# Susitna-Watana Hydroelectric Project Document
# ARLIS Uniform Cover Page

| | |
|---|---|
| **Title:**<br>Fish and aquatics instream flow study, Study plan Section 8.5, 2014-2015 Study Implementation Report. [ Main report ] | **SuWa 289** |
| **Author(s) – Personal:** | |
| **Author(s) – Corporate:**<br>R2 Resource Consultants, Inc. | |
| **AEA-identified category, if specified:**<br>November 2015; Study Completion and 2014/2015 Implementation Reports | |
| **AEA-identified series, if specified:** | |
| **Series (ARLIS-assigned report number):**<br>Susitna-Watana Hydroelectric Project document number 289 | **Existing numbers on document:** |
| **Published by:**<br>[Anchorage : Alaska Energy Authority, 2015] | **Date published:**<br>November 2015 |
| **Published for:**<br>Alaska Energy Authority | **Date or date range of report:** |
| **Volume and/or Part numbers:**<br>Study plan Section 8.5 | **Final or Draft status, as indicated:** |
| **Document type:** | **Pagination:**<br>xii, 122 pages *(main report only)* |
| **Related works(s):** | **Pages added/changed by ARLIS:** |

**Notes:**

*See other PDFs for these volumes:*

- Appendix A. 2014 instream flow winter studies
- Appendix B. Open-water hydrology data collection and open-water flow routing model (version 2.8)
- Appendix C. 2014 moving boat Acoustic Doppler Current Profiler (ADCP) measurements
- Appendix D. Habitat suitability criteria development
- Appendix E. Fish habitat modeling data: surficial substrate and cover characterization and salmon spawning observations by focus area

# Susitna-Watana Hydroelectric Project
# (FERC No. 14241)

# Fish and Aquatics Instream Flow Study
# Study Plan Section 8.5

# 2014-2015 Study Implementation Report

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

*Clean, reliable energy for the next 100 years.*

Prepared by

R2 Resource Consultants, Inc.

November 2015

# TABLE OF CONTENTS

## LIST OF TABLES

## LIST OF FIGURES

# APPENDICES

# LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

| Abbreviation | Definition |
|---|---|
| 1-D | One-dimensional |
| 2-D | Two-dimensional |
| ADCP | Acoustic Doppler Current Profiler |
| AEA | Alaska Energy Authority |
| AIC | Akaike's Information Criteria |
| AICc | AIC corrected for sample size |
| cfs | cubic feet per second |
| CIRWG | Cook Inlet Region Working Group |
| DO | Dissolved Oxygen |
| DOC | Dissolved Organic Carbon |
| DSS | Decision Support System |
| EFC | Environmental Flow Component |
| EFDC | Environmental Fluid Dynamics Code |
| EFM | Ecosystem Functions Model |
| FA | Focus Area |
| FDAML | Fish Distribution and Abundance in the Middle and Lower Susitna River (Study 9.6) |
| FDAUP | Fish Distribution and Abundance in the Upper Susitna River (Study 9.5) |
| FERC | Federal Energy Regulatory Commission |
| fps | feet per second |
| GINA | Geographic Information Network of Alaska |
| GIS | Geographic Information System |
| GPS | Global Positioning System |
| GW | Groundwater |
| HSC | Habitat Suitability Criteria |
| HSI | Habitat Suitability Index |
| IFS | Fish and Aquatics Instream Flow Study (Study 8.5) |
| IHA | Indicators of Hydrologic Alteration |
| ILF | Integrated Load Following |
| ILP | Integrated Licensing Process |
| ISR | Initial Study Report |
| LiDAR | Light Detection and Ranging |
| LR | Lower Susitna River Segment |
| mg/L | milligrams per liter |

| Abbreviation | Definition |
|---|---|
| MR | Middle Susitna River Segment |
| MWH | MWH Global |
| NTU | Nephelometric Turbidity Unit |
| OS | Operating Scenario |
| OWFRM | Open-water Flow Routing Model |
| PDO | Pacific Decadal Oscillation |
| PHABSIM | Physical Habitat Simulation |
| ppm | parts per million |
| PRM | Project River Mile |
| Project | Susitna-Watana Hydroelectric Project, FERC No. 14241 |
| Q | Flow |
| QA | Quality Assurance |
| QC | Quality Control |
| RIFS | Riparian Instream Flow Study (Study 8.6) |
| RSP | Revised Study Plan |
| RTK | Real-time kinematic |
| SIR | Study Implementation Report |
| SPD | Study Plan Determination |
| SW | Surface Water |
| TM | Technical Memorandum |
| TT | Technical Team |
| TWG | Technical Workgroup |
| USGS | United States Geological Survey |
| USR | Updated Study Report |
| VB | Visual Basic |
| VHG | Vertical Hydraulic Gradient |
| VIF | Variance Inflation Factor |
| WSE | Water Surface Elevation |
| WUA | Weighted Usable Area |

# 1. INTRODUCTION

This Instream Flow Study, Section 8.5 of the Revised Study Plan (RSP) (AEA 2012) approved by the Federal Energy Regulatory Commission (FERC) for the Susitna-Watana Hydroelectric Project, FERC Project No. 14241 (Project), focuses on establishing an understanding of important biological communities and associated habitats, and of the hydrologic, physical, and chemical processes in the Susitna River that directly influence those resources. RSP Section 8.5 also described the study methods that will be used to evaluate Project effects, including the selection of study sites, collection of field data, data analysis, and modeling. A summary of the development of this study, together with the Alaska Energy Authority's (AEA) implementation of it through the 2013 study season, appears in Part A, Section 1 of the Initial Study Report (ISR) filed with FERC in June 2014 (AEA 2014). As required under FERC's regulations for the Integrated Licensing Process (ILP), the ISR describes AEA's "overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)).

Since filing the ISR in June 2014, AEA has continued to implement the FERC-approved Study Plan for the Instream Flow Study. For example:

- Three Technical Memoranda (TM) were prepared and submitted in September 2014 that presented a) results of the analysis of the relationship between various microhabitat variables and fish abundance; 2) results of the 2013-2014 Fish and Aquatics Instream Flow Study (IFS) (Study 8.5) winter studies; and 3) results of preliminary groundwater (GW)/surface water (SW) analysis related to GW Study 7.5 that pertains to the IFS (Study 8.5). The first two TMs related to Objectives 4 and 5 of the IFS (Study 8.5). The three TMs were:
    - R2 Resource Consultants (R2). 2014a. *Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables*. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 17, 2014, Attachment G, Study 8.5 Technical Memorandum.
    - R2 Resource Consultants, Inc. (R2). 2014b. *2013-2014 Instream Flow Winter Studies*. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 17, 2014, Attachment H, Study 8.5 Technical Memorandum.
    - Geo-Watersheds Scientific (GWS) and R2 Resource Consultants (R2). 2014a. *Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River*. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 30, 2014, Attachment C, Study 7.5 Technical Memorandum.
- Five technical reports have been prepared and are included as Appendices to this Study Implementation Report (SIR). The first report (SIR Study 8.5, Appendix A) provides an updated analysis of the IFS winter studies that will factor into both the Habitat Suitability Criteria (HSC) development and the Fish Habitat Modeling. Further refinements to the Open-water Flow Routing Model (OWFRM) have been made and presented in another

report (SIR Study 8.5, Appendix B) that is supportive of addressing Objective 3 of the IFS (Study 8.5), and a companion report (SIR Study 8.5, Appendix C) describes the methods used in completing Acoustic Doppler Current Profiler (ADCP) measurements. The final two reports relate to HSC and Fish Habitat Modeling; the first (SIR Study 8.5, Appendix D) presents further detailed analysis regarding the development of HSC curves (specified in Objective 4 of the IFS [Study 8.5]) that will be used to support the Fish Habitat Modeling (specified in Objective 5 of the IFS [Study 8.5]) and the second (SIR Study 8.5, Appendix E) describes the collection of substrate and cover data from different Focus Areas that will likewise be used in the Fish Habitat Modeling, and includes observations of salmon spawning. The five Appendices include:

  - Appendix A: R2 Resource Consultants (R2). 2015. *2014 Instream Flow Winter Studies*. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: 2014-2015 Study Implementation Report, Study 8.5.
  - Appendix B: R2 Resource Consultants (R2). 2015. *Open-water Hydrology Data Collection and Open-water Flow Routing Model (Version 2.8).* Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: 2014-2015 Study Implementation Report, Study 8.5.
  - Appendix C: Brailey Hydrologic. 2015. *2014 Moving Boat Acoustic Doppler Current Profiler (ADCP) Measurements.* Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: 2014-2015 Study Implementation Report, Study 8.5.
  - Appendix D: R2 Resource Consultants (R2). 2015. *Habitat Suitability Criteria Development.* Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: 2014-2015 Study Implementation Report, Study 8.5.
  - Appendix E: R2 Resource Consultants (R2). 2015. *Fish Habitat Modeling Data: Surficial Substrate and Cover Characterization and Salmon Spawning Observations by Focus Area.* Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: 2014-2015 Study Implementation Report, Study 8.5.

- Field data collection activities have also continued and have included:
  - Recovery and downloading of data from instrumentation that monitored water level, temperature and dissolved oxygen (DO) during the 2014-2015 winter conditions. Instruments were redeployed within four Focus Areas and will remain operational throughout the 2015-2016 winter-time period.
  - Installation (June 2014) and continuous monitoring of gages at 12 tributary sites and 5 mainstem sites, and collection of spot flow measurements during July and September 2014. These gages remained operational through September 2015 when they were decommissioned.
  - Collection of a series of discharge measurements over a five day period in September 2014 within various lateral habitats and at tributary mouths in seven Focus Areas; these measurements were conducted as part of a joint effort between the IFS (Study 8.5) and Fluvial Geomorphology Modeling (Study 6.6) and were designed to occur during a relatively low-flow period in the Susitna River.

  - Collection of substrate, cover, and other hydraulic data within eight Middle Susitna River Segment (MR) Focus Areas below Devils Canyon to support two-dimensional (2-D) model development. Field surveys were completed in September 2014.
  - Completion of aerial salmon spawning surveys of the MR Focus Areas in September 2014.
  - Continued collection of HSC data that involved surveys in the MR and Lower Susitna River Segment (LR) in May, June, July, and September 2014.
  - Collection of data from 11 SW stations that were maintained at different locations along the mainstem Susitna River. Information collected at the stations included some or all of the following: stage, water temperature, camera images, and meteorological conditions. These stations were serviced in September/October 2015 during which time five were decommissioned and removed, and six were maintained and will continue to collect data.
- Data analysis and model refinements have continued including:
  - Refinements to the MR 2-D Fish Habitat Model to incorporate a common grid system that can process data from both SRH-2D and River2D model outputs, as well as outputs from the Water Quality Modeling (Study 5.6), and GW (Study 7.5) studies.
  - Continued development of a HEC-RAS hydraulic model and calibration and model simulation of remaining LR sites collected during 2013 at Trapper Creek, and transects located at Project River Mile (PRM) 95, and PRM96.
  - Completion of Version 2.8 of the OWFRM that incorporated additional cross-sectional data collected in 2014.
  - Continued analysis of HSC data and development of draft final multivariate HSC models for Chinook salmon *(Oncorhynchus tshawytscha)* fry and juvenile, chum salmon *(O. keta)* spawning, coho salmon *(O. kisutch)* fry and juvenile, sockeye salmon *(O. nerka)* spawning, Arctic grayling *(Thymallus arcticus)* fry and juvenile, whitefish fry and juvenile, and longnose sucker *(Catostomus catostomus)* juvenile and adult.
  - Continued advancement of the Decision Support System (DSS) that is leading to development of a detailed example that illustrates estimation of one metric in the Decision Support Matrix (with consideration of uncertainty) based on habitat modeling results from two flow scenarios.
- A combined GW-IFS-Riparian Instream Flow (RIFS Study 8.6) Technical Team (TT) meeting was held on December 5, 2014 to discuss and solicit questions from Licensing Participants regarding the October 2014 ISR meetings and the GW-IFS-RIFS TMs that were submitted in September 2014 (the GW-IFS TM is listed above (GWS and R2 2014a); the GW-RIFS TM is listed in SIR Study 7.5 and SIR Study 8.6 (*Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling*, submitted to the FERC September 30, 2014 [GWS and R2 2014b]). A meeting summary was subsequently prepared and made available to the Licensing Participants on AEA's public

website. A copy of the presentation materials and the meeting summary are included in SIR Study 7.5, Appendix D.

In furtherance of the next round of ISR meetings and the FERC Director's Study Determination expected in 2016, this SIR describes AEA's overall progress in implementing the IFS (Study 8.5) through the end of calendar year 2014 and up through and including the submittal of this SIR in 2015. The SIR is not intended to provide a comprehensive reporting of all field work, data collection, and data analysis since the beginning of AEA's study program, but rather to provide an update of information presented in ISR Part A for the IFS. The SIR and its Appendices describe the methods and results of these efforts, and discusses the results in terms of the eight stated objectives of the IFS (Study 8.5). Although each of the eight objectives is included in the SIR, only those for which substantial work was completed are discussed in detail.

# 2. STUDY OBJECTIVES

The overall goal of the IFS (Study 8.5) and its component study efforts is to provide quantitative indices of existing aquatic habitats that enable a determination of the effects of alternative Project operational scenarios. The eight study objectives were established and listed in RSP Section 8.5.1.2 and are summarized below:

1. Map the current aquatic habitat in main channel and off-channel habitats of the Susitna River affected by Project operations. This objective will be completed as part of the RSP Study 9.9 (Characterization and Mapping of Aquatic Habitats).
2. Select study areas and sampling procedures to collect data and information that can be used to characterize, quantify, and model mainstem and lateral Susitna River habitat types at different scales (RSP Section 8.5.4.2).
3. Develop a mainstem OWFRM that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios (RSP Section 8.5.4.3).
4. Develop site-specific HSC and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the Technical Workgroup (TWG). If study efforts are unable to develop robust site-specific data, HSC/HSI will be developed using the best available information and selected in consultation with the TWG (RSP Section 8.5.4.5).
5. Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternative operational scenarios (RSP Section 8.5.4.7).
6. Evaluate existing conditions and alternative operational scenarios using a hydrologic database that includes specific years or portions of annual hydrographs for wet, average, and dry hydrologic conditions and warm and cool Pacific Decadal Oscillation (PDO) phases (RSP Section 8.5.4.7).
7. Coordinate instream flow modeling and evaluation procedures with complementary study efforts, including Riparian Instream Flow (Study 8.6), Geomorphology (Studies 6.5 and

6.6), GW (Study 7.5), Baseline Water Quality (Study 5.5), Fish Passage Barriers (Study 9.12), and Ice Processes (Study 7.6) (RSP Section 8.5.4.8).

8. Develop a Decision Support System (DSS)-type framework to conduct a variety of post-processing comparative analyses derived from the output metrics estimated under aquatic habitat models (RSP Section 8.5.4.8).

# 3. STUDY AREA

The IFS program is focused on addressing flow-related effects of Project operations downstream of the Watana Dam (PRM 187.1). As established in the Study Plan, the Susitna River is characterized into three segments (Figure 3-1). The overall study area of the IFS includes the two lower segments of the river: the MR which extends from PRM 187.1 downstream to the Three Rivers Confluence at PRM 102.4 (Figure 3-2) and the LR which extends from the Three Rivers Confluence to Cook Inlet (Figure 3-3). Figure 3-2 also displays the locations of the ten Focus Areas that were identified as part of the River Stratification and Study Area Selection process described in ISR Study 8.5, Part A, Section 4.2.

# 4. METHODS

The IFS Study is divided into eight study components related to the study objectives outlined in Section 2 above: 1) IFS Analytical Framework, 2) River Stratification and Study Area Selection, 3) Hydraulic Routing, 4) Hydrologic Data Analysis, 5) Habitat Suitability Curve Development, 6) Habitat-Specific Model Development, 7) Temporal and Spatial Habitat Analysis, and 8) Instream Flow Study Integration. Each of the components and its related study methods have been explained in ISR Study 8.5, Part A, Section 4. This section provides an update of activities related to each of the objectives that have occurred since the June 2014 ISR. Only objectives for which work has been completed since June 2014 are discussed in detail; others are cross-referenced back to the methods in the RSP and ISR.

## 4.1. IFS Analytical Framework

### 4.1.1. Methodology

As described in ISR Study 8.5, Part A, Section 4.1, AEA implemented the methods associated with this study element in accordance with the Study Plan with no variances.

The analytical framework of the IFS was described in detail in Section 4.1.1 of the ISR and depicted in Figure 4.1-1a and Figure 4.1-1b. The instream flow framework is designed to integrate riverine processes, including geomorphology, ice processes, water quality, and GW/SW interactions to quantify changes in indicators used to measure the integrity of aquatic resources. The framework includes the development of a number of resource specific models that will be linked together to collectively evaluate Project operational effects.

Since the June 2014 ISR, work has continued on the development and refinement of these models as described in SIR for Studies 5.6, 6.6, 7.5, 7.6, 8.5 and 8.6. Of particular note is the development of a preliminary three dimensional MODFLOW GW model for FA-128 (Slough 8A) (SIR Study 7.5; Appendix B). When fully calibrated, this model will utilize inputs from the OWFRM (SIR Study 8.5), SRH-2D hydraulic models (SIR Study 6.6), and the River1D and River2D (SIR Study 7.6) Ice Processes models for evaluating Project operational effects on GW/SW interactions. Output from the MODFLOW can then be linked with the 2-D Physical Habitat Simulation (PHABSIM) Fish Habitat Models for assessing Project effects on fish habitats dependent on/influenced by GW (e.g., spawning, egg incubation, juvenile overwintering). Similar MODFLOW models can be developed and utilized for FA-104 (Whiskers Slough), FA-115 (Slough 6A), and FA-138 (Gold Creek) (SIR Study 7.5).

In addition, a combined GW-IFS-RIFS TT meeting occurred on December 5, 2014 to discuss progress on the GW analysis related to the IFS (Study 8.5) and RIFS (Study 8.6) studies.

### 4.1.2. Variances

AEA implemented the methods as described in the Study Plan and ISR Study 8.5, Part A, Section 4.1 with no variances, and there have been no additional variances since the June 2014 ISR.

## 4.2. River Stratification and Study Area Selection

AEA implemented the methods as described in the Study Plan and ISR Study 8.5, Part A, Section 4.1, with the exception of variances explained below. The methods that have been used for stratification and study area selection were described in detail in ISR Study 8.5, Part A, Sections 4.2.1.1 and 4.2.1.2 and are not repeated here. The study area selection process resulted in the selection of ten Focus Areas (FAs) located in the MR of the Susitna River (Figure 3-2) from which to conduct coordinated multi-resource studies (ISR Study 8.5, Part A, Section 4.2.1.2.1), and located in the LR of the Susitna River there are five one-dimensional (1-D) PHABSIM sites in LR-1 between PRM 92.5 and PRM 97.5 including Trapper Creek and Birch Creek confluences, five 1-D PHABSIM sites in LR-2 between PRM 65 and PRM 70 including Sheep Creek and Caswell Creek confluences, and the Deshka River confluence (PRM 44.9) (Figure 3-3) from which to conduct IFS studies.

Detailed surveys were initiated on the lower seven of the ten Focus Areas in 2013 and preliminary study results were presented for FA-128 (Slough 8A) in the Appendix N of the June 2014 ISR. However, surveys of the upper three Focus Areas (FA-151 [Portage Creek], FA-173 [Stephan Lake Complex], and FA-184 [Watana Dam]) were limited in 2013 due to access restrictions associated with Cook Inlet Regional Working Group (CIRWG) lands. These restrictions were resolved and since the June 2014 ISR, AEA completed detailed bathymetric and 2-D model calibration surveys at FA-151 (Portage Creek) that are necessary to develop 2-D hydraulic models that will be used for evaluating Project operational effects on fish and aquatic habitats (IFS Study 8.5), fish access to Portage Creek (Study 9.12), channel morphology (Study 6.6), and Ice Processes (Study 7.6). Surveys of FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) are needed to complete this study component.

