found to have a higher inorganic mercury component due to possible mineralogical sources of mercury in the drainage area.

Overall mercury concentrations in water were also found to be positively correlated with the turbidity of the water. Very little mercury was found in filtered water samples (Frenzel 2000). This is consistent with methylmercury being strongly bound to organic particles.

These results are in agreement with the results from Krabbenhoft et al. (1999). In nationwide mercury sampling, in a wide array of hydrological basins and environmental settings, wetland density was found to be the most important factor controlling methylmercury production. It was also found that methylmercury production appears proportional to total mercury concentrations only at low total mercury levels. Once total mercury concentrations exceed 1,000 nanograms per gram (ng/g), little additional methylmercury was observed to be produced. Atmospheric deposition was found to be the predominant source for most mercury. Subbasins characterized as mixed agriculture and forested had the highest methylation efficiency, whereas areas affected by mining were found to be the lowest.

A more recent study has been done by the Alaska Department of Environmental Conservation's Department of Environmental Health (ADEC 2012). ADEC is currently analyzing salmon (all five species) as well as other freshwater species for total mercury in the Susitna River drainages (Table 5.7-4). These results appear to be consistent with those in other areas of the state.

5.7.3. Study Area

Water quality and sediment samples will be collected at the sites identified in Table 5.7-5. The study area begins at RM 10.1 and extends past the proposed dam site to RM 233.4. Tributaries to the Susitna River will be sampled and include those contributing large portions of the lower river flow such as the Talkeetna, Chulitna, Deshka, and Yentna rivers. Also included are smaller tributaries such as Gold, Portage, Tsusena, and Watana creeks, and the 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 mercury 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).

- Sites that are in the Susitna River mainstem, tributary, or slough locations, most of which were monitored in the 1980s.

Additional sample sites will be added at the focus areas **(ADDITIONAL DETAILS WILL BE ADDED IN RSP).**

Soil and vegetation samples will be collected from the proposed inundation area. Avian, terrestrial furbearers, and fish samples will be collected from a variety of drainages in the study area; however, the focus will be on the proposed inundation area for the dam to establish background concentrations of methylmercury in fish prior to site development.

5.7.4. Study Methods

This study was created to respond to comments from NMFS and USFWS, among other licensing participants. Originally the study components described here were spread into several other sections of the overall study plan. They have been consolidated here to provide an overview of the proposed mercury assessment and bioaccumulation plans.

This study consists of six study components:

- Summarize available information for the Susitna River basin, including data collection from the 1980s APA Susitna Hydroelectric Project, and existing geologic information to determine if a mineralogical source of mercury exists within the inundation area.
- Collect and analyze background vegetation, soil, water, sediment, sediment pore water, and avian, terrestrial furbearer, and fish tissue samples for mercury. This will include mapping vegetation types and the lateral extent, thickness, and mercury concentrations of soils within the proposed inundation area. These data will be used to provide background concentrations for mercury, but will also help evaluate potential mitigation methods (soil and vegetation removal) should that become necessary.
- Use the water quality model to predict where in the reservoir conditions (pH, dissolved oxygen, turnover) are likely to be conducive to methylmercury formation (see Section 5.6 of Revised Study Plan).
- Utilize specialty models to predict potential fish methylmercury concentrations.
- Assess potential pathways for mercury movement from different areas of methylmercury formation to the surrounding environment.
- Prepare a technical report on analytical results, modeling, and mercury pathway assessment.

5.7.4.1. Summary of Available Information

Existing literature will be reviewed to summarize the current understanding of the occurrence of mercury in the environment. Much of that work has already been performed as part of this work plan and during previous studies (URS 2011) for this project. This review will include the following:

- A summary of 1980s APA Susitna Hydroelectric Project water quality studies, including data.
- Data collected in Alaska by both USGS and ADEC.
- A summary of the findings during development of other cold region hydroelectric projects.

5.7.4.2. Collection and Analyses of Soil, Vegetation, Water, Sediment, Sediment Pore Water, Avian, Terrestrial Furbearer, and Fish Tissue Samples for Mercury

Data will be collected from multiple aquatic media including surface water, sediment, avian, terrestrial furbearer, and fish tissue. The collection of these samples will be handled as part of other media-specific study plans. Each of these study components is described in detail below. A Quality Assurance Project Plan/Sampling and Analysis Plan (QAPP/SAP) has been developed for the Mercury Assessment and Potential for Bioaccumulation Study (Attachment 5-3). This QAPP/SAP includes specific detail describing study design, sampling procedures, and determining quality of data collected that satisfy objectives. This document is a required document when generating environmental data intended for use in making regulatory decisions. The QAPP/SAP ensures that defensible and high quality data is generated in this study by establishing performance goals and a process for evaluation of each of the study elements.

5.7.4.2.1. Vegetation

The principal concern for the vegetation study is to determine the mass of organics and mercury concentrations in the reservoir area. Plant species differ in their ability to take up mercury. At the Red Devil and Cinnabar Creek mines, alders and willows concentrate mercury at levels as much as 20 times higher than those in the other species collected in this study (Baily and Gray 1997). The mechanism of mercury uptake and reason for variation in mercury uptake by species is unclear. Siegal et al. (1985, 1987) have suggested that some species are mercury accumulators, whereas other plant species release their absorbed mercury as mercury vapor and thus lower their total concentration of mercury. Overall, leaves and needles have been found to hold the greatest accumulations of mercury in Alaska plants (Baily and Gray 1997).

The degradation rate for organic materials in water seems to be a primary source of the spike in methylmercury concentrations after filling of a reservoir (Hydro-Quebec 2003). Only the green part of the vegetation (leaves of trees and shrubs as well as forest ground cover) and the top centimeters of humus decompose quickly. Tree branches, trunks and roots, as well as deeper humus, remain almost intact decades after flooding (Morrison and Thérien 1991). Previous studies by Hydro-Quebec have shown that woody debris, even if it contains mercury, is not a problem for mercury methylation because the decay rate is slow in cold water (Hydro-Quebec 2003).

Based on these studies, up to 50 samples will be collected from various plants within the proposed inundation area. Studies are currently being completed on the distribution of types of species in the inundation zone, and this information is currently unavailable. The sampling will be biased toward total vegetative mass, that is to say species that are present in the inundation area at low frequency and size may not be sampled, because even if these plants contain mercury, their contributions to mercury methylation will be low. Multiple samples (five to seven) will be collected at different locations for each species in the inundation area. Based on the available preliminary data, it is anticipated that a majority of the samples will consist of alder *(Alnus crispa),* willow *(Salix* sp.), white spruce *(Picea glauca),* cottonwood *(Populus balsamifera),* black spruce *(Picea mariana),* paper birch *(Betula papyrifera), and* dwarf birch *(Betula nana).* Leaves and needles will be collected.

Additional details of the sampling methods will be provided in a combined Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP) for this study.

5.7.4.2.2. Soil

Studies have found that the primary source of mercury to new reservoirs was the inundated soils (Meister et al. 1979), especially the upper organic soil horizon, which often has higher mercury levels than the lower inorganic soil layers (Bodaly et al. 1984). Measuring the thickness and mercury content of these soils prior to inundation may allow predictions of possible mercury methylation, and assist with evaluating potential mitigation methods, if necessary.

To the extent possible, soil samples will be coincident with vegetative samples. The primary concern is to document the thickness and extent of organic rich soils, because these soils will have the highest concentrations of mercury and will provide most of the organic material resulting in the generation of methylmercury.

Additional details of the sampling methods will be provided in a combined SAP and the QAPP for this study.

5.7.4.2.3. Water

The purpose of the water sampling is to collect baseline water quality information to support an assessment of the effects of the proposed Project operations on water quality in the Susitna River basin.

Mercury in water will be tested monthly during the summer because it has been shown to vary in concentrations throughout the year (Frenzel 2000). Two sampling events will also be performed during the winter.

Water samples will be collected at the locations shown on Table 5.7-5. The proposed spacing of the sample locations follows accepted practice when segmenting large river systems for development of Total Maximum Daily Load (TMDL) water quality models. Water sampling during winter months will be focused on locations where flow data are currently collected, or were historically collected by USGS. Water samples will be analyzed for the parameters reported in Table 5.7-6.

Grab samples will be collected during each site visit in a representative portion of the stream channel/water body, using methods consistent with Alaska state and EPA protocols for sampling ambient water and trace metal water quality criteria. Mainstem areas of the river not immediately influenced by a tributary will be characterized with a single grab sample. Areas of the mainstem with an upstream tributary that may influence the nearshore zone or that are well-mixed with the mainstem will be characterized by collecting samples at two locations: in the tributary and in the mainstem upstream of the tributary confluence. All samples will be collected from a well-mixed portion of the river/tributary.

These samples will be collected on approximately a monthly basis (four samples from June to September). The period for collecting surface water samples will begin at ice break-up and extend to beginning of ice formation on the river. Limited winter sampling (once in December, and again in March) will be conducted where existing or historic USGS sites are located.

