AEA Susitna Water Quality and Sediment Transport Data Gap Analysis Report

July 26, 2011

Arctic Hydrologic
Consultants

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Executive Summary

A review of available data describing water quality conditions and sediment transport in the Susitna River drainage, and identification of significant data gaps, represents one of the initial steps for development of the Watana Hydro Project. Technical documents generated over the past 30 years were reviewed for water quality and sediment transport data on conditions in the drainage, and identified physical locations and time periods where data was not available. Data were examined to determine current water quality and sediment transport conditions and how these characteristics currently influence anadromous fisheries throughout the drainage. Establishment of the Susitna-Watana Project on the mainstem Susitna River will require an evaluation of current river hydrology and water quality in support of the FERC license application. Data gaps in the available data were identified to inform the next phases of the hydro development project.

In general, water quality conditions in the Susitna River and tributaries had elevated metals concentrations that periodically exceeded toxic thresholds for salmon and rainbow trout. The moderate water hardness at mainstem and some tributary locations will ameliorate toxic effects of some of the metals if in contact with aquatic life. Nutrient concentrations (e.g., nitrates and phosphates) were generally low throughout the drainage, except for select tributary locations during the fall season where nitrogen increases correspond with increasing presence of salmon carcasses. Most tributaries exceeded spawning water temperature criteria and the maintstem Susitna exceeded water temperature criteria for migration.

Although observations for metals in select areas of the Susitna River drainage were acknowledged as having a high background concentration, the sources for these metals and the potential for release following establishment of the project could increase the risk of mortality in select fish populations. Aluminum, copper, and iron concentrations in surface water throughout the areas where data were available exceeded toxics thresholds that indicate chronic problems in select populations were likely. Surface water criteria indicated that aluminum concentrations were consistently high throughout the drainage and that temperature conditions were especially high in tributaries, exceeding criteria for salmonid spawning and migration. Water quality conditions in this drainage enable fisheries to locate and reside in refugia suitable for survival of several life stages. A more dense sampling effort would be required throughout the drainage to describe how pre-project and post-project physicochemical conditions would influence existing fisheries populations in the Susitna River and tributaries. Most of the available data was almost 30 years old and did not have the spatial coverage necessary for a more comprehensive evaluation of water quality conditions. A general comment about existing data is that it does not generally represent present conditions and more current information will be necessary to construct reliable predictions about impact to critical habitats of salmon and steelhead populations in the mainstem Susitna River and at the mouths of tributaries throughout the downstream project area.

The sediment transport analysis of existing data was approached by partitioning the drainage into two parts; sediment transport would differentially be influenced by reservoir dynamics above the proposed

hydro project and below this point in a regulated river channel. Sediment transport data examined from the Susitna River drainage reflected conditions that were almost 30 years old. Review of this data limited analysis based on age and lack of points for calibration with current investigations. Predictions for changes to sediment transport in the Susitna River require that a current and comprehensive baseline of information be developed and this was not possible to complete with existing data in the lower Susitna River. Once this anchor is established describing current sediment transport conditions, generation of post-project conditions can be made. Examination of available sediment discharge rating curves predicts delta formation at the head of the newly formed reservoir as well as mouths of downstream tributaries. Water level in the regulated portion of the river will determine if important tributaries become impassable barriers to migrating fish populations. Sediment transport from the Chulitna and Talkeetna Rivers is three times as large as from the mainstem Susitna River; these tributaries may have a greater influence on habitat formation and maintenance for salmon populations. Sediment transport dynamics has an integral role in maintaining habitat connectivity for anadromous fish populations. Stage-discharge relations that are governed by both reach-scale and local aggradation and degradation as well as the magnitude of the flow are important for maintaining critical side channel and slough habitats. Project impacts are thus most likely to occur between the mouth of Devil's Canyon and the confluences with the Chulitna and Talkeetna Rivers and immediately downstream of the confluences.

1 Introduction

This report documents existing information on water quality and sediment in the Susitna River basin with emphasis on the Susitna-Watana Hydroelectric Project (Project) area and downstream reaches. The purpose of this data gap analysis is to evaluate available information for its relevance and applicability to the proposed Project for the Alaska Energy Authority (AEA), and help with the National Environmental Policy Act (NEPA) scoping and study planning activities conducted as part of the Federal Energy Regulatory Commission (FERC) licensing process. This document focuses on potential data gaps identified for the following resources that may be impacted by the proposed Project:

- Water quality
    - Conventional and metals parameters
    - Anadromous and resident fisheries
    - Analysis of toxics
- Sediment transport
    - Hydrology
    - Sediment supply, transport, and deposition/sedimentation
    - Stage-discharge relations in the aquatic habitat reaches
    - Formation and adjustment of dynamic aquatic habitats

Information needs resulting, in part, from the data gap analyses, will be refined when an updated description of Project facilities, operations, and construction activities is developed. The data reviewed for this analysis are contained in selected documents developed as part of the original Susitna Project licensing effort in the early 1980s, along with more recent, readily available reports. These documents are summarized in Section 4 of this report.

2 Background

An overview of the proposed Project site and the history of the Project are provided as context for the data gap analysis.

2.1 Site Description

The proposed Susinta-Watana Project on the Susitna River is located in the south-central region of Alaska (Figure 2-1), approximately 118 miles north of Anchorage. This region is bounded by the Alaska Range to the north and west, the Wrangell Mountains to the east, and the Chugach Mountains and the Gulf of Alaska to the south. The 19,400 square mile Susitna River basin is bordered by the Alaska Range to the north, the Chulitna and Talkeetna Mountains to the west and south, and the northern Talkeetna plateau and Gulkana uplands to the east. Major tributaries to the Susitna River include the McLaren River, the Chulitna River, the Talkeetna River, and the Yentna River. The Project site is situated at Susitna River Mile (RM) 184, as measured upstream from the mouth of the Susitna River. In the vicinity of the proposed impoundment, the river has cut a narrow, steep-walled gorge up to 1,000 feet deep.

The Susitna River is typical of unregulated northern glacial rivers with high, turbid summer flow and low, clear winter flow. Due to runoff from snowmelt and rainfall in the spring, approximately 80 percent of the annual flow occurs between May and September. As weather begins to cool in the fall, freeze up normally begins in October and continues to progress through early December; breakup generally begins in late April or early May near the mouth and progresses upstream with breakup at the proposed Project occurring in mid-May.

Fish resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide sport fishing for Anchorage, Matanuska-Susitna Borough and other areas of the State. The Susitna River is a migration corridor, spawning area, and juvenile rearing areas for five species of salmon (i.e., pink, chum, coho, sockeye, and chinook) mostly distributed from its mouth to the mouth of Devil's Canyon, a natural barrier due to water velocity at high flows; however there have been recent findings of some juvenile salmonids above Devil's Canyon . In addition to salmon, the Susitna River watershed also supports grayling, trout, whitefish, burbot, and other species important to sport fisheries

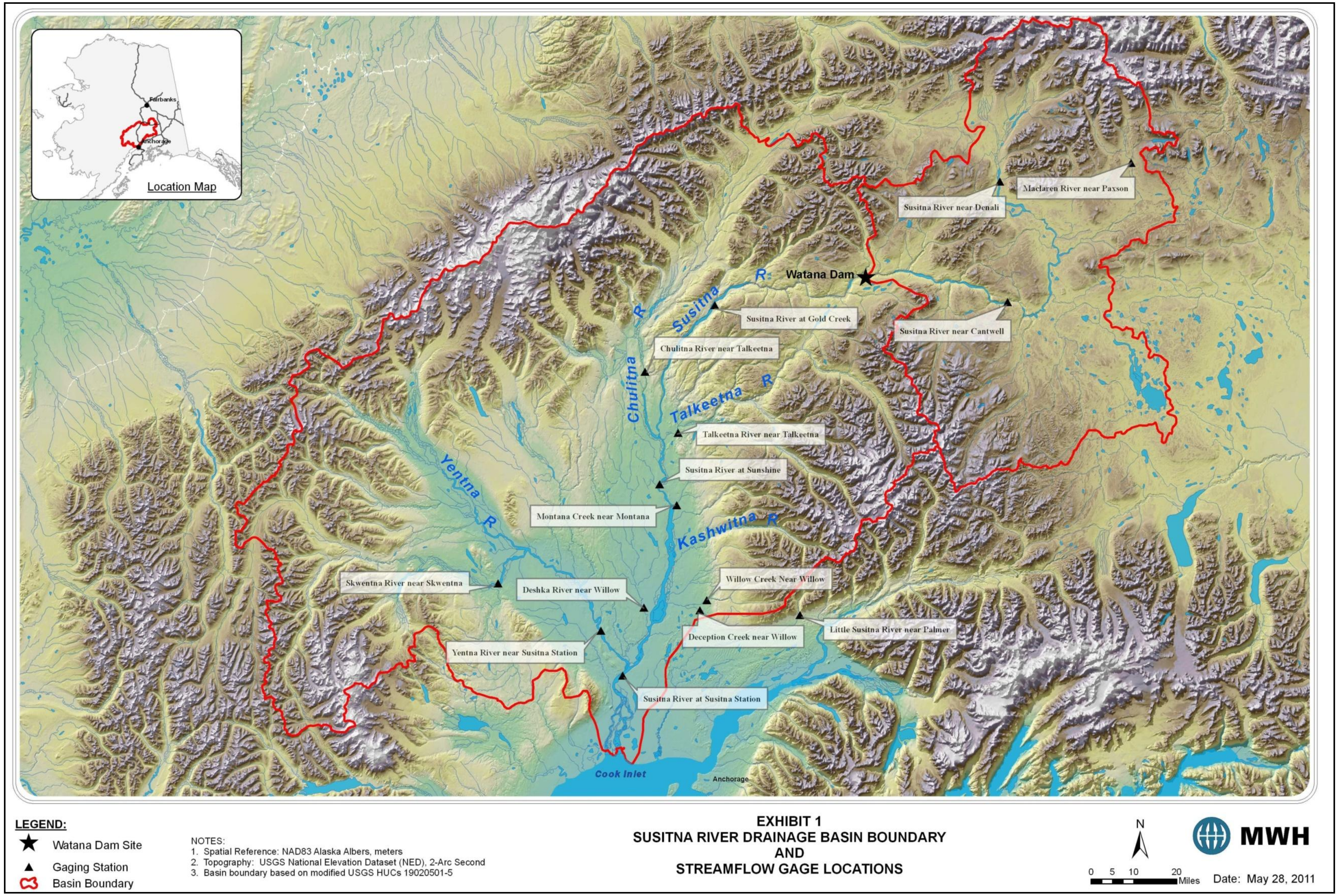

Figure 2-1. Susitna River Drainage Basin (MWH 2011).

2.2 Project History

The Susitna River was identified as a potential large hydropower site in the 1940s by the Bureau of Reclamation. In a 1976 report to Congress, the U. S. Army Corps of Engineers (Corps) proposed a two-dam scheme capable of producing 7,300 Gigawatt hours (GWh) of hydropower (Harza Ebasco 1987). This concept was adopted by the Alaska Power Authority (APA, currently the AEA), which began managing the project in 1980, and contracted with Acres America to review economic and environmental feasibility and file a FERC license application. Later Harza-Ebasco was contracted to update the license application and perform final design. The 1980's APA Project consisted of two dams: the first located in Watana Canyon at approximately Susitna River Mile (RM) 184 and a second located at the mouth of Devil's Canyon (referred to as the Devil's Canyon site in most earlier studies) (RM 152). The 1980s APA Project effort culminated in the development of a license application filed with FERC in 1983, and an amended license application prepared in 1985. The project was cancelled in early 1986 in the face of declining oil revenues. In support of the 1983 and 1985 FERC license applications, the APA conducted comprehensive baseline environmental studies throughout the basin, with the most extensive aquatic efforts focused on the middle stretch of the Susitna upstream of Talkeetna. A library of more than 3,500 reference documents was cataloged at the conclusion of the project (Harza-Ebasco 1987).

The current Susitna-Watana Hydroelectric Project being evaluated by the AEA is located approximately half-way between Anchorage and Fairbanks. The proposed Project would create a single dam on the Susitna River at RM 184 in the vicinity of Watana Canyon. The approximately 700-foot-high dam would have an approximate 557-foot difference between the elevations of the tail water and the maximum pool (AEA 2010). Watana Reservoir would be 39 miles long and a maximum of 2 miles wide. The dam's installed capacity would be around 600 megawatts (MW) with the average annual generation estimated to be 2,600 GWh (AEA 2010). The AEA is currently studying design considerations in order to formulate decisions regarding the type of dam or powerhouse (underground or surface) that would be used as well as the actual final maximum reservoir level. At this time the actual operation characteristics of the Project are not known, but the current concept is that the Project would provide peaking operations using the reservoir storage to meet daily instream flow and power needs. The current Susitna- Watana Project is thought to be a licensable project without a fatal flaw (AEA 2010).

3 Methodology for Analyzing Potential Data Gaps

The licensing effort of the 1980's APA Project generated a substantial body of literature, some of which might be used to support future licensing. To evaluate potential Project impacts and to protect wildlife and their habitats, the 1980s study effort sought to describe baseline conditions at a level of reliability necessary to detect and explain possible future changes caused by the proposed hydroelectric development as it was configured at that time (ADF&G 1985a). Additional reports related to resources in the vicinity of the proposed Project have been published since the mid-1980s.

The URS Team reviewed and synthesized data collected during the 1980s, along with more recent information from resource agencies. Information was compiled and made available for review through a URS FTP site and through an AEA SharePoint site. Not all of the older materials have been scanned, so the information on the SharePoint site was limited and only information posted by early July was available for review.

Based on the available sources of information, the primary water quality and sediment transport issues related to the construction and operation of the Susitna-Watana Project are: 1) water quality, with particular emphasis on the potential impacts to fish resources and changes to physicochemical habitat resulting from project operations, and 2) sediment transport, focusing on potential impacts to aquatic habitats and potential downstream flooding and channel stability. These issues were considered during the review of documents to identify gaps in data that would allow for meaningful comparisons of with and without project conditions.

The Susitna River was divided into segments to provide a framework for organizing and interpreting available data. Discrete segments of the river are identifiable based on longitudinal changes reflected in physical features of the river channel. A river segmentation scheme was developed in earlier technical studies that evaluated information about the Susitna River drainage through 1983. The Application for Development of a Major Project prepared by Acres (1983) detailed how river segmentation was determined and provided a description for the distinct river segments. This segmentation scheme is presented in Table 3-1.

Table 3-1. Segmentation scheme for the Susitna River Basin (APA 1983a).

Bounds of Segment (Susitna River Miles)	Average Bed Slope (feet/foot)[1]	Predominant Channel Morphology
313 – 223	n/a	Glacial and non-glacial headwaters, upper basin
223 – 184	n/a	Approximate extent of proposed reservoir impounded by Watana Dam at RM 184
184 – 149	0.00337	Steep side canyon and Devil's Canyon
149 – 144	0.00195	Single channel confined by valley walls, frequent bedrock control points
144 – 139	0.00260	Split channel morphology confined by valley walls and terraces
139 – 129.5	0.00210	Well defined split channel morphology, frequent side channels separated from main channel by vegetated islands
129.5 – 119	0.00173	Well defined split channel morphology, confined by valley walls, occasional bedrock control points
119 – 104	0.00153	Predominantly a single incised channel with few islands
104 – 95	0.00147	Transition to braided channel morphology, terraces bound broad floodplain at confluence of Susitna, Chulitna, and Talkeetna Rivers
95 – 61	0.00105	Braided channel morphology, multiple channels, sparsely vegetated floodplain
61 – 42	0.00073	Multiple channel separated by vegetated islands
42 – 0	0.00030	Split channel morphology, occasional braiding, distributary channel influenced by tidal fluctuations in Cook Inlet

[1] Average bed slopes as presented in Table E.2.1 (APA 1983a)

The segmentation scheme in Table 3-1 was initially considered for use during the data gap analyses; however, it became apparent that the resolution of the segments was too detailed given the limited available water quality and sediment transport data. A more appropriate delineation of reaches was developed specifically for use in the data gap analyses (Table 3-2).

Table 3-2. Reach segmentation for the Susitna River Basin data gap analysis.

Bounds of Reach (Susitna River Miles)	Reach Number	General Description
313 – 184	1	Upper Susitna River, including headwaters and tributaries above the proposed Watana dam site
184 – 150	2	Middle Susitna River and tributaries through Devil's Canyon and below the proposed Watana Dam site
150 – 99	3	Middle Susitna River and tributaries from the mouth of Devil's Canyon to the Susitna – Chulitna – Talkeetna confluence
99 – 0	4	Lower Susitna River from Susitna – Chulitna – Talkeetna confluence to mouth at Cook Inlet

Further details of methodologies specific to the hydrology, water quality, and sediment transport gap analyses are presented in Section 4 and Section 5.

4 Water Quality

The water quality data gap analysis included several components that included review of collected data reports and finalized data sets that could suggest possible influences on future water quality conditions. Several steps were identified for this project that satisfied objectives and are summarized as follows:

- Data Collection from Sources
- Data Review for Quality and Summaries
- Data Analysis/Interpretation
- Identify Data Gaps
- Predict Potential Project Impact

Each of the steps addressed in the following sections relates known water quality conditions where rainbow trout, grayling, and several species of salmon are present. The tolerance of fish species to environmental contaminants is an important factor for evaluation of water quality conditions as these thresholds incorporate experimental and field survey results that determine toxic effects and potential for bioaccumulation.

A standardized segmentation strategy was developed and used to describe locations where water quality information is found and conditions that may affect resident and anadromous fish populations. The water quality data gap analysis identified conditions in several reaches of the Susitna River drainage based on the reach descriptions in Table 3-2.

4.1 Summary of Data Recovered

The available existing information was collected and evaluated in terms of its potential relevance and completeness, and whether the methods used produced information that could be applicable to the anticipated environmental analysis for the proposed Project. Other sources of information used in the analysis included that derived from contacts with agency project leaders and database searches. If information was determined to be likely insufficient for satisfying environmental analysis requirements, a potential data gap was identified.