The IFS field surveys at the five LR-1 sites were completed in 2013, and preliminary hydraulic analysis for the Birch Creek and PRM97 sites were presented in ISR Study 8.5, Part A,

Appendix I: *Lower River Hydraulic Model Calibration* (R2 2014c). Transect data were collected at the Deshka River confluence as part of Study 6.6 (Fluvial Geomorphology Modeling). Since the June 2014 ISR, the Trapper and Birch Creek data and mainstem transect data at PRM95, PRM96, and PRM97 sites are undergoing additional analysis (ISR Study 8.5, Part A, Section 4.6.1.2.3). However, field measurements of the LR-2 sites are needed to complete this study component.

### 4.2.1. Variances from Study Plan

AEA implemented the methods as described in the Study Plan and ISR Study 8.5 with the exception of the variance explained below. While land access was not available for the three upper Focus Areas adjacent to CIRWG lands in 2013, this restriction was resolved in 2014 and AEA was able to complete detailed surveys in one of the three Focus Areas FA-151 (Portage Creek) by September 2014. However, surveys of FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) are still needed to complete this study component. Even so, this is not considered a variance because this study was designed to collect data over multiple years.

Sampling of sites in LR-1, LR-2, and the Deshka River was originally scheduled for 2013, but sites in LR-2 were not surveyed and were scheduled for the next year of study (ISR Study 8.5, Part A, Section 4.6.2). Surveying of 1-D PHABSIM sites in LR-2 was not conducted in 2014; however, flow data were collected in Sheep and Caswell creeks and the Deshka River (Section 4.3) and HSC data were collected in LR-2 between PRM 65 and PRM 70. The IFS sites in LR-2 must still be surveyed to complete this study component. This change in schedule will not have a substantive effect on meeting study objectives.

## 4.3. Hydrologic Data Analysis

AEA implemented the methods as described in the Study Plan and ISR Study 8.5 with the exception of the variances explained in ISR Study 8.5, Part A, Section 4.3.2 (Variances from Study Plan).

AEA's overall hydrology program includes; 1) an assessment of existing hydrology data that will summarize seasonal and long-term hydrologic characteristics for the river including daily, monthly, and annual summaries, exceedance summaries, and recurrence intervals of small and large floods; and 2) the installation and monitoring of a number of mainstem and tributary gages that will fill-in data gaps, contemporize the flow record, and provide for a more robust hydrologic data set. Activities completed in 2013 were summarized in ISR Study 8.5, Part A, Appendix A: *Hydrologic Data Collection Methods* (R2 2014d). Since the June 2014 ISR, AEA has continued implementation of the hydrology program with details of activities completed since then described below.

### 4.3.1. Methodology

#### *4.3.1.1. Hydrologic Data Collection*

In 2014, AEA continued the collection and analysis of hydrologic data at a number of existing mainstem gaging stations, collected transect data at additional mainstem locations, collected water surface elevation (WSE) data at upstream and downstream ends of Focus Areas, and maintained existing and installed new tributary gages at a total of 13 sites. The mainstem Susitna River hydrologic data collection included stage and discharge measurements, cross-sectional and areal bathymetric surveys, velocity mapping, and roughness determinations.

During open-water conditions, mainstem discharge measurements were performed using an Acoustic Doppler Current Profiler (ADCP) following current United States Geological Survey (USGS) guidance (Mueller et al. 2013). Stage, discharge and bathymetric surveys were performed at 63 mainstem cross-sections following methods described in ISR Study 8.5, Part A, Section 4.3.1.1), and numerous calibration transects were measured within Focus Areas (including inlets and outlets) using the surveying and ADCP methods. A description of the Focus Area measurements is also provided in SIR Study 8.5, Appendix C: 2014 Moving Boat Acoustic Doppler Current Profiler (ADCP) Measurements. Continuous stage measurements (along with temperature and meteorological data) were also recorded in 2014 at AEA hydrology stations, following methods described in ISR Study 8.5, Part A, Section 4.3.1.1). Table 4.3-1 shows a listing of the stations in the real-time reporting data network. In addition, forty-two staff gages were installed in September 2014 within side channels and sloughs of the Susitna River (4 in FA-144 [Slough 21], 5 in FA-141 [Indian River], 8 in FA-138 [Gold Creek], 8 in FA-128 [Slough 8A], 6 in FA-115 [Slough 6A], 4 in FA-113 [Oxbow 1], 3 at PRM 112, and 4 in FA-104 [Whiskers Slough]). All staff gages were surveyed into the project datum and were installed to allow manual opportunistic measurements to be made of water surface elevations and discharge by resource study field participants who may be within those areas. All but one of the staff gages were removed in September 2015.

Mainstem stage data were collected at the upstream and downstream ends of the eight Focus Areas below Devils Canyon to support the Fluvial Geomorphology Modeling Study (Study 6.6). For this effort, Solinst levelogger pressure transducers were installed at 11 locations along the mainstem of the Susitna River (Table 4.3-2). The leveloggers were set to record in 15-minute increments, installed on July 22 and 23, 2014 and removed in mid-September 2014. Benchmarks and WSEs were surveyed during installation and removal and hourly hydrograph data calculated in reference to the project datum.

No additional winter streamflow measurements have been made since the June 2014 ISR.

###### *4.3.1.1.1. Tributaries to the Susitna River*

Tributary gaging stations installed at selected tributaries in 2013 were maintained in 2014 and four additional sites (Tsusena Creek, Fog Creek, Portage Creek, and Gold Creek) were installed in spring/early summer 2014 (Table 4.3-3; Figure 4.3-1). The gaging stations were installed in spring/early summer of 2014 to help measure the spring snowmelt peaks. In all, there were 12 continuous sites, five companion stage-only sites located in the downstream slough of the mainstem of the Susitna River, and nine spot measurement sites measured in 2014. Details concerning the installation, monitoring, and data analysis procedures of the tributary gages are presented in ISR Study 8.5, Part A, Appendix A (R2 2014d) and this SIR Study 8.5, Appendix B. Of the 26 sites, 16 were removed in September 2014 and the remaining 10 sites removed in September 2015.

##### *4.3.1.1.2. Hydrologic Data Real-time Reporting Network Operations*

The data network system and stations that were installed in 2012 were operated through 2015 as a means to provide real-time updates on hydrology and other meteorological parameters at locations throughout the river (Table 4.3-1). These stations are connected through a radio telemetry system using spread-spectrum radio communication and a network of repeater stations to communicate to a central base station. The stations were serviced in September 2015 during which time five stations (ESS10, ESS15, ESS30, ESS50, and ESS65) were decommissioned (data needs were met) and six stations (ESS20, ESS40, ESS45, ESS55, ESS70 and ESS80) were maintained. Table 4.3-1 summarizes the current status of the original 13 ESS stations.

#### *4.3.1.2. Hydrologic Data Analyses*

Since the June 2014 ISR, the primary activities associated with hydrologic data analysis have included data compilation and Quality Assurance (QA)/Quality Control (QC) reviews of flow and stage data; tributary gaging data QC, rating curve development, and stream flow computations; and Susitna River mainstem transect cross-section and bathymetric data post-processing. Processed mainstem transect and tributary data collected through September 2014 are provided in Appendix B: Open-water Hydrology Data Collection and Open-water Flow Routing Model (Version 2.8). Tributary data analysis is ongoing and will include the revisions to daily and hourly hydrology for 59 tributaries to the Susitna River used in the Susitna River OWFRM and by other resource studies in Focus Area 2-D modeling efforts.

The analysis of representative years was also completed in 2014 with the rationale for the recommended years provided in the ISR Study 8.5, Part C, Appendix J: *Representative Years* (R2 2014e). The topic of representative years was discussed at the November 13-15, 2013 IFS TT Riverine Modelers meeting, at the Q4 2013 TWG meeting, and during the April 15-17, 2014 IFS TT Riverine Modeling Proof of Concept meeting.

#### *4.3.1.3. Indicators of Hydrologic Alteration and Environmental Flow Components*

Indicators of Hydrologic Alteration (IHA)/Environmental Flow Component (EFC) -type analyses will be used as indicators of Project effects by comparing hydrologic statistics describing Existing Conditions and Project operational scenarios. AEA proposed a list of IHA/EFC metrics at the March 21, 2014 TWG meeting. Final metrics will be developed with input from the Licensing Participants and other resource disciplines after Version 3 of the Open-water Flow Routing Model is completed. Variances from Study Plan

AEA implemented the methods as described in this section of the Study Plan with the exception of the variances explained below.

#### *4.3.1.4. Tributaries to the Susitna River*

The RSP states that "Additional gaging stations will be added at selected tributaries to help provide additional hydrologic analysis for hydrologic and fisheries studies. These tributaries will include Fog Creek, Portage Creek, and Indian River. These gaging stations will be installed in spring 2013 to help measure the spring snowmelt peaks."

Twenty-six spot measurement, continuous, and companion stage-only tributary gaging stations were installed on tributaries of the Susitna River between 2013 and 2015. Data were collected on Indian River between July 2013 and September 2015. A gage was installed on Portage Creek and data were collected between June 2014 and September 2015. A continuous gage was also installed on Fog Creek between June 2014 and September 2015, but no rating curve could be established since a tree fell after the gage was installed affecting the site hydraulics. Instead, only spot measurement streamflow data were collected at Fog Creek. Tributary inputs in the OWFRM were estimated based on drainage area and then adjusted using available tributary gaging data as described in SIR Study 8.5, Appendix B. Adjustments for Fog Creek were based on spot measurement data collected in three different years (1982, 2014, and 2015). Data gaps associated with the lack of continuous gage data on Fog Creek will not appreciably affect accretion calculations used in the OWFRM.

#### *4.3.1.5. Representative Years*

The RSP states that "Five representative years will be selected that represent, wet, average, and dry conditions, and warm and cool Pacific Decadal Oscillation phases so that Project effects for various project alternatives can be evaluated under a range of climatic and hydrologic conditions. In addition, a multi-year continuous flow record will be evaluated to identify year-to-year variations independent of average, wet, or dry conditions. The specific representative years and the duration of the continuous flow record will be selected by AEA in consultation with the TWG in Q3 2013."

A variance was noted regarding the schedule for the selection of representative years. However, AEA has developed a set of recommended representative years which were presented in ISR Study 8.5, Part C, Appendix J: *Representative Years* (R2 2014e) so this is no longer a variance.

#### *4.3.1.6. Indicators of Hydrologic Alteration and Environmental Flow Components*

The RSP states that "In consultation with the TWG, the IHA/ Environmental Flow Component (EFC) or HEC-Ecosystems Function Model (EFM) programs will be used to evaluate existing conditions and alternative operational scenarios for the Project. Select hydrologic parameters, considered to be ecologically relevant to Susitna River resources, will be developed in consultation with the TWG in Q3 2013, and initial results and potential modification reviewed by the TWG in Q1 2014." The RSP also states that "Interim results of the IHA-type analyses will be presented in the ISR."

Candidate metrics and the proposed IHA analysis were presented in the March 21, 2014 IFS TT meeting. A variance in schedule has occurred for the IHA analysis. The determination of the appropriate methodology to apply, and parameters to use, from the Indicators of Hydrologic Alteration continued through Q4 of 2014. The final metrics will be developed with input from the TWG and other resource disciplines after Version 3 of the OWFRM is available. Delay in selecting the final IHA/EFC parameters will not affect the ability to meet study objectives.

## 4.4. Reservoir Operations Model and Open-water Flow Routing Model

AEA implemented the methods as described in the Study Plan (RSP Section 8.5.4.3) with the exception of the variances described in Section 4.4.2.

### 4.4.1. Reservoir Operations Model

A reservoir operations model is needed to forecast a range of reservoir outflows associated with different operational scenarios that will be evaluated as part of the IFS. Originally HEC ResSim was used to simulate reservoir operations as described in the ISR Study 8.5, Part A, Section 4.4. As the model operational scenarios changed, it became apparent HEC ResSim could not adequately simulate conditions and a proprietary reservoir operations model was developed (MWH-ROM). This model is a water balance type of reservoir operation model that accounts for flow through the project reservoir, penstocks, and powerhouse on an hourly basis for the continuous 61-year period of record. The model is written in FORTRAN and uses a number of text input and output files.

The operation model input includes: 1) daily inflows to the reservoir; 2) daily local inflows between Watana Dam and the USGS gaging station at Gold Creek; 3) general model input parameters that describe the physical and operating rules and characteristics of the reservoir; 4) Susitna-Watana powerhouse characteristics, which contains the preliminary turbine efficiencies as a function of flow and head, preliminary generator efficiencies as a function of output, and limiting maximums of the units; 5) the Railbelt electricity load for each hour of the year from which the generation requirements at Susitna-Watana are developed; and 6) minimum flow requirements at Gold Creek for each day of the year. A description of the MWH-ROM can be found in the Engineering Feasibility Report Section 12 Project Operation and Resource Utilization (MWH 2014). The MWH-ROM will be used for all future reservoir operations modeling scenarios.

### 4.4.2. Open-water Flow Routing Model

The HEC-RAS model (USACE 2010a, 2010b, and 2010c) was selected as the platform for the Open-water Flow Routing Model (OWFRM) to route stage fluctuations downstream from the proposed Project dam under open-water conditions (i.e., summer, ice-free). Two different flow routing models have been developed: an open-water model (HEC-RAS) described in this section of the SIR and a winter model to route flows under ice-covered conditions (Study 7.6). The seasonal timing of the transition from the HEC-RAS model to the ice processes model and vice versa will vary from year to year and depends on seasonal climate conditions and conditions such as the onset of frazil and bank ice formation in the fall and loss of river and bank ice following spring breakup.

The OWFRM will utilize outputs from the Reservoir Operations Model as input to assess the magnitude, timing and frequency of hourly flow and stage conditions during open-water periods (i.e., ice-free) at numerous locations longitudinally distributed throughout the length of the river extending from PRM 187.2 downstream to PRM 29.9 (about 1.5 miles downstream from the confluence with the Yentna River) during open-water periods (i.e., ice-free). The OWFRM was developed using river cross-sections and streamflow gaging stations established on the Susitna River. Three versions of the model have been developed and provided for distribution to other resource studies. Each successive version of the model is refined and contains more detail based on additional information available.

The OWFRM V 2.8 was developed using cross-sectional data collected between 2012 and 2014 in accordance with USGS procedures and as described in ISR Study 8.5, Part A, Appendix C: *Moving Boat ADCP Measurements* [R2 2014g]). This entailed surveying of ground surface and water surface elevations at each cross-section using Real-time Kinetic (RTK) Global Positioning System (GPS) instrumentation. River bathymetry and flow velocities were measured using an ADCP system consisting of a Sontek M9 equipped with RTK GPS positioning. Water surface slopes were also measured, photographs taken and vegetation descriptions developed at each section. Flow measurements were made at each river cross-section by completing at least four passes across the channel width.

The 2012 cross-sections were measured during three field trips intended to capture high-flow (28,000 cubic feet per second [cfs]), medium-flow (16,000 cfs), and low-flow (8,000 cfs) conditions corresponding to the USGS gaging station at Gold Creek (USGS No. 15292000). The 2013 and 2014 cross-sections were surveyed to improve the OWFRM, to extend the model down to PRM 29.9, to fill in data gaps from the 2012 cross-sections to capture high-, medium-, and low-flow conditions, and to provide additional cross-sections needed in the geomorphology model (Study 6.6) and for the RIFS (Study 8.6) analysis.

Results and documentation of Version 1 of the OWFRM were completed in January 2013 (*Open-water HEC-RAS Flow Routing Model*, submitted to the FERC January 31, 2013 [R2 et al. 2013]). The January 2013 version of the model extended from the proposed Dam Site at PRM 187.1 downstream to PRM 80.0 (about 23 miles downstream from the confluence with the Chulitna River). Version 1 of the model relied on data collected during the 2012 summer field season and included data from 88 surveyed river cross-sections (16 between the proposed Dam Site and Devils Canyon, 59 between Devils Canyon and the Three Rivers Confluence, and 13 downstream from the Three Rivers Confluence). Version 2 of the OWFRM was completed in 2014 and was developed using 167 river cross-sections surveyed in 2012 and 2013, 383 flow/water surface elevation pairs, and Light Detection and Ranging (LiDAR) surveys of the floodplain in 2011. The Version 2 model extended from the proposed Dam Site at PRM 187.1 downstream to PRM 29.9.

As described in the FERC-approved Study Plan, the final Version 3 of the OWFRM was anticipated for completion as part of the Updated Study Report (USR). However an intermediate version of the model was completed that represents an update from Version 2, but is not the final version that will be presented as Version 3. This intermediate version of the model is documented in this SIR Study 8.5, Appendix B and is termed Version 2.8. Based on the differences in data collection and model completion, the Susitna River has been separated into two reaches, above and below the USGS gage Susitna River at Sunshine (USGS No. 15292780) at PRM 87.9.

Version 2.8 of the OWFRM includes a revision of the reach between the proposed Dam Site at PRM 187.1 downstream to PRM 87.9 (USGS No. 15292780 Susitna River at Sunshine), while the model from PRM 87.9 downstream to PRM 29.9 (USGS No. 15294350 Susitna River at Susitna Station) has not changed from Version 2. The reach from the Proposed Dam Site to Sunshine incorporates the additional transect and Q (flow) and WSE pair data collected in 2014, the revised LiDAR data collected in 2013, diurnal fluctuations, and adjustments of tributary estimates based on gage data collected in 2013 and 2014. In order to simulate the lower Sunshine to Susitna Station reach of the model, the results of the upper reach (Dam Site to Sunshine reach) are used as input to the lower reach and represent a boundary condition for the Sunshine to Susitna Station reach. The electronic files needed to run each of these two reaches of the OWFRM are provided separately.

The reach of the model from Sunshine to Susitna Station uses the data and calibration provided in Version 2 and documented in ISR Study 8.5, Part C, Appendix K: *Hydrology and Version 2 Open-water Flow Routing Model* (R2 2014h). The final version "Version 3" of the OWFRM will include validation of the upper Susitna River portion and revisions to the lower Susitna River portion with additional cross-section and hydrologic data. A comparison of the three completed versions and the content contained in each is provided in Table 4.4-1.

The hourly flow records from USGS gaging stations on the Susitna River were also utilized to help develop Version 2.8 of the OWFRM. Water stage, water temperature, air temperature, and time-laps photographic (camera) images of river conditions were also collected at each ESS station. The additional ESS mainstem gaging stations (Table 4.3-1) will be used to validate OWFRM output.

During the development and calibration of Version 2.8 of the OWFRM, the drainage areas of ungaged tributaries were quantified and used to help estimate accretion flows to the Susitna River between locations of mainstem USGS gages where flows are measured. The flow estimates developed for ungaged tributaries were refined based on flows that were measured in those tributaries in 2013 and 2014 (SIR Study 8.5, Appendix B). These distributions will be further refined based on final measured data collected through 2015.

### 4.4.3. Variances from Study Plan

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

Section 8.5.4.3.1 of the RSP states that "The gaging stations initially installed in 2012 will be maintained through 2013 and 2014 to help calibrate and validate the flow routing models and provide data supporting other studies." This section also states that one of the objectives is to "Install and operate 13 water-level recording stations within the mainstem Susitna River."

Version 1 of the OWFRM (R2 et al. 2013) was developed in January 2013 following submittal of the RSP. However, as noted in ISR Study 8.5, Part A, Section 4.4.2, during the development of the OWFRM it became apparent that all 13 mainstem water-level recording stations were not needed for calibration purposes (see Table 4.4-2 and Figure 4.4-1 for locations of these stations) since the 15-minute USGS data were used for model calibration. Thus, the data available from the mainstem ESS stations will be primarily used in validation of Version 3 of the model. Use of the ESS data for validation purposes is an important element in the development of the final Version 3 OWFRM and is not a variance.