Review of existing data (URS 2011) indicates that few exceedances occur with metals concentrations during the winter months. If the 2013 data sets suggest that mercury concentrations exceed criteria or thresholds, then an expanded 2014 water quality monitoring program will be conducted to characterize conditions on a monthly basis throughout the winter months.

Variation of water quality in a river cross-section is often 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. Cross-section profiles will be conducted for field water quality parameters (e.g., temperature, pH, dissolved oxygen, and conductivity) to determine the extent of vertical and lateral mixing. If conditions show that mixing is not nearly complete at a representative cross-section, then a flow-integrated sampling technique employed by USGS—known as the equal width increment/equal transit rate (EWI) method (Edwards and Glysson 1988; Ward and Harr 1990)—will be used. In this method, an isokinetic sampling device (a sampler that allows water to enter without changing its velocity relative to the stream) is lowered and raised at a uniform transit rate through equally-spaced vertical increments in the river cross-section. This can be done either by wading with hand-held samplers or from a boat using a winch-mounted sampler, depending on river stage and flow conditions. The number of vertical increments used will differ between sites depending upon site-specific conditions. The river conditions at most water quality monitoring locations prohibit wading, even though the USGS method cites this procedure. Application of transect measurements at many of the sites will only be applied where river conditions are safe enough to do so and may not be at ideal locations and times.

Additional details of the sampling methods will be provided in a combined SAP and the QAPP for this study.

5.7.4.2.4. Sediment and Sediment Pore Water

In general, all sediment samples will be 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 will be analyzed for mercury (Table 5.7-6). In addition, sediment size and total organic carbon (TOC) will be included to evaluate whether these parameters are predictors for elevated mercury concentrations. Samples will be collected just below and above the proposed dam site. Additional samples will be collected near the mouth of tributaries near the proposed dam site, including Fog, Deadman, Watana, Tsusena, Kosina, Jay, and Goose creeks, and the Oshetna River. The purpose of this sampling will be to determine where metals, if found in the water or sediment, originate in the drainage.

Mercury occurrence is typically associated with fine sediments, rather than with coarse-grained sandy sediment or rocky substrates. Therefore, the goal of the sampling will be to obtain sediments with at least 5 percent fines (i.e., particle size <63 µm, or passing through a #230 sieve).

Surficial sediment sampling will be conducted with a Van Veen sampler lowered from a boat by a power winch. This sampling device collects high-quality sediment samples from the top four to six inches of sediment. Three sediment samples will be collected at each of the sites sampled. These three samples will be collected and analyzed separately to characterize the presence of mercury and generate statistical summaries for site characterization. A photographic record of each sediment sample will be assembled from images of newly collected material.

Care will be taken to ensure the following:

- The sampler will not be overfilled with sediment.
- The overlying water is present when the sampler is retrieved.
- At least two inches of sediment depth is collected.
- There is no evidence of incomplete closure of the sampling device.

If a sediment sample does not meet all of the criteria listed above, it will be discarded and another sample will be collected.

Sediment interstitial water, or pore water, is defined as the water occupying the space between sediment particles. Interstitial waters will be collected from sites listed above and separated from sediments in the field house laboratory using a pump apparatus to draw pore water from each of the replicate samples. Filtering of samples will utilize a 0.45-µm pore size filter in both the lab apparatus and field apparatus. In some cases, pore water may be drawn from sediment samples in the field by using 100-milliliter (mL) syringes immersed in the dredge sample once a sediment sample is collected in a sample jar. These would be cases where sediment samples have slightly coarser particle sizes and pore water extraction in the field is possible. In other instances, where sediment samples have finer particle sizes requiring more time to draw samples for laboratory analysis, these samples will be transferred to the field laboratory for pore water extraction.

ADDITIONAL INFORMATION WILL BE ADDED ON FOCUS AREAS IN RSP

Additional details of the sampling methods will be provided in a combined SAP and QAPP for this study.

5.7.4.2.5 Avian – **ADDITIONAL INFORMATION WILL BE ADDED IN RSP**

5.7.4.2.6 Terrestrial Furbearers **ADDITONAL INFORMATION WILL BE ADDED IN RSP**

5.7.4.2.7. Fish Tissue

Methylmercury is ubiquitous in the environment, and can be found in fish throughout Alaska. The primary concern of this study is not to catalogue this source of mercury in the environment; rather, it is to evaluate the potential for increasing mercury concentrations above background due to filling of the reservoir.

Methylmercury bioaccumulates, and the highest concentrations are typically in the muscle tissue of adult predatory fish. Targeting adult fish is a good way of monitoring methylmercury migration to the larger environment. While it may be possible for methylmercury generated by the reservoir to affect other species, there does not appear to be any pathway by which this could happen without also affecting fish. Avian species have the potential to bypass fish by feeding on small fish species and macroinvertebrates; however, bird species can move between drainages and sources of mercury, and it is difficult to determine what contributions may be from the reservoir or from outside sources.

Target fish species in the vicinity of the Susitna-Watana Reservoir will be Dolly Varden, arctic grayling, stickleback, whitefish species, burbot, and resident rainbow trout. If possible, filets will be sampled from seven adult individuals from each species. The larger number of samples from existing fish species will allow for some statistical control over the results.

Salmon will not be sampled. Preliminary data suggests that approximately 30 Chinook (king) salmon spawn in the Watana area. Collecting a sufficient number of samples from this resource would seriously deplete it. Instead, sampling data from ADEC will be used to evaluate mercury concentrations in this resource (ADEC 2012). It should be noted that most of the mercury in salmon is oceanic in origin.

There is a well-known positive correlation between fish size (length and weight) and mercury concentration in muscle tissue (Bodaly et al. 1984; Somers and Jackson 1993). Larger, older fish tend to have higher mercury concentrations. These fish will be the targets for sampling.

Body size targeted for collection will represent the non-anadromous phase of each species life cycle. For stickleback, whole fish samples will need to be used. Collection times for fish samples will occur in late August and early September. Samples will be analyzed for methyl and total mercury (Tables 5.7-6). As previously stated, the study is prejudiced toward finding fish with the highest mercury concentrations that are drainage-specific.

Liver samples will also be collected from burbot and analyzed for mercury and methylmercury.

Field procedures will be consistent with those outlined in applicable Alaska state and/or EPA sampling protocols (USEPA 2000). Clean nylon nets and polyethylene gloves will be used during fish tissue collection. Species identification, measurement of total length (mm), and weight (g) will be recorded, along with sex and sexual. If possible, efforts will be made to determine the age of the fish, including an examination of otoliths and scales.

It is possible that adult fish of all species may not be present or available in the drainage. In this case, younger fish may be sampled. To eliminate the bias associated with differences in fish size, appropriate statistical procedures will be used to determine the mean mercury concentration for a specific fish size (Hydro Quebec 2003).

Additional details of the sampling methods will be provided in a combined SAP and the QAPP for this study.

5.7.4.3. **Modeling**

Reservoir impoundments have been documented to cause significant increases in fish mercury levels by factors that generally ranged from 3 to 7 (Hydro-Quebec 2003). The phenomenon is temporary, and mercury concentrations generally returned to baseline values after 7 to 30 years.

Reservoir construction involves raising the water level and flooding a large quantity of terrestrial organic matter (vegetation and the surface layers of soils). During the early years of a reservoir's existence, this organic matter is subject to accelerated bacterial decomposition, which increases methylation of the mercury accumulated in the soil from the atmosphere. The production of methylmercury is governed by the amount and type of flooded organic matter and by biological and physical factors such as bacterial activity, water temperature, oxygen content of the water, etc.

Part of the methylmercury produced is released into the water column where it may be transferred to fish via zooplankton. Insect larvae feeding in the top centimeters of flooded soils can assimilate the methylmercury available and transfer it to fish (Figure 5.7-2).

There is evidence that mercury concentrations in fish correlate closely with environmental parameters such as pH (Qian et al. 2001; Ikingura and Akagi 2003), organic carbon (Cope et al. 1990; Suns and Hitchin 1990; Driscoll et al. 1995), and wetland area (Greenfield et al. 2001). However, because fish assimilate the vast majority of their mercury burden from their diet, such correlations are indirect (Westcott and Kalff 1996; Lawson and Mason 1998). It is, however, possible to predict the potential for mercury methylation based on the pH, dissolved oxygen content, organic carbon, and wetland area of an individual drainage.

There are several ways to predict the occurrence of methylmercury in a newly formed reservoir. One way is to model the physical conditions that create methylation of mercury. If the conditions for methylation are present (low DO, low pH, organic content, etc.), then it is presumed that methylation will occur, and the methylmercury will be transferred outside the reservoir. This type of modeling will be done as part of the model for the reservoir (see Section 5.6 Water Quality Modelign Study). This type of modeling does not predict specific impacts to the ecosystem, but merely suggests that such impacts could occur, and where in the reservoir methylmercury may be forming. Such an approach has considerable value in evaluating potential mitigation measures.