A review of existing data generated by governmental agencies and organizations was used as background information to evaluate current and past water quality conditions in the Susitna River drainage. Natural resource agencies were identified and lead staff contacted for location of relevant information and web sites searched for general description of drainage conditions as well as for water quality data that could be further analyzed. The following agencies were initially identified for available information from the Susitna River drainage and contiguous areas:

- Alaska Department of Environmental Conservation
- Alaska Department of Fish and Game
- Alaska Department of Natural Resources
- U.S. Environmental Protection Agency, Region 10
- U.S. Fish and Wildlife Service
- U.S. Geological Survey
- National Oceanic and Atmospheric Administration-Fisheries
- Alaska Energy Authority/Alaska Power Authority
- American Geophysical Union

Relevant documents were collected in electronic form and stored in an electronic bibliography for use in data review and summarization (Appendix A). Water quality data discovered in document review was either included in a spreadsheet and used in further analysis for data gap analysis or was summarized using numerical expressions including minimum value, average value, and maximum value recorded at a station in the Susitna River drainage including tributaries. Results from river and tributary stations were organized according to river mile location and aggregated into river segment categories.

Existing data was organized along a longitudinal gradient (Headwaters to Mouth) so that data gaps in water quality information could be identified by visually examining the summary water quality tables (Appendix B). The origin of data entries in these summary water quality data tables were found in several documents listed in Tables 4-1 and Table 4-2. Table 4-1 lists data resources used to build the summary water quality data tables prior to complete access to the extensive reference library on the AEA SharePoint Site. Table 4-2 lists resources on the AEA SharePoint Site that were reviewed for additional water quality information. Table 4-3 is a collection of references that may include relevant water quality information but were not accessible during the review of existing information. Many of these remaining documents were not available in electronic form on the project SharePoint site, but were published during the same years as those reviewed. The same available data sets had been cited and used in multiple documents throughout this time period and did not offer new information for this data gap analysis. However, these resources could be collected at a later data and examined for relevant water quality information.

Table 4-1. Data Resources Used to Create Water Quality Data Summary Tables (Appendix B).

DATE	SOURCE	AUTHOR	TITLE	LOCATION
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 5, Exhibit E, Chapters 1&2	University of Washington Library
1986	Alaska Power Authority	Harza-Ebasco Susitna Joint Venture	Susitna Hydroelectric Project Water Quality Monitoring 1985	http://sharepoint.aidea.org/railbeltlargehydro/Reference%20Library/Susitna%20Historical%20Documents/Pre%202000%20Documents/3402.pdf (AEA Reference Library)
1990	United States Geological Survey	USGS	Largest Rivers in the United States	http://pubs.usgs.gov/of/1987/ofr87-242/
2008	United States Geological Survey	USGS	Suspended Sediment Database Daily Values of Suspended Sediment and Ancillary Data	http://co.water.usgs.gov/sediment/conc.frame.html
1986	United States Geological Survey	USGS	USGS 15291000 SUSITNA R NR DENALI AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291000&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1975	United States Geological Survey	USGS	USGS 15291200 MACLAREN R NR PAXSON AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291200&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list

DATE	SOURCE	AUTHOR	TITLE	LOCATION
1986	United States Geological Survey	USGS	USGS 15291500 SUSITNA R NR CANTWELL AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291500&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292000 SUSITNA R AT GOLD CREEK AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292000&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292400 CHULITNA R NR TALKEETNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292400&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list

DATE	SOURCE	AUTHOR	TITLE	LOCATION
2011	United States Geological Survey	USGS	USGS 15292700 TALKEETNA R NR TALKEETNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292700&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292780 SUSITNA R AT SUNSHINE AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292780&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1981	United States Geological Survey	USGS	USGS 15294300 SKWENTNA R NR SKWENTNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294300&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15294345 YENTNA R NR SUSITNA STATION AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294345&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_

DATE	SOURCE	AUTHOR	TITLE	LOCATION
				form=brief_list
2003	United States Geological Survey	USGS	USGS 15294350 SUSITNA R AT SUSITNA STATION AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294350&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
2010	United States Geological Survey	USGS	USGS 15292000 SUSITNA R AT GOLD CREEK AK DAILY DISCHARGE, CUBIC FEET PER SECOND	http://waterdata.usgs.gov/nwis/uv/?site_no=15292000&PARAmeter_cd=00065,00060,00062,72020
2004	URS Corp.	URS	Talkeetna Airport, Phase II Hydrologic/Hydraulic Assessment	https://sftp101.urscorp.com/human.aspx?OrgID=9164

Table 4-2. Additional Documents Reviewed from Reference Library on AEA SharePoint Site.

DOC_ID	Author	Title	Date	Review Notes
127	ACRES	BEFORE THE FERC, APPLICATION FOR LICENSE FOR MAJOR PROJECT SUSITNA HYDROELECTRIC PROJECT VOL. 5A, EXHIBIT E, CHAPTERS 1 & 2	02/01/1983	second review- review of electronic version included water quality data that was already captured in summary table (USGS, R&W)
128	ACRES	BEFORE THE FERC, APPLICATION FOR LICENSE FOR MAJOR PROJECT SUSITNA HYDROELECTRIC PROJECT VOL. 5B, EXHIBIT E, CHAPTER 2, (FIGURES)	02/01/1983	reviewed-included water quality figures; data already captured in summary table; did not pull data from figures
129	ACRES	BEFORE THE FERC, APPLICATION FOR LICENSE FOR MAJOR PROJECT SUSITNA HYDROELECTRIC PROJECT VOLUME 6A,	02/01/1983	reviewed-contains general water quality observations; no specific data

DOC_ID	Author	Title	Date	Review Notes
		EXHIBIT E, CHAPTER 3		
130	ACRES	BEFORE THE FERC, APPLICATION FOR LICENSE FOR MAJOR PROJECT SUSITNA HYDROELECTRIC PROJECT VOL. 6B, EXHIBIT E, CHAPTER 3 (FIGURES)	02/01/1983	could not get document to open from SharePoint Site; assume no data appears that its only figures
192	R&M	PRELIMINARY CHANNEL GEOMETRY, VELOCITY AND WATER LEVEL DATA FOR THE SUSITNA RIVER AT DEVIL'S CANYON	04/22/1981	reviewed-no water quality data; contains WSE and velocity
296	TES	ENVIRONMENTAL STUDIES, SUBTASK 7.14, ENVIRONMENTAL ANALYSIS OF ALTERNATIVE ACCESS PLANS	10/01/1981	reviewed-no water quality data
346	ADF&G	FRESHWATER HABITAT RELATIONSHIPS DOLLY VARDEN CHAR	05/01/1981	reviewed-no water quality data
347	ADF&G	FRESHWATER HABITAT RELATIONSHIPS ARCTIC GRAYLING	04/01/1981	reviewed-no water quality data
349	ADF&G	FRESHWATER HABITAT RELATIONSHIPS ROUND WHITEFISH	04/01/1981	reviewed-no water quality data
350	ADF&G	FRESHWATER HABITAT RELATIONSHIPS THREESPINE STICKLEBACK	04/01/1981	reviewed-no water quality data
385	ACRES	FISH AND WILDLIFE MITIGATION POLICY NOVEMBER 1981, REVISED MARCH 1982, REVISED APRIL 1982	04/01/1982	reviewed-no water quality data
471	ACRES	WATER RESOURCES ANALYSIS REVIEW OF EXISTING WATER RIGHTS IN THE SUSITNA RIVER BASIN	12/01/1981	reviewed-no water quality data; water rights issue summary
585	ADF&G	SUSITNA HYDRO AQUATIC STUDIES PHASE II BASIC DATA REPORT VOL. 4 AQUATIC HABITAT AND INSTREAM FLOW STUDIES 1982 PARTS 1 & 2	01/01/1983	reviewed-appears that contains water quality data in appendix, however appendix not included in scanned document; includes data from sloughs and tributaries
885	ADF&G	ADF&G SU HYDRO AQUATIC STUDIES MAY 1983 - JUNE 1984 PROCEDURES MANUAL FINAL DRAFT	02/02/1984	reviewed-contains methods and site selection for WQ data during FY 1984; need to see if data report is available

DOC_ID	Author	Title	Date	Review Notes
887	NEWBURY	THE DESTRUCTION OF MANITOBA'S LAST GREAT RIVER	01/01/1983	reviewed-no water quality data
938	ADF&G	AQUATIC STUDIES PROCEDURES MANUAL PHASE II-FINAL DRAFT 1982-83 (FY 83)	08/31/1983	reviewed-is companion document to DOC_585 and explains methods for collected WQ data and site selection
1247	ACRES	HYDROLOGY HYPOTHETICAL DAM BREAK ANALYSIS	03/01/1982	reviewed-no water quality data
1308	ADF&G	SUBTASK 7.10 PHASE I FINAL DRAFT VOL. 2 PART 1 AQUATIC HABITAT AND INSTREAM FLOW PROJECT	01/01/1981	reviewed- includes water quality data from 1981, would like to summarize along with data from 5 year study; WQ data associated with fisheries evaluation sites includes sloughs and tributaries; basic WQ parameters (temp, DO, pH, Conductivity, turbidity); Because of the age of the data, it is not essential that it is summarized without the subsequent years. Data would be extremely outdated compared to conventional data from other resources.
1450	ADF&G	1984 SUSITNA HYDRO AQUATIC STUDIES, REPORT #1 - ADULT ANADROMOUS FISH INVESTIGATION: MAY - OCTOBER 1983	01/01/1984	reviewed-no water quality data in this report but included in Report No. 3 from this series (need to obtain); activities of ADF&G during 1983 open water season
1613	ADF&G	PRELIMINARY ENVIRONMENTAL ASSESSMENT OF HYDROELECTRIC DEVELOPMENT ON THE SUSITNA RIVER	03/01/1978	reviewed-contains water quality data from 1977 (most of it unreadable), some USGS data that already is included in summary table; Temp, DO, pH, Conductivity, turbidity data for slough and tributaries; most likely same locations as in early 80s. Data would be extremely outdated and not included in summary tables.
1770	APA	ALASKA POWER AUTHORITY COMMENTS ON THE FERC DEIS OF MAY 1984 VOL. 1 INTRODUCTION	08/01/1984	reviewed-no water quality data
1772	APA	ALASKA POWER AUTHORITY COMMENTS ON THE FERC DEIS OF MAY 1984 VOL. 2B TECHNICAL COMMENTS - AQUATIC RESOURCES	08/01/1984	reviewed-no water quality data
1776	APA	ALASKA POWER AUTHORITY COMMENTS ON	08/01/1984	reviewed-no water quality data

DOC_ID	Author	Title	Date	Review Notes
		THE FERC DEIS OF MAY 1984 VOLUME 5 APPENDIX III - THERMAL ALTERNATIVES TO SUSITNA		
1778	APA	APA COMMENTS ON THE FERC DEIS MAY 1984 VOL. 7 APPENDIX V - TEMPERATURE SIMULATIONS, SUSITNA RIVER, WATANA DAM TO SUNSHINE GAGING STATION, OPEN WATER	08/01/1984	reviewed-no water quality data; simulated river temperatures
1931	ADF&G	REPORT NO. 3 AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER 1983) CHAPTER 2: CHANNEL GEOMETRY INVESTIGATIONS	09/01/1984	reviewed-contains no water quality data (only chapter 2) Need Chapters 3 and 4 to get WQ data (not scanned); companion to other ADF&G reports on 5 year study
1954	GRIMAS	ON THE FOOD CHAIN IN SOME NORTH SWEDISH RIVER RESERVOIRS	01/01/1965	reviewed-no water quality data; literature concerning impacts to fish from hydro power projects in Sweden
2049	ADF&G	REPORT NO. 4 ACCESS AND TRANSMISSION CORRIDOR AQUATIC INVESTIGATIONS (JULY - OCTOBER 1983)	01/01/1984	reviewed-no Susitna River WQ data; need Report No. 3 (not scanned)

Table 4-3. Documents of Interest (Possible Water Quality Data Source) But Not Available Electronically on AEA SharePoint Site.

DOC_ID	Author	Title	Date	Notes
220	ACRES	TASK 6 - DEVELOPMENT SELECTION, SUBTASK 6.05, DEVELOPMENT SELECTION REPORT, FINAL	12/01/1981	Could not locate on SharePoint Site
221	ACRES	TASK 6 - DEVELOPMENT SELECTION SUBTASK 6.05, DEVELOPMENT SELECTION REPORT, APPENDICES A-J	12/01/1981	Could not locate on SharePoint Site
586	ADF&G	SUSITNA HYDRO AQUATIC STUDIES PHASE II BASIC DATA REPORT VOL. 4 AQUATIC HABITAT AND INSTREAM FLOW STUDIES 1982 APPENDIX A THRU C	01/01/1983	Report contains WQ data from 5 year fisheries evaluation study conducted by ADF&G
587	ADF&G	SUSITNA HYDRO AQUATIC STUDIES PHASE II BASIC DATA REPORT VOL. 4 AQUATIC HABITAT AND INSTREAM FLOW STUDIES 1982 APPENDIX D THRU J	01/01/1983	Report contains WQ data from 5 year fisheries evaluation study conducted by ADF&G
746	D&M	UNDERGROUND CABLE SYSTEMS: POTENTIAL ENVIRONMENTAL IMPACTS DRAFT REPORT	08/31/1981	Could not locate on SharePoint Site

1932	ADF&G	REPORT NO. 3 AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER, 1983) CHAPTER 3: CONTINUOUS WATER TEMPERATURE INVESTIGATION	09/01/1984	Report contains WQ data from 5 year fisheries evaluation study conducted by ADF&G
1933	ADF&G	REPORT NO. 3 AQUATIC HABITAT AND INSTREAM FLOW INVESTIGATIONS (MAY-OCTOBER 1983) CHAPTER 4: WATER QUALITY INVESTIGATIONS	09/01/1984	Report contains WQ data from 5 year fisheries evaluation study conducted by ADF&G
2867	ADF&G	TASK 29 AND 37 SUPPORT TECHNICAL REPORT CONTINUOUS WATER TEMPERATURE INVESTIGATIONS	06/01/1985	Could not locate on SharePoint Site; could contain valuable summary info on continuous temperature monitoring

4.2 Data Quality

Data quality was evaluated, wherever possible, using companion information available from source documents. Quality objectives for existing data sets including: laboratory and field precision measurements, laboratory analysis accuracy, analytical bias, and matrix spikes are evaluated to determine comparability between data sets used in the data gaps evaluation. The consequence for using data that varies in comparability in this data gap analysis would bias conclusions by interpreting data with thresholds that were prescribed for use with lower method detection limits and reporting limits. Data that meet expectations for laboratory analysis performance or for measurement quality objectives in the field increases the sensitivity for detecting change and for correctly concluding water quality conditions. Combining multiple data sets that had differing data quality characteristics may result in improperly declaring a condition when using older data with higher reporting limits and matched with current criteria or thresholds.

Generally, most of the data discovered and used for this data gap analysis is more than 20 years old. Many of the documents did not report data quality expressions and so an evaluation for comparability of data sets was not possible. The exception was the United States Geological Survey (USGS) data where long-term monitoring at select stations was completed in the drainage. The comparability of data among USGS stations was not in question, but the lack of DQOs from older data did not enable a comparison between USGS and other existing data sets. Any interpretations of data close to pollutant concentration criteria were interpreted as exceeding the standard. This conservative approach was taken in order to preserve the intent of water quality criteria and to suggest additional studies that should be conducted in order to advance definitive decisions.

4.3 Applicable Water Quality Standards

Evaluation of water quality conditions began with determination of individual parameter exceedances and by identifying the location in the drainage where the exceedance occurred. The purpose for this analysis was to identify locations that presented potentially degraded conditions to important fish populations in the drainage and the conditions under which these occurred. The Alaska State Water Quality Standards were used for these comparisons against existing data as reported in Table 4-4.

Table 4-4. Alaska State Water Quality Standards for the Protection of Aquatic Life and Wildlife (18 AAC 70, May 2011).

Parameter	Criteria
Color (platinum-cobalt scale)	Color or apparent color may not reduce the depth of the compensation point for photosynthetic activity by more than 10% from the seasonally established norm for aquatic life. For all waters without a seasonally established norm for aquatic life, color or apparent color may not exceed 50 color units or the natural condition, whichever is greater.
Fecal Coliform Bacteria	Not applicable.
Dissolved Oxygen	D.O. must be greater than 7 mg/l in waters used by anadromous or resident fish. In no case may D.O. be less than 5 mg/l to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning (see note 2). For waters not used by anadromous or resident fish, D.O. must be greater than or equal to 5 mg/l. In no case may D.O. be greater than 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.
Total Dissolved Solids	TDS may not exceed 1,000 mg/l. A concentration of TDS may not be present in water if that concentration causes or reasonably could be expected to cause an adverse effect to aquatic life.
pH	May not be less than 6.5 or greater than 8.5. May not vary more than 0.5 pH unit from natural conditions.
Temperature	May not exceed 20°C at any time. The following maximum temperatures may not be exceeded, where applicable: Migration routes 15°C Spawning areas 13°C Rearing areas 15°C Egg & fry incubation 13°C For all other waters, the weekly average temperature may not exceed site-specific requirements needed to preserve normal species diversity or to prevent appearance of nuisance organisms.
Turbidity	May not exceed 25 NTU above natural conditions. For all lake waters, may not exceed 5 NTU above natural conditions.

Additional data describing metals concentrations had been identified and aggregated into a summary table. The Alaska State Water Quality Standards for metals and other xenobiotics are reported in Table 4-5. Results from data comparisons for metals will inform on any elevated concentration in the drainage. Most metals water quality criteria are based on hardness concentrations measured at the same time. Due to the nature of the water quality summary and review, determining specific metals criteria for individual sample collections was not achievable. Therefore metal exceedances of state criteria were not determined. In Section 4.7 of this report, metal concentrations found in the Susitna River and tributaries were compared to known toxic thresholds providing valuable information on the impact of metals on fish populations.