Section 8.5.4.3.2 of the RSP states that "The U.S. Army Corps of Engineers, Hydrologic Engineering Center (HEC) reservoir system simulation model HEC-ResSim Version 3.0 will be used to develop the reservoir outflows used in the Instream Flow Study.

Preliminary versions of the reservoir operations model were developed using HEC ResSim. However, during model development it became apparent that HEC ResSim could not accommodate all of the necessary reservoir modeling components. In response to this development, a proprietary reservoir operations model was developed (MWH-ROM) and will be used for development of reservoir operations scenarios.

## 4.5. Habitat Suitability Criteria Development

AEA implemented the methods as described in the Study Plan with the exception of the variances described in Section 4.5.2. The general basis for and methods used for developing HSC and HSI were described in the FERC-approved Study Plan and further detailed in the ISR Study 8.5, and ISR Study 8.5, Part C, Appendix M: *Habitat Suitability Curve Development* (R2 2014i). As noted in the ISR, HSC and HSI are considered together and are reported hereafter as HSC/HSI.

Since the June 2014 ISR, activities associated with the HSC/HSI study component have included: 1) selection of final draft priority fish species and life stages and periodicity tables; 2) collection of summer (May-October) and winter (February-April) microhabitat use and availability data in the MR and LR; 3) development of updated histograms displaying frequency of use for different microhabitat variables by season (summer vs. winter) and by river segment (MR and LR); 4) development of draft final multivariate preference curves for Chinook salmon fry and juvenile, chum salmon spawning, coho salmon fry and juvenile, sockeye salmon spawning, Arctic grayling fry and juvenile, whitefish fry and juvenile (round *[Prosopium cylindraceum]* and humpback *[Coregonus pidschian]*), and longnose sucker juvenile and adult; 5) recommendation of HSC/HSI thresholds values to help define habitat preference; and 6) for species and life stages with insufficient site-specific observations for development of preference curves, habitat utilization measurements were compared to HSC developed as part of the 1980s Susitna River studies.

A detailed description of each of these elements is presented in SIR Study 8.5, Appendix D and summarized below.

### 4.5.1. Select Priority Fish Species and Development of Periodicity Information

Defining the species of interest (i.e., priority species) and then developing an understanding of the timing of different life stage functions (i.e., periodicity) for each of the species is an important aspect of instream flow studies. Both the 1980s studies and the current licensing studies (IFS Study 8.5, and Fish Distribution and Abundance in the Middle and Lower Susitna River [FDAML] Study 9.6) recognized the importance of defining priority species and their life stage periodicities for evaluating potential Project effects. A proposed final list of priority fish species for potential development of HSC curves was developed in collaboration with the Technical Working Group (TWG) during meetings held in Q1 and Q2 2013, and during a Technical Team meeting held in Q1 2014. The species rankings were based on information presented in the 1980s technical studies, results of the 2013 and 2014 HSC surveys, management status, and perceived sensitivity to changes in habitat due to potential Project operations. The ranking specifies the general methodology that will be used to develop HSC for a particular species and life stage based the number of site-specific observations collected during 2013-2014 surveys, availability of HSC curves developed during the 1980s Susitna studies, availability of HSC curves from outside the Susitna basin, and life history information.

Draft periodicity tables were presented in the ISR Study 8.5, Part A, Appendix H: *Periodicity Tables* (R2 2014j). The draft periodicity tables were developed to describe the temporal periods which each priority species and life stage are expected to occur in the Project area. No updates or refinements have been made to the draft periodicity tables since the submittal of the June 2014 ISR.

### 4.5.2. Development of Draft Final HSC/HSI

The HSC/HSI Development Study has been implemented following methods described in the FERC-approved Study Plan with the exception of variances noted in Section 4.6.2.

Specific activities used in development of the draft HSC have included: 1) study site selection and distribution; 2) collection of site-specific HSC/HSI data during summer and winter sampling events; 3) development of histograms using 2013-2014 habitat utilization data to display the frequency of microhabitat use by river segment, season, and comparisons with 1980s HSC for specific species and life stages; and 4) development of draft final HSC for those species and life stages with sufficient observations (2013 and 2014 data) using statistical methods.

#### *4.5.2.1. HSC/HSI Sample Area Selection*

Summer and winter HSC surveys utilized both random and non-random sampling in selection of HSC sampling sites. Utilizing both a random and non-random site selection approach provided representative sampling of a range of macrohabitat types available to fish, while also ensuring that sufficient numbers of observations were collected.

Summer HSC sampling occurred at random locations within the LR and MR of the Susitna River. A majority of the HSC sampling sites were within the ten Focus Areas located within the MR of the Susitna River. During 2013, HSC sampling was conducted at seven of the ten Focus Areas (FA-104 [Whiskers Slough], FA-113 [Oxbow 1], FA-115 [Slough 6A], FA-128 [Slough 8A], FA-138 [Gold Creek], FA-141 [Indian River], and FA-144 [Slough 21]). In 2014, HSC sampling was conducted in all ten MR Focus Areas and in the Trapper-Birch and Sheep-Caswell Creek complexes in the LR (SIR Study 8.5, Appendix D, Figures 4.2-1 and 4.2-2). Because of the spatial clustering of spawning activities, HSC spawning surveys in 2014 were only conducted at those locations (within and outside of Focus Areas) where spawning was observed during the 1980s and 2013 surveys.

Winter HSC sampling in the MR occurred during two winter periods (2012-2013 and 2013-2014) (SIR Study 8.5, Appendix A). Data collection primarily occurred within three Focus Areas: FA-104 (Whisker Slough), FA-128 (Slough 8A), and FA-138 (Gold Creek); however, opportunistic sampling also occurred within FA-141 (Indian River) (SIR Study 8.5, Appendix D, Figure 4.2-3). These Focus Areas were selected for the 2012-2014 sampling effort because they contain a diversity of habitat types with GW influence, they have documented fish utilization by multiple fish species and life stages, and they could be safely accessed during the winter.

A detailed description of the random sampling approach used for HSC sampling is presented in ISR Study 8.5, Part A, Section 4.5.1.3. In summary, the stratification approach splits macrohabitat into linear habitat units of 500-meter (main and side-channels) and 200-meter-long (off-channel) segments. These units were then stratified into areas of known fish use versus unknown fish use based on studies conducted in the 1980s. Individual sample sites (100-meter and 50-meter) were then placed within the habitat units, in areas that visually appeared to have the greatest diversity of microhabitat types (i.e., fast and slow, deep and shallow water) and could be safely surveyed.

The general location of each summer and winter sampling site within the LR and MR segment is presented in SIR Study 8.5, Appendix D, Figures 5.2-1 through 5.2-15.

#### *4.5.2.2. Collect Site-Specific Habitat Use Information*

As previously stated, both summer and winter HSC/HSI surveys were completed to evaluate potential seasonal difference in habitat use by target fish species. During each survey, microhabitat data (e.g., water depth, velocity, substrate composition, cover, water quality) were recorded at each fish observation point.

While fish microhabitat use information was collected on all species and life stages encountered (with the exception of sculpin *[Cottid]*), the locations, timing, and methods of sampling efforts targeted key (high-moderate priority) species and life stages identified in consultation with the TWG during Q1 2013.

#### *4.5.2.3. Summer Surveys*

Summertime surveys were completed in 2013 and 2014 to collect site-specific information on microhabitat use and availability for development of multivariate HSC. Collection of summer 2014 HSC data closely followed the methods utilized during the summer 2013 sampling. The only notable differences between the summer 2013 and 2014 sampling methods were the frequency of sampling (approximately every 2 weeks in 2013, approximately monthly in 2014) and the increased intensity of vertical hydraulic gradient (VHG) or indicator measurements completed in 2014 for the detection of GW upwelling. A detailed description of the 2013-2014 sampling methods is presented in ISR Study 8.5, Part A, Section 4.5.1.4 and SIR Study 8.5, Appendix D.

#### *4.5.2.4. Winter Surveys*

The 2012-2013 and 2013-2014 winter surveys were conducted during February, March, and April. Methods utilized during the 2013-2014 study were initially developed during the 2012-2013 pilot winter study conducted at FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Detailed descriptions of the 2012-2013 and 2013-2014 winter surveys are provided in the ISR Study 8.5, Part C, Appendix L: *2012-2013 Instream Flow Winter Studies* submitted to the FERC June 3, 2014 (R2 2014k), the TM, *2013-2014 Instream Flow Winter Studies* submitted to the FERC September 17, 2014 (R2 2014b), and in SIR Study 8.5, Appendix A. Although no winter

HSC/HSI surveys have been completed since issuance of the ISR in June 2014, results of the 2012-2013 and 2013-2014 winter surveys have now been incorporated into the assessment of microhabitat use and comparisons between summer and winter microhabitat use have been completed.

#### 4.5.3. Habitat Availability Data Collection

Habitat availability measurements were completed in accordance with procedures described in ISR Study 8.5, Part A, Section 4.5.1.7.

All 2013-2014 HSC/HSI data were entered into spreadsheet format and subsequently checked for data entry accuracy. Any necessary edits or corrections were then made to the database and checked by a senior staff member for completeness. A database of 2013-2014 HSC utilization and availability data has been completed and is available (see Section 5 for a link to the data).

### 4.5.4. Habitat Utilization Data and Frequency Histograms

Frequency histograms were developed using the 2013-2014 HSC data to visually compare habitat utilization (velocity, depth, and substrate type) between the LR and MRs, seasonal habitat use within the MR, and HSC developed during the 1980s studies. The histograms were developed following methods described in ISR Study 8.5, Part A, Section 4.5.1.8. Along with the histogram plots, the range and median habitat utilization values were also determined (SIR Study 8.5, Appendix D).

For comparison purposes the following guidelines were adapted:

- Frequency distributions were only generated for a particular species and life stage with greater than 10 habitat use observations.
- A bin size of 0.2 feet was used for depth and mean column velocity histograms.
- The frequency of fish observations in each of the bins was normalized to create probability histograms with values between 0 and 1.
- For the comparison between summer and winter microhabitat use, only those observations collected from within sample areas (FA-104 [Whiskers Slough], FA-128 [Slough 8A], FA-138 [Gold Creek], and FA-141 [Indian River]) common to both surveys were included.
- The 1980s HSC curves are presented exactly as reported in their respective source references with the exception of substrate which was adjusted to allow for a comparison between the two studied (1980s and 2013-2014).

### 4.5.5. HSC/HSI Modeling

Habitat suitability modeling provides information on which habitat variables (of those collected synoptic with HSC) are most predictive of fish presence, as well as final predictive multivariate HSC models to be used to assess Project effects. Habitat suitability was determined based on the likelihood of habitat use by each fish species-life stage. Habitat parameters were measured where fish were observed (utilization data) and at additional stratified random locations at each selected sampling site (availability data). The probability of fish presence as a function of these habitat variables was modeled with univariate and multivariate logistic regression.

The ISR Study 8.5, Part C, Appendix M (R2 2014i) and SIR Study 8.5, Appendix D provide a detailed descriptions of the methods used for HSC/HSI development. The only notable change in the HSC/HSI modeling methods described in ISR Study 8.5, Part C, Appendix M (R2 2014i) and SIR Appendix D, is that the SIR combines data collected in 2013 and 2014 where the June 2014 ISR only included data collected in 2013.

### 4.5.6. Other Methods for HSC/HSI Curve Development

For some of the target species and life stages, there were insufficient habitat use observations collected during the 2013-2014 surveys to construct site-specific HSC/HSI curves. For species and life stages that are rarely observed, AEA is considering and evaluating a number of other methods (e.g., references cited in ISR Study 8.5, Part A, Section 4.5.1.9) for developing HSC.

### 4.5.7. Winter Habitat Use Sampling

The IFS winter studies were comprised of two primary components: 1) monitoring of water level, water quality, and ice conditions and 2) fish behavior and habitat use observations. Surface water level and surface and intergravel water quality were continuously monitored at various monitoring stations, while instantaneous measurements of depth, water quality and ice thickness were also recorded during field visits. Site specific observations of habitat utilization by fish species were recorded during electrofishing and underwater video surveys. Methods utilized during the 2013-2014 study were initially developed during the winter 2012-2013 pilot effort and are described in detail in R2 2014k and R2 2014b. Winter studies were coordinated with the study leads for IFS (Study 8.5), FDAML (Study 9.6), GW (Study 7.5), Geomorphology (Study 6.5), Baseline Water Quality (Study 5.5), and Ice Processes (Study 7.6).

The continuation of winter studies during 2014-2015 was specified in ISR Study 8.5 (IFS), Part C, Section 7.5.1 and ISR Study 9.6 (FDAML), Part C, Section 7.1 and primarily consisted of the second season of monitoring of water level and water quality conditions within selected Focus Areas. For this, 25 continuous water level loggers and 108 water quality instruments (consisting of 102 surface and intergravel water temperature loggers, and 6 combined intergravel temperature and DO loggers), were again installed during September 2014 in representative habitats and in salmon spawning areas in FA-104 (Whiskers Slough), FA-128 (Slough 8A), and FA-138 (Gold Creek) (Figure 4.5-1, Figure 4.5-2, and Figure 4.5-3). Instruments were also installed within side channel habitats in FA-144 (Slough 21) in areas with substantial GW influence and observed salmon spawning (SIR Study 8.5, Appendix A, Figure 3-4). Configuration and deployment of instrumentation followed methods previously described in R2 2014k and R2 2014b. No biological monitoring or sampling was completed during the 2014-2015 winter period. Water level and water quality loggers deployed during the winter 2014-2015 period were maintained and downloaded during September 2015. A total of 18 water level loggers and 53 water quality instruments (consisting of 51 surface and intergravel temperature loggers and 2 combined intergravel temperature and DO loggers) were also redeployed at select sites during this effort to collect additional data through winter 2015-2016 in the Susitna River main channel and in salmon spawning habitats of FA-104 (Whiskers Slough), FA-128 (Slough

8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21). Prominent spawning habitats and areas in which limited data have been collected were prioritized for 2015-2016 data collection.

### 4.5.8. Stranding and Trapping

No formal stranding and trapping surveys were conducted during the 2013-2014 data collection effort. The Study Plan indicated that field surveys would be conducted at potential stranding and trapping areas on an opportunistic basis following up to three flow reduction events during 2013-2014 (RSP Section 8.5.4.5.1.2.2). During a May 17, 2013 Technical Team meeting, participants indicated that site-specific stranding and trapping studies should be a low priority. Because the Project does not yet exist, the effects of Project-induced flow fluctuations cannot be directly studied in the Susitna River. Although specific stranding and trapping surveys were not conducted during 2013-2014, this change is not expected to adversely impact achieving Project objectives. As discussed and documented during the May 17, 2013 TWG meeting, ramping criteria developed in Washington State (Hunter 1992) will be proposed as fallback criteria during effects analyses.

### 4.5.9. River Productivity

Development of HSC/HSI for macroinvertebrates and algae will follow a similar general approach to that for fish, and will include a literature search for available information and field studies to supplement literature-based information and to provide site-specific data. The development of HSC/HSI information for macroinvertebrates and algae is ongoing as part of the more comprehensive River Productivity Study (Study 9.8). No macroinvertebrate or algae HSC/HIS data collection occurred in 2014.

### 4.5.10. Relationship between Microhabitat Use and Fish Abundance

In response to the April 1, 2013 FERC Study Plan Determination (SPD) (FERC 2013), AEA completed a detailed evaluation of fish abundance measures and eight additional habitat variables (surface flow and GW exchange flux, surface and intergravel DO and temperature, macronutrients, pH, dissolved organic carbon (DOC), alkalinity, and chlorophyll-a) to determine whether relationships were evident and if additional HSC curve development was warranted. A TM, *Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables* (R2 2014a), describing the results of the evaluation was submitted to the FERC on September 17, 2014.

Most of the analyses used in the evaluation involved comparisons between habitat data collected by various studies and fish abundance data collected by the FDAML (Study 9.6) and Fish Distribution and Abundance in the Upper Susitna River (FDAUP) (Study 9.5). Fish abundance data collected at random sites in the Upper River Segment of the Susitna River (UR), MR, and LR using electrofishing, seining, and snorkeling were used for these comparisons.

### 4.5.11. Variances from Study Plan

The HSC Development Study has been implemented following methods described in the FERC-approved Study Plan with the exception of the variances explained below.

- During 2013 HSC sampling was conducted in the MR below Devils Canyon (PRM 151.8); but no HSC sampling was conducted in the MR above Devils Canyon, or in the LR. In 2014, HSC sampling was conducted in the MR above and below Devils Canyon and in the LR at two tributary complexes (Trapper/Birch creeks and Sheep/Caswell creeks). Additional sampling effort in the MR above Devils Canyon and in the LR will be conducted to complete this study component. These changes are not anticipated to adversely impact achieving Project objectives.
- Spawning redd dimensions were not collected as part of the 2013-2014 HSC spawning surveys. The Study Plan states "Redd dimensions (length and width in feet to nearest 0.1 foot) will be collected." Redd dimension measurements were recorded as part of the 2012 Pilot HSC surveys. Additional redd measurements were not deemed necessary to develop evaluation metrics. This change is not anticipated to adversely impact achieving Project objectives as spawning redd dimensions are not an input variable in the IFS Fish Habitat Modeling.
- Substrate composition was simplified to include only two gravel size classes (small and large). The Study Plan states: "Substrate size (dominant, sub-dominant, percent dominant) characterized in accordance with a Wentworth grain size scale modified to reflect English units." Field personnel found it impracticable to attempt to accurately differentiate gravel composition into three size classes in turbid water conditions. Using two size classifications to describe gravel is consistent with substrate classifications used on numerous other HSC/HSI curve development studies and is not anticipated to impact HSC/HSI curve development.
- Only one velocity measurement (mean column) was recorded for each individual fish microhabitat use observation. The Study Plan states "Location in water column (distance from the bottom), focal point and mean column velocity (feet per second [fps] to nearest 0.05 fps) measured using a Price AA current meter". Most fish captures occurred using electrofishing, seining or a combination of the two methods which precluded the identification of fish focal point position within the water column. The IFS habitat models rely on mean column water velocities and therefore not measuring focal point velocity will have no adverse impacts on HSC/HSI development or on the habitat modeling.
- The Study Plan indicated that "field surveys will be conducted at potential stranding and trapping areas on an opportunistic basis following up to three flow reduction events during 2013." During a May 17, 2013 TT meeting, participants indicated that site-specific stranding and trapping studies should be a low priority. Because the Project does not yet exist, the effects of Project-induced flow fluctuations cannot be directly studied in the Susitna River. Some opportunistic observations of potential stranding and trapping areas were recorded during substrate classification surveys conducted during falling river stage conditions in September 2013, but the observations did not follow robust survey protocols. Although specific stranding and trapping surveys were not conducted in 2013 or 2014, this change is not expected to adversely impact achieving Project objectives. As discussed and documented during the May 17, 2013 TWG meeting, ramping criteria developed in Washington State (Hunter 1992) will be proposed as fallback criteria during

effects analyses. These criteria were developed to protect juvenile salmonids exposed to flow fluctuations associated with hydropower operations.