The other way of predicting the occurrence of methylmercury is to model concentrations in fish tissue after filling of the reservoir. Schetagne et al. (2003) found a strong correlation between the ratio of flooded area, the mean annual flow through of the reservoir, and maximum mercury concentrations in fish tissue. This approach was further refined by Harris and Hutchinson (2008) to provide a predictive tool for methylmercury concentrations in fish. Regression calculations using historical data from multiple reservoirs have determined the coefficients that control these equations. The drawback to these models is that they only predict peak methylmercury concentrations, not when these concentrations will occur or subside.

Phosphorous release modeling is a semi-empirical way to derive the same result, but has the added benefit of being able to predict when peak methylmercury concentrations will occur, and when they are likely to subside (Hydro-Quebec 2003). Unfortunately, they require considerably more input parameters, which can create additional uncertainty in the results.

5.7.4.3.1. Harris and Hutchison Model

The model assumes that the primary source of methylmercury in a new reservoir is the flooded terrain, while the primary methylmercury removal mechanism is outflow/dilution. The highest methylmercury concentrations in fish are therefore associated with reservoirs that flood large areas, but have low flow-through.

The formula is as follows:

$$\text{Peak Increase factor} = 1 + K_1 * \frac{\text{Area flooded}}{Q + K_2\,(\text{Area total})}$$

Where

Peak increase factor = peak increase factor in fish methylmercury over background

Area flooded = flooded area (km^2)

Q = mean annual flow (km^3/yr.)

K_1 = regression coefficients (km/yr.)

K_2 = regression coefficients (1/yr.)

Area total = Total reservoir area (km^2)

The values of K1 and K2 are adjusted for piscivorous and non-piscivorous species of fish. The use of area in the denominator reflects an assumption that methylmercury removal mechanisms other than outflow are primarily related to area (e.g., photodegradation, burial and sediment demethylation) rather than volume. This approach has been calibrated and tested in the field, with good results (Harris and Hutchinson 2008). This method will be used to estimate methylmercury concentrations in fish at the proposed reservoir.

5.7.4.3.2. Phosphorous Release Model

The more complex method of estimating methylmercury impacts was pioneered by Messier et al. (1985) based on the phosphorus release model of Grimard and Jones (1982), and has been confirmed by decades-long studies of reservoirs by Hydro-Quebec (2003).

Studies have shown that a simple model cannot explain all the differences observed between reservoirs with regard to maximum fish mercury levels (Hydro-Quebec 2003). The filling time is another important factor in determining the maximum levels in fish; several authors have demonstrated that mercury is released into the water column very rapidly when organic matter from soils and vegetation is flooded (Morrison and Thérien 1991; Kelly et al. 1997). Chartrand et al. (1994) showed that the changes in reservoir water quality correspond to bacterial decomposition of organic matter (as does mercury release) and peak two or three years after impoundment in reservoirs filled in one year or less, but after six to ten years in impoundments that took 35 months to fill. Thus, a longer filling time leads to lower peak values, but prolongs the period of elevated mercury levels.

The percentage of flooded land area located in the drawdown zone is another important factor because it is an indicator of the active transfer of methylmercury to fish by periphyton and benthic organisms. In fact, this transfer can occur for over 14 years in shallow areas that are rich in flooded organic matter and protected from wave action (Tremblay and Lucotte 1997). Where forest soil cover is thin, wave action along the exposed banks of the drawdown zone quickly erodes the mercury-rich organic matter and deposits it in deeper, colder areas that are less conducive to methylation. This erosion considerably reduces the area of flooded soil that still has organic matter colonized by the benthic organisms responsible for much of the transfer of methylmercury to fish. Therefore, the larger the percentage of flooded land area in a reservoir drawdown zone, the smaller and shorter in duration the increase in fish mercury levels is likely to be. Colder water and the vegetation and soil cover that contained less decomposable organic matter (Association Poulin Thériault-Gauthier & Guillemette Consultants Inc. 1993) may also help mitigate the increase in fish mercury levels.

The Hydro-Quebec model is semi-empirical, not mechanistic: decaying organic material releases phosphorous at a set rate (the phosphorus release curve), which controls decomposition of the organic material in the inundation zone. This turns out to be a fairly accurate measure of the bioavailability of mercury for fish, and can be used to predict mercury concentrations in muscle tissues.

The basic equation used by Hydro-Quebec is as follows:

$$V(P_r)_t = \frac{P_i}{Ø} * (1-e^{-Øt}) + \frac{rB}{\alpha - r} * \left(\frac{e^{-rt}-e^{-Øt}}{Ø-r} + \frac{e^{-Øt}-e^{-\alpha t}}{Ø-r}\right) + V(P_r)_0 e^{-Øt}$$

Where:

V	=	Reservoir volume (m^3)
P_r	=	Concentration of total phosphorous in the reservoir at time t (mg/m^3)
t	=	time in years after reservoir filling
Pi	=	Total phosphorous from inflows (mg/yr.)
Ø	=	The sum of the sedimentation coefficient and the flushing coefficient (r)
r	=	The reservoir flushing coefficient (per year)
α	=	The phosphorous release coefficient = ½(365/X)
X	=	The half-life of the organic matter in days
B	=	$\alpha(I_t)S_{max}$
S_{max}	=	Maximum surface area flooded (m^3)
T	=	Time (year)

When solved for Pr, this allows for the calculation of the amount of decomposable organic matter (mgC/m2) at a specific time (It), calculated by:

$$I_t = (P_r)_0 + \ * 4((Pr)_t - (P_r)_0)$$

Where It is the decomposition factor at the time t. This result can then be used to calculate mercury concentrations in non-piscivorous (NP) species and piscivorous (P) species of fish:

$$(Hg_{np})_t = (Hg_{np})_{t-1} * \left(\frac{1}{2^{365/u}}\right) + dI_t$$

Where:

Hg_{np} = mercury concentration in non-piscivorous muscle tissue (mg/kg)
u = half-life of mercury in fish (days). This is typically set at 700 days in northern climates, but can be adjusted.
d = a transfer factor

For the predatory species, the decomposition factor was replaced by a factor (f) for mercury transfer from the prey to the predator:

$$(Hg_p)_t = (Hg_p)_{t-1} * \frac{(1)}{(2^{365/u})} + f(Hg_{np})_t$$

Where Hgp = mercury concentration in piscivorous muscle tissue.

These formulas have been tested, and found to be very effective in predicting mercury concentrations in fish tissue (Figure 5.7-2). Note that the predictions generally tend to overestimate the changes actually recorded. This situation reflects a conscious choice on the part of the developers of the formula to be conservative with their predictions.

The phosphorous release model will be used if the previous methods (the water quality model or the Harris and Hutchison model) suggest there may be significant methylmercury production in the reservoir.

5.7.4.4. Pathway Assessment

Assessment of the potential pathways for mercury in the environment will be based on readily available literature (Hydro-Quebec 1993; Johnston et al. 1991; Therriault and Schneider 1998), and additional mercury studies, to ensure the most applicable methods are used to meet Project needs. The goal of the pathway assessment will be to evaluate the potential pathways for methylmercury to move into the ecosystem, both from the reservoir and downstream of the reservoir.

The pathway assessment will incorporate both existing conditions, and conditions with the reservoir and dam in place. The reservoir representation will be developed based on the local bathymetry and dimensions of the proposed dam. The Water Quality Modeling Study (Section 5.6) provides for a three-dimensional model to be developed for the proposed reservoir to represent the spatial variability in hydrodynamics and water quality in longitudinal, vertical, and lateral directions. The model will be able to simulate flow circulation in the reservoir, turbulence mixing, temperature dynamics, nutrient fate and transport, interaction between nutrient and algae, and potentially sediment and metal transport.

5.7.4.5. Technical report on Analytical Results and Mercury Assessment

The technical report will include a description of the study goals and objectives, assumptions made, sample methods, analytical results, models used, and other background information. Field data, laboratory report, and quality assurance information will be attached. Mercury will be modeled using two methods:

1. Water quality modeling of the reservoir will predict whether the conditions for the formation of methylmercury will be present, and where in the reservoir this may occur.
2. The linear model of Harris and Hutchinson (2008) to provide an initial prediction of peak mercury concentrations in fish.

The phosphorous release model may be used if there is a need to evaluate when peak methylmercury production may occur.

The report will include a conceptual model showing mercury inputs to the reservoir, mercury methylation, mercury circulation among different media (fish, air, water, sediment, etc.), and bioabsorption and transfer. Strategies to manage mercury methylation, bioaccumulation, and biomagnification will be reviewed (Mailman et al. 2006).

Sediment, water, and tissue results from toxics analysis will use the federal NOAA Screening Quick Reference Tables (SQuiRTs). These are thresholds used as screening values for evaluation of toxics and potential effect to aquatic life in several media and will be implemented where ADEC water quality, sediment, or tissue criteria are not available.