Table 4-5. Alaska State Water Quality Standards for Toxics and Other Deleterious Organic and Inorganic Substances (December 2008).

Parameter	Acute Criteria (CMC)	Chronic Criteria (CCC)
Aluminum, *Total recoverable*	**750 µg/L** (1-hr avg)	**87 µg/L** (4-day avg)
Ammonia, *(total ammonia nitrogen in mg N/l)*	**1.77 to 28.1** Criteria are pH dependent[1] (1-hr avg)	Criteria are pH and temperature dependent[2] (30-day avg)
Arsenic, *dissolved*	**340 µg/L** (1-hr avg)	**150 µg/L** (4-day avg)
Barium	No Criteria	No Criteria
Cadmium, *dissolved*	Criteria Hardness Dependent[3] (1-hr avg)	Criteria Hardness Dependent[3] (4-day avg)
Chloride, *dissolved*	**860,000 µg/L** (1-hr avg) Applies to dissolved chloride when associated with sodium.	**230,000 µg/L** (4-day avg) Applies to dissolved chloride when associated with sodium.
Copper, *dissolved*	Criteria Hardness Dependent[3] (1-hr avg)	Criteria Hardness Dependent[3] (4-day avg)
Iron	No Criteria	**1,000 µg/L**
Lead, *dissolved*	Criteria Hardness Dependent[3] (1-hr avg)	Criteria Hardness Dependent[3] (4-day avg)
Manganese	No Criteria	No Criteria
Mercury, *dissolved*	**1.4 µg/L** (1-hr avg)	**0.77 µg/L** (4-day avg)
Mercury, *Total*	**1.694 µg/L**	**0.9081 µg/L**
Nickel, *dissolved*	Criteria Hardness Dependent[3] (1-hr avg)	Criteria Hardness Dependent[3] (4-day avg)
Selenium, *Total recoverable*	See Note[4] (1-hr avg)	**5.0 µg/L** (4-day avg)
Zinc, *dissolved*	Criteria Hardness Dependent[3] (1-hr avg)	Criteria Hardness Dependent[3] (4-day avg)

[1]pH values in the Susitna River range from 6.8 to 8.6. Using Appendix C in the *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances* the criteria for Total Ammonia Nitrogen as N would range from 1.77 to 28.1 mgN/L.

[2]Chronic criteria for Ammonia should be calculated based on pH and temperature when early life stages of fish are present as shown in Appendix D of the *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances.*

[3]To calculate dissolved metals criteria please refer to the table in Appendix A of the *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances*.

[4] The CMC = 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 g/l and 12.82 g/l, respectively.

Turbidity measurements were summarized from existing data sets, but not evaluated against criteria and not interpreted further. The turbidity criterion is based on comparison against a natural background measurement and requires several observations from the same location within a specified period of time. Unless turbidity exceedances were identified at a location and within a reviewed report it was not possible to appropriately determine a turbidity exceedance from existing data. In addition, the Susitna River and several of the tributaries are glacially fed and already very turbid.

4.4 Locations Exceeding Water Quality Standards

Identification of locations and timing of water quality exceedance was compared against fish population presence in each of the four reaches. High concentrations of conventional parameters and/or metals concentrations were initially screened and identification of location and time of year when water quality exceedances may have occurred. The next step in evaluation of existing data was the comparison between fish population presence and exceedance of toxics threshold concentrations. Both evaluations measure effects of water quality conditions on aquatic life, both direct and indirect assessments of impairments. Some of the high concentrations for metals appear to exceed toxics criteria, but the geologic setting of this river drainage is a major influence on water chemistry.

Earlier studies indicated naturally elevated metals background concentrations from select sampling sites throughout the drainage (Harza-Ebasco 1986). The following was an excerpt taken from this document explaining which of the metals had elevated concentrations and the potential activities that may have been related to these toxics:

The original License Application (APA 1983a, b) reviews the concentrations of metals in Susitna River water and evaluates them using published criteria and guidelines (Alaska Administrative Code (ACC) 1984; EPA 1976; McNeely et al. 1979; Sittig 1981). Many natural metal concentration exceeded these criteria and guidelines. As stated in the original License Application, the measured levels of heavy metals in the Susitna River represent natural conditions. With the exception of some placer mining operations, the watershed supports no significant industry, agriculture, or urbanization. It was concluded, consequently, that the exceedance of water quality criteria by certain metal concentrations is representative of a naturally affected aquatic ecosystem. Nevertheless, the high levels of certain heavy metals warrant further investigation. Metals which exceeded applicable criteria included both dissolved and total recoverable aluminum (Al), cadmium (Cd), copper (Cu), manganese (Mn), mercury (Hg), and zinc (Zn). In addition, the dissolved fraction of bismuth (Bi) and the total recoverable quantities of iron (Fe), lead (Pb), and nickel (Ni) also exceeded the criteria.

Temperature data collection has been the most abundant type of water quality evaluation conducted in the Susitna River drainage. Recently, tributaries have been the focus of many water temperature studies as this water quality parameter may represent the greatest threat of impairments to the mainstem condition (Table 4-6 through Table 4-8 and Figure 4-1). Highlighted numerical values in Table 4-6 and Table 4-7 represent temperature violations at a tributary location during a particular month. The summer months (May through September) represent the most stressful period of the year for impaired water quality conditions. According to state water quality standards, the maximum temperature that must not be exceeded in waters where spawning activity occurs is 13°C. This was the criterion used to evaluate tributary temperatures within the Susitna River Basin since it is known that fish populations use the tributaries and sloughs as spawning areas.

A limited number of conventional water quality parameters have been collected at locations throughout the drainage. Most of this information had been collected for projects 30-40 years ago (1970's – 1980's) and does not represent a complete characterization of conventional water quality conditions. Water quality indicators that have been measured periodically at mainstem Susitna River and tributary stations are nutrients. Mainstem nutrient concentrations were low in almost all cases and the age of this data is reflected in poor detection limits reported in original literature (e.g., ortho-phosphate ≤0.1 mg/L). Examination for temporal or spatial patterns in both nitrate and phosphate concentrations indicated a potential relationship with salmon carcass presence. The temporary increase in nitrate concentrations (e.g., Talkeetna River, Appendix B-1) occurs during the fall season and coincides with presence of the salmon spawning season. Influence of the fisheries on surface water quality is measurable in some locations of the drainage.

Almost all tributaries exceeded the spawning temperature criteria during the summer months in 2008 and 2009 (Table 4-6 and Table 4-7). The highest summer water temperatures were seen in Alexander Creek and Kroto Creek. Alexander Creek is located in Reach 4 at the lower end of the watershed while Kroto Creek is located in Reach 2 and below major river tributaries (e.g. Chulitna River and Talkeetna River). Due to the locations of these tributaries within the basin, temperature modifications to the mainstem are unlikely to occur. The coldest water temperatures recorded during the summer months were in the East Fork of the Chulitna River. This tributary is located at the northern edge of the basin. Smaller tributaries to the Susitna River serve primarily as coldwater refugia to salmon and steelhead populations, especially during the summer months.

Table 4-6. 2008 Susitna River Basin Temperatures (Cook Inlet Keepers, via personal communication).

Month	Temperature (°C)	Station Name												
		Alexander Creek	Byers Creek	Cache Creek	Chijuk Creek	Deception Creek	East Fork Chulitna River	Kroto (Deshka) Creek	Little Willow Creek	Montana Creek	Moose Creek (Talkeetna)	Trapper Creek	Troublesome Creek	Willow Creek
June	Max	**16.0**	**17.1**	11.8	**14.3**	**13.9**	10.2	**19.3**	12.3	**13.3**	**17.2**	**17.2**	**13.5**	--
	Min	11.0	5.1	3.2	11.0	5.6	2.6	13.2	5.9	5.2	8.9	10.0	4.5	--
	Mean	13.9	10.6	6.7	12.9	9.4	5.9	16.0	8.9	8.9	12.3	13.3	8.5	--
July	Max	**22.0**	**19.6**	**15.3**	**20.8**	**15.7**	11.6	**20.4**	**15.6**	**16.5**	**19.8**	**19.2**	**17.0**	**14.8**
	Min	11.1	9.8	4.5	10.1	7.9	4.6	10.9	7.7	8.4	10.2	11.9	7.6	7.6
	Mean	14.3	13.6	8.8	13.8	10.7	7.3	14.5	10.4	10.9	13.1	14.2	11.0	10.2
August	Max	**18.3**	**16.5**	**13.7**	**16.1**	**13.9**	10.5	**20.3**	**13.8**	**14.5**	**15.0**	**16.0**	**13.2**	**13.4**
	Min	12.6	10.7	5.4	10.0	8.1	4.5	10.6	8.3	8.0	9.5	11.1	7.9	8.1
	Mean	15.1	13.1	9.7	13.3	10.6	7.2	14.5	10.5	10.7	12.3	13.4	10.7	10.5
September	Max	--	**15.2**	11.6	**13.5**	11.4	9.2	**17.2**	11.2	11.9	12.9	12.5	12.1	11.2
	Min	--	5.2	0.2	2.0	1.9	-0.1	4.9	1.7	2.0	3.8	3.4	1.6	2.3
	Mean	--	10.4	6.6	9.0	7.7	5.2	10.1	7.6	8.1	9.1	9.5	7.8	7.7

Note: Temperatures may not exceed 20°C at any time. Applicable temperature criteria for protection of the salmon life cycle are as follows: migration routes 15°C, spawning areas 13°C, rearing areas 15°C, egg & fry incubation 13°C.

Table 4-7. 2009 Susitna River Basin Temperatures (Cook Inlet Keepers, via personal communication).

Month	Temperature (°C)	Station Name												
		Alexander Creek	Byers Creek	Cache Creek	Chijuk Creek	Deception Creek	East Fork Chulitna River	Kroto (Deshka) Creek	Little Willow Creek	Montana Creek	Moose Creek (Talkeetna)	Trapper Creek	Troublesome Creek	Willow Creek
May	Max	--	7.0	6.4	**17.2**	12.8	6.5	**18.1**	8.1	10.5	--	**16.3**	6.0	--
	Min	--	5.5	3.2	5.3	2.0	3.1	9.5	5.8	0.1	--	2.8	4.3	--
	Mean	--	6.2	4.7	10.0	7.2	4.6	12.6	6.9	4.8	--	9.5	5.2	--
June	Max	**22.1**	**18.9**	**14.9**	**19.6**	**15.2**	11.5	**20.7**	**14.4**	**15.1**	--	**18.8**	**16.0**	**13.9**
	Min	10.9	6.2	3.6	6.7	5.6	3.3	9.6	6.3	5.2	--	9.2	4.2	7.1
	Mean	14.9	11.9	8.3	14.0	11.0	6.8	15.6	10.7	10.2	--	13.8	10.1	10.2
July	Max	**22.6**	**22.8**	**20.7**	**24.3**	**18.8**	**15.5**	**24.5**	**19.5**	**18.8**	**18.1**	**22.2**	**19.9**	**18.8**
	Min	13.1	11.9	7.8	13.9	10.3	6.2	14.1	11.0	10.0	12.4	13.6	10.3	10.6
	Mean	18.1	17.1	13.9	17.8	14.1	10.5	18.7	14.6	14.2	14.7	17.3	14.8	14.3
August	Max	**18.1**	**19.1**	**17.3**	**17.3**	**15.1**	**13.7**	**17.8**	**15.8**	**16.4**	**16.9**	**17.7**	**16.5**	**16.3**
	Min	9.5	10.7	5.8	9.3	8.8	3.8	11.6	8.7	9.2	9.5	11.1	8.0	8.9
	Mean	14.6	13.9	10.4	13.1	11.4	8.1	13.7	11.7	11.8	12.6	13.7	11.4	11.8
September	Max	**17.3**	**14.3**	11.5	**13.1**	11.2	9.3	12.6	12.1	**13.1**	**17.5**	**13.2**	11.2	12.6
	Min	2.9	5.2	0.8	7.7	6.9	1.0	4.8	2.8	2.9	7.1	4.2	2.3	3.5
	Mean	10.1	10.2	6.7	10.4	9.6	5.5	9.5	7.9	8.4	10.5	9.4	7.8	8.2

Month	**Temperature (°C)**	**Station Name**												
		Alexander Creek	Byers Creek	Cache Creek	Chijuk Creek	Deception Creek	East Fork Chulitna River	Kroto (Deshka) Creek	Little Willow Creek	Montana Creek	Moose Creek (Talkeetna)	Trapper Creek	Troublesome Creek	Willow Creek
October	Max	--	7.7	4.7	--	--	4.8	6.4	6.5	--	--	--	6.7	--
	Min	--	4.7	0.9	--	--	0.0	2.4	1.7	--	--	--	1.9	--
	Mean	--	6.3	3.0	--	--	2.7	5.0	4.2	--	--	--	4.1	--

Note: Temperatures may not exceed 20°C at any time. Applicable temperature criteria for protection of the salmon life cycle are as follows: migration routes 15°C, spawning areas 13°C, rearing areas 15°C, egg & fry incubation 13°C.

Table 4-8. Location of continuous temperature monitoring data on tributaries of the Susitna River mainstem (Cook Inlet Keeper, 2008 and 2009).

Stream Name	Description	Latitude	Longitude
Alexander Creek	Approx. 2 miles upstream from Susitna River	61.44000	-150.59600
Byers Creek	Upstream from Park's Highway	62.71158	-150.20407
Cache Creek	1/2 mile downstream from landing strip	62.38900	-151.08100
Chijuk Creek	At Oilwell Road Crossing	62.07963	-150.58314
Deception Creek	Upstream from Willow-Fishhook Road	61.76200	-150.03400
East Fork Chulitna River	Downstream from Park's Highway	63.14500	-149.42100
Kroto (Deshka) Creek	1 mile upstream from Susitna River	61.74000	-150.32000
Little Willow Creek	0.25 miles downstream from Parks Highway	61.81000	-150.09900
Montana Creek	End of Access Road South of Helena	62.12800	-150.01900
Moose Creek (Talkeetna)	At Oilwell Road Crossing	62.22900	-150.44100
Trapper Creek	At Bradley Road Crossing	62.26600	-150.18400
Troublesome Creek	Downstream from Park's Highway	62.62700	-150.22700
Willow Creek	0.25 miles upstream from Susitna River	61.78000	-150.16100

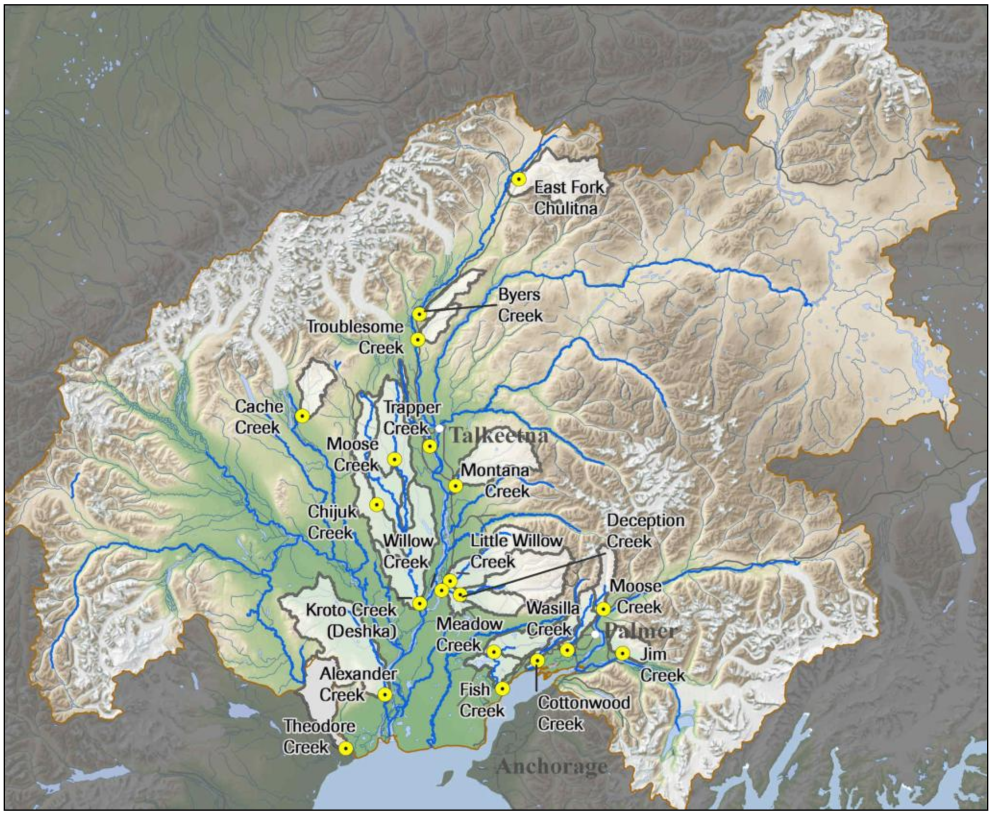

Figure 4-1. Mat-Su temperature monitoring locations, corresponding watersheds are highlighted.

Water quality summary data tables (Appendix B) were reviewed for concentrations of parameters that exceeded water quality criteria. Summer temperature measurements primarily at tributary stations exceeded criteria in the lower three reaches (reaches 2-4) in some cases for spawning and others, migration. High aluminum concentrations occurred at the upper three reaches (reaches 1-3) and forms of mercury had exceeded criteria only at lower mainstem stations. High background concentrations of metals have been noted from past studies and may have an effect on the fisheries should these elements become bioavailable. In areas like reach 4 where metals criteria had been exceeded, factors that promote elemental forms that become bioavailable are present like low dissolved oxygen concentrations and pH (Table 4-9).