- The results the 2012-2013 IFS winter pilot study was distributed during Q1 2014 rather than Q3 2013, as was prescribed in RSP Section 8.5.4.5.1.2.1 (AEA 2012). This variance was described in the ISR Study 8.5, Part A, Section 4.5.2 (AEA 2014).
- Mesohabitat type was not recorded for fish observation/capture points. Mesohabitat mapping was completed as part of RSP Study 9.9. After the mesohabitat mapping task is complete, Geographic Information System (GIS) data layers containing the location of HSC/HSI fish use observations will be compared to GIS data layers containing mesohabitat types to determine mesohabitat use by individual fish species and life stages. This change will not adversely impact Project objectives.
- The Study Plan indicated that macroinvertebrate “sampling will occur at six stations, each with three sites (one mainstem site and two off-channel sites associated with the mainstem site), for a total of 18 sites. River Productivity sampling occurred at five stations on the Susitna River, each station with three to five sites (establishing sites at all macrohabitat types present within the station), for a total of 20 sites. Four stations were located in Focus Areas (FA-184 [Watana Dam], FA-173 [Stephen lake Complex], FA-141 [Indian River], and FA-104 [Whiskers Slough]). Station RP-81 is located in the vicinity of the mouth of Montana Creek. This change will not adversely impact achieving Project objectives since the greater sample coverage per site offsets the reduction of one site.
- The FERC-approved Study Plan for the Biological Cues Study indicated Deshka River Chinook salmon and Yentna River sockeye salmon datasets would be examined for flow-dependent biological cues. Mainly due to the lack of the necessary data, the Deshka River and the Yentna River were not used for this study. As noted above (ISR Study 8.5, Part A, Section 4.5.1.1.14), through discussions with ADF&G, the Taku River and Stikine River Chinook salmon stocks were selected and the analysis completed.

As part of the April 1, 2013 FERC Study Plan Determination, FERC recommended that the following additional variables be compared to fish distribution and abundance: surface flow and groundwater exchange fluxes, dissolved oxygen (intergravel and surface water), macronutrients, temperature (intergravel and surface water), pH, dissolved organic carbon, alkalinity, and Chlorophyll-a. If strong relationships are evident between fish habitat use and any of these variables, FERC suggested that additional HSC preference curves may need to be developed for the various species and life stages. Most of the data necessary to complete this analysis was not available as of June 2014 (ISR Study 8.5, Part A, Section 4.5.2 and Part C, Section 7.5.1.2.1). Since then, a detailed evaluation of the comparison of fish abundance measures with specific microhabitat variable measurements was completed and presented in a Technical Memorandum (*Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables*) submitted to the Federal Energy Regulatory Commission (FERC) on September 17, 2014 and discussed at the October 17, 2014 ISR meetings (2014a). This delay did not impact achieving objectives of this study component,

## 4.6. Habitat-Specific Model Development

AEA implemented the methods related to habitat model development for both the MR and LR as described in the Study Plan. There were no variances pertaining to the MR, but a few variances occurred relative to the LR that are described in ISR Study 8.5, Part A, Section 4.6.2 and Part C, Section 7.6.1.2. The habitat-specific models represent the core analytical tools that will be used to first, determine the relationships between the amount of streamflow and the quantity and quality of physical habitats of fish at different locations in the Susitna River and during different times, and second, using those relationships in combination with outputs from other resource models evaluate the effects of different Project operations on those habitats.

Since the June 2014 ISR, work on this study component has included: 1) collection of field data to support 2-D hydraulic model development in FA-151 (Portage Creek); 2) collection and analysis of surficial substrate and cover data to support Fish Habitat Modeling at each of the eight MR Focus Area below Devils Canyon ; 3) completion of aerial spawning surveys in Focus Areas downstream of Devils Canyon; 4) continued development and refinement of the 2-D hydraulic models and the PHABSIM based Fish Habitat Modeling framework that will be applied to the ten Focus Areas within the MR; and 5) continued analysis and calibration of the 1-D HEC-RAS hydraulic models for application of the Fish Habitat Models for the Trapper and Birch creeks and 1-D transects in PRM95, PRM96, and PRM97 sites. Details of each of these activities are described below.

### 4.6.1. Collection of Field Data in FA-151 (Portage Creek)

Detailed surveys to collect bathymetric data and other physical and hydraulic data required for 2-D hydraulic model development were completed for the lower seven of the ten Focus Areas in 2013. While land access was not available for the three upper Focus Areas adjacent to CIRWG lands in 2013, this restriction was resolved in 2014 and AEA was able to complete detailed surveys in one of the three Focus Areas FA-151 (Portage Creek) by September 2014. However, surveys of FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) are still needed to complete this study component. As before, the collection of data at FA-151 (Portage Creek) was closely coordinated between and among the different resource leads to ensure that data necessary for developing the different resource models was being collected. The bathymetric surveys were completed on June 22, 2014 following the same general procedures described in ISR Study 8.5, Part A, Section 4.6.1.2.2. Two sets of 2-D model calibration transects were likewise measured in FA-151, the first on June 22 and the second on September 15, 2014 (Figure 4.6-1). Detailed methods used for collecting the field data for the calibration transects are provided in SIR Study 8.5, Appendix C.

### 4.6.2. Collection and Analysis of Surficial Substrate and Cover Data

Physical and hydraulic data (boundary conditions, stage and discharge measurements, bathymetric surveys, velocity mapping, roughness (channel substrate), and cover determinations were collected in 2013 at seven Focus Areas: FA-104 (Whiskers Slough), FA-113 (Oxbow 1), FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River), FA-144 (Slough 21) using methods described in ISR, Study 8.5, Part A, Section 4.6.2. Since the June 2014 ISR, AEA has completed the collection of substrate and cover data at FA-151

(Portage Creek) using the same general field methods as used for the first seven Focus Areas. The same substrate categories as used for the HSC data collection were applied during the substrate surveys with the substrate size (dominant, subdominant, and percent composition) within each Focus Area characterized in accordance with a Wentworth grain size scale. Categories of cover habitat were characterized as: boulders, aquatic vegetation, overhanging vegetation, undercut bank and woody debris. Cover features were identified during the 2013 and 2014 field surveys and mapped on enlarged, laminated aerial photographs as polygons. The substrate and cover data from all eight Focus Areas were analyzed and translated into Geographic Information System (GIS) layers for use in habitat modeling. Detailed descriptions of field data collection and analysis methods are provided in SIR Study 8.5, Appendix E.

### 4.6.3. Completion of Aerial Spawning Surveys

Aerial surveys to map areas of salmon redds and salmon spawning activity were conducted by helicopter on September 10 and September 26, 2014 within Focus Areas downstream of Devils Canyon (SIR Study 8.5, Appendix E). Surveys were performed during low flow conditions when salmon were actively spawning. The surveys were completed on each Focus Areas and covered the extent of all wetted main channel (i.e., main channel, side channel and tributary mouth) and off-channel (i.e., side slough and upland slough) habitat within each Focus Area. Susitna River discharge at the USGS Gold Creek Gage (USGS No. 15292000) was approximately 16,000 cfs for the September 10 flight and 13,500 cfs during the September 26 survey (USGS 2015). The 2014 survey results were digitized into GIS layers and comparisons made with survey results completed in the 1980s. Results of this mapping will be used in part to compare spawning area use between current and 1980s studies and as part of the habitat model validation process to compare model predictions of habitat with known areas of spawning use.

### 4.6.4. Refinement of 2-D Hydraulic and Fish Habitat Models – Middle River Segment

Since the June 2014 ISR, AEA has continued working on both the 2-D hydraulic models (SRH-2D and River2D) as well as the 2-D PHABSIM based Fish Habitat Models for the MR. Work completed on the 2-D hydraulic models is described in SIR Study 6.6 (Geomorphology) and Study 7.6 (Ice Processes).

Work completed on the Fish Habitat Models has focused on development of a unique grid system compatible with both SRH-2D and River2D outputs that will allow cell by cell hydraulic computations. In addition, the conceptual planning for the Visual Basic (VB) habitat time series model was completed. Since salmonids (salmon and trout) have discreet spawning locations and bury their eggs within the stream gravels, a cell by cell analysis is needed to determine successful spawning and emergence (effective spawning habitat). A conceptual outline of the steps needed for development of the VB time series model was developed and is undergoing additional review and modification. A cell by cell analysis is not needed for free swimming life stages since they are capable of movement from one location to another as flows change. The analysis for free swimming life stages will evaluate each Focus Area as a single unit based on the habitat flow relationship developed for the range of flows modeled at each Focus Area.

### 4.6.5. Continued analysis and calibration of 1-D Hydraulic Models – Lower River Segment

AEA has continued analysis of the 1-D transect hydraulic data sets collected in LR-1 in 2013 (Trapper Creek and Birch Creek, and mainstem sites PRM95, PRM96, and PRM97. Field data collection methods and initial analyses were presented in ISR Study 8.5, Part A, Appendix I (R2 2014c) and were presented during the Proof of Concept meetings held April 15-17, 2014 (ISR Study 8.5, Part C, Appendix N: *Middle River Fish Habitat and Riverine Modeling Proof of Concept* [R2 et al. 2014]). Data are being analyzed using the 1-D HEC-RAS hydraulic model (Version 4.1) to simulate water levels at the respective transect locations. Work has included preparation of model input data, calibration of hydraulic models using survey data and Version 2 of the OWFRM (ISR Study 8.5, Part C, Appendix K [R2 2014h]), preliminary model simulations and sensitivity analysis, and where possible, development of stage-discharge rating curves.

### 4.6.6. Variances from Study Plan

AEA implemented the methods as described in the Study Plan pertaining to MR Fish Habitat Modeling with no variances. As described in the Study Plan schedule of activities, most Fish Habitat Modeling activities will occur after the ISR. While land access was not available for the three upper Focus Areas adjacent to CIRWG lands in 2013, this restriction was resolved in 2014 and AEA was able to complete detailed surveys in one of the three Focus Areas (FA-151-Portage Creek) in September 2014. However, surveys of FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) are still needed to complete this study component. This delay is not considered a variance because this study was designed to collect data over multiple years.

AEA implemented the methods as described in the Study Plan pertaining to LR Fish Habitat Modeling with the exception of the variance explained below:

- The Study Plan (*Selection of Focus Areas and Study Sites in the Middle and Lower Susitna River for Instream Flow and Joint Resource Studies – 2013 and 2014*, submitted to the FERC March 1, 2013 [R2 2013]) indicated that 1-D PHABSIM sites in LR geomorphic reaches LR-1 and LR-2 would be surveyed in 2013. Sites in LR-1 (PRM97, PRM96, PRM95, Trapper Creek, Birch Creek), and Deshka River (PRM 44.9) were surveyed in 2013, but survey of sites in LR-2 between PRM 65 and PRM 70 (including Sheep Creek and Caswell Creek) was deferred to the next study year in order to evaluate the effectiveness of the model outputs and evaluate the need for additional sites (ISR Study 8.5, Part A, Section 4.6.2). Surveying of 1-D PHABSIM sites in LR-2 was not conducted in 2014; however, flow data were collected in Sheep and Caswell creeks and the Deshka River (Section 4.3) and HSC data were collected in LR-2 between PRM 65 to PRM 70. Surveying, hydraulic model calibration and habitat modeling of LR-2 sites is needed to complete this study component; this change in schedule will not have a substantive effect on meeting study objectives.

## 4.7. Temporal and Spatial Habitat Analyses

AEA implemented the methods as described in the Study Plan with the exception of the variance described in Section 4.7.3.

### 4.7.1. Temporal Analysis

AEA described the general approaches that will be used in completing the temporal habitat analysis in RSP Section 8.5.4.7.1.1, with further details provided in ISR Study 8.5, Part C, Section 7.7.1.1.1 and during the IFS TT Proof of Concept meeting on April 15-17, 2014. These include varial zone analysis, effective spawning/incubation habitat analysis, analysis of rearing habitats, breaching flow analysis, and analysis of other riverine processes (e.g., water quality, sediment deposition, ice) that may directly influence fish habitats. As noted in SIR Study 8.5, Section 4.6.4, modifications have been made to the 2-D Fish Habitat Model to allow for a cell by cell analysis of spawning and incubation habitats over time, which is needed to complete the effective spawning/incubation habitat analysis.

### 4.7.2. Spatial Analysis

How data and habitat-flow relationships developed from one location relate to other non-modeled locations is the focus of the spatial analysis. AEA presented and discussed four options (linear distance, microhabitat linear distance, macrohabitat area, and macrohabitat area weighted by fish use) for completing the spatial analysis during the IFS TT Proof of Concept meeting on April 15-17, 2014 and described these further in ISR Study 8.5, Part C, Section 7.7.1.1.2. Pros and cons of each of the options were presented, and although no singular approach was agreed to, there was general agreement that the approach involving weightings based on fish use was not appropriate since the HSC analysis was already addressing fish habitat preferences. Further evaluation of the different approaches will be completed.

### 4.7.3. Variances from Study Plan

AEA implemented the methods as described in the Study Plan, with the exception of the variance noted in ISR Study 8.5, Part A, Section 4.7.2 that pertained to the completion of a meeting specific to evaluating spatial and temporal methods. However, since then, AEA completed the Proof of Concept meeting in April 15-17, 2014 during which spatial and temporal analyses were explicitly discussed with further analyses presented in ISR Study 8.5, Part C, Section 7.7.1. As a result, there are no variances associated with this study component.

## 4.8. Instream Flow Study Integration

AEA implemented the methods as described in this section of the Study Plan with no variances.

### 4.8.1. Decision Support System

In the ISR (ISR Study 8.5, Part C, Section 7.8), AEA proposed five key evaluation metrics for anadromous fish habitat, and flow charts were presented detailing the process for developing those metrics. Further, AEA stated that consideration was being given to incorporating several key uncertainties associated with each riverine resource analysis. During both the April 15-17, 2014 Proof of Concept meeting, and the October 2014 ISR meetings, Licensing Participants expressed interest in the DSS process, and encouraged further development of the study integration components of the project sooner in the project timeline. The issue of addressing uncertainties associated with model outputs has been a continuing theme in the discussions with the agencies and was explicitly raised during the October ISR meetings. To further advance this analysis, AEA is currently developing an example to demonstrate how the issues of uncertainty can be addressed as part of the DSS process.

Specifically, an example of the estimation of several metrics in the decision support matrix with consideration of uncertainty in the HSC step is being developed. The example will be based on habitat results from limited example flow scenarios for FA-128 (Slough 8A) (e.g., as used in the Proof of Concept) and final draft coho salmon juvenile HSC curves. The example will use hydrology from the selected moderate flow year, 1985, for the open-water period only. Specific activities used in the development of the example include: 1) estimating flow at FA-128 (upstream and downstream ends) for the open-water period in 1985 under existing conditions and under a Project operational scenario; 2) estimating weighted usable area (WUA) for coho salmon juveniles during the 1985 open-water period, including standard errors for existing conditions and Project operational scenario flow estimates; 3) estimating expected values (mean results) for three WUA metrics based on these data; and 4) simulating other potential results based on the standard error in the HSC model estimates, and reviewing the potential impact of uncertainty on decisions based on the selected metrics.

### 4.8.2. Variances from Study Plan

AEA implemented the methods as described in this section of the Study Plan with no variances.

# 5. RESULTS

Field data that has been QA/QC'd, and used in developing: 1) ISR Study 8.5 Parts A and C; 2) Post-ISR TMs (*Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables* [R2 2014a]; *2013-2014 Instream Flow Winter Studies* [R2 2014b]) and 3) SIR Study 8.5 are available on the Geographic Information Network of Alaska (GINA) website at the links below.

- http://gis.suhydro.org/isr/08-Instream_Flow/8.5-Fish_and_Aquatics_Instream_Flow/
- http://gis.suhydro.org/Post_ISR/08-Instream_Flow/8.5-Fish_and_Aquatics_Instream_Flow/
- http://gis.suhydro.org/SIR/08-Instream_Flow/8.5-Fish_and_Aquatics_Instream_Flow/

See Table 5-1 for a listing of data files pertaining to this SIR on the GINA website.

## 5.1. IFS Analytical Framework

Since the June 2014 ISR, AEA continues to work within the construct of the IFS analytical framework described in ISR Study 8.5, Part A, Section 4.1. This has included the continued interaction with resource study leads and the development and refinement of the different resource models that will be used for evaluating Project effects. The IFS analytical framework will continue to serve as a means to demonstrate interrelationships between riverine habitats and associated resource studies and models that will be used to address specific questions.

## 5.2. River Stratification and Study Area Selection

AEA is following the stratification and study area selection process that was described in ISR Study 8.5, Part A, Section 4.2 and 5.2. This has included the selection of ten Focus Areas in the MR and two study areas in the LR in which to conduct detailed IFS studies. The results of the field verification habitat mapping analysis (SIR Study 9.9) completed for MR found only minor differences in the original macrohabitat calls and support the current selection of the Focus Areas as being representative of macrohabitats in other sections of river. Although the inclusion of a few additional habitat features may strengthen the IFS analysis, no modifications to existing Focus Areas or adding additional study areas were indicated. Therefore the study area selection process for the MR has been completed. Analysis of the instream flow data collected in the Geomorphic Reach LR-1 study sites is not complete, and field studies at the Geomorphic Reach LR-2 sites have not occurred. A determination for the need for additional sites in the LR will be made once all data have been collected and analyzed from LR-1 and LR-2.

## 5.3. Hydrologic Data Analysis

### 5.3.1. Mainstem Susitna River

Results from the stage and discharge surveys collected from 2012 to 2014 are summarized in Table 5.3-1 and locations are provided in Figure 5.3-1. The table indicates whether or not a bathymetry profile was collected, the date of the measurement, and the corresponding discharge and water surface elevation. Each discharge measurement has an associated rating of poor, fair, good, or excellent (see ISR Study 8.5, Part A, Appendix C [R2 2014g] and this SIR Study 8.5, Appendix B for more detail). Of the 224 discharge measurements, 2 were rated as poor, 13 as fair, 110 as good, and 99 as excellent.

Technical memoranda, dated December 2013 (ISR Study 8.5, Part A, Appendix C [R2 2014g]) and October 2015 (SIR Study 8.5, Appendix C) and prepared by Brailey Hydrologic, provide a more detailed description of the ADCP boat measurement data collection, and the QA/QC process that was applied to the data including the calculation of uncertainty. Detailed information on the mainstem transect bathymetry, WSE, and flow measurement data collected in 2012 and 2013 can be found in ISR Study 8.5, Part A, Section 4.3 and Section 5.3 and ISR Study 8.5, Part A, Appendix C. The 2014 mainstem transect data are described in the SIR Study 8.5, Appendix B and SIR Study 8.5, Appendix C.

Overall, field procedures and data processing in 2014 ensured the ADCP measurements collected met project data quality objectives. Although compass performance was compromised by hardware and software issues, these problems were avoided by relying on bottom-track positioning for all but one measurement. Moving bed bias was quantified using constant-heading loop tests, which eliminate the effect of variable heading (compass) errors. Bad bottom-tracking represents another concern, but results of 35 comparison measurements at USGS gages indicate that bad bottom-tracking had no discernible effect on measurement accuracy. Because only two of the comparison measurements had more than 15% bad bottom-tracking, additional uncertainty was added for measurements exceeding 15% bad bottom-tracking. Uncertainties computed from the variation between repeated transects were added to those resulting from bad bottom-tracking, short exposure durations, use of GPS positioning (1 measurement), instrument bias, and systematic errors. Following current USGS guidance, the resulting uncertainties were used to rate each measurement as Excellent, Good, Fair, or Poor. Despite challenging measurement conditions and the added uncertainties identified above, 86% of the measurements performed in 2014 were rated either Good or Excellent.

Flow measurements associated with the development of 2-D-hydraulic models were collected in seven Focus Areas within the MR in 2013 and are described in ISR Study 8.5, Part A, Appendix C (R2 2014g). Additional Focus Area measurements were collected in 2014 at FA-151 (Portage Creek) which are described in SIR Study 8.5, Appendix C. Similar procedures as those used in 2012 and 2013 were used for the 2014 2-D calibration transects at FA-151. A 2-D calibration transect was planned for the downstream end of FA-151, but could not be measured due to flow velocities over 15 ft/s and associated standing waves.

### 5.3.2. Tributaries to Susitna River

Site schematics are provided in this SIR Study 8.5, Appendix B, Attachment 1 for all continuous tributary gaging sites. These schematics include the location of the benchmarks, transect profile, staff gage, and water level recorder. Streamflow and staff gage measurements for the data collected in 2013 and 2014 are provided in SIR Study 8.5, Appendix B, Attachment 2. The rating curves used to produce the hourly hydrograph data are provided in SIR Study 8.5, Appendix B, Attachment 3. The hourly records for each of the continuous gaging sites are extensive and are provided on the GINA website (see Table 5-1 for data locations). Additional data collected at select tributary locations for the 2014-2015 period will be provided once they have been finalized.