An example for SQuiRT values can be found at the following web site:

http://mapping2.orr.noaa.gov/portal/sanfranciscobay/sfb_html/pdfs/otherreports/squirt.pdf

Specific thresholds and criteria for toxics in each of the media will be included in a QAPP.

Coordination will occur with the instream flow, ice processes, productivity, and fish studies to obtain information needed to reflect the results of this study in the context of the various Project scenarios.

5.7.5. Consistency with Generally Accepted Scientific Practice

Field sampling practices proposed in this study are consistent with ADEC (2003, 2005); USGS (Ward and Harr 1990); Edwards and Glysson 1988); and EPA (USEPA 2000). Results will be compared to established NOAA cleanup levels (NOAA 2012). Studies, field investigations, laboratory testing, engineering analysis, etc. will be performed in accordance with general industry-accepted scientific and engineering practices. The methods and work efforts outlined in this study plan are the same or consistent with analyses used by applicants and licensees and relied upon by FERC in other hydroelectric licensing proceedings.

The Clean Water Act Section 401 Water Quality Certification process includes a baseline assessment of mercury conditions and will determine if existing conditions will result in a potential for bioaccumulation. The monitoring strategy used in this study follows scientifically accepted practice for identifying impacts to water quality and will be used for Project certification. ADEC and USGS are currently pursing similar sampling programs for fish tissue in the state (ADEC 2012; Frenzel 2000; and Krabbenhoft et al. 1999).

FERC has a long history of performing similar studies during hydroelectric permitting, including most recently at the Middle Fork American River Project (FERC Project No. 2079) in 2011; and Yuba County Water Agency Yuba River Development Project (FERC Project No. 2246).

5.7.6. Schedule

The study elements will be completed in several stages and based on the timeline shown below.

Table 5.7-7. Schedule for Implementation of the Mercury Assessment and Potential for Bioaccumulation Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Water Quality Monitoring (monthly)						—	—	—	—				
Soil and Vegetation Sampling							—						
Sediment Sampling							—						
Avian and Furbearer Studies							—						
Fish Tissue Sampling			—				—						
Data Analysis and Management								—	—				
Initial Study Report									Δ				
Follow-up studies (as needed)									--------	--------	---------		
Updated Study Report													▲

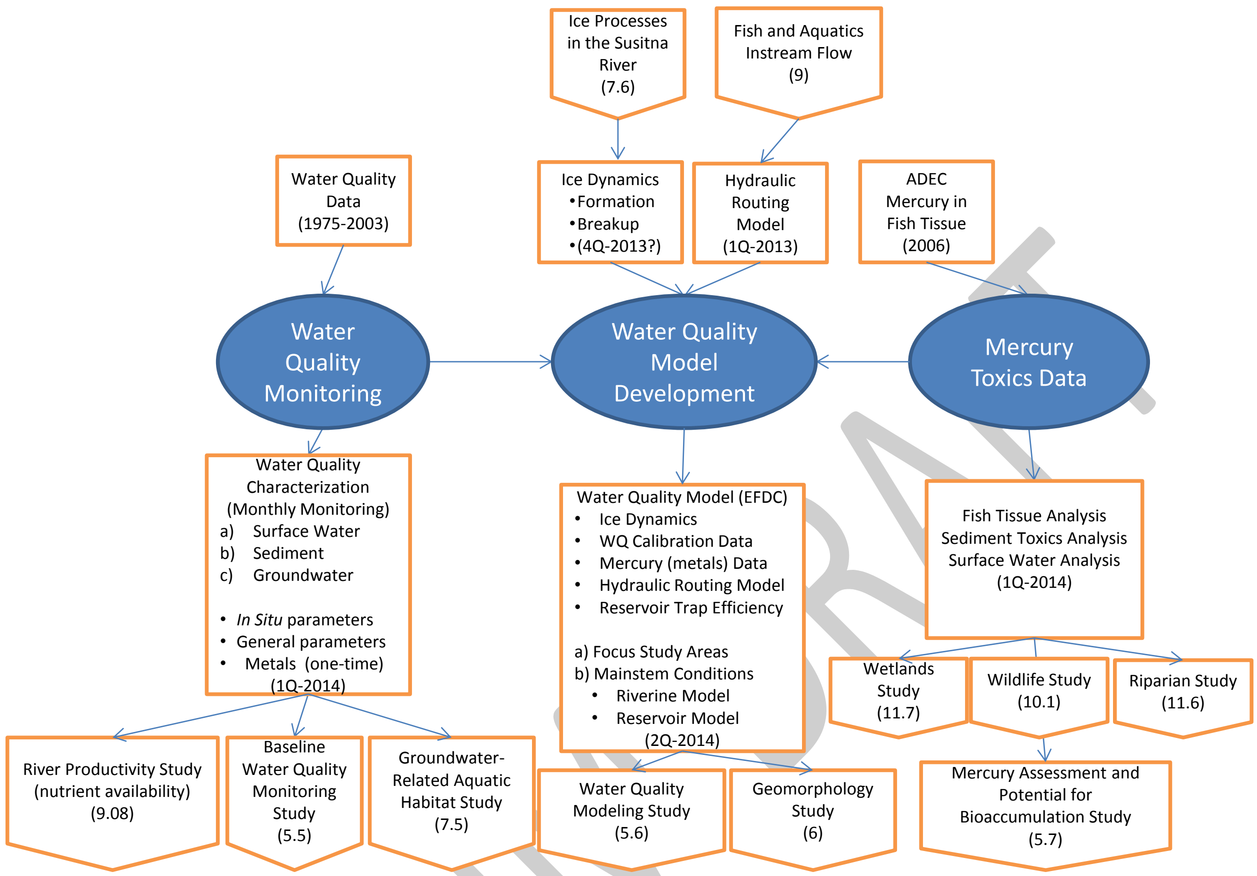
Legend:

—— Planned Activity
Δ Initial Study Report
▲ Updated Study Report

A flow chart describing interdependencies (below) outlines origin of existing data and related historical studies, specific output for each element of the Water Resources studies, and where the output information generated in the Water Resources studies will be directed. This chart provides details describing the flow of information related to the Water Resources studies, from historical data collection to current data collection. Data were examined in a Water Quality Data Gap Analysis the previous year (URS 2011) and this information was used, in part, to assist in making decisions about the current design for the Baseline Water Quality Monitoring Study and for ensuring that the current modeling effort would be able to compare the 1980s study results with current modeling results.

Integral portions of this interdependency chart are results from the Ice Processes Study and from the Fish and Aquatic Instream Flow Study. The Ice Processes Study will support water quality model development (Study Plan 5.6) with information about timing and conditions for ice formation and ice break-up. The Fish and Aquatic Instream Flow Study represents the effort to develop a hydraulic routing model that will be coupled with the EFDC water quality model. Water quality monitoring efforts for field parameters, general chemistry, and metals (including mercury) will be used as a calibration data set for developing the predictive EFDC model.

INTERDEPENDENCIES FOR WATER RESOURCES STUDIES



5.7.7. Level of Effort and Cost

UNDER REVISION

The following are costs associated with individual tasks for conducting mercury baseline monitoring in the Susitna basin for 2013–2014:

Planning ($70,000)

Sampling ($400,000)

Data Analysis ($250,000)

Reporting ($100,000)

5.7.8. Literature Cited

ADEC. 2005. Water Quality Assessment and Monitoring Program. Alaska Department of Environmental Conservation: Division of Water. Juneau, Alaska. 58p.

ADEC. 2012. Mercury concentration in fresh water fish Southcentral Susitna Watershed. Personal communication with Bob Gerlach, VMD, State Veterinarian. June 2012.

Alaska Energy Authority (AEA). 2011. Pre-Application Document: Susitna-Watana Hydroelectric Project FERC Project No. 14241. Volume I of II. Alaska Energy Authority, Anchorage, AK. 395p.Arctic

Environmental Information and Data Center (AEIDC), 1985. Preliminary draft impact assessment technical memorandum, Volume 1. Main text.

Association Poulin Thériault - Gauthier & Guillemette Consultants Inc. 1993. *Méthode de caractérisation de la phytomasse appliquée aux complexes Grande-Baleine et La Grande*. Report by Association Poulin Thériault - Gauthier & Guillemette Consultants Inc. for Hydro-Québec. 152 p. and appendices.

Bailey, E.A., and Gray, J.E. 1997. Mercury in the terrestrial environment, Kuskokwim Mountains region, southwestern Alaska, in Dumoulin, J.A. and Gray J.E., ed., Geologic studies in Alaska by the U.S. Geological Survey, 1995: U.S. Geological Survey, Professional Paper 1574, p. 41-56.

Bodaly R.A., Hecky R.E., Fudge R.J.P. 1984. Increases in fish mercury levels in lakes flooded by the Churchill River Diversion, Northern Manitoba. *Can. J. Fish. Aquat. Sci.* 41:682-691.