Table 4-9. Location of water quality criteria exceedances in the Susitna River drainage.

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Criteria Exceedance
313 – 184	1	Upper Susitna River, including headwaters and tributaries above the proposed Watana dam	Aluminum Iron

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Criteria Exceedance
		site	
184 - 150	2	Middle Susitna River and tributaries through Devil's Canyon and below the proposed Watana Dam site	Total Dissolved Gas Temperature (for Migration) Aluminum
150 – 99	3	Middle Susitna River and tributaries from the mouth of Devil's Canyon to the Susitna – Chulitna – Talkeetna confluence	Temperature for Migration Aluminum Iron Total Mercury (Mainstem at Gold Creek)
99 – 0	4	Lower Susitna River from Susitna – Chulitna – Talkeetna confluence to mouth at Cook Inlet	Temperature for Spawning (Talkeetna River) Dissolved Oxygen pH Iron Mercury

The State of Alaska periodically prepares a list of impaired water bodies (303d list) that reports the type and magnitude of pollution problems. The impairments are presented on the ADEC web site and can be found at the following address:

http://www.dec.state.ak.us/water/wqsar/Docs/2010impairedwaters.pdf

The Susitna River and associated tributaries are not listed by the State of Alaska as impaired.

4.5 Timing of Pollutant Introduction

Evaluation of several groups of water quality parameters were previously compared against state criteria and are compared against biological toxics thresholds for salmon species using the no observed effects concentrations (NOECs) and lowest observed effects concentrations (LOECs). In addition, longitudinal station comparisons described how water quality conditions changed as the Susitna River flows downstream through distinct physical settings and influenced by tributary conditions.

Pollutant introduction can enter the Susitna River mainstem during many of the months of the year and remain sequestered until water quality conditions that favor mobilization occurs. Timing for pollutant mobilization can vary based on location in the drainage such as in the mainstem and tributaries to the

Susitna River. The physical settings of each reach will have a major influence on how water quality conditions could materialize and become factors of pollutant mobilization. The descriptions of these settings for the length of the Susitna River and the fisheries that could be affected by water quality impairments are combined in Table 4-10.

Mainstem

Distinct settings were identified using physical channel characteristics and surrounding topography of the mainstem Susitna River. A previous strategy for naming distinct reaches was suggested by Acres (1983) in the FERC Application for License (Table 4-10).

Tributaries

Tributaries to the Susitna River potentially represent sources of pollution that would be identified as data is analyzed from mainstem stations. The tributary rivers and streams tend to be influenced by human development in the watershed and so are important focal points for further evaluation. The connectivity between the mainstem Susitna River and the tributaries are further examined for value as fish population refugia and limitations to this type of access by the fisheries from pollution barriers, if present.

Table 4-10. Presence of fish species by Susitna River reach and segment.

River Mile (RM)	Reach	Average Bed Slope	Segment Description	Fish Species Present
313	Reach 1		Headwaters	
313-233			Upper Drainage Basin	Grayling, Rainbow Trout, Longnose Sucker
184-223			Area of Probable Inundation	Grayling, Burbot, Longnose Sucker, Round and Humpback Whitefish, Slimy Sculpin, Dolly Varden, Lake Trout, Chinook Salmon
184	Reach 2		Watana Dam Site	Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Chinook Salmon, Longnose Sucker
152			Devil's Canyon Proposed Site	Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Chinook Salmon, Longnose Sucker
149-144	Reach 3	0.00195	Single channel confined by valley walls. Frequent bedrock control points.	Chum, Coho, Chinook, and Pink Salmon, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
144-139		0.00260	Split channel confined by valley wall and terraces.	Chum, Coho, Chinook, and Pink Salmon, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
139-129.5		0.00210	Split channel confined occasionally by terraces and valley walls. Main channels, side channels and sloughs occupy valley bottom.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
129.5-119		0.00173	Split channel with occasional tendency to braid. Main channel frequently flows against west valley wall. Subchannels and sloughs occupy east floodplain.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker

River Mile (RM)	Reach	Average Bed Slope	Segment Description	Fish Species Present
119-104	Reach 3	0.00153	Single channel frequently incised and occasional islands.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
104-95		0.00147	Transition from split channel to braided. Occasionally bounded by terraces. Braided through the confluence with Chulitna and Talkeetna Rivers.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Arctic Lamprey, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
95-61	Reach 4	0.00105	Braided with occasional confinement by terraces.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Arctic Lamprey, Dolly Varden, Humpback Whitefish, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
61-42		0.00073	Combined patterns; western floodplain braided, eastern floodplain split channel.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Arctic Lamprey, Dolly Varden, Eulachon, Rainbow Trout, Burbot, Longnose Sucker
42-0		0.00030	Split channel with occasional tendency to braid. Deltaic distributary channels begin forming at about RM 20.	Chum, Coho, Chinook, Pink, and Sockeye Salmon, Arctic Lamprey, Dolly Varden, Eulachon, Rainbow Trout, Burbot, Longnose Sucker

Information gathered from tributary locations was arranged in a master table reporting existing data. These data were gathered from several sources (Section 4.1) and summarized for review of data gaps so that conclusions could be derived about potential impacts in each of the four reaches. Temperature data indicated that exceedances occurred during summer months and so were not affected by other factors during the remainder of the year. Metal concentrations were highest during the summer period in tributaries to the Susitna River. However, some metals concentrations were also periodically high outside of the summer period and this was important for evaluating effects to salmon and steelhead populations that were present at the same time.

4.6 Distribution of Primary Fish Species in the Susitna Drainage

Several species of fish are located in the Susitna River drainage that are ecologically and economically important to the region. The appearance of species in the Susitna River drainage is ordered by migration preferences. The presence of sensitive life stages at specific times during the year, and particularly during periods when water quality conditions are poor, provides some insight as to the influence impaired water quality conditions has on aquatic life and location of sources for impairment. A comparison of water quality conditions with fish presence identified convergence of biologically stressful periods during the year with the potential for toxics effects to fish species. The following excerpt from a 1983 ACRES EXHIBIT E report provides a general insight into fish species distribution.

"BEFORE THE FERC, APPLICATION FOR LICENSE FOR MAJOR PROJECT SUSITNA HYDROELECTRIC PROJECT VOL. 5A, EXHIBIT E, CHAPTERS 1 & 2" Prepared by ACRES February 1983, Alaska Power Authority.

Fishery resources in the Susitna River comprise a major portion of the Cook Inlet commercial salmon harvest and provide sport fishing for Anchorage and the surrounding areas. Anadromous fish in the Susitna basin include all five species of Pacific salmon: pink (humpback); chum (dog); coho (silver); sockeye (red); and chinook (king) salmon. The Susitna River is a migrational corridor, spawning area, and juvenile rearing area for the five species of salmon from its point of discharge into Cook Inlet to Devil's Canyon, where salmon appear to be prevented from moving upstream by the water velocity at high flow. Spawning occurs primarily in the tributaries, sloughs, and side channels; limited spawning occurs in the mainstem. Preliminary data indicate that the majority of the 1981 Susitna River escapement of sockeye, pink, chum, and coho salmon spawned above the Yentna River confluence and below Curry Station. Data also show that sloughs between Devil's Canyon and Talkeetna provide spawning habitat for pink, sockeye, and chum salmon. Field data show that juvenile chinook and coho salmon occur throughout the lower river, concentrating at slough and mainstem habitat during winter and at tributary mouths during summer.

Grayling abound in the clear-water tributaries of the upper basin; these populations are relatively unexploited. Grayling as well as lake trout also inhabit many lakes. The mainstem Susitna has populations of burbot and round whitefish, often associated with the mouths of clear-water tributaries. Dolly Varden, humpback whitefish, sculpin, sticklebacks, and long-nosed suckers have also been found in the drainage. Rainbow trout, like the anadromous species, have not been found above Devil's Canyon.

Fish presence is outlined in the following table (Table 4-11) and contains specific activities along with what functions the reaches serve in completing the life cycle.

The basis for evaluation of direct impairments to fisheries from elevated concentrations of metals and other toxics was aligned with presence of individual fish species, location, and life stage presence. The beginning of this analysis used information reported in Table 4-12. Each of the fish species have limited distribution in the drainage and represent focus for post-project evaluation by determining how water quality conditions may change in select settings with multiple project operational scenarios.

Table 4-11. Fish populations and life stage uses in Susitna River reaches.

Bounds of Reach (Susitna River Miles)	Reach Number	Life Stage and Salmon Species	Life Stage/Activity			
			Adult	Smolt/ Juvenile	Rearing	Spawning
313 – 184	1	Chinook Salmon	Limited (Historical)	Tributaries (Jay Creek and Oshetna River)		
		Coho Salmon				
		Sockeye Salmon				
		Pink Salmon				
		Chum Salmon				
		Steelhead				
		Grayling	Abundant (Tributaries)		Abundant (Tributaries)	Abundant (Tributaries)
184 – 150	2	Chinook Salmon				
		Coho Salmon				
		Sockeye Salmon				
		Pink Salmon				
		Chum Salmon				
		Steelhead				
		Grayling				
150 – 99	3	Chinook Salmon	Present	Mainstem & Sloughs (Summer-tributaries)		Limited Mainstem

Bounds of Reach (Susitna River Miles)	Reach Number	Life Stage and Salmon Species	Life Stage/Activity			
			Adult	Smolt/ Juvenile	Rearing	Spawning
		Coho Salmon	Present	Mainstem & Sloughs (Summer-tributaries)		Limited Mainstem
		Sockeye Salmon	Present			Limited Mainstem & Sloughs
		Pink Salmon	Present			Limited Mainstem & Sloughs
		Chum Salmon	Present			Limited Mainstem & Sloughs
		Rainbow Trout	Present			Limited Mainstem
		Grayling				
99 - 0	4	Chinook Salmon	Present	Mainstem & Sloughs (Summer-tributaries)		Limited Mainstem
		Coho Salmon	Present	Mainstem & Sloughs (Summer-tributaries)		Limited Mainstem
		Sockeye Salmon	Present			Limited Mainstem
		Pink Salmon	Present			Limited Mainstem
		Chum Salmon	Present			Limited Mainstem
		Rainbow Trout	Present			Limited Mainstem
		Grayling				

The summary of salmon and steelhead population presence indicates that the mainstem river is used primarily as a migration corridor. There is limited spawning occurring in reach 3 and reach 4 (the lower mainstem), with earlier life stages relying on coldwater refugia from some of the tributaries. Important habitat includes sloughs for rearing and migration of juveniles and smolts and tributary confluences.

4.7 Influence of Pollutants on Fish Species

Existing water conditions were compared against toxics concentration thresholds known to affect fish species (Table 4-12 and Table 4-13). Thresholds are expressed in a variety of ways (e.g., LC_{50}, LOEL, NOEL, etc.) and were used to compare known conditions within each of the river reach segments. This evaluation was the basis for determining pre-project conditions and then re-evaluating to project potential water quality conditions that might affect fish species once the project is constructed.

Comparison of existing metals data results are made with the toxics threshold criteria in Table 4-13 in order to determine if concentrations are likely to adversely affect fish populations. Not all fish species of interest in the Water Quality Data Gap Analysis had available toxics information for comparison.

Table 4-12. Available toxics threshold concentrations that effect select fish species known to occur in the Susitna River drainage.

SPECIES	CHEMICAL	STUDY TIME	LC_{01}(µg/L)	LC_{10}(µg/L)	Mean dose LC_{50}(µg/L)	Mean dose LOEL (µg/L)	Mean dose NOEL(µg/L)
Steelhead	Aluminum				7,761		1,496
Steelhead	Antimony				19,749		5,193
Chinook	Arsenic	96hr			66,216		17,411
Steelhead	Beryllium	28day			380		
Sockeye	Cadmium (dissolved)	96hr			18		
Chinook	Cadmium (dissolved)	96hr			13		4
Steelhead	Cadmium (dissolved)	96hr			12		2
Chinook	Chromium (hexavalent)	96hr			124,152		10
Steelhead	Chromium (hexavalent)	96hr			69,000		49
Steelhead	Chromium (trivalent)	96hr			23,250		
Steelhead	Cobalt	28day			490		
Chinook	Copper	96hr			59		24
Sockeye	Copper	96hr			283		100
Steelhead	Copper	96hr			74		12
Steelhead	Iron						5,000
Steelhead	Lead	96hr			24,565		131
Steelhead	Magnesium	96hr	367,000	660,500			
Steelhead	Manganese	28day			2,910		
Steelhead	Nickel	96hr			13,841		162
Chinook	Nitrate-Nitrogen	96hr			1,310,000		
Chinook	Nitrate-Nitrogen	7day			1,080,000		
Steelhead	Nitrate-Nitrogen	96hr			1,360,000		
Steelhead	Nitrate-Nitrogen	7day			1,060,000		
Steelhead	Nitrite-Nitrogen	96hr			190 - 390		
Chinook	Selenium (IV)	96hr			19,111		102
Chinook	Selenium (VI)	96hr			112,918		6,944
Steelhead	Selenium (IV)	96hr			10,490		47
Steelhead	Selenium (VI)	96hr			24,000		2,891
Steelhead	Silver	96hr			65		0
Coho	Sulfate (Copper Sulfate)	24hr			23 - 100		
Coho	Sulfate (Copper Sulfate)	96hr			19.3 - 31.9		
Coho	Sulfate (Copper Sulfate)	30 day				500	
Sockeye	Sulfate (Copper Sulfate)	96hr			100 - 240		
Chinook	Sulfate (Copper Sulfate)	24hr			78 - 145		
Chinook	Sulfate (Copper Sulfate)	96hr			54 - 60		
Steelhead	Thallium	28day			170		
Coho	Total Suspended Solids	96hr			1,300,000	1,300,000	
Chinook/Steelhead	Total Suspended Solids					20,000 - 650,000	100,000 - 1,300,000
Steelhead	Vanadium	28day			160		
Steelhead	Zinc	96hr			915		187
Chinook	Zinc	96hr			969		861
Sockeye	Zinc	96hr			2,041		595

Note: Values taken from *Biological Evaluation for Central Puget Sound Stormwater National Pollution Discharge Elimination System Permits, January 2009.*

Conclusions from this toxics threshold comparison mostly indicated that some metals concentrations did exceed the NOELs (No observed Effects Levels) and that this was consistent in multiple reaches for the same metals (Table 4-13). At least one of the several salmon/rainbow trout species may show chronic effects from the metals concentrations indicated from existing data, but much of this information does not reflect current conditions and may no longer be a factor in determining suitability of the chemical habitat for the fisheries. The sources of the metals that do reside in some of the physical habitat are of concern if mobilization occurs with changes in the hydrology of the river from project operations and if inundation of tributaries that supply the metals-laden sediment is a condition of these changes.

Table 4-13. Location of water quality conditions that present potential bioaccumulation of toxics in fish species in the Susitna River drainage.

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Toxics Threshold Exceedance
313 – 184	1	Upper Susitna River, including headwaters and tributaries above the proposed Watana dam site	Aluminum LC50 and NOEL; *(MacLaren River, Summer)* Copper NOEL; *(MacLaren River, Summer)* Iron NOEL; *(MacLaren River, Summer and Mainstem at Vee Canyon, Summer)*
184 - 150	2	Middle Susitna River and tributaries through Devil's Canyon and below the proposed Watana Dam site	NO DATA
150 – 99	3	Middle Susitna River and tributaries from the mouth of Devil's Canyon to the Susitna – Chulitna – Talkeetna confluence	Cadmium LC_{50} and NOEL; *(Mainstem at Gold Creek, Summer)* Aluminum LC_{50} and NOEL; *(Mainstem at Gold Creek, Spring & Summer)* Copper LC_{50}; *(Mainstem at Gold Creek, Summer)* Copper NOEL; *(Mainstem at Gold Creek, Spring & Summer)* Iron NOEL; *(Mainstem at Gold Creek, Spring & Summer)*
99 - 0	4	Lower Susitna River from Susitna – Chulitna – Talkeetna confluence to mouth at Cook Inlet	Aluminum LC_{50}; *(Mainstem at Sunshine, Spring & Summer)* Aluminum NOEL; *(Mainstem at Sunshine, Spring, Summer& Fall and Talkeetna River, Summer)* Copper LC_{50}; *(Mainstem at Sunshine, Spring and Mainstem at Susitna, Winter, Spring & Summer and Talkeetna River, Summer)* Copper NOEL; *(Mainstem at Sunshine, all year and Mainstem at Susitna, all year and Talkeetna River, Spring & Summer)*

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Toxics Threshold Exceedance
			Iron NOEL; *(Mainstem at Sunshine, Spring & Summer and Mainstem at Susitna, Spring, Summer, Fall and Talkeetna River, Summer)* Lead NOEL; *(Mainstem at Sunshine, Spring & Fall and Mainstem at Susitna, all year and Talkeetna River, Summer & Fall)* Zinc NOEL; *(Mainstem at Sunshine, Summer and Talkeetna River, Spring)*

4.8 Data Gaps and Need for Additional Information

Surface water data collected from existing sources was limited and primarily focused on conditions 30 years past (1980s). A greater volume of data describing conventional parameters was available at both mainstem and tributary sites, but was discontinuous over the length of the Susitna River corridor. Metals data was also discontinuous and this presents a challenge for evaluating potential for contamination of important refugia used by important salmon and rainbow trout populations in this drainage. A greater amount of monitoring for metals that represents the upper and lower boundaries of each reach (1 through 4) and at the mouth of major tributaries and other important fisheries tributaries would be beneficial in determining impact of project operations.

Table 4-14 below summarizes some of the data gaps that were identified in this analysis. Identified data gaps will need to be refined, modified, and developed as the licensing study planning process evolves. Information gaps that are ultimately determined to be worthy of future study will be determined based on analysis of project issues and the needs of the regulatory process. The critical points for water quality monitoring are important mainstem and tributary habitats used by fisheries during different phases of life cycles. The need to know how these important habitats will respond to changes in hydrologic regime and sediment load is important background information that will enable stronger predictions to be made about effects from project operations. A general comment about existing data is that it does not generally represent present conditions and more current information will be necessary to construct reliable predictions about impact to critical habitats of salmon and rainbow trout populations in the mainstem Susitna River and at the mouths of tributaries throughout the downstream project area.