### 5.3.3. Realtime Hydrologic Data and Network

A summary of the types of data collected at the 13 SW stations in the realtime hydrologic data network is provided in Table 4.4-2. This table includes the location of each station (PRM), the periods of monitoring various parameters (water level, water temperature, and air temperature), and whether camera images were collected. A map of these stations is provided in Figure 4.4-1. As noted in Section 4.3.3, five of the ESS stations were decommissioned in September 2015, and six maintained (Table 4.3-1).

### 5.3.4. Representative Years

Project effects will need to be evaluated over a range of climatic and hydrologic conditions which requires the selection of representative year types from the hydrologic record. The selection of representative years is described in the June 2014 ISR Study 8.5, Part C, Appendix J (R2 2014e). The years selected include 1981 (wet/warm), 1985 (average), and 1976 (dry/cold). The years selected were also discussed at the April 15-17, 2014 IFS TT Riverine Modeling Proof of Concept meeting (http://www.susitna-watanahydro.org/wp-content/uploads/2014/03/2014_04_15_TT_Riverine_RepresentativeYears.pdf).

### 5.3.5. Indicators of Hydrologic Alteration and Environmental Flow Components

As noted in SIR Study 8.5, Section 4.3, the candidate metrics and proposed IHA analysis were presented in the March 21, 2014 IFS TT Meeting (http://www.susitna-watanahydro.org/wp-content/uploads/2014/03/2014-03-21TT_IFS_Presentation-IHA.pdf) with details provided in the ISR Study 8.5, Part C, Section 7.3. The final metrics will be developed with input from the TWG and other resource disciplines after Version 3 of the OWFRM is available. A fully developed set of metrics will be available for use prior to the USR.

## 5.4. Reservoir Operations and Open-water Flow Routing Modeling

### 5.4.1. Reservoir Operations Model

Results of the MWH-ROM can be found in the Engineering Feasibility Report Section 12 (MWH 2014). The Engineering Feasibility Report provides average monthly total release to the Susitna River at Watana Dam for the 61-years. Operational conditions have changed since the release of the June 2014 ISR. AEA has modified the maximum load following operations model (Operating Scenario [OS]-1b) to reduce powerhouse discharge variability through assigning peak mode operation to other existing hydropower plants on the Railbelt grid (Integrated Load Following [ILF]-1). Additional detail on the project operations is provided in the Engineering Feasibility Report Section 12.1.4. Other ILF operations may be evaluated during the impact assessment. The MWH-ROM output serves as input into the OWFRM that can be used to predict stage and flow conditions resulting from a given powerhouse discharge at locations downstream. Project simulations for ILF-1 runs using the most recent Version 2.8 OWFRM are being conducted and will include ILF-1 project operations for two of the representative years.

### 5.4.2. Open-water Flow Routing Model

This section provides the results of the field data collection in 2014 and the calibration and steps used for Version 2.8 of the OWFRM. A complete description of the development of Version 2.8 of the model is provided in SIR Study 8.5, Appendix B.

#### *5.4.2.1. Field Data Collection*

Version 2.8 of the OWFRM relied on field data that were collected between 2012 and 2014. These data included:

- Cross-sections of the Susitna River surveyed between PRM 29.9 and PRM 187.2.
- Flow measurements and concurrent WSE surveys at the river cross-sections as described in ISR Study 8.5, Part A, Section 4.4; ISR Study 8.5, Part A, Appendix A [R2 2014d] and C [R2 2014g]; and SIR Study 8.5, Appendix B and C.
- Stage hydrographs measured at gaging stations established on the Susitna River.

Data collection methods are described in ISR Study 8.5, Part A, Section 4.3: Hydrologic Data Analysis and SIR Study 8.5, Section 4.3: Hydrologic Data Analysis. A summary of the cross-sectional profile data collected between 2012 and 2014 is provided in Table 5.3-1. This table summarizes the cross-section location, date of data collection, and the associated water surface elevations or discharge measurements. The locations of the cross-sections are shown in Figure 5.3-1.

### *5.4.2.2. Model Development and Calibration*

Version 2.8 of the OWFRM was developed from the 216 cross-sections surveyed between 2012 and 2014. For safety reasons, no mainstem transect data were collected in the Devils Canyon reach. Instead, cross-sectional profiles were estimated using the LiDAR topography data and a rectangular conveyance channel (ISR Study 8.5, Part C, Appendix K [R2 2014h]). For numerical stability under unsteady conditions, additional river cross-sections were included approximately 1000 feet downstream of measured cross-sections. A longitudinal thalweg profile of the Susitna River was then developed from the 216 cross-sections (Figure 5.4-1). The channel gradient was steepest through Devils Canyon (0.57 percent) with a gradual reduction in channel gradient downstream.

#### *5.4.2.2.1. Steady State Model*

The OWFRM was first calibrated under steady-state conditions using over 500 pairs of flow/water surface elevation measurements obtained at the 216 cross-sections in 2012, 2013, and 2014. The relative magnitude of these flow measurements was assessed by using the concurrent flows in the Susitna River at Gold Creek (USGS No. 15292000) and Susitna River at Sunshine (USGS No. 15292780) as a common reference point (Figure 5.4-2 and Figure 5.4-3). Transects upstream of PRM 102.5 were assessed using the Susitna River at Gold Creek gage as shown in Figure 5.4-2 while transects downstream of PRM 102.5 were assessed using the Susitna River at Sunshine gage as shown in Figure 5.4-3. Similar to the previous work, flows at transects compared to the Susitna River at Gold Creek were considered high if the flow was greater than 24,000 cfs, medium if they were between 17,700 cfs and 24,000 cfs, and low if they were less than 17,700 cfs. Flows at transects compared to the Susitna River at Sunshine Gage were considered high if the flow was greater than 60,600 cfs, medium if they were between 45,500 cfs and 60,600 cfs, and low if they were less than 45,500 cfs.

Calibration procedures generally followed those applied to previous versions of the model with a few exceptions. No changes were made to the downstream boundary condition or the cross-sections or calibration in the Devils Canyon reach. Interpolated cross-sections were not included every 1000 feet, but were instead only included downstream of measured cross-sections. To make the model more representative of varying channel and vegetation types, changes were made to the Manning's *n*'s. Multiple Manning's *n*'s were used both within the main channel and within the overbank. As a result, many channels had six different manning's *n*'s. In some cases (for less than half of the transects) it was necessary to vary Manning's *n* by flow magnitude. However, the magnitude of Manning's *n*'s did not vary significantly from those presented in ISR Study 8.5 for Version 2 of the OWFRM (ISR Study 8.5, Part C, Appendix K [R2 2014h]).

The goal was for calibration to simulate water surface elevations to within plus or minus 0.2 feet of the observed water surface elevation for the transects upstream of the Three Rivers Confluence and 0.25 feet of the observed water surface elevation for the transects downstream of the confluence. Almost all of the calculated water surface elevations fell within this range. The model was calibrated by selecting a reasonable Manning's "n" based on records of field observations and photographs, and by adjusting the shape of the interpolated cross-section located downstream from each surveyed cross-section. A summary of the Manning's "n" coefficients that were used for model calibration is presented in Figure 5.4-4. The Manning's "n" coefficients ranged from 0.03 to 0.04.

*5.4.2.2.2. Unsteady State Model.*

Version 2.8 of the model was calibrated under unsteady-state conditions using the data available between 2012 and 2014. Accretion estimates were included in the model using either a tributary point source or uniform lateral inflow as described in ISR Study 8.5, Part C, Appendix K, Section 5.4.2.2: Unsteady-State Model Calibration (R2 2014h). Accretion estimates are calculated using measured USGS gage data and calculated travel times between gages. Travel times were calculated by observing peak flow arrival times and were estimated as 6.91 miles per hour between the Dam Site and the Susitna River at Gold Creek gage, 3.86 miles per hour between the Gold Creek and Sunshine gages, and 2.21 miles per hour between the Sunshine and Susitna Station gages. Accretion estimates were then distributed to discrete subbasins using a percentage distribution. The basin distribution percentage was based on drainage area and modified to reflect measured tributary gage data available. Specific accretion calculations and tributary hydrology is described in SIR Study 8.5, Appendix B, Section 6.5. In some cases the USGS gage data have conflicting measurements and mass balance cannot be maintained between the Gold Creek Gage, Chulitna Gage, Talkeetna Gage, and Sunshine Gage. In these cases, the priority is given to the Gold Creek, Chulitna, and Talkeetna gages.

Unsteady model calibration results comparing measured and simulated hydrographs for the July 28 – August 4 2013 period and the entire 2013 open-water period in the Susitna River at Gold Creek (USGS No. 15292000) are shown in Figures 5.4-5 and 5.4-6, respectively. These figures show good agreement between the hourly measured USGS streamflow and the simulated hourly streamflow. The comparison of the measured and simulated streamflow at the Susitna River at Sunshine (USGS No. 15292780) is shown in Figures 5.4-7 and 5.4-8, respectively. These figures show similar magnitudes and shape of the hydrographs, but in some periods, there are distinct differences between the measured and simulated hydrographs. The previous two versions of the model and hydrology placed a higher priority on the Susitna River at Sunshine gage and used adjusted values for the Talkeetna and Chulitna River values. In discussion with other riverine modelers (e.g., Study 6.6 [Fluvial Geomorphology Modeling] Study 7.6 [Ice Processes]), a higher priority is placed on the Talkeetna and Chulitna River gages due to the robustness of data at those gage sites. As a result the model does not always closely match flows at the Susitna River at Sunshine gage. This approach was a conscious decision among the multiple study groups to work within the constraints of the data available while also meeting the needs of each individual study's goals.

Version 2 of the OWFRM is documented in the ISR Section 8.5, Part C, Appendix K (R2 2014h). This version of the model was used to simulate the reach from the Sunshine gage to the Susitna Station gage. A new tributary hydrology for this reach has been updated and is provided in SIR Section 8.5, Appendix B, Section 6.5.3. The new tributary hydrology was used to re-run the Version 2 model for the 2013 calibration period. The results from this simulation for the Susitna River at Susitna Station for the July 28 – August 4, 2013 period and the entire 2013 open-water period are shown in Figures 5.4-9 and 5.4-10, respectively.

#### *5.4.2.3. Model Validation*

The OWFRM was calibrated under both steady and unsteady state conditions using data collected in 2013. It will be subsequently validated during development of Version 3 of the OWFRM using data from ESS stations.

#### *5.4.2.4. Model Runs*

Potential downstream changes in flow and water surface elevations will be assessed by comparing pre-Project conditions with an ILF-1 operation condition. AEA has modified the Operating Scenario (OS) 1-b to reduce powerhouse discharge variability through assigning peak mode operation to other existing hydropower plants on the Railbelt grid. Other intermediate load following operations may be evaluated during impact assessment. Simulation runs of two representative years are being conducted using the ILF-1 operation condition.

## 5.5. Habitat Suitability Criteria Development

### 5.5.1. Select Priority Fish Species

A priority ranking of the 19 fish species to be considered for site-specific HSC was developed in collaboration with TWG during Q2 2013 (Table 5.5-1). Five of the original 19 species (lake trout *[Salvelinus namaycush]*, northern pike *[Esox lucius]*, sculpin, Arctic lamprey *[Lethenteron japonicum]*, and threespine stickleback *[Gasterosteus aculeatus]*) were considered a low priority for development of site-specific HSC due to low numbers within the study area or that their habitat needs were similar to other species.

The priority list was further refined during a March 21, 2014 TT meeting during which the remaining species were once again ranked using results of the 2013 HSC surveys, management status, and perceived sensitivity to changes in habitat due to potential Project operations (Table 5.5-2).

### 5.5.2. Development of Draft Final HSC/HSI

Draft final HSC/HSI have been developed using site-specific habitat use and availability data collected over two sampling years in the LR and MR segment of the Susitna River. A detailed description of the results of the 2013-2014 HSC/HSI sampling is presented in SIR Study 8.5, Appendix D. A summary description of the HSC/HSI sample area, collection of summer and winter habitat use data, and resulting habitat frequencies histograms is presented below.

#### *5.5.2.1. HSC/HSI Sample Area Selection*

During the 2014 HSC sampling effort, 72 additional sites were selected and sampled. For the combined 2013-2014 HSC sampling, a total of 129 sites were sampled (including both 50- and 100-meter sampling sites [164 and 328 feet, respectively]) for collection of site-specific data to define microhabitat use and availability by spawning and freshwater 'rearing' (juvenile resident or anadromous fish) or adult (resident fish) life stages. Both microhabitat utilization and availability data were collected during each sampling event. Microhabitat availability data was combined with habitat utilization data for developing species and life stage habitat preference.

Collection of habitat availability data allows modeling of fish presence/absence as a function of single or multiple parameters (e.g., water depth, velocity, cover, water quality, temperature, and GW upwelling) using availability measurements at locations where fish were not observed, and utilization measurements as locations where fish were observed (Manly et al. 1993).

#### *5.5.2.2.* Collect Site-Specific Habitat Use Information

Both summer (May-September) and winter (October-April) HSC data were collected to determine if significant differences in seasonal microhabitat use were evident. Summer 2014 field data collection was expanded to include all ten MR Focus Areas and two LR tributary complexes. Summertime data collection occurred during eight separate surveys from mid-May through late-September at 129 sample sites. Many of the sites were sampled more than once resulting in 267 unique sampling events. A total of 2,799 microhabitat use measurements were collected for 12 different species of fish from within ten different macrohabitat types. Sampling in the LR, and the three upstream most Focus Areas (FA-151 [Portage Creek], FA-173 [Stephan Lake Complex], FA-184 [Watana Dam]) that were unsampled in 2013, accounted for just over 19 percent of the total number of summer observations.

#### *5.5.2.3.* Summer Surveys

Summertime HSC data collection was completed during eight separate sampling sessions from June through September 2013 and May through September 2014 (Table 5.5-3). Habitat measurements were collected for four life history stages (spawning, juvenile, fry, and adult) and twelve fish species: Chinook, sockeye, chum, coho, and pink *(O. gorbuscha)* salmon; rainbow trout *(O. mykiss)*; Arctic grayling; Arctic lamprey; Dolly Varden *(S. malma)* char; whitefish (round and humpback); longnose sucker; and burbot *(Lota lota)*.

Combined 2013 (n=57) and 2014 (n=72) sampling included 129 individual habitat segments representing ten different habitat types (Table 5.5-3). Each of the selected habitat segments was sampled a minimum of once and in many cases twice, resulting in a total of 267 unique sampling events. A total of 2,799 observations of site-specific habitat use were used in development of the HSC models. A summary of the 2013-2014 HSC observations is presented by species and life stage in Table 5.5-4. Of the 2,799 utilization observations collected, approximately 80 percent were from MR Focus Areas (Table 5.5-4). Chum, sockeye, pink, and coho salmon were the only species observed spawning during the 2013-2014 surveys. Nearly half (44.7%) of all spawning observations were in side slough macrohabitat types with the next highest percentage (35.6%) of spawning observed in side channel habitat (Table 5.5-4).

#### *5.5.2.4. Winter Surveys*

Winter 2012-2013 HSC sampling was conducted in open-water areas of FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Winter 2013-2014 HSC sampling was expanded to open-water areas within FA-104 (Whiskers Slough), FA-128 (Slough 8A) and FA-138 (Gold Creek) (Figures 4.5-1 through 4.5-3) (R2 2014k; R2 2014b); with one additional opportunistic sampling event conducted in FA-141 (Indian River). Selection of winter sampling sites was non-random and relied on fish utilization information obtained during summer surveys, the availability of open-water areas, and safety concerns. Using these criteria, 8 open-water sites were selected for sampling during 2012-2013 and expanded to 18 sites for the 2013-2014 sampling. One additional site was located in FA-141 (Indian River), but was only sampled once during the winter sampling. Like the summer sampling, many of the winter sites were visited multiple times throughout the winter resulting in 45 unique sampling events.

A total of 59 electrofishing surveys were conducted during the winter HSC data collection efforts in FA-104 (Whiskers Slough), FA-128 (Slough 8A), FA-138 (Gold Creek), and FA-141 (Indian River). Over both winter survey years, a total of 291 site-specific HSC observations were recorded for eight fish species (Chinook, sockeye, chum and coho salmon, rainbow trout, Arctic grayling, longnose sucker, and Arctic lamprey) (Table 5.5-5). Most HSC observations were of fry and juvenile salmonids (coho salmon (126 observations), sockeye salmon (68 observations), and chum salmon (42 observations). The distribution of winter observations within FA-104 (Whiskers Slough), FA-128 (Slough 8A), and FA-138 (Gold Creek) was nearly equal with 38.5 percent, 26.1 percent, and 34.0 percent of the total respectively. A detailed description of results of the 2012-2014 winter studies surveys is provided in the SIR Study 8.5, Appendix A.

### 5.5.3. Habitat Utilization Data and Frequency Histograms

Summer and winter habitat utilization data were used to develop frequency histograms to compare habitat utilization (velocity, depth, and substrate type) between the LR and MR segments, seasonal habitat use within the MR, and HSC developed during the 1980s studies. A detailed comparison of the similarities and difference in habitat use between river segments, seasonal use, and the finding of the 1980s HSC studies is presented in SIR Study 8.5, Appendix D, Attachments 1, 2, and 3.

A summary of the major findings by river segment, season and comparison with the 1980s HSC are presented below.

#### *5.5.3.1. River Segment Comparison*

Although there were some minor differences in the depth and velocity of water utilized by fish in the LR and MRs, a visual assessment of the range of microhabitat use by high priority species and life stages common to both the LR and MRs of the Susitna River suggested little difference in microhabitat utilization between the two segments. Of the 12 high priority species/life stages, Chinook fry and juvenile, coho fry and juvenile, longnose sucker juvenile, and whitefish fry were observed during HSC surveys of both the LR and MRs of the Susitna River (Table 5.5-4).

#### *5.5.3.2.* Seasonal Comparison

A comparison of summer and winter microhabitat use observations was completed to determine if differences in microhabitat (water depth and velocity) selection between seasons justifies development of separate (summer and winter) HSC models. Only Chinook fry and juvenile, coho fry and juvenile, chum fry, and sockeye fry and juvenile had enough observations between the seasons to draw any conclusions regarding differences in habitat. It was assumed that sockeye and chum salmon fry migrate out of the Susitna River shortly after breakup and so comparisons of microhabitat use or selection between summer and winter seasons may not be appropriate.

When compared to summer habitat use, the maximum velocity and depth use during the winter was 1-3 times lower for overwintering Chinook and coho salmon. The use of lower velocity areas during the winter is not surprising given that nearly all fish species exhibit physiological and/or behavioral responses to the seasonal change in habitat from summer to winter, such as movement to off-channel and low velocity habitat. The dramatic shift in use of lower velocity areas by fry and juvenile Chinook and coho, during the winter, appears to justify an adjustment of the velocity preference model between seasons.

#### *5.5.3.3. 1980s and 2013-2014 Comparison*

A comparison of HSC curves developed from the 1980s studies and habitat use data collected as part of the 2013-2014 data collection effort was completed for a select number of species and life stages including Chinook and coho salmon juvenile, pink salmon spawning, Arctic grayling adult, rainbow trout adult, and whitefish adult (SIR Study 8.5, Appendix D, Attachment 3). Pink salmon spawning and whitefish adult were the only two species/life stages with a sufficient number of 2013-2014 site-specific observation (>30) to provide a meaningful comparison to the 1980s HSC. A visual comparison of the 2013-2014 pink salmon spawning data (n=53) and the 1980s HSC suggests strong similarity in habitat utilization. Due to the limited number of site-specific observations collected for whitefish adult during the 2013-2014 sampling (n=38), it is difficult to draw any conclusions when compared to the 1980s HSC. Additionally, differences in data collection methods between the 1980s and 2013-2014 surveys make comparison of results problematic.