Bodaly, R.A., St. Louis, V.L., Paterson, M.J., Fudge, R.J.P., Hall, B.D., Rosenberg, D.M., and Rudd, J.W.M., 1997, Bioaccumulation of mercury in the aquatic food chain in newly flooded areas, in Sigel, A., and Sigel, H., eds., Metal ions in biological systems: Mercury and its effects on environment and biology: New York, Marcel Decker, Inc., p. 259-287.

Bodaly R.A., Beaty K.G., Hendzel L.H., Majewski A.R., Paterson M.J., Rolfhus K.R., Penn A.F., St. Louis V.L., Hall B.D., Matthews C.J.D., Cherewyk K.A., Mailman M., Hurley, J.P., Schiff S.L., Venkiteswaran J.J., 2004. Experimenting with hydroelectric reservoirs, Environmental Science & Technology, American Chemical Society. pp. 346A-352A.

Bodaly R.A., Jansen W.A., Majewski A.R., Fudge R.J.P., Strange N.E., Derksen A.J., Green D.J. 2007. Post impoundment time course of increased mercury concentrations in fish in hydroelectric reservoirs of Northern Manitoba, Canada. Arch. Environ. Con tam. Toxicol. 53:379-389.

Chartrand, N., Schetagne, R., Verdon, R. 1994. *Enseignements tirés du suivi environnemental au complexe La Grande*. 18th Congress of the International Commission on Large Dams, Durban (South Africa). Paris: International Commission on Large Dams. p. 165-190.

Cope, W.G., Wiener, J.G., and Rada, R.G. 1990. Mercury accumulation in yellow perch in Wisconsin seepage lakes — relation to lake characteristics. Environ. Toxicol. Chem. 9: 931–940.

Driscoll, C.T., Blette, V., Yan, C., Schofield, C.L., Munson, R., and Holsapple, J. 1995. The role of dissolved organic carbon in the chemistry and bioavailability of mercury in remote Adirondack lakes. Water Air Soil Pollut. 80: 499–508.

Edwards, T.K., and D.G. Glysson. 1988. Field methods for measurement of fluvial sediment. U.S. Geological Survey Open-File Report 86-531, 118 p.

Engstrom, D.R., and Swain, E.B. 1997, Recent declines in atmospheric mercury deposition in the Upper Midwest: Environmental Science and Technology, v. 31, no. 4, p. 960-967.

Fitzgerald, W.F., Engstrom, D.R., Mason, R.P., and Nater, E.A. 1998. The case for atmospheric mercury contamination in remote areas: Environmental Science and Technology, v. 32, no. 1, p. 1-7.

Frenzel, S.A. 2000. Selected Organic Compounds and Trace Elements in Streambed Sediments and Fish Tissues, Cook Inlet Basin, Alaska. USGS Water-Resources Investigations Report 00-4004. Prepared as part of the National Water-Quality Assessment Program.

Gray J.E., Theodorakos P.M., Bailey E.A., Turner R.R., 2000. Distribution, speciation, and transport of mercury in stream-sediment, stream-water, and fish collected near abandoned mercury mines in southwestern Alaska, USA. Science of the Total Environment 260:21- 33.

Greenfield, B.K, Hrabic T.R., Harvey C.J. Carpenteer S.R. 2001. Predicting mercury levels in yellow perch. Use of water chemistry, tropi ecology and spatial traits. Can J. Fish Aquat. Scie. Vol 58 : 1419 –1429.

Grigal D.F., 2003. Mercury sequestration in forests and peatlands: a review. *Journal of Environmental Quality* 32:393-405.

Grimard, Y., Jones, H. G. 1982. Trophic upsurge in new reservoirs: a model for total phosphorous concentration, *Canadian Journal of Fisheries and Aquatic Sciences*, Vol. 39 (1982). p. 1473-1483.

Hall, B.D., Rosenberg D.M., Wiens A.P. 1998. Methylmercury in aquatic insects from an experimental reservoir. *Can. J. Fish. Aquat. Sci*. 55:2036-2047.

Harris, R., and Hutchinson, D., 2008. Lower Churchill Hydroelectric Generation Project Environmental Baseline Report: Assessment of the Potential for Increased Mercury Concentrations. Prepared by Tetra Tech Inc. March 4, 2008.

Hydro-Quebec. 1993. Grande-Baleine complex. Feasibility study. Part 2: Hydroelectric complex. Book 6: Mercury, Hydro-Quebec, Montreal, Quebec.

Hydro-Quebec. 2003. Environmental Monitoring at the La Grande Complex Summary Report 1978–2000: Evolution of Fish Mercury Levels. Joint Report: Direction Barrages et Environment Hydro-Quebec Production and Groupe Conseil, Genivar Inc. December 2003.

Ikingura, J.R., and Akagi, H. 2003. Total mercury and methylmercury levels in fish from hydroelectric reservoirs in Tanzania. Sci. Total Environ. 304: 355–368.

Johnston, T.A., Bodaly R.A., Mathias J.A. 1991. Predicting fish mercury levels from physical characteristics of boreal reservoirs. Can. J. Fish. Aquat. Sci. 48:1468-1475.

Kabata-Pendias, A., Pendias H., 1992. Trace elements in soils and plants. 2nd ed. CRC Press, Inc., Boca Raton, Florida, pp. 365.

Kelly C.A., Rudd J.W.M., Bodaly R.A., Roulet N.P., St. Louis V.L., Heyes A., Moore T.R., Schiff S., Aravena R., Scott K.J., Dyck B., Harris R., Warner B., Edwards G. 1997. Increases in fluxes of greenhouse gases and methylmercury following flooding of an experimental reservoir. Environmental Science & Technology 31:1334-1344.

Krabbenhoft, D.P., Wiener, J.G., Brumbaugh, W.G., Olson, M.L., DeWild, J.F., and Sabin, T.J. 1999. A national pilot study of mercury contamination of aquatic ecosystems along multiple gradients, in Morganwalp, D.W., and Buxton, H.T., eds., U.S. Geological Survey Toxic Substances Hydrology Program—Proceedings of the Technical Meeting, Charleston, South Carolina, March 8-12, 1999—Volume 2, Contamination of hydrologic systems and related ecosystems: U.S. Geological Survey Water-Resources Investigations Report 99-4018B, p. 147-162.

Lawson, N.M., and Mason R.P. 1998. Accumulation of mercury in estuarine food chains. *Biogeochemistry*. 40:235–247.

Lindberg, S., Bullock, R., Ebinghaus, R., Engstrom, D., Feng, X., Fitzgerald, W., Pirrone, N., Prestbo, E., and Seigneur, C., 2007. A synthesis of progress and uncertainties in attributing the sources of mercury in deposition: Ambio, v. 36, no. 1, p. 19-32.

Lindqvist, O., 1991. Mercury in the Swedish environment: 9. Mercury in terrestrial ecosystems bioavailability and effects. Water, Air, and Soil Pollution, 55(1–2):101–108.

Lockhart, W.L., Stem G.A., Low G., Hendzel M., Boila G., Roach P., Evans M.S., Billeck B.N., DeLaronde J., Friesen S., Kidd K.A., Atkins S., Muir D.C.G., Stoddart M., Stephens G., Stephenson S., Harbicht S., Snowshoe N., Grey B., Thompson S., DeGraff N., 2005. A history of total mercury in edible muscle of fish from lakes in northern Canada. Science of the Total Environment 351-352:427-463.

Mailman, M., Stepnuk L., Cicek N., Bodaly R.A. 2006. Strategies to lower methylmercury concentrations in hydroelectric reservoirs and lakes: A review. Science of the Total Environment 368:224-235.

Meister, J.F., DiNunzio J., Cox J.A. 1979. Source and level of mercury in a new impoundment. *Journal of the American Water Works Association* 71:574-576.

Messier, D., Roy, D. and Lemire R., 1985. Reseau de surveillance ecologique du complexe La Grande 1978-1984. Evolution du mercure dans la chair des poissons. Societe d'energie de la Baie James. 179 pages.

Morrison, K. and Thérien, N. 1991. Influence of Environmental Factors on Mercury Release in Hydroelectric Reservoirs, Montréal, Quebec, Canadian Electrical Association, 122 p.

Morrison, K., Thérien, N. 1991b. Experimental evolution of mercury release from flooded vegetation and soil. Water, Air and Soil Pollution, Vol. 56 (1991). p. 607-619.

National Oceanic and Atmospheric Administration (NOAA). 2012. Screening Quick Reference Tables (SQuiRTs), National Oceanic and Atmospheric Administration, Office of Response and Restoration, http://response.restoration.noaa.gov/sites/default/files/SQuiRTs.pdf.

Qian, S.S., Warren-Hicks, W., Keating, J., Moore, D.R.J., and Teed, R.S. 2001. A predictive model of mercury fish tissue concentrations for the southeastern United States. Environ. Sci. Technol. 35: 941–947.

Rosenberg, D.M., Berkes F., Bodaly R.A., Hecky R.E., Kelly C.A., Rudd J.W.M. 1997. Large scale impacts of hydroelectric development. Environ. Rev. 5:27-54.