Table 4-14. Reach segmentation for the Susitna River Basin data gap analysis.

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Data Gaps
313 – 184	1	Upper Susitna River,	1. Surface water and

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Data Gaps
		including headwaters and tributaries above the proposed Watana dam site	sediment analysis for metals not available for mainstem, only for one tributary. 2. 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. 3. Continuous temperature data is not available for mainstem, tributary, and sloughs potentially used for spawning and rearing.
184 - 150	2	Middle Susitna River and tributaries through Devil's Canyon and below the proposed Watana Dam site	1. Temperature data is not available above and below most tributaries on the mainstem Susitna River. 2. Overall, very limited surface water data available for this reach. 3. Metals monitoring data does not exist or is limited. 4. Analysis of sediments for metals immediately below the proposed Project ; sediments may become transportable once the Project begins operation. 5. Monitoring of mainstem and sloughs (ambient conditions and metals)

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Data Gaps
			needed for determining bioaccumulation potential of juvenile Chinook and Coho salmon.
150 – 99	3	Middle Susitna River and tributaries from the mouth of Devil's Canyon to the Susitna – Chulitna – Talkeetna confluence	1. Sources for metals detected at high concentrations in mainstem (1 location). Improvements to sampling would include consideration for increasing spatial coverage of sampling points to provide adequate representation of conditions. 2. Current data reflects large spatial data gaps between upper reach 1 and the mid- to lower reach 3 and 4. 3. Monitoring of mainstem and sloughs for juvenile Chinook and Coho survival. 4. Continuous temperature data is not available for mainstem, tributary, and sloughs potentially used for spawning and rearing.
99 - 0	4	Lower Susitna River from Susitna – Chulitna – Talkeetna confluence to mouth at Cook Inlet	1. Although has the most data available, most data is old and most likely does not represent current conditions.

Bounds of Reach (Susitna River Miles)	Reach Number	General Description	Water Quality Data Gaps
			2. Metals data not available for mouth of Chulitna River. Influence of major tributaries (Chulitna and Talkeetna Rivers) on water quality conditions is unknown. There are no monitoring stations in receiving water at these mainstem locations. 3. Metals data not available for the Skwentna River or the Yentna River. 4. Continuous temperature data is not available for the mainstem and sloughs potentially used spawning and rearing habitat.

4.9 Potential Influence of the Project on Water Quality Conditions

The evaluation of potential toxics effects from metals on several salmon populations in this drainage necessitates the comprehensive collection of metals and conventional water quality data for a more thorough evaluation for how project operations will affect potential for exposure. Several of the evaluations involving comparison of salmon/rainbow trout presence at reach locations resulted in exceedance of either NOELs or LC_{50}s. In cases where just NOELs were exceeded there is likely no adverse impact to a life stage or adult of the species, but the potential sensitivity to minor increases in toxics concentrations is likely to occur.

Potential for bioaccumulation of metals in salmon/rainbow trout populations in the lower reaches of this drainage is present and changes to the hydrology of the mainstem river system will influence characteristics of exposure to toxics. There are four ways in which the potential for bioaccumulation of toxics may be increased by project operations:

- Change in hydrology magnifies delivery of metals from tributary sources at select locations on the mainstem and in sloughs (reduce dilution effects by reducing mainstem flow)

- Create slower moving water that will enhance conditions that promote mobilization of toxics (e.g., low dissolved oxygen concentrations, low pH, low redox potential)
- Inundate/expose mouths of tributaries that are important for survival of juvenile/smolt life stages and that may expose aquatic life to mobilized toxics
- Promote establishment of temperature barriers at the mouths of inundated tributaries so that loss of thermal refugia occurs for juveniles and smolts

Changes to the hydrologic characteristic of the river from project operations could enhance fisheries habitat for both chemical and physical conditions. Those improvements in water quality conditions might be result from the following:

- Temperature conditions could be improved in tributary confluence habitat should the mainstem temperatures remain lower (cooling effect of tributary water temperature that is high during the summer)
- Reduction in sediment load from the upper river (reach 1) that may be carrying metals associated with fine sediment (silt) and that is additive to the burden contributed by large tributary rivers like the Chulitna River
- Dissolved oxygen concentrations and thermal refugia could remain more constant and spatially contiguous so as not to present migrational barriers to fisheries currently known to inhabit the Susitna River drainage.

Currently, there is no way to know the characteristics of important chemical and physical refugia that are used by the salmon/rainbow trout populations. Predictions for how the project might influence conditions require the characterization of refugia known to be important to life stages for the anadromous and resident fish species. A map of the refugia compared to hydrology and area of inundation for both the mainstem and tributaries offers a more reliable base of information from which to make these predictions.

4.10 Long-term Monitoring Concepts

Predictions made for influence of project operations on water quality could be evaluated through a long-term monitoring program. Several issues are important to keep in mind when developing this monitoring program and specific items could be included as components:

1. Implement temperature monitoring upstream and downstream of major tributaries on the mainstem Susitna River and those known to sustain important spawning areas. Additional temperature monitoring in sloughs should be included as these are important rearing areas for Chinook and Coho salmon. Summer coldwater refugia are important for survival of smolt and juvenile Chinook and Coho salmon and locations along the river should be characterized if the potential for habitat loss is possible by proposed operational scenarios.
2. Metals monitoring is currently sparse and needs to cover a greater spatial area in the drainage so that potential exposure to toxics from inundation of tributary mouths can be predicted.

Changes to flow and the immediate physiochemcial conditions at tributary mouths could be lethal to juveniles and smolts that use these areas as refugia during rearing in summer months.

3. Update monitoring data with a new monitoring program that generates both conventional and metals data using up-to-date analytical methods. Older data have higher reporting limits and instrument detection limits that are not compatible with much of the current water quality criteria adopted by the State of Alaska.

Any monitoring program should be evaluated periodically to determine where data are no longer needed or needed only on a less frequent basis. Key monitoring locations should be established as response locations to project operations that serve as an early warning of potential water quality problems that would affect salmon/rainbow trout populations..

5 Sediment Transport

Consideration of the impacts of the proposed Watana Project on sediment transport can be separated into two groups based on whether they occur upstream (i.e., Reach 1) or downstream of the proposed Project (i.e., Reach 2 through Reach 4). Upstream issues primarily relate to sedimentation where the Susitna River enters the reservoir, erosion along the reservoir shoreline, or sedimentation at the mouth of tributaries flowing into the reservoir. Downstream sediment transport issues primarily relate to the following influences on channel morphology, aquatic habitats, channel erosion and flooding: 1) regulated flows released from the proposed Project, 2) the discontinuity in sediment supply and transport through the proposed reservoir and 3) sediment transport capacity below the major tributary confluences (Reaches 3 and 4).

The following sources of information were reviewed and found to have pertinent data to sediment transport issues associated with the proposed Watana Project:

Acres. 1983a. *Before the Federal Energy Regulatory Commission Application for License for Major Project Susitna Hydroelectric Project. Volume 5A, Exhibit E, Chapters 1 & 2.* Prepared for Alaska Power Authority.

Acres. 1983b. *Before the Federal Energy Regulatory Commission Application for License for Major Project Susitna Hydroelectric Project. Volume 5B, Exhibit E, Chapter 2 Figures.* Prepared for Alaska Power Authority.

AEA. 2010. *Railbelt Large Hydro Evaluation Preliminary Decision Document*. Prepared by the Alaska Energy Authority (AEA).

APA. 1984. *Susitna Hydroelectric Project Economic and Financial Update.* Draft Report dated February 27, 1984. Prepared by the Alaska Power Authority (APA).

Knott, J.M. and S.W. Lipscomb. 1985. *Sediment Discharge Data for Selected Sites in the Susitna River Basin, Alaska, October 1982 to February 1984.* USGS Open File Report 85-157. Prepared in cooperation with the Alaska Power Authority. Anchorage, Alaska.

Knott, J.M. Lipscomb, S.W., and T.W Lewis. 1986. *Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska, October 1983 to September 1984.* USGS Open File Report 86-424W. Prepared in cooperation with the Alaska Power Authority. Anchorage, Alaska.

Knott, J.M. Lipscomb, S.W., and T.W Lewis. 1987. *Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska: Data for Water Year 1985 and Trends in Bedload Discharge, 1981-85.* USGS Open File Report 87-229. Prepared in cooperation with the Alaska Power Authority. Anchorage, Alaska.

Quane, T., Morrow, P., and I. Quaral. Undated. *Task 14 Support Technical Report, Hydrological Investigations at Selected Lower Susitna River Study Sites.* Prepared by Alaska Department of Fish and Game, Aquatic Habitat and Instream Flow Project. Susitna Hydro Aquatic Studies Report Series. Prepared for Alaska Power Authority. Anchorage, Alaska.

R&M Consultants. 1985. *Lower Susitna River Aggradation Study: Field Data. Final Report.* Prepared under contract to Harza – Ebasco Susitna Joint Venture. Prepared for Alaska Power Authority. Document No. 2719.

Seagren, D.R., and R.G. Wilkey. 1985. *Summary of Water Temperature and Substrate Data from Selected Salmon Spawning and Groundwater Upwelling Sites in the Middle Susitna River.* Technical Data Report No. 12. Prepared by the Alaska Department of Fish and Game. Anchorage, Alaska.

An overarching issue that affects the identification of data gaps relative to sediment transport and its potential impacts is the near absence of sediment transport data collected more recently than the 1980s. To establish whether the conditions represented by the data collected in the 1980s are still representative of current conditions, at the least a baseline comparison of current and 1980's era morphological characteristics in each of the identified subreaches is required. Without a basis for assessing the suitability of the historical data, identification of specific data gaps is difficult. Thus, a primary data gap is a baseline of existing hydraulic, geomorphic, and sediment conditions within the reaches potentially affected by the proposed Project. The following paragraphs describe the results of the review of relevant available documents and the identification of apparent data gaps; however, until a current conditions baseline is established, there is no basis for interpreting in a meaningful way some of the historically collected data.

5.1 Considerations Upstream of Watana Dam

Sediment transport considerations upstream of Watana Dam are grouped into one of three categories: 1) sedimentation where the Susitna River enters the reservoir, 2) erosion along the reservoir shoreline, and 3) sedimentation at the mouth of tributaries flowing into the reservoir.

5.1.1 Sedimentation where the Susitna River enters Watana Reservoir

The construction and operation of the proposed Susitna-Watana Project will impound a reservoir for approximately 39 miles upstream from the dam. The reservoir will create a backwater that will change the hydraulics of the Susitna River such that the capacity to transport coarse sediment through the impoundment will effectively cease and fine sediment transport capacity within the reservoir will decrease significantly. The bed material sediment that enters the reservoir will form a delta where the river enters the reservoir. The hydrologic dataset of flows into the reservoir (MWH 2011) can be coupled with sediment discharge rating curves developed during the 1980s to estimate the load delivered to the delta; however, the sediment discharge rating curves are not available in the vicinity of the proposed dam site. Given the potential for much of the coarse sediment from headwater glaciers and tributaries to settle out in the broad valleys above the proposed dam site (Acres 1983a), the lack of existing rating curves for the reach where the Susitna River enters the Watana Reservoir is a data gap. Accurate characterization of the annual sediment loading to the reservoir will serve two main purposes: 1) it provides a basis for evaluating loss of storage due to sedimentation, and 2) the amount of sediment trapped in the reservoir is the deficit of sediment supplied to downstream reaches.

5.1.2 Watana Reservoir Shoreline Erosion

The impoundment of the Watana Reservoir will seasonally inundate hillslopes around the perimeter of the reservoir. No information was identified to estimate the contribution and gradation of sediment eroded from the reservoir perimeter. The erosion may occur in response to seasonal variations in pool level, local changes in groundwater elevations, freezing and thawing, landslides, ice floes, wind driven waves, and waves from recreational boaters, should access for recreational boating be provided. Thus, within-reservoir perimeter erosion and sediment delivery is a data gap.

5.1.3 Sedimentation at Tributary Mouths

Similar to the situation that is expected to occur where the Susitna River enters Watana Reservoir, sedimentation is expected to occur where tributaries enter the reservoir. The amount and distribution of sedimentation may impact the connectivity between the reservoir and the tributary channels. The formation of a delta may lead to flows conditions that do not permit upstream fish passage. The reviewed information does not contain data describing the annual loads and the gradations of the sediment that could be transported to and deposited at the mouth of tributaries that enter the reservoir, and therefore this is a data gap.

5.2 Considerations Downstream of Watana Dam

Sediment transport issues downstream of Watana Dam are expected to stem from the influences of the regulated outflows and the deficit of sediment because of trapping in the reservoir. These issues are particularly important because fish resources have the greatest potential to be impacted by the Project, and most of the potential impacts would occur downstream of the Project (AEA 2010). The effect of altered flows on anadromous and resident fish habitats and their associated populations was the major focus of studies conducted in the 1980s (APA 1984). The major fish habitats are located in the Susitna River, side channels, side sloughs, upland sloughs, and tributary mouths (APA 1984). Elimination of the bed material sediment load from the upstream basin could lead to clear-water scour in the reach between the dam and the head of Devil's Canyon and possibly coarsening of the bed material which could have adverse effects on any existing salmonid habitat in the reach. Additionally, reduced flows could change sediment transport capacity immediately downstream of the confluences with the Chulitna and Talkeetna Rivers in Reach 3, which in turn could lead to some form of local aggradation and aggradation-induced flooding and lateral channel erosion. Conversely, reduced flows could enhance the existing stability of the reach between the mouth of Devil's Canyon and the Chulitna/Talkeetna Rivers confluence. Depending on the balance between the reduced flows and the sediment introduced by tributaries downstream of the dam, it is possible that there could be coarse sediment deposition within the Reach 2 that might increase the available habitat for various life stages of salmonid species downstream of the mouth of the Canyon.

5.2.1 Regulated Hydrology

The hydrology of the Susitna River Basin is critical in determining how the proposed Watana Project can be operated, and how the reservoir regulation and associated releases from the Project affect the downstream hydrologic and sediment transport regimes. A water balance reflecting proposed operations, conducted at an increment short enough to characterize operations scenarios (e.g., an hourly increment), depends on natural flows to the proposed reservoir, and the natural flows are a function of the basin hydrology. The following sources were reviewed for hydrologic data:

Acres. 1983a. *Before the Federal Energy Regulatory Commission Application for License for Major Project Susitna Hydroelectric Project. Volume 5A, Exhibit E, Chapters 1 & 2.* Prepared for Alaska Power Authority.

Acres. 1983b. *Before the Federal Energy Regulatory Commission Application for License for Major Project Susitna Hydroelectric Project. Volume 5B, Exhibit E, Chapter 2 Figures.* Prepared for Alaska Power Authority.

MWH. 2011. *Watana Hydroelectric Project Susitna Watershed Historical Hydrology.* NTP 2 Technical Memorandum No. 3. AEA11-022. Prepared for Alaska Energy Authority. Bellevue, WA.

The *Watana Hydroelectric Project Susitna Watershed Historical Hydrology Technical Memorandum* (MWH 2011) summarizes available hydrologic data and presents statistics for estimating flow at the Watana Dam site. The data presented in this memorandum appear to be an expansion of the data presented in the Acres 1983 reports. A daily flow dataset was modeled over a 57 year period using measurements from USGS gages upstream (near Cantwell) and downstream (near Gold Creek) of the proposed Project. Monthly and annual flood frequency and flow-duration relationships were developed from daily flow measurements collected by the USGS for the Susitna River at Cantwell and Gold Creek, in the Chulitna River near Talkeetna, and in the Susitna River at Sunshine and Susitna Station. The *Technical Memorandum* also includes a monthly and average annual flow distribution for the Susitna River watershed. As shown in Figure 5-1, it was calculated that on an average annual basis, flows at the Watana dam site accounts only for 17 percent of the flow measured at the Susitna Station USGS gage. Figure 5-1 also shows that the Chulitna River provides nearly the same contribution as the flows at the Watana dam site to the annual flow measured at the Susitna Station USGS gage.