### 5.5.4. HSC/HSI Modeling

Draft final multivariate HSC models have been developed for the 12 high priority species and life stages proposed for application in the habitat-flow analysis for evaluating Project operational effects. Both univariate and multivariate modeling results were produced for each of the 12 species and life stages (Chinook salmon fry and juvenile, chum salmon spawning, coho salmon fry and juvenile, sockeye salmon spawning, Arctic grayling fry and juvenile, whitefish fry and juvenile, and longnose sucker juvenile and adult). The status of HSC/HSI development for all priority species and life stages in presented in Table 5.5-6.

For the HSC/HSI modeling, a multiple regression approach was used to combine all significant predictors (identified during univariate modeling) into a combined index of preference or suitability. Interactions among variables (e.g., the impact of velocity depends on substrate type) may be important, and were examined using multiple regression. Multiple regression candidate models included all combinations of main effects for which univariate models were found to be predictive. The multivariate models were compared using the Akaike's Information Criteria (AIC) criterion, and models within AIC of 2.0 of the best-fit model (Burnham and Anderson 2002) were considered potential final models.

Some of the more significant model assumptions, data considerations, and variable thresholds include:

- Priority ranking for development of HSC models was given to those species and life stages that are assumed to select and utilize specific microhabitat areas for rearing or spawning purposes.
- Only those data (utilization and availability) collected concurrently were used as part of the model development.
- Possible random effect in fish use among sites was considered.
- Only those sampling events that included fish observations were used for developing the multivariate HSC curves for each species and life stage.
- Macrohabitat type has not been included in HSC modeling.
- Substrate and cover types have been simplified into groups of similar classes to test the best fit of the HSC model.
- Threshold values have been proposed for many of the variables to set minimum and/or maximum ranges within the HSC models (Table 5.5-7).
- Although the presence of GW upwelling was considered critical to defining spawning suitability in the 1980s studies, statistical analysis of the 2013-2014 data currently does not support that conclusion.
- Limits within the sampling methods (high water velocity), sometimes restricted the areas that could be safely sampled to determine the outmost extent of fish utilization.

A detailed description of the HSC/HSI modeling, terms, and data considerations specific to model results for each of the 12 species and life stages are presented in SIR Study 8.5, Appendix D. As an example, the results of the HSC/HSI modeling for two species and life stages (chum salmon spawning and coho fry) are presented here.

#### *5.5.4.1. 2013-2014 HSC Model for Chum Salmon Spawning*

##### *5.5.4.1.1. Univariate Analysis*

Utilization of available substrate and upwelling locations by chum salmon spawning is summarized in Table 5.5-8. Model AIC results comparing fixed and random effects models and models with interaction between spawning site type and predictors are displayed in Table 5.5-9. Random effects models fit better in all cases. There were some differences between random and select spawning sites in the preference for depth. Spawning at the select sites was not obviously selective for depth, whereas there was more spawning at deeper locations for the random sites. Therefore, the inclusion of select sites in the model may cause an overestimate of preference for shallow sites.

The models showing the best predicted univariate relationships for each predictor are compared using AIC in Table 5.5-10. For depth, the linear model (increasing) had the lowest AIC, but the quadratic model had similar AIC and has a better ecological interpretation, with the beginning of a decline in preference near 3 feet deep. For DO, the linear model had similar AIC to the null model, but the linear relationship was decreasing, indicating a reduction in preference for higher DO levels (Figure 5.5-1). The predictors tested in the multivariate model below are depth (quadratic), velocity (quadratic), water temperature (linear), upwelling (2-level factor) and substrate (3-level factor).

##### *5.5.4.1.2. Multivariate Analysis*

Based on the univariate model results, depth, velocity, substrate, upwelling, and water temperature were included in the multivariate modeling. Using all of these variables, the highest adjusted Variance Inflation Factor (VIF) is 1.40, indicating that confidence intervals around predicted coefficients may be 18 percent wider than they would be with uncorrelated predictors. This VIF (1.4) was well below the threshold of 10 typically used to indicate a concern for multicollinearity.

Including upwelling and substrate as separate factors in the model is not possible because of the low sample sizes retained in 8 different groups (e.g., six downwelling sites with all-gravel substrate). Thus, the full model was first tested with three options, 1) upwelling only, 2) substrate only, or 3) a combined upwelling substrate group, consisting of all downwelling sites as one level of the factor, then the four substrate groups with upwelling as four additional levels. When these three options were compared, the AICc (AIC corrected for sample size) values were 1) 1000.6; 2) 969.4; and 3) 971.3. Thus, the categorical substrate factor was the best predictor of chum spawning preference and therefore, upwelling was not included in further multivariate comparisons.

The multivariate AIC results are compared in Table 5.5-11. The best fit main effects model includes substrate, linear effects for depth and temperature, and quadratic effects for velocity. All two-way interaction terms were tested with the best-fit main effects model and with the model including a quadratic effect rather than a linear effect for depth. The interaction between velocity and temperature improved the fit for both of these models, and no other interaction did. This interaction allows for a different velocity preference depending on SW temperature, and is included in the HSC model. The second best-fit model, with AIC 1.2 greater than the best fit model is proposed for the HSC because it is within 2.0 of the top model, and the relationship with depth is more ecologically reasonable. This model matches expected and common relationships between depth and velocity and selection of spawning sites for chum salmon.

The draft Final HSC multivariate model for chum salmon spawning is:

$$\log\left(\frac{p}{1-p}\right) = C_k + 0.999depth - 0.155depth^2 + 0.408vel - 1.23vel^2$$

$$-0.225temp + 0.247(vel * temp) + \gamma_{site} + \varepsilon,$$

where:

$p$ is the probability of chum salmon spawning,

$k$ indexes eight intercept values for substrate/upwelling combinations:

$C_1 = 0.811$ (all gravel substrate)

$C_2 = 0.382$ (gravel dominant mixed substrate)

$C_3 = -0.131$ (gravel subdominant mixed substrate)

$C_4 = -0.999$ (no gravel, but cobble dominant),

$\gamma_{site}$ is the random effect for site, and

$\varepsilon$ is random error (assumed normally distributed).

The random site effect and the random error term are included in the above displayed model to highlight the intention of the model, which is to discriminate among habitats based on physical features. The non-modeled differences among sites are included in the random site effect, and all other sources of variance are included in the random error term. It is important to note that this model is not intended to be predictive of the level of spawning that will occur in a particular location.

The above model applies only to sites with dominant or subdominant gravel or dominant cobble substrates, and with depths of at least 0.30 feet; other sites are assigned a suitability of zero. This model also applies only to the ranges of all variables that were observed during HSC sampling. Locations on the river with habitat values outside of the observed ranges are assigned a suitability based on threshold values (Table 5.5-7). HSC for temperatures, depths and velocities outside of these observed ranges but within the allowed ranges displayed in Table 5.5-7 are set on a linear trajectory from the last modeled point to the zero suitability endpoint, as displayed in Figures 5.5-2, 5.5-3, and 5.5-4.

### *5.5.4.2. 2013-2014 HSC Model for Coho Salmon Fry*

#### *5.5.4.2.1. Univariate Analysis*

The utilization of cover by coho salmon fry, including turbidity as a cover type and a potential interacting factor, is summarized in Table 5.5-12. Because there are often multiple cover types at the same location, individual cover types cannot be assessed in a single model. Instead, the forms of cover showing increased utilization were combined into one factor – cover or no cover. Although the preference is not increased for boulder cover overall, it is increased in non-turbid water, so boulder is retained as a cover type. There is some apparent interaction with turbidity – cover is utilized mainly in non-turbid water.

The univariate regression models are displayed with AIC results in Table 5.5-13. The random effects model improves the fit for all univariate models, and is used for the HSC analyses in this Section. Cover interacting with turbidity, depth (quadratic), and velocity (linear) were selected for inclusion in the multivariate analysis based on the model results. A decreasing relationship between DO and preference improves predictions, but it is not an ecologically reasonable relationship and is therefore not included in multivariate analysis (Figure 5.5-5).

#### *5.5.4.2.2. Multivariate Analysis*

Based on the univariate model results, depth, velocity, and presence/absence of cover interacting with turbidity were included in multivariate modeling. The interaction factor is included by creating a three-level factor with levels of "turbid" for locations with Nephelometric Turbidity Units (NTU)>30, and locations with cover vs. no cover split for non-turbid sites. Using all of these variables, there was no evidence that multicollinearity was an issue of concern based on variance inflation factors. The square root of the highest VIF was 1.01, indicating that confidence intervals around predicted coefficients may be 1 percent inflated.

The best-fit model included the cover/turbidity factor, a quadratic relationship with depth, and a linear decreasing relationship with velocity (Table 5.5-14). Two interactions reduced the AIC, depth:velocity and depth:cover/turbidity. The depth:velocity interaction is related to a higher preference for deep, fast water than the main effects model captures. This relationship is based on a relatively low number of observations in deep, fast water, and may be due to fry captured during migration rather than rearing. This interaction is not included in the final draft model. The interaction between cover/turbidity and depth is included, however, as the data suggest a preference for a more shallow depth when there is no cover or when the water is turbid.

The draft final model for coho salmon fry is presented below in three equations, one for each cover/turbidity group:

<u>With Cover and NTU ≤ 30</u>:

$$\log\left(\frac{p}{1-p}\right) = -1.91 + 2.51 * depth - 0.744 * depth^2 - 1.08 * vel + \gamma_{site} + \varepsilon,$$

<u>With No Cover and NTU ≤ 30</u>:

$$\log\left(\frac{p}{1-p}\right) = -1.97 + 1.34 * depth - 0.744 * depth^2 - 1.08 * vel + \gamma_{site} + \varepsilon,$$

<u>With NTU > 30</u>:

$$\log\left(\frac{p}{1-p}\right) = -3.33 + 2.46 * depth - 0.744 * depth^2 - 1.08 * vel + \gamma_{site} + \varepsilon,$$

where:

$p$ is the probability of coho salmon fry presence,

$\gamma_{site}$ is the random effect for site, and

and $\varepsilon$ is random error (assumed normally distributed).

The random site effect and the random error term are included in the above displayed model to highlight the intention of the model, which is to discriminate among habitats based on physical features. The non-modeled differences among sites are included in the random site effect, and all other sources of variance are included in the random error term. It is important to note that this model is not intended to be predictive of the number of fish that will occur in a particular location.

The draft final HSC model for coho salmon fry is displayed as a function of depth and velocity in Figure 5.5-6 and Figure 5.5-7, respectively.

The same general model development process was followed for all species and life stages for which sufficient observations for model development have been attained. For those species and life stages with insufficient numbers of site-specific observations, additional data collection efforts may be warranted or alternative methods for HSC development will need to be developed.

### 5.5.5. Other Methods for HSC/HSI Curve Development

For moderate and low priority species and life stages with an insufficient number of observations for development of site-specific HSC models, alternative HSC development method(s) will need to be used. Alternative methods were described in the FERC-approved Study Plan for developing HSC including site specific curves. Alternative curve development methods are being evaluated for all species lacking the requisite numbers of site specific measurements.

### 5.5.6. Winter Habitat Use Sampling

The sections below summarize the overall results and findings of the 2012-2013 and 2013-2014 winter studies, in terms of water surface elevations, measurements of water quality, and fish observations. These topics are described in greater detail in SIR Study 8.5, Appendix A and were previously summarized in ISR Study 8.5, Part C, Appendix L (R2 2014k) and in a September 2014 TM (R2 2014b). Water level and water temperature data were retrieved from IFS instruments during September 2014, but this information was collected too late to be included in the September 2014 TM. Therefore, the time series plots originally contained within that TM have been revised to include the September 2014 data and are now presented in this report (SIR Study 8.5, Appendix A). Continuous data collected during the 2014-2015 winter period were downloaded during September 2015 and additional time is needed to complete analysis of these data. Data associated with IFS winter studies have been compiled and were delivered as a comprehensive set (SIR Study 8.5, Table 5-1). Data associated with IFS winter fish captures have been consolidated within the HSC database and are discussed in SIR Study 8.5, Appendix D, while FDAML (Study 9.6) winter fish results are summarized in SIR Study 9.6.

#### *5.5.6.1. Water Surface Elevations*

Water levels at main channel and various other continuous monitoring sites within FA-104 (Whiskers Slough), FA-128 (Slough 8A) and FA-138 (Gold Creek) varied widely over the 2012-2013 and 2013-2014 winter periods in response to ice formation and staging (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b). In general, water levels declined during late September and October 2013 and several monitoring locations likely became dewatered prior to main channel staging in November and early December. Water levels at many sites increased markedly in response to main channel staging and/or ice jamming events. An ice jam downstream of FA-104 (Whiskers Slough) in November 2013 caused many habitats to become inundated by backwatered main channel flow, while a main channel ice jam near FA-128 (Slough 8A) was likely the cause for a side channel to become breached by main channel flow in January 2014. During the ice-covered period (i.e., January – April 2014), most habitats experienced minor stage fluctuations. Though nearly all areas were either breached or backwatered by main channel streamflow during staging and/or ice breakup, the magnitude and duration of the stage response to these events was less in side slough, upland slough and tributary habitats relative to side channel sites. In addition, these areas were generally less susceptible to dewatering during winter than side channel areas, though this appeared to be dependent upon site-specific conditions (e.g., GW upwelling) (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b).

#### *5.5.6.2. Water Quality*

Water temperatures at each main channel monitoring site were approximately 6-8°C at the time of deployment in September 2013 and decreased during the fall to nearly 0°C at the time of ice freeze-up in November and December 2013 (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b). Main channel surface and intergravel temperatures were nearly 0°C during ice covered periods (e.g., January/February – April) in each season of study. In general, tributary monitoring sites most closely resembled the main channel temperature regime during winter as temperatures at each of these sites ranged between 0 to 1°C for ice-covered periods. Various side channel habitats were breached or backwatered by main channel flow in association with freeze-up and ice jamming. Although surface and intergravel temperatures in side channels were typically below 1°C during breaching or backwater episodes, intergravel temperatures at some sites were nearly 4°C following such events. Side slough and upland slough habitats were generally characterized by consistently warmer surface and intergravel temperatures (2–4°C) compared to other macrohabitat types.

Continuous intergravel DO data recorded at two sites for two seasons in FA-128 (Slough 8A) were similar. Median DO concentration was 5.21 milligrams per liter (mg/L) at 128-SL8A-15 during March-April 2013 and 5.88 mg/L at 128-SL8A-40 during September 2013-March 2014 (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b). With the exception of two periods, one in November 2013 and one in February 2014, DO concentrations were generally stable during each monitoring period and ranged from approximately 4.0 mg/L to 6.5 mg/L. During November 2013, concentrations were between 9–11 mg/L and approximately 7 mg/L during one week in February 2014. While it is not known whether Slough 8A was breached during November 2013, the elevated intergravel DO levels during February 2014 were coincident with an observed breach event within Slough 8A by main channel streamflow. Intergravel DO at FA-138 (Gold Creek) Site 138-SL11-04 fluctuated between 7–10 mg/L during the September 2013 through April 2014 monitoring period with some temporary excursions to values less than 4 mg/L. The median DO concentration was 10.33 mg/L during the measurement period.

Instantaneous measurements of SW temperature recorded during September 2014 indicated cooler water in side slough and upland slough habitats relative to the Susitna River main channel and side channel areas. Following freeze-up, the inverse of this relationship was observed with slough habitats typically warmer than main channel and side channel areas (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b). Although specific conductance values generally differed between main channel and off-channel habitats during winter, the degree and manner in which values differed was not consistent. In FA-104 (Whiskers Slough) and FA-128 (Slough 8A), specific conductance measured during February and March 2014 in main channel and side channel sites tended to be higher than off-channel and tributary areas, while conductance measured in FA-138 (Gold Creek) side sloughs was often equivalent to or higher than main channel sites (R2 2014b).

The majority of the main channel and side channel habitats were completely ice-covered during the studies, although open-water leads were present in certain locations (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b). The open leads in main channel areas were likely related to high SW turbulence or velocity, while open-water in side channel, side slough and upland sloughs were likely linked to warmer water temperatures as influenced by GW. During February and March 2014, ice thickness measurements at instantaneous water quality sites was generally greater than 3 feet in the main channel, and ranged from 0–2 feet at side channel sites, 0–1 foot in side sloughs, 0–2 feet at upland sloughs, and 0–1.5 feet in tributaries (SIR Study 8.5, Appendix A; R2 2014b).

#### *5.5.6.1. Fish Observations*

A total of 59 electrofishing surveys were conducted during the 2012-2013 and 2013-2014 winter data collection efforts in FA-104 (Whiskers Slough), FA-128 (Slough 8A), FA-138 (Gold Creek), and FA-141 (Indian River) (SIR Study 8.5, Appendix A; R2 2014a; R2 2014b), 21 of which were conducted at night. Fish species captured during day and night electrofishing surveys consisted of Chinook, sockeye, chum and coho salmon, rainbow trout, Arctic grayling, Longnose sucker, lamprey, and sculpin.

A total of 248 fish were captured during 29 daytime electrofishing surveys conducted between February–April 2014, while 659 fish were captured during 16 nighttime surveys. Overall, a total of 288 site specific HSC observations were recorded for eight fish species during the winter studies (Table 5.5-5). Most HSC observations were of coho salmon (124 observations), sockeye (68 observations), and chum (42 observations) though other observations were recorded for Chinook salmon, rainbow trout, Arctic grayling, longnose sucker and lamprey (Table 5.5-5).

Few fish were detected during underwater video surveys; no fish were observed at sites in FA-104 (Whiskers Creek) or FA-128 (Slough 8A) during February, March, and April 2014, and only a few juvenile salmon (unidentified 60-120 mm fork length) were observed during nighttime surveys at FA-138 (Gold Creek) at Site 138-SL11-22. As a result, no HSC observations were made based on underwater video surveys (SIR Study 8.5, Appendix A; R2 2014k; R2 2014b; ISR Study 9.6, Appendix C: *Winter Sampling Report (2012-2013)*, submitted to the FERC June 3, 2014 [R2 and LGL 2014a]; *2013-2014 Winter Fish Study*, submitted to the FERC September 17, 2014 [R2 and LGL 2014b]).

### 5.5.7. Stranding and Trapping

During a May 17, 2013 TT meeting, participants indicated that site-specific stranding and trapping studies should be a low priority. As such, no formal stranding and trapping surveys were completed in 2013 or 2014. If stranding and trapping surveys are not completed, ramping criteria developed in Washington State (Hunter 1992) will be proposed as fallback criteria during effects analyses. This was noted during the May 17, 2013 TWG meeting.

#### 5.5.8. River Productivity

At this time, data processing and analysis needed for HSC/HSI curve/model development for macroinvertebrates and algae is not yet complete. Draft HSC/HSI curves and model development for macroinvertebrates and algae are scheduled for completion following the second year of study and prior to the USR.

#### 5.5.9. Relationship between Microhabitat Use and Fish Abundance

In response to the April 1, 2013 FERC SPD [FERC 2013], a detailed evaluation of fish abundance measures and eight additional habitat variables (surface flow and GW exchange flux, surface and intergravel DO and temperature, macronutrients, pH, DOC, alkalinity, and chlorophyll-a) was completed to determine whether relationships were evident and if additional HSC curve development was warranted (R2 2014a).

There were three crucial requirements to be met for habitat variables to be included in HSC development. The first is that there is a predictive and direct relationship between the habitat variable and fish presence; second, that changes to the habitat variable as a function of flow can be spatially and quantitatively predicted at the Focus Area scale; and third, that predicted changes in the variable are observable at a temporal scale (hours to days) similar to changes in flow conditions in response to Project operations. If any of these criteria cannot be met, then the individual variable was not considered as part of site-specific HSC curve development.