Rylander, L.D., Grohn J., Tropp M., Vikstrom A., Wolpher H., De Castro e Silva E., Meili M., Oliveira L.J. 2006. Fish mercury increase in Lago Manso, a new hydroelectric reservoir in tropical Brazil. *Journal of Environmental Management* 81:155-166.

Saiki, M.K., and Martin, B.A. 2010. Mercury concentrations in fish from a Sierra Nevada foothill reservoir located downstream from historic gold-mining operations Environ. Monit. Assess 163:313–326.

Schetagne, R., J. Therrien, J. and R. Lalumière. 2003. Environmental Monitoring at the La Grande Complex. Evolution of Fish Mercury Levels. Summary Report 1978–2000. Direction Barrages et Environment, Hydro-Québec Production and Groupe Conseil GENIVAR inc. 185 p. and appendix.

Shacklette, H.T., and Boerngen, J.G. 1984. Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States. USGS Professional Paper 1270.

Siegal, S.M., Siegal, B.Z., Lipp, C., Kruckeberg, A., Towers, G.H.N., and Warren, H. 1985. Indicator plant-soil mercury patterns in a mercury-rich mining area of British Columbia: Water, Air, and Soil Pollution, v. 25, p. 73-85.

Siegal, S.M., Siegal, B.Z., Barghigiani, C., Aratani, K.. Penny, P., and Penny, D., 1987. A contribution to the environmental biology of mercury accumulation in plants: Water, Air, and Soil Pollution, v. 33, p. 65-72.

Somers, K.M. and D.A. Jackson. 1993. Adjusting mercury concentration for fish-size covariation: a multivariate alternative to bivariate regression. Can. J. Fish. Aquat. Sci. 50: 2388-2396.

St. Louis, V. L., Rudd, J.W.M, Kelly, C.A., Beaty, K.G., Bloom, N.S. and Flett, R.J. 1994. The importance of wetlands as sources of methylmercury to boreal forest ecosystems. Can. J. Fish. Aquat. Sci. 51: 1065–1076.

Suns, K., and Hitchin, G. 1990. Interrelationships between mercury levels in yearling yellow perch, fish condition and water-quality. Water Air Soil Pollut. 50: 255–265.

Swain, E.B., Engstrom, D.R., Brigham, M.E., Henning, T.A., and Brezonik, P.L. 1992. Increasing rates of atmospheric mercury deposition in midcontinental North America: Science, v. 257, p. 784-787.

Therriault, T.W. and Schneider, D.C. 1998. Predicting change in fish mercury concentrations following reservoir impoundment. Environmental Pollution 101:33-42.

Tremblay, A. and Lucotte, M. 1997. Accumulation of total mercury and methylmercury in insect larvae of hydroelectric reservoirs. Can. J. Fish. Aquat. Sci. 54: 832-841.

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.

U.S. Environmental Protection Agency (USEPA). 1997. Mercury Study Report to Congress Volume I: Executive Summary. December 1997. EPA-452/R-97-003.

USEPA. 2000. Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories: Volume 1 Fish Sampling and Analysis, 3rd Edition. EPA-823-B-00-007. United States Environmental Protection Agency, Office of Water. Washington, D.C. 485p.

Ward J.C., Harr, C.A. 1990. Methods for collection and processing of surface-water and bed material samples for physical and chemical analyses. U.S. Geological Survey Open-File Report 90-140. 71.

Westcott, K. and Kalff, J. 1996. Environmental Factors Affecting Methyl Mercury Accumulation in Zooplankton. Can. J. Fish. Aquat. Sci. 53: 2221–2228.

Wiener, J.G., Knights, B.C., Sandheinrich, M.B., Jeremiason, J.D., Brigham, M.E., Engstrom, D.R., Woodruff, L.G., Cannon, W.F., and Balogh, S.J. 2006. Mercury in soils, lakes, and fish in Voyageurs National Park (Minnesota)—Importance of atmospheric deposition and ecosystem factors: Environmental Science and Technology, v. 40, p. 6261-6268.

5.7.9. Tables

Table 5.7-1

Sediment Results from the Susitna River Drainage

Location	Mercury (µg/g dry weight)
Talkeetna River	0.04
Deshka River	0.46
Colorado Creek	0.18
Costello Creek	0.23
National median value	0.06

From Frenzel (2000)

Table 5.12-2

Whole Body Slimy Sculpin Results from the Susitna River Drainage

Location	Mercury (µg/g dry weight)
Talkeetna River	0.08
Deshka River	0.11
Costello Creek	0.08

From Frenzel (2000)

Table 5.7-3

Speciated Mercury Results from Susitna River Drainage (µg/g dry weight)

Location	Sediment		Fish	Water	
	Inorganic mercury	Methylmercury	Inorganic mercury	Inorganic mercury	Methylmercury
Deshka River	0.021	0.00510	0.246 (SS)	Not sampled	Not sampled
Costello Creek	0.169	0.00004	0.101 (DV)	0.00497	0.00002

SS = whole slimy skulpin
DV = dolly varden fillet
From Frenzel (2000)

Table 5.7-4
Summary of ADEC Data for Mercury in Fish Tissue
Susitna River Drainage

Species	Number of Samples	Mean	Std. Deviation
Arctic Char	3	0.21000	0.052915
Burbot	1	0.09400	0
Grayling	18	0.10239	0.033477
Northern Pike	98	0.21071	0.206272
Salmon – Pink	16	0.25813	0.051279
Salmon – Red	14	0.02907	0.017398
Salmon – Silver	5	0.09520	0.053905
Stickleback – Nine Spine*	1	0.07600	0
Stickleback – Three Spine*	2	0.07350	0
Lake Trout	3	0.38000	0.319531
Rainbow Trout	27	0.11187	0.086007
Whitefish - Round	7	0.10929	0.048623

*Concentrations in mg/kg. * indicates sample analyzed as whole body composite sample. All other fish samples analyzed as skinless fillets. Samples that were below detection limits were listed as 1/2 of detection limit. NOTE: If Std. Dev. is listed as 0, all the samples were below detection limits (ADEC, 2012).*

Table 5.7-5. Proposed Susitna River Basin Mercury Monitoring Sites

Susitna River Mile	Description	Susitna River Slough ID	Latitude (decimal degrees)	Longitude (decimal degrees)
25.8	Susitna Station	NA	61.5454	-150.516
28.0	Yentna River	NA	61.589	-150.468
29.5	Susitna above Yentna	NA	61.5752	-150.248
40.6	Deshka River	NA	61.7098	-150.324
55.0	Susitna	NA	61.8589	-150.18
83.8	Susitna at Parks Highway East	NA	62.175	-150.174
97.2	Talkeetna River	NA	62.3418	-150.106
98.5	Chulitna River	NA	62.5574	-150.236
103.0	Talkeetna	NA	62.3943	-150.134
120.7	Curry Fishwheel Camp	NA	62.6178	-150.012
136.8	Gold Creek	NA	62.7676	-149.691
138.6	Indian River	NA	62.8009	-149.664
138.7	Susitna above Indian River	NA	62.7857	-149.651
148.8	Susitna above Portage Creek	NA	62.8286	-149.379
148.8	Portage Creek	NA	62.8317	-149.379
184.5	Susitna at Watana Dam site	NA	62.8226	-148.533
223.7	Susitna near Cantwell	NA	62.7052	147.538

Table 5.7-6. List of parameters and frequency of collection.

Media	Analyses	Frequency of Collection	Holding Time
Surface Water, sediment pore water	Total and methylmercury (EPA-7470A)	Monthly	48 hours
Soil, Sediment	Total mercury (EPA 245.2/7470A)	One Survey-summer	28 days
Avian, Terrestrial Furbearers, and Fish Tissue	Total and methylmercury (EPA-1631)	One Survey-late summer	7 days