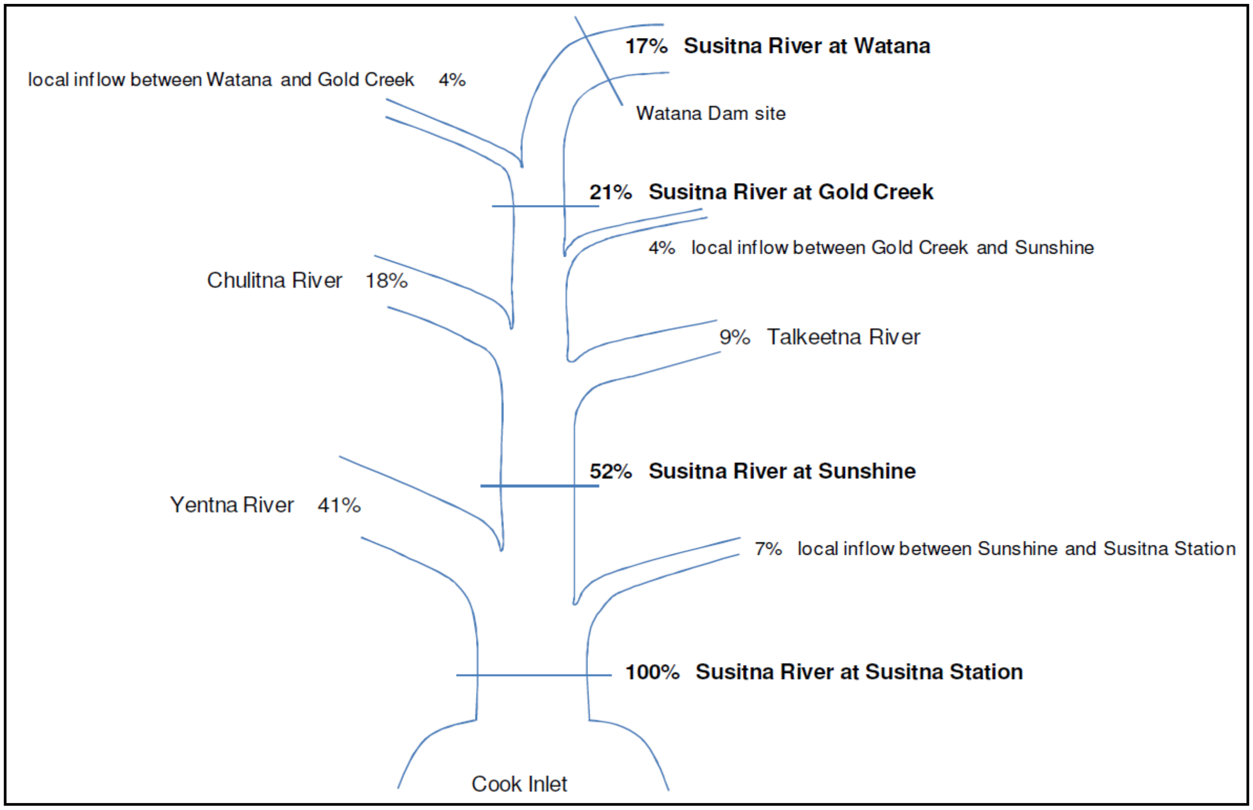

Figure 5-1. Average annual flow distribution for the Susitna River (MWH 2011).

While the *Historical Hydrology Technical Memorandum* (MWH 2011) includes a long-term dataset of flows into the proposed reservoir, some gaps in the available dataset are evident. For example, the dataset lumps all inflows together, but analyses of access to tributaries, thermal refugia in the tributaries, and loading of sediment from the tributaries to the reservoir will require flow datasets for each tributary of interest. Another gap is the absence of a regulated flow dataset released from the proposed Watana Project for the proposed Project configuration and proposed operations. Evaluations of aquatic habitat, fisheries resources, water quality, and downstream erosion and flooding impacts will require comparisons of with- and without-Project hydrology. It is expected that seasonal storage and release operations would have the general effect of reducing summer high flows and increasing winter low flows. The regulated hydrology may affect access to aquatic habitats as well as sediment transport rates and timing that ultimately govern formation and maintenance of dynamic aquatic habitats. Studies may also require flow datasets from tributaries, particularly where the delivery of flow and sediment to the main channel may have the potential to mitigate impacts of the Project (i.e., tributaries between the Project and the confluences of the Susitna, Chulitna, and Talkeetna Rivers).

In addition to gaps in surface hydrology, as reported in the *Application for License for Major Project Susitna Hydroelectric Project* (Acres 1983a), datasets are not available to describe groundwater flows (both from the mainstem Susitna to side channel and sloughs and from the valley slopes to the valley bottom) and the exchange of flow between the surface, hyporheic zone, and groundwater. It is believed that groundwater flow and hyporheic flow are key during incubation of salmonid eggs and rearing of juvenile salmon. Temperature data in Table 4-6 indicate that periodic exceedance of criteria for protection of egg and fry development occurs in tributaries throughout the drainage. Detailed temperature data for sloughs and portions of the mainstem is not available and represents a data gap for identifying location and extent of groundwater influence in slough and mainstem areas important for egg growth and rearing.

5.2.2 Sediment Continuity

USGS studies from the 1980s found that the Chulitna and Talkeetna Rivers, despite a combined smaller drainage area than the upper Susitna River, transport three times as much total sediment as the upper Susitna River (Knott and Lipscomb 1985; Knott et al. 1986; Knott et al. 1987). The *Lower Susitna River Aggradation Study: Field Data* (R&M Consultants 1985) reports that approximately 80 percent of the total sediment load in the Susitna River below Talkeetna originates in the Chulitna and Talkeetna Rivers. Based on this information, the trapping of sediment in the proposed Watana Reservoir may only substantially influence the sediment dynamics between the dam site and the Susitna – Chulitna – Talkeetna confluence (primarily Reach 2 since Devil's Canyon is bedrock controlled and currently has a very low sediment storage potential). The magnitude of the influence will depend largely on the natural sediment loading from the upper watershed and ability of the sediment loading from the tributaries between the dam site and the Susitna – Chulitna – Talkeetna confluence to mitigate sediment impacts of the Watana Project. None of the available documents contain data describing the amount and gradation of sediment delivered by these tributaries to the Susitna River.

On an annual average basis, the flow contributions from the Susitna River and the Chulitna River to the flow at Susitna Station USGS gage are similar; however, the morphology of these two systems is markedly different. The relatively stable channel morphology of the Susitna River indicates that much of the sediment generated in the headwaters is stored in the upper basin such that the sediment supply delivered downstream of the Watana dam site more closely matches the transport capacity of the flows, or that the channel in Reach 2 downstream of Devil's Canyon is coarser and the bed and banks have become armored over time. Alternately, the braided morphology of the Chulitna River indicates an excessive sediment supply relative to transport capacity. Further quantification of the sediment supply and transport capacity would help identify the sensitivity of the channel morphology (and associated aquatic habitats) to the effects of the proposed Watana Project. The relative stability of the Susitna River morphology upstream of the Susitna – Chulitna confluence in Reach 2 could possibly even be enhanced depending on the regulated outflows from the Project. Information on sediment continuity could provide a basis for evaluating whether the Susitna River below the Chulitna confluence would be at risk of aggradation, and if so, whether the magnitude would alter aquatic habitats and hydraulic connectivity to these habitats. Side channels and sloughs are of particular importance to fisheries, so changes to the relationships between flow and stage at which the habitats are accessible could impact the fisheries. Other impacts could affect the cleaning of spawning gravels, hyporheic flows through redds, groundwater inflows, and hydraulic connectivity for out migration to the main channel. Since

Project operations would have some effect, the focus may be on the rate of change as opposed to the magnitude of change.

Numerical modeling of the sediment transport dynamics would provide a basis for comparing the changes in channel morphology and aquatic habitat associated with the proposed Project and the proposed operations. One-dimensional HEC-2 hydraulic models were developed in the 1980s to support the calculation of water-surface profiles and channel hydraulics (Acres 1983a). The models represented the reach between Devil's Canyon (Susitna RM 186.8) and Talkeetna (RM 99), excluding Devil's Canyon (Susitna RM 162.1 to RM 150.2). The HEC-2 hydraulic model covers nearly the entire reach of interest for sediment modeling. Even if the geometric data are deemed to no longer be representative of existing conditions due to changes in channel morphology, the data provide points of reference for comparing changes in channel morphology over time. Review of historical and current aerial photography, and comparison of new surveys at selected locations would provide a basis for evaluating whether the historical survey data are appropriate, or whether new data are required. Bed material sediment data are another requirement for sediment transport modeling. The focus of the samples collected in the 1985 *Aggradation Study* (R&M Consultants 1985) focused on the 12.5 miles downstream from the confluence of the Susitna River with the Chulitna and Talkeetna Rivers. Other sources characterize bed material sediment (Seagren and Wilkey 1985), but the characterizations are primarily visual classifications for use in comparing selected salmon spawning areas and groundwater upwelling areas, so the data are not appropriate as primary data for sediment transport modeling. The available sources of information do not document bed material samples collected within the reach between the proposed Project and the Susitna – Chulitna – Talkeetna confluence, so the lack of this information is a data gap.

As part of the 1980s studies, a study was conducted to evaluate the response of stage and flow at selected aquatic habitat locations along the lower Susitna River (Quane et al. undated). The selected study sites were located between Susitna RM 91.6 and RM 35.2 (approximately between the Susitna – Talkeetna confluence and the Susitna – Yentna confluence). While this study identified the hydraulic conditions necessary for flows to access the habitats, none of the findings are specific to the reach between the proposed Project and the confluence of the Susitna – Chulitna – Talkeetna Rivers. The lack of this type of hydraulic data related to habitat accessibility in this reach is a data gap. Appropriate hydraulic information could include stage – discharge relationships at the head and mouth of representative major habitat types and stage – duration relationships, either on an annual, season or life stage-specific basis.

5.2.3 Analysis of Sediment Transport Data Gaps

The identified sediment data gaps are summarized as follows:

1. The lack of existing sediment rating curves for the reach where the Susitna River enters the Watana Reservoir.
2. The lack of within-reservoir perimeter erosion and sediment delivery data.

3. The lack of data describing the annual loads and the gradations of the sediment that could be transported to and deposited at the mouth of tributaries that enter the reservoir.
4. The lack of information on the volume and gradations of bed material stored in the channel between the Susitna-Watana dam site and the head of Devil's Canyon.
5. The absence of a regulated flow dataset released from the proposed Watana Project for the proposed Project configuration and proposed operations. Evaluations of aquatic habitat, fisheries resources, water quality, and downstream erosion and flooding impacts will require comparisons of with- and without-Project hydrology.[1]
6. The lack of flow datasets from tributaries, particularly where the delivery of flow and sediment to the main channel may have the potential to mitigate impacts of the Project (i.e., tributaries between the Project and the confluences of the Susitna, Chulitna, and Talkeetna Rivers).[2]
7. The lack of data describing the amount and gradation of sediment delivered by these tributaries to the Susitna River.
8. The lack of data to quantify sediment supply and transport capacity (sediment continuity) to identify the sensitivity of the channel morphology (and associated aquatic habitats) to the effects of the proposed Watana Project.
9. The lack of historical and current aerial photography, and comparison of new topographic surveys at selected locations that would provide a basis for evaluating whether the historical survey data and hydraulic model output are still appropriate, or whether new data are required.
10. The lack of quantitative bed material data collected within the reach between the proposed Project and the Susitna – Chulitna – Talkeetna confluence.
11. The absence of information on hydraulic conditions necessary for flows to access habitats between the proposed Project and the confluence of the Susitna – Chulitna – Talkeetna Rivers. Appropriate hydraulic information could include stage – discharge relationships at the head and mouth of representative major habitat types and stage – duration relationships, either on an annual, season or life stage-specific basis.

The available sediment data are focused around the confluence of the Susitna – Chulitna – Talkeetna Rivers. Since the available data was primarily collected in the early to mid 1980s, the data are insufficient for evaluating temporal and spatial changes in major habitat types; however, if additional information is collected, the existing information could provide a reference for evaluating temporal and spatial changes within the various reaches of the Susitna River.

The available information, and particularly the focus of the numerous studies conducted in the 1980s, indicate that the geomorphology of the Susitna River and its associated aquatic habitats, channel

[1] To be provided by MWH
[2] To be provided by MWH

stability and flooding potential may be sensitive to changes in the hydrologic and sediment transport regime caused by the construction and operation of the proposed Watana Project. Simulations of with- and without project conditions using mathematical computer models may be required to better understand the effects of the Project. However, development and application of appropriate models is frequently data intensive, and the current lack of available hydrologic and sediment data prevent such modeling from being conducted in all potentially impacted areas.

6 References

Note – this section focuses on references used to describe toxic thresholds and aquatic resources. Other material reviewed as part of the Water Quality and Sediment Gap Analysis is presented in Appendix A, Bibliography of Reference Literature

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APPENDIX A:

BIBLIOGRAPHY OF REFERENCE LITERATURE

Dam Reports

DATE	SOURCE	AUTHOR	TITLE	LOCATION
2009	Alaska Energy Authority	HDR Alaska; Northern Economics	Project Evaluation, Interim Memorandum, Final	http://www.aidea.org/aea/SusitnaFiles/031609EvaluationWOappen.pdf
2009	Alaska Energy Authority	R&M Consultants; Acres; Jack Linnard Consulting	Susitna Project Watana and High Devil's Canyon RCC Dam Cost Evaluation Final	http://www.aidea.org/aea/SusitnaFiles/111609_SusitnaProject-RCCDamConceptReport.pdf
2010	Alaska Energy Authority	AEA	Railbelt Large Hydro Evaluation Preliminary Decision Document	ftp://ftp.aidea.org/RailbeltLargeHydro/112310FinalWLetter.pdf
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 2, Exhibit B	University of Washington Library
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 4, Exhibit G	University of Washington Library
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 5, Exhibit E, Chapters 1&2	University of Washington Library
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 6B, Exhibit E, Chapter 3	University of Washington Library
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 7, Exhibit E, Chapters 4-6	University of Washington Library
1983	Alaska Power Authority	Acres	FERC Application for License for Major Project Susitna Hydroelectric Project, Vol. 9 Exhibit E, Chapter 10	University of Washington Library

DATE	SOURCE	AUTHOR	TITLE	LOCATION
1984	University of Alaska – Anchorage	Alaska Power Authority	Susitna Hydroelectric Project Economic and Financial Update	http://www.aidea.org/aea/SusitnaFiles/022784EconomFinUpdate.pdf

Environmental Reports

DATE	SOURCE	AUTHOR	TITLE	LOCATION
2011	Alaska Department of Fish and Game	ADF&G	Catalog of Waters Important for Spawning, Rearing, or Migration of Anadromous Fishes – Southcentral Region, Effective June 1, 2011	http://www.adfg.alaska.gov/sf/SARR/AWC/index.cfm?ADFG=data.AWCdata
2011	Alaska Energy Authority	MWH	Watana Hydroelectric Project Susitna Watershed Historical Hydrology	AEA11-022
2006	Aquatic Restoration and Research Institute	Jeffery C. Davis; Gay A. Davis	Montana Creek Ecological and Water Quality Assessment	http://www.dec.state.ak.us/water/acwa/pdfs/fy06_montana_creekfinal.pdf
2008	Aquatic Restoration and Research Institute	Jeffery C. Davis; Gay A. Davis	Water Quality Evaluation of the Lower Little Susitna River	http://www.dec.state.ak.us/water/wqsar/pdfs/LittleSusitnaRiverWaterQualityDECFY08FinalReportv2.0.pdf
2007	Cook Inlet Aquaculture Association	CIAA	Susitna River Watershed Project	Smolts Volume 25, Issue 1.
1964	United States Department of the Interior	V. K. Berwick, J. M. Childers, M. A. Kuenrzel	Magnitude and Frequency of Floods in Alaska, South of the Yukon River	http://www.dggs.dnr.state.ak.us/webpubs/usgs/c/text/c-0493.PDF
2006	United States Environmental Protection Agency	EPA	2006 Waterbody Report for Susitna River	http://iaspub.epa.gov/tmdl_waters10/attains_waterbody.control?p_au_id=AK-20505-007_00&p_cycle=2006&p_state=AK&p_report_type=#sources
1984	United States Geological Survey	Elisabeth Snyder	Activities of the Alaska District, Water Resources Division	http://www.dggs.dnr.state.ak.us/webpubs/usgs/of/text/of84-0246.PDF
1985	USGS	James M. Knott; Stephen W. Lipscomb	Sediment Discharge Data for Selected Sites in the Susitna River Basin, Alaska, Oct. 1982- Feb 1984	USGS Open File Report 85-157
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DATE	SOURCE	AUTHOR	TITLE	LOCATION
		Lewis	Alaska	
1987	United States Geological Survey	James M. Knott; Stephen W. Lipscomb; Terry W. Lewis	Sediment Transport Characteristics of Selected Streams in the Susitna River Basin, Alaska	http://www.dggs.alaska.gov/webpubs/usgs/of/text/of87-0229.PDF
1986	United States Geological Survey	John R. Williams; John P. Galloway	Radiocarbon dating in Western Copper River Basin and adjacent uplands and in the uppermost Matanuska River Valley	http://www.dggs.dnr.state.ak.us/webpubs/usgs/of/text/of86-0390.PDF

Direct Data Sources

DATE	SOURCE	AUTHOR	TITLE	LOCATION
2005	American Geophysical Union	John A. Harrison; Nina Caraco; Sybil P. Seitzinger	Global patterns and sources of dissolved organic matter export to the coastal zone: Results from a spatially explicit, global model	https://sftp101.urscorp.com/human.aspx?OrgID=9164
1986	Alaska Power Authority	Harza-Ebasco Susitna Joint Venture	Susitna Hydroelectric Project Water Quality Monitoring 1985	http://sharepoint.aidea.org/railbeltlargehydro/Reference%20Library/Susitna%20Historical%20Documents/Pre%202000%20Documents/3402.pdf (AEA Reference Library)
1977	United States Environmental Protection Agency	National Park Service	STORET Station Details, DENA_NURE_1396-A42875	http://iaspub.epa.gov/waters10/attains_get_services.storet_station?p_org=11NPSWRD&p_station=DENA_NURE_1396
1977	United States Environmental Protection Agency	National Park Service	STORET Station Details, DENA_NURE_1766-A43469	http://iaspub.epa.gov/waters10/attains_get_services.storet_station?p_org=11NPSWRD&p_station=DENA_NURE_1766
1990	United States Geological Survey	USGS	Largest Rivers in the United States	http://pubs.usgs.gov/of/1987/ofr87-242/
2008	United States Geological Survey	USGS	Suspended Sediment Database Daily Values of Suspended Sediment and Ancillary Data	http://co.water.usgs.gov/sediment/conc.frame.html
1986	United States Geological Survey	USGS	USGS 15291000 SUSITNA R NR DENALI AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291000&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1975	United States Geological Survey	USGS	USGS 15291200 MACLAREN R NR PAXSON AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291200&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15291500 SUSITNA R NR CANTWELL AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15291500&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=

DATE	SOURCE	AUTHOR	TITLE	LOCATION
				0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292000 SUSITNA R AT GOLD CREEK AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292000&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292400 CHULITNA R NR TALKEETNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292400&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
2011	United States Geological Survey	USGS	USGS 15292700 TALKEETNA R NR TALKEETNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292700&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15292780 SUSITNA R AT SUNSHINE AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15292780&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1981	United States Geological Survey	USGS	USGS 15294300 SKWENTNA R NR SKWENTNA AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294300&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
1986	United States Geological Survey	USGS	USGS 15294345 YENTNA R NR SUSITNA STATION AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294345&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&forma

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2003	United States Geological Survey	USGS	USGS 15294350 SUSITNA R AT SUSITNA STATION AK	http://nwis.waterdata.usgs.gov/nwis/qwdata?site_no=15294350&agency_cd=USGS&inventory_output=0&rdb_inventory_output=file&TZoutput=0&pm_cd_compare=Greaterthan&radio_parm_cds=all_parm_cds&format=html_table&qw_attributes=0&qw_sample_wide=wide&rdb_qw_attributes=0&date_format=YYYY-MM-DD&rdb_compression=file&submitted_form=brief_list
2010	United States Geological Survey	USGS	USGS 15292000 SUSITNA R AT GOLD CREEK AK DAILY DISCHARGE, CUBIC FEET PER SECOND	http://waterdata.usgs.gov/nwis/uv/?site_no=15292000&PARAmeter_cd=00065,00060,00062,72020
2004	URS Corp.	URS	Talkeetna Airport, Phase II Hydrologic/Hydraulic Assessment	https://sftp101.urscorp.com/human.aspx?OrgID=9164

APPENDIX B:

WATER QUALITY DATA SUMMARIES FROM EXISTING SOURCES

Appendix B-1. Existing Water Quality Data (Conventional Parameters) for the Susitna River and Tributaries, Table 1 of 2.