Of the eight variables requested by the FERC for further investigation of possible HSC development, three (VHG as a surrogate for surface and GW exchange flux, SW DO, and temperature) are included as part of the HSC suitability curve development process. Intergravel DO and temperature continue to be collected, but this data will be used to develop threshold (highs and lows) that can be applied as part of the effective spawning habitat analysis.

For the five remaining variables (pH, DOC, alkalinity, macronutrients, and chlorophyll-a), statistical analysis was completed to estimate the probability that these variables are “strong” predictors of habitat use by the target species and life stages (R2 2014a). Of the five variables, only pH demonstrated a strong relationship with salmonids (resident and anadromous fry and juvenile) habitat use in the MR and LR. The analysis shows that 90-100% of salmonids are selecting habitats in the pH range of 6.2-8.7. Therefore, it is recommended that a pH range of 6.5-8.5 be used as a threshold by which to evaluate the loss or gain in habitat area.

A detailed description of the predictive value of each of these five variables is presented in the September 2014 TM (R2 2014a). Recommendations regarding inclusion of each of the variables in future HSC development activities are presented in Table 5.5-15.

### 5.6. Habitat-Specific Model Development

Since the June 2014 ISR, work on this study component has included: 1) collection of field data to support 2-D hydraulic model development in FA-151 (Portage Creek); 2) collection and analysis of surficial substrate and cover data to support Fish Habitat Modeling at each Focus Area; 3) completion of aerial spawning surveys in Focus Areas downstream of Devils Canyon; 4) continued development and refinement of the 2-D hydraulic models and the PHABSIM based Fish Habitat Modeling framework that will be applied to the ten Focus Areas within the MR; and 5) continued analysis and calibration of the 1-D HEC-RAS hydraulic models for application of the Fish Habitat Models for the Trapper and Birch creeks and 1-D transects in PRM95, PRM96 and PRM97. Details of each of these activities are described below.

### 5.6.1. Collection of Field Data in FA-151 (Portage Creek)

Detailed surveys to collect bathymetric data and other physical and hydraulic data required from 2-D hydraulic model development were initiated on the lower seven of the ten Focus Areas in 2013 and study results presented in the June 2014 ISR. However, limited surveys were completed on the upper three Focus Areas (FA-151 [Portage Creek]; FA-173 [Stephan Lake Complex]; FA-184 [Watana Dam]) due to access restrictions associated with CIRWG lands. These restrictions were resolved and since the June 2014 ISR, AEA has completed detailed bathymetric and 2-D model calibration surveys at FA-151. As before, the collection of data at FA-151 was closely coordinated between and among the different resource leads to ensure that data necessary for developing the different resource models was being collected. The bathymetric surveys were completed on June 22, 2014 following the same general procedures described in ISR Study 8.5, Part A, Section 4.6.1.2.2. Two sets of 2-D model calibration transects were likewise measured in FA-151, the first on June 22 and the second on September 15, 2014 (Figure 4.6-1). Measurement procedures followed those established in 2013 that required all of the 2-D calibration measurements be completed on the same day. Detailed methods used for collecting the field data for the calibration transects are provided in SIR Study 8.5, Appendix C.

### 5.6.2. Collection and Analysis of Surficial Substrate and Cover Data

Substrate maps showing geo-referenced polygons of substrate and cover composition for each surveyed Focus Area are presented in SIR Study 8.5, Appendix E. For illustration purposes the substrate and cover maps for FA-128 (Slough 8A) are displayed in Figure 5.6-1 and Figure 5.6-2, respectively. The substrate Figure 5.6-1 shows both the distribution of coarse and fine substrate within the entire Focus Area, and in the figure inset, the dominant and subdominant particle size and the percent composition of each substrate polygon that will be used for aquatic habitat modeling.

The fish habitat cover Figure 5.6-2 depicts locations of boulders, aquatic vegetation, overhanging vegetation, undercut bank and woody debris. Aquatic vegetation is a cover type that consists of both submergent and emergent vegetation. Some of the gravel and sand bars that are frequently inundated have sparse emergent vegetation such as willow and alder seedlings and saplings. Inundation of this vegetation will provide cover to fish such as juvenile salmonids. Gravel bars and riparian areas that have not been exposed to the scouring effects of spring break up or high flow events become colonized by more mature vegetation including trees and shrubs. These trees and shrubs were characterized as overhanging vegetation and will represent aquatic cover when those areas become inundated. As for substrate, the cover polygons will be used in the habitat modeling.

### 5.6.3. Completion of Aerial Spawning Surveys

The spawning areas identified during the September 2014 aerial surveys were mapped and digitized into GIS layers of observed spawning activity. Salmon redds were enumerated and mapped in FA-104 (Whiskers Slough), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21) and are displayed in SIR Study 8.5, Appendix E. Figure 5.6-3 depicts the spawning area map for FA-128. The map (and the maps in SIR Study 8.5, Appendix E) displays spawning areas observed during each of the aerial surveys, as well as areas identified during HSC ground surveys in 2013 and 2014, and during the 1980s studies.

No evidence of spawning activity was apparent in FA-113 (Oxbow 1), FA-115 (Slough 6A) or FA-151 (Portage Creek) during either aerial spawning survey conducted in September 2014. The vast majority of salmon spawning areas observed during the September 2014 aerial surveys were located in side channel and side slough macrohabitats. A main channel spawning area documented during the surveys was located in FA-141 (Indian River) on the north bank of the main channel immediately upstream and downstream of the Indian River confluence.

Overall, the distribution of salmon spawning recorded during the 1980s was generally similar to salmon spawning areas observed in 2013-2014. At a broad scale, results during each period indicated that tributary and slough (side slough and upland slough) habitats were primary spawning areas for salmon species, while main channel and side channel habitats were considered secondary or incidental spawning areas. At a finer scale, discrete areas of salmon spawning mapped within each Focus Area during 2013 and 2014 closely resemble the spatial extent of spawning mapped during 1980s surveys. Although some differences in spawning distribution are apparent between recent and 1980s spawning surveys, some discrepancies are attributable to changes in habitat accessibility and/or channel configuration. For example, salmon access and use of spawning areas documented in Slough 11 (FA-138 [Gold Creek]); and Slough 21 (FA-144 [Slough 21]) during the 1980s may have been hindered by the presence of large beaver dams near the outlets of each channel.

### 5.6.4. Refinement of 2-D Hydraulic and Fish Habitat Models – Middle River Segment

Since the June 2014 ISR, AEA has continued working on both the 2-D hydraulic models (SRH-2D and River2D) as well as the 2-D PHABSIM based Fish Habitat Models for the MR. Work completed on the 2-D hydraulic models is described in SIR Study 6.6 (Fluvial Geomorphology Modeling) and Study 7.6 (Ice Processes).

Work completed on the Fish Habitat Models has focused on development of a unique grid system compatible with both SRH-2D and River2D outputs that will allow cell by cell hydraulic computations. In addition, the conceptual planning for the Visual Basic (VB) habitat time series model was completed. Since salmonids (salmon and trout) have discreet spawning locations and bury their eggs within the stream gravels, a cell by cell analysis is need to determine successful spawning and emergence (effective spawning habitat). A conceptual outline of the steps needed for development of the VB time series model was developed and is undergoing additional review and modification. A cell by cell analysis is not needed for free swimming life stages since they are capable of movement from one location to another as flows change. The analysis for free swimming life stages will evaluate each Focus Area as a single unit based on the habitat flow relationship developed for the range of flows modeled at each Focus Area.

### 5.6.5. Continued analysis and calibration of 1-D Hydraulic Models – Lower River Segment

AEA has continued analysis of the 1-D transect hydraulic data sets collected in Trapper Creek and Birch Creek, and mainstem transects located at PRM95, PRM96 and PRM97. Field data collection methods and initial analyses were presented in ISR Study 8.5, Part C, Appendix O: *Fish Habitat Modeling in the Lower River* (R2 2014l) and as well presented during the Proof of Concept meeting held April 15-17, 2014 (ISR Study 8.5, Appendix N: *Middle River Fish Habitat and Riverine Modeling Proof of Concept* [R2 et al. 2014]). Data are being analyzed using the 1-D HEC-RAS hydraulic model (Version 4.1) to simulate water levels at the respective transect locations. Work has included preparation of model input data, calibration of hydraulic models using survey data and Version 2 of the OWFRM (ISR Study 8.5, Part C, Appendix K [R2 2014h]), preliminary model simulations and sensitivity analysis, and where possible, development of stage-discharge rating curves.

## 5.7. Temporal and Spatial Analysis

### 5.7.1. Temporal Analysis

Since the June 2014 ISR, AEA has completed modifications to the 2-D Fish Habitat Model to enable cell by cell analysis of spawning and incubation habitats needed to conduct the effective spawning and incubation modeling within the Focus Areas. AEA will continue working on model refinements needed to complete the temporal analyses as described in RSP Study 8.5, Section 8.5.4.7.1 and ISR Study 8.5, Part C, Section 7.7.1.1.1.

### 5.7.2. Spatial Analysis

AEA presented four options for completing the spatial analysis during the IFS TT Proof of Concept meeting on April 15-17, 2014 and described these further in ISR Study 8.5, Part C, Section 7.7.1.1.2, one of which (option involving weightings based on fish use) was deemed inappropriate for further consideration. Further discussions are needed with the Licensing Participants regarding the remaining three options before selection of a specific approach for conducting the spatial analysis can be made.

## 5.8. Instream Flow Study Integration

Study integration efforts are continuing with one of the primary goals being to provide more information and explanation of the DSS that AEA is developing. One aspect of this relates to the issue of uncertainty, and AEA is working on developing an example to demonstrate how this issue can be addressed as part of the DSS process.

# 6. DISCUSSION

## 6.1. IFS Analytical Framework

The IFS analytical framework developed in 2012 was and continues to be applied as work progresses on the IFS and related resource studies. This framework has proven especially beneficial in the development and successful implementation of key interdisciplinary resource studies and the identification of data dependencies between studies. Continued adherence to this framework will ensure successful completion of the overall IFS study as specified in the FERC-approved Study Plan.

## 6.2. River Stratification and Study Area Selection

AEA has followed the stratification and study area selection process that was described in ISR Study 8.5, Part A, Sections 4.2 and 5.2. This has included the selection of ten Focus Areas in the MR (FA-104 [Whiskers Slough], FA-113 [Oxbow 1], FA-115 [Slough 6A], FA-128 [Slough 8A], FA-138 [Gold Creek], FA-141 [Indian River], FA-144 [Slough 21]), FA-151 [Portage Creek]), (FA-173 [Stephan Lake Complex] and FA-184 [Watana Dam]). Results of the field verification habitat mapping analysis (SIR Study 9.9) completed for the MR found only minor differences in the original macro-habitat calls and support the current selection of the Focus Areas. As a result, no modifications to existing Focus Areas or adding additional study areas were indicated; the study area selection process for the MR has been completed.

Analysis of the 1-D PHABSIM data collected in the Geomorphic Reach LR-1 study sites is not complete, and although HSC and tributary gaging work has been conducted in LR2, field studies to collect 1-D PHABSIM transect data at the Geomorphic Reach LR-2 sites have not occurred. A determination for the need for additional sites in the LR will be made once all data have been collected and analyzed from LR-1 and LR-2.

## 6.3. Hydrologic Data Analysis

### 6.3.1. Mainstem Susitna River

The study objectives of the hydrologic data analysis for the mainstem Susitna River were met through collection of cross-sectional and hydrologic data to support a variety of resource studies and development of physical, hydraulic and habitat models. The results from the water surface elevation and discharge measurement surveys collected between 2012 and 2014 were used in development of Version 2.8 of the OWFRM. In all years ADCP data collection and analysis techniques were adjusted to accommodate specific field and equipment conditions. In all cases, any modifications of protocols were documented and are available for review (ISR Study 8.5, Part A, Appendix C [R2 2014g]; SIR Study 8.5, Appendix C). As noted in SIR Study 8.5, Section 5.3, 2-D flow measurements were performed in FA-151 (Portage Creek).

Although not a requirement in the RSP, additional data were collected in the Susitna River to meet all resource study needs. Pressure transducers were installed at upstream and downstream ends of Focus Areas during 2014 to measure WSE and meet needs of the Fluvial Geomorphology Modeling Study (Study 6.6). Forty-two staff gages were also installed in side channels and sloughs of the Susitna River to assess stage height during resource study field activities and for use in 2-D modeling efforts.

### 6.3.2. Tributaries to the Susitna River

Tributary gaging measurements were completed in accordance with the Study Plan and will be used to help synthesize a long-term period of record. These synthesized records will be used in the OWFRM and other riverine-related studies, such as Water Quality Modeling (Study 5.6), Fluvial Geomorphology Modeling (Study 6.6); and GW (Study 7.5). Hourly hydrograph data are available to the public on the GINA website (see Table 5-1 for location information). Additional tributary data collected during the 2014-2015 period have not yet been finalized. The available tributary data were used to adjust the tributary hydrology estimates. Additional revisions will be made to the synthesized tributary records once all the tributary gage data are finalized. This effort is anticipated in Q4 2015. No additional tributary gage data are anticipated for development of Version 3 of the OWFRM. However, future tributary gage data may be necessary to support 2-D Focus Area or other riverine modeling efforts.

### 6.3.3. Realtime Hydrologic Data and Network

The objectives of the Real-time Hydrologic Data Network were met in 2014 with the continuation of collection of data at the mainstem recording stations. As noted in Section 4.3.3, five of the ESS stations were decommissioned in September 2015, and six maintained (Table 4.3-1).

### 6.3.4. Representative Years

Study objectives for Representative Years have been met; recommendations were presented during the Proof of Concept Meeting in 2014 and described in ISR Study 8.5, Part C, Appendix J.

### 6.3.5. Indicators of Hydrologic Alteration and Environmental Flow Components

The final IHA metrics will be developed with input from the TWG and other resource disciplines after Version 3 of the OWFRM is available. A fully developed set of metrics will be available for use prior to the USR.

## 6.4. Reservoir Operations and Open-water Flow Routing Modeling

### 6.4.1. Reservoir Operations Model

The Reservoir Operations Model is on target to meet the study objectives identified in the Study Plan. The Reservoir Operations Model will be simulated using several different conditions. Operational scenarios will be developed under the direction of AEA and the TWG. Once operational scenarios have been identified, they will be simulated using the Reservoir Operations Model and the output will be provided for use by other studies, in particular the OWFRM. Additional detail and discussion concerning the model will be provided in the USR.

### 6.4.2. Open-water Flow Routing Model

The OWFRM Version 2.8 developed in 2015 (Version 2.8) has met Project objectives. The model was refined by including diurnal fluctuations, revised LiDAR data collected in 2013 to extend over bank channel cross-sections, and additional transect data collected in 2013 and 2014. This version of the model is complete for the Dam Site to Sunshine reach. The final Version 3 of the OWFRM will be developed and distributed for review in the last year of the study. Version 3 will include revisions to the lower Susitna River portion with additional cross-section and hydrologic data. Specific tasks to complete the OWFRM include:

- Validation of the OWFRM using 2014 USGS data and the 2012-2015 ESS station data.
- Improvement to tributary hydrology estimates of diurnal fluctuations for the Sunshine to Susitna Station reach.
- Completion and calibration of the OWFRM for the Sunshine to Susitna Station Reach.
- Simulation of the 61-year period of record.

Several other studies included in this project have also developed flow routing models to meet their specific needs. These include Reservoir Operations (ISR Study 8.5, Part A, Section 4.4), Ice Processes (River1D) (ISR Study 7.6), Water Quality (Environmental Fluid Dynamics Code [EFDC]) (ISR Study 5.6), and Fluvial Geomorphology Modeling (ISR Study 6.6). The Reservoir Operations Model has a river component that is used to incorporate minimum instream flow conditions into the simulation of the with-Project scenario. The water quality model has a different time step and utilizes different transects. The ice processes modeling utilizes the OWFRM to link with an under ice model (River1D). The sediment transport modeling uses input from the OWFRM and also includes a steady-state 2-D hydraulic model at Focus Areas. Each of these models is being developed for specific purposes and where appropriate, cross-comparisons of model outputs will be made for QA/QC purposes. As noted, the OWFRM will continue to be used to evaluate stage conditions in the Susitna River with and without the Project and will also provide inputs to certain models.

## 6.5. Habitat Suitability Criteria Development

The overall goal of the HSC study is to develop site-specific HSC/HSI curves for various priority species and life stages of fish for use in assessing the effects of the proposed Project on the quantity and quality of fish habitats through the use of aquatic habitat models (ISR Study 8.5, Part A, Sections 5.6 and 6.6).

The goal of the HSC Development Study was to collect sufficient habitat utilization and availability data to develop site-specific HSC models to support the evaluation of Project effects.

SIR Study 8.5, Appendix D presents the statistical approach used for developing draft final HSC models for the priority species and life stages of fish found in the Susitna River using site-specific habitat utilization and availability data. For species and life stages with some, but not enough site-specific observation to construct HSC models, additional data collection may be warranted. Development of site-specific empirical HSC/HSI data will not be attainable for some species and life stages due to their low abundance or primary use of tributary rather than mainstem habitats. In those cases, alternative HSC development methods (literature based, enveloping, guilding, expert opinion/roundtable discussions, and Bayesian statistical) are being evaluated.

### 6.5.1. 2013-2014 HSC Sampling

Both summer (May-September) and winter (October-April) HSC data were collected to determine if significant differences in seasonal microhabitat use were evident. Summer 2014 field data collection was expanded to include all ten MR Focus Areas and two LR tributary complexes. Summertime data collection occurred during eight separate surveys from mid-May through late-September at 129 sample sites. Many of the sites were sampled more than once resulting in 267 unique sampling events. A total of 2,799 microhabitat use measurements were collected for 12 different species of fish from within ten different macrohabitat types. Sampling in the LR, and the three upstream most Focus Areas (FA-151 [Portage Creek], FA-173 [Stephan Lake Complex], FA-184 [Watana Dam]) that were unsampled in 2013, accounted for just over 19 percent of the total number of summer observations.

### 6.5.2. Winter Habitat Use Sampling

Winter 2012-2013 and 2013-2014 HSC data collection was concentrated within three MR Focus Areas (FA-104 [Whiskers Slough], FA-128 [Slough 8A], and FA-138 [Gold Creek]) during three separate sampling events (February, March, and April). Winter habitat use measurements for rearing Chinook, coho, chum, and sockeye salmon made up over 96 percent of the total number of observations (n=291). For salmon species, there were a similar number of HSC measurements for the fry (n=131) and juvenile (n=151) life stages. The distribution of observations within the three Focus Areas was similar with 38.5 percent collected at FA-104 (Whiskers Slough), 26.1 percent at FA-128 (Slough 8A), and 34 percent at FA-138 (Gold Creek). There were 4 observations of habitat use in FA-141 (Indian River) that accounted for the remainder of the winter HSC measurements.

### 6.5.3. Habitat Utilization Frequency Histograms

Frequency distributions (i.e., histograms) were generated for mean velocity, depth, and substrate utilization for each species. Frequency bin widths of 0.2 were used to evaluate the mean velocity and depth utilization distributions. Histogram plots of depth and mean column velocity utilization were then produced for each species and life stage for which sufficient field observations were recorded. Summer HSC data were plotted for the LR and MR, and as a combined dataset. Winter HSC were plotted for summer and winter observations. Additionally, a comparison of microhabitat use observed during the 2013-2014 surveys and the 1980s HSC curves was completed.

#### *6.5.3.1. River Segment Comparison*

Although there were some minor differences in the depth and velocity of water utilized by fish in the LR and MRs, the range (percentiles) of microhabitat use was generally similar between the segments for most species and life stages.

#### *6.5.3.2. Seasonal Comparison*

A comparison of summer and winter microhabitat use observations was completed to determine if difference in microhabitat (water depth and velocity) selection between seasons justifies development of separate (summer and winter) HSC models. The comparison could only be made for those species and life stages with sufficient (>10) habitat use observations between the two seasons.