5.7.10. Figures

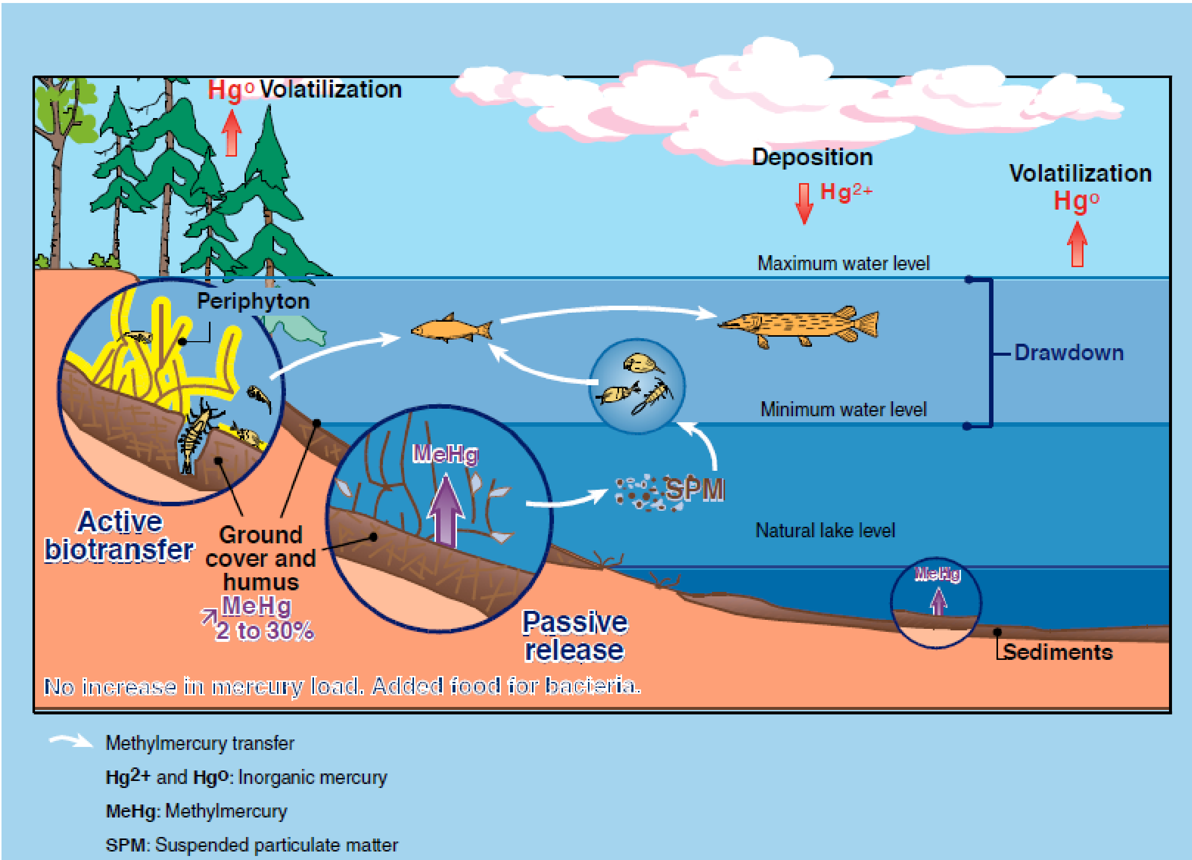


Figure 5.7-1. Transfer of Methymercury to Fish Shortly after Impoundment from Hydro-Quebec (2003).

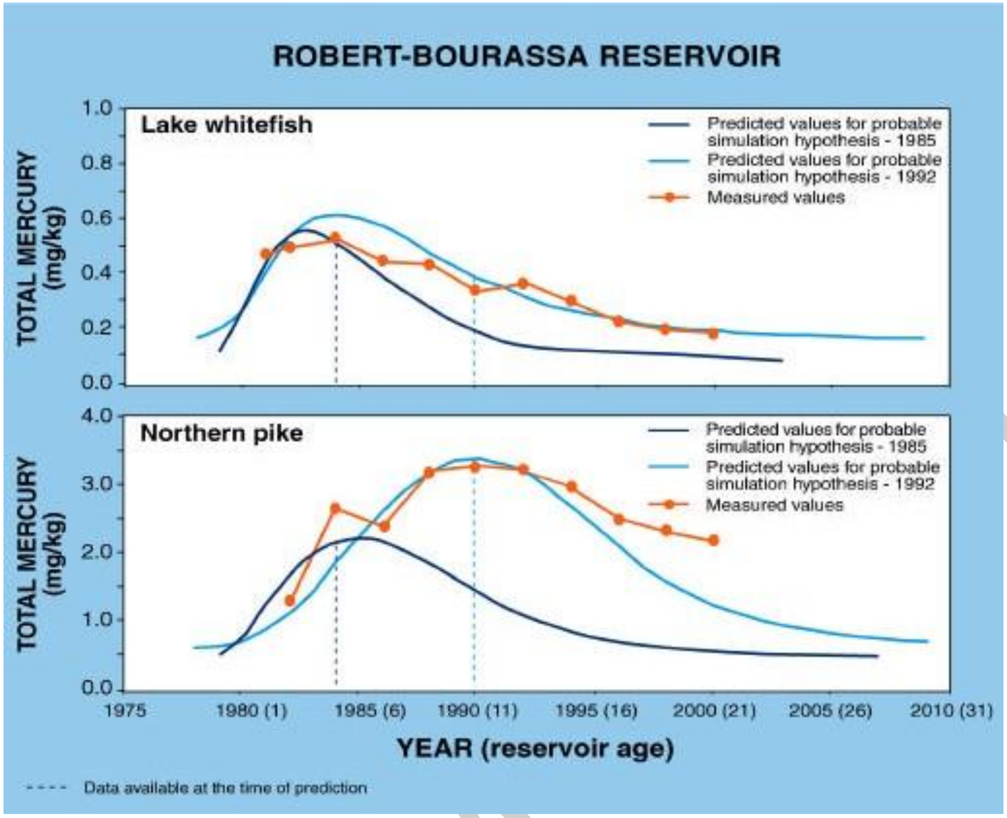


Figure 5.7-2 Example of Predicted and Actual Mercury Concentrations in Fish (from From Hydro-Quebec 2003

Glossary of Terms and Acronyms

Water Quality

ADEC:	Alaska Department of Environmental Conservation.
Advection:	Advection is a transport mechanism of a substance by a fluid due to the fluid's bulk motion.
AEIDC:	Arctic Environmental Information and Data Center.
Anadromous fisheries:	Fish that migrate between the ocean and freshwater.
Anoxic:	Without oxygen.
APA:	Alaska Power Authority.
Aquatic:	Relating to water; living in or near water, or taking place in water.
AWQS:	Alaska Water Quality Standards (18 ACC 70.020(b)).
Benthic:	Living and feeding in the sediment at the bottom of a water body.
Bioabsorption:	Uptake of nutrients or contaminants by organisms.
Bioavailable:	The availability nutrients or contaminants for biological uptake.
Bioaccumulation:	The accumulation of contaminants in organisms over time.
Biomagnification:	The concentration of contaminants in higher trophic lives of the ecosystem over time.
Channel geometry:	Shape of a river or stream channel.
Chlorophyll-a:	A type of chlorophyll that is most common in photosynthetic organisms such as higher plants, red and green algae.
Coefficient:	Multiplicative factor in a mathematical equation.
Cohesive sediment:	Sediment particles composed primarily of clay-sized materials which stick together due to their surface ionic charges. Many pollutants, such as heavy metals, pesticides, and nutrients preferentially adsorb to cohesive sediments. In addition the sediments themselves are sometimes a water quality concern due to turbidity.
Cross-section:	A section formed by a plane cutting through an object, usually at right angles to an axis.
CWA:	Clean Water Act, the federal law that protects water quality in the United States.
Deciduous:	Trees or shrubs that lose their leaves seasonally.
Demethylation	Conversion of methylmercury to other forms of mercury.
Dissolved/particulate	

Partitioning: Water quality parameters can be associated with solid, inorganic particles or appear as a dissolved form in surface water. This reference is typical for nutrients where parameters like phosphorus are either measured as a dissolved form in water or are part of a larger "clump" of material suspended in the water column. Partitioning is accomplished by filtering (typically 45μ pore size) to differentiate dissolved from particulate forms.

Divalent mercury: Hg(I) and Hg(II) or Hg2+ are mercury compounds commonly found in nature, including mercuric sulphide (HgS), mercuric oxide (HgO) and mercuric chloride ($HgCl^2$). Some mercury salts, such as mercury chloride, form a vapor and can be transported in the air.

DOC: Dissolved oxygen content.

Drawdown zone: The area of the shoreline periodically submerged and exposed to air during operations of a reservoir.

EFDC: Environmental Fluid Dynamics Code. A modeling program for water bodies.

EPA: Environmental protection agency.

Eutrophication: The ecosystem response to the addition of artificial or natural substances, such as nitrates and phosphates, to an aquatic system.

Evapotranspiration: The sum of evaporation and plant transpiration from the Earth's land surface to atmosphere.

EWI: Equal width increment method. A sampling device is lowered and raised at a uniform rate through equally-spaced vertical increments in a river cross-section. It is a flow-integrated sampling technique employed by USGS.

Field duplicates: Field duplicates are identical field samples obtained from one location at the same time. They are treated as separate samples throughout the sample handling and analytical processes. These samples are used to assess total error (precision) associated with sample heterogeneity, sample methodology, and analytical procedures. This procedure is useful in determining total (sampling and analytical) error because it evaluates sample collection, sample preparation, and analytical procedures.

FLIR: Forward Looking Infra-Red.