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters – Conventional: Temp (°C)	DO (mg/L)	Orthophosphates (mg/L)	Nitrate Nitrogen (mg/L)	Bedload Discharge (ton/day)	Suspended Sediment Discharge (ton/day)	Turbidity (NTU)[w]	TSS (mg/L)	Suspended Sediment Load (tons/yr)	TDS (mg/L)	Conductivity (umhos/cm)
Denali	290.8	USGS	15291000	7/25/1986	29	Winter	209	≈0		≤ 0.1	0.05		17			2,965,500		≈351
						Spring	2860	0-8		≤ 0.1	0-0.07		up to 75,000	≈20				121-467
						Summer	7507	2-10.6		≤ 0.1	0-0.09		up to 186,000	45-350				123-205
						Fall	2381	0-5.2		≤ 0.1			up to 12100					≈226
Paxson (MacLaren R.)	259.8	USGS	15291200	7/25/1975	17	Winter				≤ 0.1								
						Spring	2344	0-11.0		≤ 0.1	≈0.09		up to 10,400					100-182
						Summer	2396	0.5-10		≤ 0.1	0-0.34		up to 16,000	90-190				84-170
						Fall	680	0.5-3.5		≤ 0.1	≈0.07		up to 192					≈144
Vee Canyon[u]	223.1	USGS	15291500	7/30/1986	24	Winter	1000	≈0		≤ 0.1			≈19			2,965,500		
						Spring	13000	0-10		≤ 0.1	0.02-0.16		up to 175,000					91-250
						Summer	14437	4.0-13	11.5-12.0	≤ 0.1	0-0.25		up to 196,000					125-187
						Fall	4872	1-5.5		≤ 0.1	≈0.88		up to 2,070					≈174
Vee Canyon	223.1	R&M				Winter		≈0		≤ 0.1				0		6,898,000		
						Summer				≤ 0.1				320-720				
Mainstem Susitna at Watana Dam Site	184.2	APA and ADF&G		10/16/1985	1	Winter												
						Spring		3.7-9.0										
						Summer		1.9-14.4	9.9-11.6									
						Fall		0-4.0	11.5									
Watana Damsite	183	R&M				Winter		≈0		≤ 0.1				0				
						Summer				≤ 0.1								
Mainstem Susitna D/S of Devil's Canyon	150.1	APA and ADF&G		10/16/1985	1	Winter												
						Spring		5.5-8.6										
						Summer		2.6-15.1										
						Fall		0.5-4.3										
Mainstem Susitna U/S of Portage Creek	149.4	APA and ADF&G		10/9/1985	1	Winter												
						Spring												
						Summer			10.9-14.8					45-200	52-482			
						Fall			12.3-13.8					4.2-8.2	7.5-12			
Mainstem Susitna at LRX 53	140.1	APA and ADF&G		10/17/1985	1	Winter												
						Spring		5.5-8.5										
						Summer		2.8-15.0										
						Fall		0-6.7										
Gold Creek	136.6	USGS	15292000	9/23/1986	37	Winter	1884	0	10.9-16.2	0.03-0.09	0.15-0.16		2.9-18	0.1-0.7				260-279
						Spring	19931	0-	11.6-	≤ 0.031	0.05-0.69		up to 197,000	.01-50				70-286

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters										
								Conventional										
								Temp (°C)	DO (mg/L)	Orthophosphates (mg/L)	Nitrate Nitrogen (mg/L)	Bedload Discharge (ton/day)	Suspended Sediment Discharge (ton/day)	Turbidity (NTU)[w]	TSS (mg/L)	Suspended Sediment Load (tons/yr)	TDS (mg/L)	Conductivity (umhos/cm)
								13.0	14.7									
						Summer	54810	4.5-14.1	8.5-12.7	0-0.184	0.02-0.25	350-1970	up to 250,000	23-290				87-227
						Fall	6160	0-6.5	11.1-13.3	0-0.061		≈1.3	up to 15,000	5.3-10				107-300
Gold Creek	136.6	R&M		9/30/1981		Winter		≈0		≤ 0.1				0		7,731,000	100-188	84-300
						Summer				≤ 0.1		up to 2180	up to 157,000[v]	728			55-140	75-227
Mainstem Susitna D/S of Gold Creek Bridge	135.8	APA and ADF&G		10/17/1985	1	Winter												
						Spring												
						Summer		2.8-14.9	10.3-13.7					22-220	53-592			
						Fall		0-4.8	12.3-12.5					3.6-7.9	3.7-10			
Mainstem Susitna at Curry Station	120.7	APA and ADF&G		10/17/1985	1	Winter												
						Spring		5.9-8.4										
						Summer		2.7-15.3	10.1-13.9					20-396	39-512			
						Fall		0-4.9	12-12.2					3.2-7	6.8-9			
Mainstem Susitna at Talkeetna Station	103	APA and ADF&G		10/12/1985	1	Winter												
						Spring		4.6-9.2						30-210	37-476			
						Summer		2.9-16.4	9.8-12.0					16-480	5.5-8.0			
						Fall		1.3-5.3	12-12.5					4-16				
Talkeetna[u] (Chulitna R.)	98.0	USGS	15292400	7/22/1986	28	Winter	1269	≈0		≤ 0.1	≈0		≤ 100					≈115
						Spring	11217	0-9.1		≤ 0.1	0.18-.025	up to 18300	up to 100,000					108-190
						Summer	21950	3.8-9.5		≤ 0.1	0.16-0.36	up to 13800	up to 262,000					101-144
						Fall	5533	1.6-8.0		≤ 0.1			up to 5,000	194-360				123-152
Talkeetna (Talkeetna R.)	97.0	USGS	15292700	5/18/2011	57	Winter	609	≈0	7.1-4.6	0-0.061	0.02-0.46			0.4-2.6				143-230
						Spring	6650	0-12	10.4-13.8	0-0.4	0.35-0.40			0.4-69				49-255
						Summer	10630	3.5-13.5	9.9-12.5	≤ 0.031	0.1-0.21	up to 1940 (R&M)		2-340				62-157
						Fall	3160	0.5-9.0	12.3-15.3	≤ 0.06	0.14-1.22			0.8-1.4				84-176
Mainstem Susitna above Parks Highway Bridge	86.2	APA and ADF&G		10/15/1985	1	Winter												
						Spring		4.1-8.9										
						Summer		3.6-12.8	10.5-12.3					80-400	178-751			
						Fall		0.8-5.6	11.7-12.4					19-36	60-93			
Sunshine	83.9	USGS	15292780	6/25/1986	15	Winter	4036	≈0	12.8-14.4	0.031-0.12		81		0.5-2.7				159-240
						Spring	37207	0-11	9.8-	0.031-0.12		up to 13600	up to 500,000	0.16-0.2				50-242

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters										
								Conventional										
								Temp (°C)	DO (mg/L)	Orthophosphates (mg/L)	Nitrate Nitrogen (mg/L)	Bedload Discharge (ton/day)	Suspended Sediment Discharge (ton/day)	Turbidity (NTU)[w]	TSS (mg/L)	Suspended Sediment Load (tons/yr)	TDS (mg/L)	Conductivity (umhos/cm)
									13.8									
						Summer	63740	5-14	9-13.4	0.031-0.061		up to 10000	up to 1,620,000	43-500				80-170
						Fall	25217	2.0-5.0	12.8-14.6	≤ 0.031		up to 1500	up to 25,000	≈23				112-138
Sunshine	83.9	R&M				Winter		≈0		≤ 0.1				0				
						Summer				≤ 0.1		up to 4520		up to 1056				
Skwentna (Skwentna R.)	28.0	USGS	15294300	9/11/1981	22	Winter	996	≈0		≤ 0.1			≈52					177-333
						Spring	8572	0-5		≤ 0.1			up to 40,300					≈206
						Summer	13182	5.5-12		≤ 0.1			up to 88,100	30-220				111-136
						Fall	9275	1.5-6		≤ 0.1			up to 10,500					≈177
Susitna (Yentna R.)	28.0	USGS	15294345	5/21/1986	5	Winter	2693	≈0	10.9-11.1	≤ 0.1		3.4-124	≈31					189-216
						Spring	26429	0-12	10.6-13.4	≤ 0.1		up to 157,000	up to 11,300					82-115
						Summer	47895	3.9-11.6	10.4-12.1	≤ 0.1		up to 13,300	up to 542,000					93-142
						Fall	16650	2.0-7.0		≤ 0.1		up to 8,220	up to 19,600					
Susitna	25.8	USGS	15294350	10/25/2003	48	Winter		≈0	9.9-12.7	≤ 0.1	0.16-0.23	≈15	29-171	1-3				180-225
						Spring		0-11.4	10.0-13.9	≤ 0.1	≈0.34	up to 15,000	up to 476,000	0.7-590				59-238
						Summer		2.5-14.8	9-12.3	≤ 0.1	0-0.23	up to 21,000	up to 1,330,000	up to 790				96-154
						Fall		0-5	10.5-13	≤ 0.1	0.16-0.28	up to 2000	up to 80,800	1.2-75				108-230

*for tributaries, River Mile is at confluence with Susitna and shaded in green

[u] nearly all Data is older than 1970

[w] Denali and Paxson Station Data only available in JTU

[t] some values may be older

[v] figure is from 1952

Appendix B-2. Existing Water Quality Data (Conventional Parameters) for the Susitna River and Tributaries, Table 2 of 2.

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters																
								Conventionals																
								Significant Ions (mg/L)							Total Hardness (mg/L)	pH	Total Alkalinity (mg/L)	Free CO_2 (mg/L)	TOC (mg/L)	COD	True Color (Pt-Co units)	Chlorophyll-a (ug/L)	Total Dissolved Gas (% Sat)	Total Coliform Bacteria (colonies/100mL)
								HCO_3^-	Cl^-	SO_4^{2-}	Ca (diss.)	Mg (diss.)	Na (diss.)	K (diss.)										
Denali	290.8	USGS	15291000	7/25/1986	29	Winter	209	≈137	≈21	≈36	≈41	≈8	≈18	≈6.3	≈140	≈7.6		≈5.5			≈0			
						Spring	2860	52-196	3-30	9.2-39	17-51	1.9-16	2.1-23	2.3-6.6	50-180	7.1-7.5		5.2-25			5-30			
						Summer	7507	51-83	1.5-9.0	13-31	18-24	1.7-6.4	2.2-7.5	1.3-36	52-84	7.4-7.9		1.5-4.5			0-10			
						Fall	2381	≈92	≈11	≈20	≈29	≈3.6	≈10	≈2.1	≈87	7.8		≈2.3			≈5			
Paxson (MacLaren R.)	259.8	USGS	15291200	7/25/1975	17	Winter																		
						Spring	2344	≈78	≈4.3	≈20	≈27	≈3.9	≈2.8	≈2.5	≈84	≈7.6		≈3.1			0			
						Summer	2396	34-54	0.4-3.5	13-22	11-20	2.2-4.3	0.8-2.1	1.4-2.6	36-62	6.8-7.8		1.1-9.6			0-20			
						Fall	680	≈59	≈4	≈22	≈18	≈5.4	≈3.5	≈1.6	≈67	≈7.6		≈2.4			≈5			
Vee Canyon[u]	223.1	USGS	15291500	7/30/1986	24	Winter	1000																	
						Spring	13000	48-54	3.5-7.4	7.5-12	14-17	1.8-2.4	2.2-48	2.8-7.3	42-54	7.4-7.6		2.2-3.1			30-40			
						Summer	14437	59-72	2.1-9.2	10-18	18-25	2.2-4.4	2.1-6.3	1.4-5.2	58-76	7.5-8.1		0.7-3.6		8-39	5-10			
						Fall	4872	≈67	≈8.5	≈16	≈27	≈1.1	≈5	≈0.3	≈70	≈7.2		≈6.8			≈10			
Vee Canyon	223.1	R&M				Winter		57-161	16-30	11-39	25-51	3.8-16.0	6.3-23.0	2.0-9.0										
						Summer		39-81	1.5-11	2-31	13-29	1.1-6.4	2.1-10.0	1.3-7.3										
Mainstem Susitna at Watana Dam Site	184.2	APA and ADF&G		10/16/1985	1	Winter																		
						Spring																		
						Summer										8-8.2							97.07-100.97	
						Fall										8.4							96.71-98.84	
Watana Damsite	183	R&M				Winter																		
						Summer																		
Mainstem Susitna D/S of Devil's Canyon	150.1	APA and ADF&G		10/16/1985	1	Winter																		
						Spring																	112.21-114.52	
						Summer																	108.83-118.32	
						Fall																	106.16-109	
Mainstem Susitna U/S of Portage Creek	149.4	APA and ADF&G		10/9/1985	1	Winter																		
						Spring																		
						Summer										6.8-8.2								
						Fall										7.2-8.3								
Mainstem Susitna at LRX 53	140.1	APA and ADF&G		10/17/1985	1	Winter																		
						Spring																		
						Summer																		
						Fall																		
Gold Creek	136.6	USGS	15292000	9/23/1986	37	Winter	1884	92-98	24-35	12-18	31-39	4.5-5.8	11-17	2.1-2.4	99-120	7.6-8.0	46-88	1.6-33	1.1-1.2	2-16	≈5			
						Spring	19931	28-97	1.8-	4.7-	9.9-	0.3-	2.4-	1.0-	30-110	7.0-		1.3-24	1.8-10		5-50			

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters – Conventionals – Significant Ions (mg/L): HCO_3^-	Cl^-	SO_4^{2-}	Ca (diss.)	Mg (diss.)	Na (diss.)	K (diss.)	Total Hardness (mg/L)	pH	Total Alkalinity (mg/L)	Free CO_2 (mg/L)	TOC (mg/L)	COD	True Color (Pt-Co units)	Chlorophyll-a (ug/L)	Total Dissolved Gas (% Sat)	Total Coliform Bacteria (colonies/100mL)
									33	27	33	7.4	17	3.8		8.0								
						Summer	54810	35-106	1.4-12	1-27	11-37	1.3-5.7	2.6-5.4	1.0-4.4	35-110	7.5-8.3	23-87	0.5-16	1.4-3.8	1.3-24	0-30			
						Fall	6160	45-107	5-20	12-38	16-37	2.2-8.3	4-13	1.1-5	49-120	7.2-8.3		1.2-10	≈4.2		0-12			
Gold Creek	136.6	R&M		9/30/1981		Winter		46-88	5.7-37	10-38	18-39	3.2-10	4.9-21.1	1.2-5										
						Summer		23-87	1.2-15	1-31	10-37	1.2-7.8	1.8-10	0.9-4.4										
Mainstem Susitna D/S of Gold Creek Bridge	135.8	APA and ADF&G		10/17/1985	1	Winter																		
						Spring																		
						Summer										6.8-8.0							102.04-107.49	
						Fall										8.1-8.3							101.56-106.59	
Mainstem Susitna at Curry Station	120.7	APA and ADF&G		10/17/1985	1	Winter																		
						Spring																		
						Summer										6.8-8.0							93.27-96.92	
						Fall										7.7-8.2							91.76-101.62	
Mainstem Susitna at Talkeetna Station	103	APA and ADF&G		10/12/1985	1	Winter																		
						Spring																		
						Summer										7.4-8.0								
						Fall										7.8-8.3								
Talkeetna[u] (Chulitna R.)	98.0	USGS	15292400	7/22/1986	28	Winter	1269	≈52	≈1	≈11	≈19	≈1.9	≈0.5	≈0.4	≈56	≈7.1		≈6.6			≈0			
						Spring	11217	73-78	1.4-2.0	20-22	24-26	4.4-4.6	2.3-2.7	1.3-1.8	77-84	7.4-8.0		1.2-5.0			5-15			
						Summer	21950	46-59	0-2.5	10-14	14-18	2.5-4.1	1.2-1.7	0.7-2.2	46-59	7.2-8.1		0.6-5.5			5-10			
						Fall	5533																	
Talkeetna (Talkeetna R.)	97.0	USGS	15292700	5/18/2011	57	Winter	609	46-70	11-27	10-24	17-26	1.9-5.6	7.7-15	1.0-1.9	20-78	7.3-8.2		0.8-41	0.7-1.8		0-25			≈21
						Spring	6650	25-64	2.4-34	2.4-21	7-26	1-3.4	2.4-15	0.5-2.4	22-79	7.1-8.2		0.6-40	≈1.6		0-10			≈130
						Summer	10630	25-50	1.4-9.5	1-18	6.8-17	0.4-3.9	2.7-9.7	0.5-2.9	22-50.8	7.3-8.6		0.6-30	0.4-2.6		0-80			33-190
						Fall	3160	36-55	3.6-12	6-20	9.8-19	0.8-2.8	3.6-8.4	0.5-1.2	29.9-57.5	7.2-8.0		0.6-12.0	≈2.1		0-10			≈92
Mainstem Susitna above Parks Highway Bridge	86.2	APA and ADF&G		10/15/1985	1	Winter																		
						Spring																		
						Summer										7.4-8.5								
						Fall										7.8-8								
Sunshine	83.9	USGS	15292780	6/25/1986	15	Winter	4036		6.8-16	16-19	20-33	2.9-4.2	5.5-11	1.4-2	55-99.4	7.8-8.2		≈1.2	≈2					
						Spring	37207	31-86	2.5-	5.7-	11-31	1.4-	1.9-	1-2.1	33-96	7.2-		3.9-91	0.4-7.4		0-100			