Flow mixing: Moving water exhibits different flow patterns (e.g., isolated roughness, wake interference, and quasi-smooth) and these patterns influence predictability of water quality conditions within a model. This term refers to a rate of mixing that is included among other rates like heat flux and heat transport when calibrating a surface water temperature model.

g:	Grams.
Grid spacing:	The surface area of the waterbody is partitioned into "grids" and defined as various shapes. The EFDC model (Environmental Fluid Dynamics Code) can auto-generate shapes described as "curvilinear-orthogonol grids" that serve as cells within which a water quality prediction is made. The center of each grid is the point water quality is predicted by the EFDC model.
Groundwater upwelling:	Groundwater driven springs that occur within water bodies. These help to regulate temperature and create thermal refugia for fish.
Heat flux:	Heat flux or thermal flux is the rate of heat energy transfer through a given surface.
Heat transport:	Same definition as for "heat flux".
Hg_p:	Mercury concentration in piscivorous muscle tissue.
Hg_{np}:	Mercury concentration in non-piscivorous muscle tissue.
HSC curves:	Habitat suitability criteria (HSC) curves are a component of instream flow modeling that links to the hydraulic flow model to create a habitat-flow relationship. HSC curves consist of an X-Y graph, with the X axis representing a range of water velocity, water depth, and substrate characteristics, while the Y axis represents the probability of use for a given value. Separate HSC curves are typically developed for each species by life stage and for each parameter; i.e. separate curves are developed for velocity, depth, and substrate.
Humus:	An upper soil horizon rich in organic material.
Hydrodynamics:	Turbulence in water accounted for by basic equations in a water quality model that predict motion and movement of dissolved and solid particles in a 3-dimensional matrix.
Ice Dynamics:	Processes involving formation and breakup of ice in riverine and reservoir settings and how these events influence surface water conditions.
ILP:	Integrated licensing process.
Inorganic mercury:	Metallic mercury and divalent mercury.
Inundation area:	Area that will be flooded in creating a reservoir.
Isokinetic:	Refers to flow properties of water that moves through a sampling device that maintains consistency between surrounding riverine flow with that moving through the sampling device.
FERC:	Federal energy regulatory commission.

LAET:	Lowest Apparent Effects Threshold. This is the lowest concentration of a compound in that can be tolerated by the majority of benthic organisms.
LC50:	Lethal concentration 50. Also sometimes called the median lethal dose. This is the standard measure of the toxicity of a specific concentration of an element or compound. It will kill half the population of a specific test-animal in a specified period of time. The lower the number, the more toxic the material. LC50 values cannot be directly extrapolated from one species to another.
Macroinvertebrates:	Macroinvertebrates are organisms without backbones, which are visible to the eye without the aid of a microscope. Aquatic macroinvertebrates live in water of lakes, rivers, and streams. Examples of macroinvertebrates include fly larvae, beetles, dragonfly larvae, aquatic worms, snails, leeches etc.
Mainstem:	The main channel of a large river.
Matrix spikes:	Matrix spike are environmental samples that are spiked in the laboratory or in the field with a known concentration of a target analyte to verify percent recoveries. Matrix spike and matrix spike duplicate samples are primarily used to check matrix interferences. They can also be used to monitor laboratory performance.
Matrix spike duplicates:	A duplicate of the matrix spike analyzed to check precision of the matrix spike analyses.
Mercury:	Mercury (Hg) is an element that occurs naturally in the environment. It exists in several different chemical forms.
MET:	Meteorological station. Used for recording weather conditions.
Metallic mercury:	Also known as elemental mercury or Hg^0, it is mercury in its pure, un-combined form. It is a shiny, silver-white metal that is liquid at room temperature. At room temperature metallic mercury slowly evaporates, forming a vapor.
Methylmercury:	Also known as organic mercury, MeHg, or CH3Hg+, it is mercury combined with a methyl group. It is formed when mercury is combined with carbon and other elements by natural anaerobic organisms that live lakes, rivers, wetlands, sediments, soils and the open ocean. Methylmercury is not readily eliminated from organisms, and is biomagnified in aquatic food chains.
NELAP:	National Environmental Laboratory Accreditation Program.
NMFS:	National Marine Fisheries Service.
Organometals:	Metals that easily bond with carbon. Common examples include mercury, iron, and copper.
Otoliths:	An otolith, also called statoconium or otoconium, is a structure in the saccule or utricle of the inner ear, specifically in the vestibular

	labyrinth of vertebrates. The layers on an otolith can be used to estimate the age of a fish.
P_i:	Total phosphorous from inflows (mg/yr.)
P_r:	Concentration of total phosphorous in the reservoir at time t.
Peak increase factor:	Peak increase factor in fish of methylmercury over background concentrations.
Periphyton:	Periphyton are algae, cyanobacteria, heterotrophic microbes, and detritus that are attached to submerged surfaces in most aquatic ecosystems. It serves as an important food source for invertebrates and some fish. It can also absorb contaminants; removing them from the water column.
Phosphorus release model:	Decaying organic material releases phosphorous at a set rate.
Phosphorus cycle:	Movement of phosphorous through the environment.
Photodegradation:	Breakdown of a compound by light, usually sunlight.
Piscivorous:	Fish-eating.
Point/nonpoint sources:	Point sources are sources of water or contaminants that originate from a definitive place, for example a stream entering a reservoir. Nonpoint sources are from diffuse sources, for example rainfall or atmospheric deposition of dust.
Pore water:	Water that exists within the spaces of sediment.
Project:	The Susitna-Watana Dam project.
Q:	Mean annual flow.
QAPP:	Quality assurance project plan.
Radiant temperature:	Temperature of an object as measured using infrared radiation. This is just the surface temperature of an object.
Regression calculations:	A statistical method used to predict the behavior of a dependent variable. The result is an equation representing the relation between selected values of one variable (x) and observed values of the other (y). It allows the prediction of the most probable values of x based on the measured values of y.
Resident fisheries:	Non migrating fish.
Reservoir release temp.:	Temperature of water released from a reservoir.
Reservoir storage:	Amount of water stored in a reservoir.
Rinsate blanks:	Sample of water used to rinse field equipment to check if equipment was clean prior to sampling.
Riparian:	Relating to or living or located on the bank of a natural water body.
Riverine:	Located on or inhabiting the banks of a river.

RM:	River mile. Distance along the Susitna River, as measured from the mouth.
RSP:	Revised study plan.
SAP:	Sampling and analyses plan.
S_{max}:	Maximum surface area flooded by a reservoir.
Section 401:	Water Quality Certification process under the CWA.
Sediment:	Material deposited at the bottom of aquatic systems such as streams, rivers, and lakes.
Sediment diagenesis:	The sum of all the processes that bring about changes (e.g., composition and texture) in sediment. The processes may be physical, chemical, and/or biological in nature.
Sediment transport:	Movement of sediment in a water body.
Silica cycle:	Movement of silica through the environment.
Sloughs:	A side channel from a river. Commonly formed by migration of a river and its tributaries over time.
SNTEMP:	Modeling program used in the 1980s for the Susitna project.
Solar Degree Days:	The number of degree hours (heating and cooling) with respect to a standard reference temperature and totaled for the period of one day.
Speciated:	Determining the chemical form of various metals, for example chromium or mercury.
SPM:	Suspended particulate matter.
SQuiRT:	Screening Quick Reference Tables. These are thresholds developed by NOAA that are used as screening values for evaluation of toxics and potential effect to aquatic life in several media.
TDS:	Total dissolved solids.
Temperature Regime:	Spatial and temporal temperature patterns in the aquatic environment. Often used to refer to temperature patterns on a seasonal basis.
Thermal refugia:	Water temperatures have critical impacts on fish physiology, distribution, and behavior. At the limits of their thermal tolerance, fish may move to localized patches of colder or warmer water, known as thermal refugia. In Alaska this typically are areas of water bodies that stay relatively warm throughout the winter.
TIR:	Thermal infra-red.
TMDL:	Total maximum daily load.
TOC:	Total organic carbon.

TSS:	Total suspended solids.
Transect measurements:	Measurements across a river, stream or other water body. Usually performed at right angles to flow.
Trophic level:	Relationship of different organisms in a food chain. For example, bacteria are grazed on by phytoplankton, which in are eaten by macroinvertebrates, which are fed on by fish. Each part of the food chain is considered to be a separate trophic level.
Turbidity:	The cloudiness or haziness of a fluid caused by individual particles (suspended solids) that are generally invisible to the naked eye.
TWG:	Technical Work Group.
µg/g:	Micrograms per gram. Also known as parts per million (ppm).
µm:	Micrometer.
USFWS:	U.S. Fish and Wildlife Service.
USGS:	U.S. Geological Survey.
V:	Reservoir volume in cubic meters.
Vertical stratification:	Vertical variations in a water body.
Water Quality Kinetics:	Transfer of water quality characteristics from one reach to another.
Zooplankton:	Heterotrophic organisms drifting in bodies of water.

5.8. Attachments

Attachment 5-1. QUALITY ASSURANCE PROJECT PLAN FOR BASELINE WATER QUALITY MONITORING

<The QAPP for Baseline Water Quality Monitoring will be provided

Attachment 5-2. Quality Assurance Project Plan for Water Quality Modeling.

<The QAPP for Water Quality Modeling will be provided

Attachment 5-3. Quality Assurance Project Plan for Mercury Assessment and Potential for Bioaccumulation.

<The QAPP for Mercury Assessment will be provided.