								Water Quality Parameters																
								Conventionals																
								Significant Ions (mg/L)																
Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	HCO_3^-	Cl^-	SO_4^{2-}	Ca (diss.)	Mg (diss.)	Na (diss.)	K (diss.)	Total Hardness (mg/L)	pH	Total Alkalinity (mg/L)	Free CO_2 (mg/L)	TOC (mg/L)	COD	True Color (Pt-Co units)	Chlorophyll-a (ug/L)	Total Dissolved Gas (% Sat)	Total Coliform Bacteria (colonies/100mL)
									21	18		4.5	11			8.3								
						Summer	63740	≈52	2.2-5.8	3-16	14-23	2-3.5	2.3-4.4	1.1-2.8	43.6-72	7.1-8.3		1.1-2.1	1.7-3.2		≈25			
						Fall	25217	≈52	5.1-6	12-15	17-18	2.7-3	4.1-4.4	≈1.2	37.8-45.7	7.4-8.3		≈3.3	≈2.7		≈8			
Sunshine	83.9	R&M				Winter		46-88	5.7-37	10-38	18-39	3.2-10	4.9-21.1	1.2-5										
						Summer		23-87	1.2-15	1-31	10-37	1.2-7.8	1.8-10	0.9-4.4										
Skwentna (Skwentna R.)	28.0	USGS	15294300	9/11/1981	22	Winter	996	≈77	≈12	≈24	≈28	≈4.3	≈7.7	≈1.7	≈88	≈7.1		≈9.8			≈10			
						Spring	8572	≈78	≈10	≈19	≈27	≈3.6	≈7.9	≈1.8	≈82	≈7.7		≈2.5			≈15			
						Summer	13182	≈52	≈6	≈20	≈17	≈5	≈4.4	≈0.9	≈63	≈7.4		≈3.3			≈20			
						Fall	9275	≈64	≈6	≈27	≈21	≈3.9	≈5	≈1.1	≈74	≈7.7		≈2			≈5			
Susitna (Yentna R.)	28.0	USGS	15294345	5/21/1986	5	Winter	2693									7.1-7.9								
						Spring	26429									7.0-8.0								
						Summer	47895									7.4-8.3								
						Fall	16650																	
Susitna	25.8	USGS	15294350	10/25/2003	48	Winter		70-98	9.6-15	15-20	24-31	3.6-5.0	6.2-9.0	1.5-2.5	75-95	7.5-7.6	60-75	1.8-17	0.4-4		0-5	ND-1.2		≤ 20
						Spring		37-88	1.4-15	3.7-18	11-30	1.6-4.9	1.8-8.3	0.8-1.8	36-93.7	7.1-8.1		1.1-19						
						Summer		45-69	1.2-12	1-22	15-22	2-3.3	1-1.8	0.9-4.4	44-66	7.5-8.5	36-57	0.4-8.0	2.7-11		0-10			
						Fall		55-92	3.1-18	13-20	16-31	2.6-4.6	2.8-8.6	1.1-2.0	51.6-96	7.6-8.0		1.4-15			≈10			

Appendix B-3. Existing Water Quality Data (Metals) for the Susitna River and Tributaries, Table 1 of 3.

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters: Metals in Water, unfiltered (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
Denali	290.8	USGS	15291000	7/25/1986	29	Winter	209						≈60		≈10				
						Spring	2860						0-4000		≈20				
						Summer	7507						up to 3200		≈10				
						Fall	2381						≈610		≈60				
Paxson (MacLaren R.)	259.8	USGS	15291200	7/25/1975	17	Winter													
						Spring	2344						≈370						
						Summer	2396	≈10000	≤ 100	≤ 20	≈1	≈40	≈20000	≤ 200	0-10		≈18	≤ 50	≈90
						Fall	680												
Vee Canyon[u]	223.1	USGS	15291500	7/30/1986	24	Winter	1000												
						Spring	13000						660-5000						
						Summer	14437						up to 12000		up to 230				
						Fall	4872						up to 900						
Vee Canyon	223.1	R&M				Winter													
						Summer													
Mainstem Susitna at Watana Dam Site	184.2	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Watana Damsite	183	R&M				Winter													
						Summer													
Mainstem Susitna D/S of Devil's Canyon	150.1	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna U/S of Portage Creek	149.4	APA and ADF&G		10/9/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at LRX 53	140.1	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Gold Creek	136.6	USGS	15292000	9/23/1986	37	Winter	1884		≤ 100	≤ 1	≤ 1		≈120	≤ 1	≤ 20	≤ 0.1	1	≤ 1	≈10
						Spring	19931	≈14000	≤ 100	≤ 20	≤ 1	14-50	40-20000	≈5	10-370	≤ 0.1	2-5	≈2	10-80
						Summer	54810	≈13000	100-500	0-30	≤ 1	15-190	430-24000	≤ 200	10-390	2-13	2-12	≤ 50	20-120
						Fall	6160	≈500		≤ 20	≤ 1		≈800	≤ 200	≈20	≈0.2	≤ 1	≤ 50	≈30
Gold Creek	136.6	R&M		9/30/1981		Winter													
						Summer													
Mainstem Susitna D/S of Gold Creek Bridge	135.8	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Curry Station	120.7	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Talkeetna Station	103	APA and ADF&G		10/12/1985	1	Winter													
						Spring													

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters: Metals in Water, unfiltered (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
						Summer													
						Fall													
Talkeetna[u] (Chulitna R.)	98.0	USGS	15292400	7/22/1986	28	Winter	1269						≈0		≈10				
						Spring	11217						0-810		10-30				
						Summer	21950						up to 4300		20-280				
						Fall	5533												
Talkeetna (Talkeetna R.)	97.0	USGS	15292700	5/18/2011	57	Winter	609		0-22	≤ 1	≤ 1	1-10	≈80	≤ 10	3-10		≤ 1		≤ 20
						Spring	6650		0-100	≤ 1	0-1	20-40	60-2800	≤ 30	10-70		≤ 10		10-230
						Summer	10630	≈4600	0-200	1-5	≤ 1	20-100	70-17000	≤ 200	10-520		1-2	≤ 10	20-90
						Fall	3160		0-200	≤ 20	1-2	≤ 20	150-180	≤ 200	0-30		1-2		≤ 20
Mainstem Susitna above Parks Highway Bridge	86.2	APA and ADF&G		10/15/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Sunshine	83.9	USGS	15292780	6/25/1986	15	Winter	4036		100	0-1	1	5-20	110-1100	≤ 1	2-10	0.1	1-2	≈20	10-30
						Spring	37207	up to 22000	0-2000	≤ 20	≤ 1	5-200	160-37000	0-300	10-730	0.1-0.9	≤ 1	≤ 200	20-150
						Summer	63740	up to 15000	100-500	0-35	0-1	0-35	7600-32000	2-13	170-670	0.1-0.6	1-3	18-30	40-200
						Fall	25217	up to 2200	200	≤ 20	≤ 1	20	≈3700	≤ 200	100	≤ 0.1	3	≤ 50	30
Sunshine	83.9	R&M				Winter													
						Summer													
Skwentna (Skwentna R.)	28.0	USGS	15294300	9/11/1981	22	Winter	996								≈0				
						Spring	8572						≈550						
						Summer	13182								≈0				
						Fall	9275												
Susitna (Yentna R.)	28.0	USGS	15294345	5/21/1986	5	Winter	2693												
						Spring	26429												
						Summer	47895												
						Fall	16650												
Susitna	25.8	USGS	15294350	10/25/2003	48	Winter			100	≤ 20	≤ 1	up to 140	240-720	≤ 200	30-40	≤ 0.5	1-3	0-4	20-30
						Spring			100-200	≤ 20	≤ 1	20-60	230-16000	≤ 200	20-410	≤ 0.5	0-3	0-5	10-60
						Summer			up to 400	≤ 1	≤ 1	30-90	7900-42000	≤ 200	320-870	≤ 1	7-40	1-2	80-180
						Fall			≤ 100	≤ 20	≤ 1	20-30	260-5400	≤ 200	20-130	≤ 0.5	1-4		20-30

*for tributaries, River Mile is at confluence with Susitna and shaded in green

[t] some values may be older

[u] nearly all Data is older than 1970

[v] figure is from 1952

[w] Denali and Paxson Station Data only available in JTU

Appendix B-4. Existing Water Quality Data (Metals) for the Susitna River and Tributaries, Table 2 of 3.

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters: Metals in Water, filtered (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
Denali	290.8	USGS	15291000	7/25/1986	29	Winter	209												
						Spring	2860												
						Summer	7507												
						Fall	2381												
Paxson (MacLaren R.)	259.8	USGS	15291200	7/25/1975	17	Winter													
						Spring	2344												
						Summer	2396												
						Fall	680												
Vee Canyon[u]	223.1	USGS	15291500	7/30/1986	24	Winter	1000												
						Spring	13000												
						Summer	14437												
						Fall	4872												
Vee Canyon	223.1	R&M				Winter													
						Summer													
Mainstem Susitna at Watana Dam Site	184.2	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Watana Damsite	183	R&M				Winter													
						Summer													
Mainstem Susitna D/S of Devil's Canyon	150.1	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna U/S of Portage Creek	149.4	APA and ADF&G		10/9/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at LRX 53	140.1	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Gold Creek	136.6	USGS	15292000	9/23/1986	37	Winter	1884		≤ 100	≤ 1	≤ 1		≈10	≤ 1			1	≤ 1	≤ 10
						Spring	19931		≈60	≤ 3	≤ 1	≈5	20-100	0-1	0-40	≤ 0.1	2	≈3	≤ 40
						Summer	54810		0-44	0-20	≤ 1	2-5	50-320	0-5	2-180	≤ 0.2	1-2	0-3	6-20
						Fall	6160						≈40		≤ 10				
Gold Creek	136.6	R&M		9/30/1981		Winter													
						Summer													
Mainstem Susitna D/S of Gold Creek Bridge	135.8	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Curry Station	120.7	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Talkeetna Station	103	APA and ADF&G		10/12/1985	1	Winter													
						Spring													

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters											
								Metals in Water, filtered (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
						Summer													
						Fall													
Talkeetna[u] (Chulitna R.)	98.0	USGS	15292400	7/22/1986	28	Winter	1269												
						Spring	11217												
						Summer	21950												
						Fall	5533												
Talkeetna (Talkeetna R.)	97.0	USGS	15292700	5/18/2011	57	Winter	609	10-160	≤ 100	≤ 1	≤ 1	≤ 10	8-40	≤ 10	3-10		≤ 1	≤ 1	3-13
						Spring	6650	10-380	0-20	≤ 3	0-2	≤ 30	12-100	≤ 30	3-20		0-8	0-2	5-90
						Summer	10630	20-290	7-23	0-5	≤ 2	≤ 10	13-410	≤ 10	3-20		0-2	0-5	6-30
						Fall	3160	20-100	7-32	≤ 1	0-2	≤ 10	0-61	≤ 10	1-30		0	≤ 1	≈10
Mainstem Susitna above Parks Highway Bridge	86.2	APA and ADF&G		10/15/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Sunshine	83.9	USGS	15292780	6/25/1986	15	Winter	4036		25-100	≤ 1	≤ 1	1-10	17-40	≈3	2-10	≤ 1	1	≤ 1	10-30
						Spring	37207		19-41	≤ 1	0-1	≤ 1	12-180	≤ 1	3-20	≤ 0.1	1	≤ 1	20-31
						Summer	63740		0-70	0-24	0-1	2-10	10-330	≤ 1	7-12	≤ 0.1	1-3	0-2	14-65
						Fall	25217						≈60		≤ 10				
Sunshine	83.9	R&M				Winter													
						Summer													
Skwentna (Skwentna R.)	28.0	USGS	15294300	9/11/1981	22	Winter	996												
						Spring	8572												
						Summer	13182												
						Fall	9275												
Susitna (Yentna R.)	28.0	USGS	15294345	5/21/1986	5	Winter	2693												
						Spring	26429												
						Summer	47895												
						Fall	16650												
Susitna	25.8	USGS	15294350	10/25/2003	48	Winter			≈40	≤ 2	≈1	≤ 2	60-150	≤ 2	10-30	0-0.1	0-3	≈0	≤ 20
						Spring		10-50	20-80	≤ 3	≤ 1	≤ 20	20-370	2-11	10-20	0-0.3	0-3	0-5	12-33
						Summer		40-350	20-200	≤ 2	≤ 1	≤ 3	10-460	≤ 5	6-20	≤ 0.5	1-3	0-2	8-160
						Fall		40-150	25-38	≤ 1	≤ 1	≈3	40-230	≤ 5	10-21	0.1-3	1-4	≈1	6-18

Appendix B-5. Existing Water Quality Data (Metals) for the Susitna River and Tributaries, Table 3 of 3.

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters – Metals in Suspended Sediment (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
Denali	290.8	USGS	15291000	7/25/1986	29	Winter	209												
						Spring	2860												
						Summer	7507												
						Fall	2381												
Paxson (MacLaren R.)	259.8	USGS	15291200	7/25/1975	17	Winter													
						Spring	2344												
						Summer	2396												
						Fall	680												
Vee Canyon[u]	223.1	USGS	15291500	7/30/1986	24	Winter	1000												
						Spring	13000												
						Summer	14437												
						Fall	4872												
Vee Canyon	223.1	R&M				Winter													
						Summer													
Mainstem Susitna at Watana Dam Site	184.2	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Watana Damsite	183	R&M				Winter													
						Summer													
Mainstem Susitna D/S of Devil's Canyon	150.1	APA and ADF&G		10/16/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna U/S of Portage Creek	149.4	APA and ADF&G		10/9/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at LRX 53	140.1	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Gold Creek	136.6	USGS	15292000	9/23/1986	37	Winter	1884				0	≤ 10	≈110	0-4	7-10		0	0	10
						Spring	19931		≈40			1-9	30-120	0-4	7-8		0	0-1	≈10
						Summer	54810		70-400	0-10	≤ 1	15-190	4600-24000	0-47	70-390	0.1-0.4	3-6	8-29	20-110
						Fall	6160				≤ 1								
Gold Creek	136.6	R&M		9/30/1981		Winter													
						Summer													
Mainstem Susitna D/S of Gold Creek Bridge	135.8	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Curry Station	120.7	APA and ADF&G		10/17/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Mainstem Susitna at Talkeetna Station	103	APA and ADF&G		10/12/1985	1	Winter													
						Spring													

Station Name	Station Susitna River Mile*	Original Data Source	USGS Station Code	Most Recent Sample Date[t]	Years of Record	Season	Mean Instantaneous Discharge (cfs)	Water Quality Parameters											
								Metals in Suspended Sediment (ug/L)											
								Al	Ba	Cd	Se	Cu	Fe	Pb	Mn	Hg	As	Ni	Zn
						Summer													
						Fall													
Talkeetna[u] (Chulitna R.)	98.0	USGS	15292400	7/22/1986	28	Winter	1269												
						Spring	11217												
						Summer	21950												
						Fall	5533												
Talkeetna (Talkeetna R.)	97.0	USGS	15292700	5/18/2011	57	Winter	609												
						Spring	6650		0-80		0		40-690	0-3	0-6		≤ 1		0-10
						Summer	10630		0-90	0	0		3100-6800		90-190		≤ 1		20-70
						Fall	3160										≈2		
Mainstem Susitna above Parks Highway Bridge	86.2	APA and ADF&G		10/15/1985	1	Winter													
						Spring													
						Summer													
						Fall													
Sunshine	83.9	USGS	15292780	6/25/1986	15	Winter	4036		0-80	0	0-1	≤ 20	120-1100		10-30	0	≈2	≈2	≈10
						Spring	37207		0-60		≤ 1	1	120-160	0	6-20	0	0-1	16	20-31
						Summer	63740		80-300	1-11	0	16-63	7400-32000	0-38	160-660	0.1-0.6	4-15	16-51	0-190
						Fall	25217												
Sunshine	83.9	R&M				Winter													
						Summer													
Skwentna (Skwentna R.)	28.0	USGS	15294300	9/11/1981	22	Winter	996												
						Spring	8572												
						Summer	13182												
						Fall	9275												
Susitna (Yentna R.)	28.0	USGS	15294345	5/21/1986	5	Winter	2693												
						Spring	26429												
						Summer	47895												
						Fall	16650												
Susitna	25.8	USGS	15294350	10/25/2003	48	Winter			0-100	≤ 10	≤ 1	140	300-400	≤ 99	0-30	≈1	0-0.1	1-4	0-30
						Spring			60-200	≤ 10	≤ 1	1-54	230-16000		0-400	≤ 0.1	0-6	4-21	0-50
						Summer			70-400	≤ 10	≤ 1	29-89	7800-38000	14-94	320-850	≤ 1	0.3-0.6	32-52	80-180
						Fall			≤ 100	≤ 10	≤ 1	20-54	≈300	9-97	0-130	0	1-4		6-18