For the fry and juvenile life stages of Chinook and coho salmon, habitat use between seasons was significantly different in both the overall range (0-100 percentile) and median ($50^{th}$ percentile) depth and velocity use. When compared to summer habitat use, the maximum velocity and depth use during the winter was 1-3 times lower for both species and life stages. The use of lower velocity areas during the winter is not surprising given that nearly all fish species exhibit physiological and/or behavioral responses to the seasonal change in habitat from summer to winter, such as movement to off-channel and low velocity habitat. The dramatic shift in use of lower velocity areas by fry and juvenile Chinook and coho, during the winter, appears to justify an adjustment of the velocity preference model between seasons.

Although it is not possible to construct a unique winter habitat preference model without wintertime habitat availability data, a reduction in the maximum velocity threshold from 3.0 feet per second in the summer to 1.5 feet per second in the winter is recommended. This reduction or limitation in the range of suitable velocities would increase the sensitivity of the habitat modeling to detect changes in suitable habitat for overwintering Chinook and coho salmon.

#### *6.5.3.3. 1980s and 2013-2014 Comparison*

A comparison of HSC developed from the 1980s studies and habitat use data collected as part of the 2013-2014 data collection effort was completed for Chinook and coho salmon juvenile, pink salmon spawning, Arctic grayling adult, rainbow trout adult, and whitefish adult.

Pink salmon spawning and whitefish adult were the only two species/life stages with a large enough number of 2013-2014 site-specific observation (>30) to provide a meaningful comparison to the 1980s HSC. A visual comparison of the 2013-2014 pink salmon spawning data (n=53) and the 1980s HSC appears to indicated strong similarities in habitat utilization. Even though the 1980s pink salmon spawning HSC were not developed from Susitna River but were transferred from site-specific data collected from the Terror River (Alaska), the 1980s HSC should be considered as a potential source of HSC for the current effort. Similarities between the 1980s HSC and 2013-2014 habitat use data for Arctic grayling, rainbow trout, and whitefish adult was not nearly as evident. There were only 8 habitat use observations of rainbow trout adult during the 2013-2014 surveys making it difficult to draw any conclusion from a comparison of the data.

### 6.5.4. HSC Models

Multivariate HSC models have been developed from 2013-2014 HSC sampling data for Chinook salmon fry and juvenile, chum salmon spawning, coho salmon fry and juvenile, sockeye salmon spawning, Arctic grayling fry and juvenile, whitefish fry and juvenile, and longnose sucker juvenile and adult. Completing the statistical analysis for a diverse data set collected over a wide range of habitat conditions required certain model assumptions (see Section 5.5.4), data grouping or consolidations and applying threshold to set minimum and/or maximum ranges within the HSC models. Further modification to the HSC/HSI models will be completed after reviewing comments from the Licensing Participants and the FERC. Final HSC model assumptions and data considerations will be presented in the USR.

## 6.6. Habitat-Specific Model Development

Since the June 2014 ISR, work on this study component has continued and was centered around the five activities described in Section 5.6 that are discussed briefly below.

### 6.6.1. Collection of Field Data in FA-151 (Portage Creek)

Detailed surveys to collect bathymetric data and other physical and hydraulic data have now been completed on the eight Focus Areas below Devils Canyon. Surveys in the upper two Focus Areas (FA-173 [Stephan Lake Complex]; FA-184 [Watana Dam]) are yet to be completed.

### 6.6.2. Collection and Analysis of Surficial Substrate and Cover Data

Substrate and cover data have been collected and analyzed for the lower eight Focus Areas and substrate maps showing geo-referenced polygons of substrate and cover composition for each surveyed Focus Areas prepared (SIR Study 8.5, Appendix E). For illustration purposes the substrate and cover maps for FA-128 (Slough 8A) are displayed in Figure 5.6-1 and Figure 5.6-2, respectively.

### 6.6.3. Completion of Aerial Spawning Surveys

Aerial spawning surveys were completed in September 2014 and spawning areas mapped and digitized into GIS layers of observed spawning activity. Salmon redds were enumerated and mapped in FA-104 (Whiskers Slough), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21) and are displayed in SIR Study 8.5, Appendix E. Overall, the distribution of salmon spawning recorded during the 1980s was generally similar to salmon spawning areas observed in 2013-2014. At a broad scale, results during each period indicated that tributary and slough (side slough and upland slough) habitats were primary spawning areas for salmon species, while main channel and side channel habitats were considered secondary or incidental spawning areas. At a finer scale, discrete areas of salmon spawning mapped within each Focus Area during 2013 and 2014 closely resemble the spatial extent of spawning mapped during 1980s surveys. This information will be used in validation of the 2-D Fish Habitat Models.

### 6.6.4. Refinement of 2-D Hydraulic and Fish Habitat Models – Middle River Segment

AEA has continued working on both the 2-D hydraulic models (SRH-2D and River2D) as well as the 2-D PHABSIM based Fish Habitat Models for the MR. Work completed on the 2-D hydraulic models is described in SIR Study 6.6 (Fluvial Geomorphology Modeling) and Study 7.6 (Ice Processes). Work completed on the Fish Habitat Models has focused on development of a unique grid system compatible with both SRH-2D and River2D outputs that will allow cell by cell hydraulic computations. In addition, the conceptual planning for the Visual Basic (VB) habitat time series model was completed.

### 6.6.5. Continued analysis and calibration of 1-D Hydraulic Models – Lower River Segment

Since the June 2014 ISR, AEA has continued analysis of the 1-D transect hydraulic data sets collected in Trapper Creek and Birch Creek, and mainstem transects located at PRM95, PRM96, and PRM97 sites. These data will continue to be evaluated with final models developed for use in the habitat modeling.

## 6.7. Temporal and Spatial Habitat Analyses

AEA has advanced the methods for modeling important key species and life stage habitats in the Focus Areas, including spawning and incubation habitats that must be tracked over discrete time steps as part of an effective spawning and incubation habitat analysis. AEA will continue to refine these and other methods as needed to address Project operational effects that are time sensitive (e.g., load following will be evaluated via varial zone modeling).

AEA has also identified and presented to the Licensing Participants four options for expanding the habitat-flow modeling results from the Focus Areas to the remaining unmeasured portions of the MR. These were discussed during the IFS TT April 15-17 Proof of Concept meeting. An additional option raised during the meetings was to simply rely on the models developed in the Focus Areas for evaluating Project operational effects without expansion to un-measured areas. AEA will discuss these options further with the Licensing Participants and a final approach will subsequently be selected.

## 6.8. Instream Flow Study Integration

Based on an evaluation of several approaches and discussion with the TWG as part of the IFS TT Riverine Modelers meeting of November 13-15, 2013, AEA decided to use the matrix method as the basis for the DSS for decision making, with the possible consideration of addressing uncertainties in a decision analysis framework. In two follow-up meetings including the April 15-17, 2014 Proof of Concept meeting, and the October 2014 ISR meetings, Licensing Participants expressed a strong interest in the DSS process, and encouraged further development of the study integration components of the project sooner in the project timeline. The issue of addressing uncertainties associated with model outputs has been a continuing theme in the discussions with the agencies and was explicitly raised during the October ISR meetings. To further advance this analysis, AEA is currently developing an example to demonstrate how the issues of uncertainty can be addressed as part of the DSS process. AEA is planning on working in collaboration with the Licensing Participants in developing the final DSS that will be used for evaluating overall Project effects across resource disciplines and user groups.

# 7. CONCLUSION

The IFS study, which consists of eight study components, was initiated in 2013 in accordance with the FERC- approved Study Plan and resulted in the selection of study areas and study sites that are being used across resource disciplines. Major field efforts were associated with collection of mainstem Susitna River and tributary hydrology data, bathymetry and topographic data, HSC/ HSI fish habitat data (winter and open-water periods), and characterization of substrates and cover. Data collection and analysis efforts have continued throughout 2014 and into 2015 and have substantively contributed to completion or near-completion of certain study elements, and have also helped to identify and prioritize all remaining work needed for the successful completion of the study. Highlights of each of the study components are presented below along with a listing of remaining work needed to meet the study objectives.

## 7.1. IFS Analytical Framework

- AEA developed and successfully implemented the IFS analytical framework in 2012-2013, and continued to apply the framework in 2014 and into 2015.
- AEA will continue to adhere to this framework to ensure successful completion of the overall IFS study.

## 7.2. River Stratification and Study Area Selection

- AEA successfully developed and applied the stratification and study area selection process described in ISR Study 8.5, Part A, Section 4.2 and 5.2. This process resulted in the selection of ten Focus Areas in the Middle River Segment and two study areas associated with important tributary mouths in the Lower River Segment for conducting detailed studies.
- The representativeness of the ten Focus Areas was tested based on habitat mapping that was field verified in 2014. As a result, no modifications to existing Focus Areas or adding additional study areas are warranted and the study area selection process for the Middle River Segment has been completed.
- Field studies were completed in the upper LR in Geomorphic Reach LR-1 (Trapper and Birch creeks, and transects at PRM95, PRM96 and PRM97) of the Lower River Segment but work still needs to be completed at the lower study area in LR-2 (Caswell and Sheep creeks and mainstem transects). A determination for the need for additional sites in the LR will be made once all data have been collected and analyzed from LR-1 and LR-2.

## 7.3. Hydrologic Data Analysis

The collection and analysis of hydrologic data will continue for the LR in the next year of the study using methods and procedures in accordance with the Study Plan. This will include collection of water level and discharge data on the mainstem in the LR using previously applied methods. Data collection efforts needed for tributary hydrology estimates used in the OWFRM are complete. However, additional data may be necessary to support 2-D modeling or other riverine resource study efforts. No changes from the Study Plan were necessary for field data collection procedures for mainstem transect data, tributary measurements, or winter gaging. Changes to the mainstem hydrology stations in 2013 (as described in ISR Study 8.5, Part A, Section 4.3.2) and in 2014 (SIR Study 8.5, Appendix C) were made to reflect actual application of these data to modeling and other efforts. As such, completion of the data collection efforts and hydrologic analyses described above will achieve the objectives of this study component in support of the IFS Study Plan.

## 7.4. Reservoir Operations and Open-water Flow Routing Modeling

The Reservoir Operations Model will be simulated under conditions outlined in the Study Plan with the exception of the modeling platform. The Study Plan identified HEC ResSim as the modeling platform for reservoir operations modeling. Early model runs were simulated with HEC ResSim, but an additional proprietary reservoir operations model (MWH-ROM) became necessary in order to incorporate all the necessary model components. It is anticipated that the MWH-ROM will be used for all future reservoir operation modeling developments. Output from the reservoir operations model is used as input into the OWFRM to evaluate impacts of the Project on downstream streamflows and WSE. The OWFRM will continue to be refined and will include updates to the LR. Both the Reservoir Operations Model and the OWFRM, in combination with those specific to Fluvial Geomorphology Modeling (Study 6.6), Ice Processes (Study 7.6), Water Quality (Study 5.6), GW (Study 7.5) and Fish Habitat Modeling (Study 8.5), as well as data and information provided from other Study 8.5 components, and information from FDAML (Study 9.6), River Productivity (Study 9.8) and Fish Passage Barriers (Study 9.12) will provide analytical tools and data to address the objectives of the Study Plan.

## 7.5. Habitat Suitability Criteria Development

### 7.5.1. Proposed Methodologies and Modifications

To complete this study component, AEA will implement the methods in the FERC-approved Study Plan (RSP Section 8.5.4.5) except as described in Section 4.5.11 of this report. These activities are described below and will include:

#### HSC/HSI Model Development

Finalization list of priority species: A revised priority ranking of species for HSC development was proposed during a TT meeting on 21 March 2014.

- Finalize species and life stage periodicity: Detailed interim periodicity tables were developed for twelve of the priority species and life stages and presented in the June 2014 ISR Study 8.5. The interim periodicity tables were developed from site-specific data (list) and in general are consistent with periodicity information developed in the 1980s. Additional site-specific information will be developed during analysis of the results of FDAML (Study 9.6) and may modify the draft periodicity values for some life stages. Final species and life stage periodicity will be developed as part of the USR.
- For moderate and low priority species and life stages, select alternative HSC development method(s). Alternative methods were described in the FERC-approved Study Plan for developing HSC including site specific curves. Alternative curve

development methods will be identified for all species lacking the requisite numbers of site specific measurements. These methods will be presented to the agency and stakeholders representatives during subsequent TWG or TT meetings. Complete development of HSC using alternative methods for those species and life stages with insufficient numbers of site-specific observations (i.e., Adult Arctic grayling, Bering cisco [*Coregonus laurettae*], burbot, and eulachon [*Thaleichthys pacificus*]).

- Two years of HSC sampling has been completed in the MR Focus Areas below Devils Canyon, and one year of study has been completed in MR Focus Areas downstream of FA-151 (Portage Creek) and in the LR. An additional year of study will be completed in MR FA-151 (Portage Creek), FA-173 (Stephan Lake Complex), and FA-184 (Watana Dam) and in the LR.
- Conduct additional HSC surveys to collect site-specific habitat use observations for pink salmon spawning and adult whitefish and rainbow trout. Sample site selection, timing, and survey methods would be directed towards maximizing the number of observations for each species/life stage
- Continue to review potential relationships between spawning habitat selection/preference and GW upwelling or downwelling. Although upwelling/downwelling was not a strong predictor of habitat preference, a weighting factor or threshold may be warranted as a way to assign a relative importance to spawning areas with upwelling/downwelling.
- Complete multivariate HSC modeling utilizing new/additional observations for moderate priority species and life stages with sufficient numbers and diversity of observations to develop site-specific HSC. Review and evaluate both univariate and multivariate HSC modeling results and proposed HSC based on alternative methods with agency and stakeholder representatives.
- Develop final HSC models for all priority species and life stages for use in the IFS habitat modeling. Final HSC will be included in the USR.

**Winter Studies**

- Review and analysis of continuous stage, water temperature and DO data recorded during winter 2014-2015. These continuous data will be used to evaluate potential relationships between main channel stage fluctuation and water levels in Focus Area habitats and to describe the effect of water level change on surface and intergravel habitat conditions in habitats utilized for juvenile fish rearing and salmon egg incubation. Data collected during this period represents the second complete winter season of IFS winter studies data collection identified in the RSP and ISR.
- Retrieval of instrumentation deployed during winter 2015-2016. Instruments deployed during September 2015 to continuously record water level and water quality conditions in MR Focus Areas will be maintained and downloaded.
- Conduct fish behavior and fish habitat utilization studies during an additional winter period. Coordinated fish monitoring and sampling will occur in association with IFS and FDAML winter studies to describe relative distribution of fish among macrohabitat types and site-specific microhabitat utilization. Water level will also be monitored at selected habitat features such as side channel or side slough hydraulic controls/inlets that may

help discern changes to aquatic habitat conditions through the winter period. Data collection will primarily occur in FA-104 (Whiskers Slough), FA-128 (Slough 8A) and FA-138 (Gold Creek) and secondarily in Focus Area habitats proximal to these areas (e.g., FA-141 [Indian River]) and accessible during winter.

#### 7.5.1.1. Decision Points from Study Plan

There were no decision points in the FERC-approved Study Plan to be evaluated for this study following completion of 2014 work.

#### 7.5.1.2. Modifications to Study Plan

No modifications are needed to complete the HSC/HSI model development.

### 7.5.2. Conclusion

Over 3,000 site-specific observations of habitat use were collected during summer and winter HSC/HSI surveys of the Susitna River. Habitat use and availability measurements were collected from 129 sampling sites during 267 unique sampling events. Collection of synoptic habitat use and availability data, allowed for development of habitat suitability or preference models (univariate and multivariate) for individual species and life stages with sufficient numbers of observations. Utilizing the 2013-2014 HSC/HSI survey data, multivariate HSC/HSI models were developed for Chinook salmon fry and juvenile, chum salmon spawning, coho salmon fry and juvenile, sockeye salmon spawning, Arctic grayling fry and juvenile, whitefish fry and juvenile, and longnose sucker juvenile and adult. No additional data collection is proposed for these species and life stages.

Comparison of HSC/HSI data collected in different river segments (LR and MR) and season, displayed similar ranges and median values for water depth and velocity use of most species and life stages. The one notable exception was between summer and winter habitat use by early life stages of Chinook and coho salmon. This apparent difference in habitat use between summer and winter seasons may justify the development of wintertime HSC/HSI for these two species.

An evaluation of fish abundance measures and eight additional habitat variables (surface flow and GW exchange flux, surface and intergravel DO and temperature, macronutrients, pH, DOC, alkalinity, and chlorophyll-a) showed generally weak relationships between the variables and fish habitat use (R2 2014a). The one exception was for pH. Although there was insufficient synoptic data for inclusion of pH in development of the HSC/HSI models, a minimum and maximum threshold range has been proposed for use in evaluating potential Project impacts.

Although HSC/HSI models have been developed for a majority of the high and moderate priority fish species and life stages, additional targeted data collection is proposed for a select number of species and life stages. For those species and life stages with limited numbers of observation other methods for developing HSC will need to be developed. Alternative methods were described in the FERC-approved Study Plan for developing HSC including site specific curves including the use of literature based curves, developing envelope curves, expert opinion/round table discussions and/or the use of Bayesian statistical methods. These methods will be presented to the agency and stakeholders representatives during subsequent TWG or TT meetings.

## 7.6. Habitat-Specific Model Development

- Bathymetric, ADCP, and substrate/cover characterization surveys were completed for seven of the ten Focus Areas; data are used in development of 2-D hydraulic models (SRH-2D [Study 6.6]; and River2D [Study 7.6]) that will provide hydraulic data to the 2-D PHABSIM Fish Habitat Models for developing habitat-flow relationships for target fish species and life stages. In 2014, similar bathymetry, velocity, stage, substrate, and cover data were collected for FA-151 (Portage Creek).
- In 2014, collected supplemental physical/hydraulic data at seven Focus Area features below Devils Canyon.
- In 2013, completed physical and hydrologic surveys in the LR consisting of the collection of field data at 1-D single transect locations that will be used for defining habitat-flow relationships. LR field data collection consisted of three site visits (June, August, and September) at the Geomorphic Reach LR-1 fish habitat sites to coincide with high, moderate, and low flow conditions.
- Preliminary hydraulic model calibrations using HEC-RAS were completed in 2013 for two of the LR fish habitat sites located in Geomorphic Reach LR-1 to provide analysis to be presented at the Proof of Concept meeting. The hydraulic modeling results were imported into PHABSIM and an example of the habitat modeling output was generated using available HSC. Examples of WUA and a habitat time series analysis were presented at the Proof of Concept meeting April 15-17, 2014. Completed further calibrations of the transect data in 2014.
- Conducted aerial salmon spawning surveys at Focus Areas below Devils Canyon to validate salmon spawning habitat metrics that will be generated from the 2-D PHABSIM Fish Habitat Modeling (ISR Study 8.5, Part C, Section 7.3).
- AEA will complete the development of habitat-specific models in the MR with specific efforts to include:
    - Collection of substrate and cover data within the remaining two Focus Areas above Devils Canyon (FA-173 [Stephan Lake Complex] and FA-184 [Watana Dam Site]).
    - Finalization of 2-D hydraulic models in each of the eight Focus Areas that have already been surveyed between PRM 104 and PRM 151: (FA-104 [Whiskers Slough], FA-113 [Oxbow 1], FA-115 [Slough 6A], FA-128 [Slough 8A], FA-138 [Gold Creek], FA-141 [Indian River], FA-144 [Slough 21]), and FA-151 [Portage Creek]), and the two Focus Areas that have not yet been surveyed (FA-173 [Stephan Lake Complex] and FA-184 [Watana Dam]). The 2-D hydraulic models will be developed under Study 6.6 (Fluvial Geomorphology Modeling) but reviewed and potentially adjusted for use in habitat modeling.

- Finalization of the Visual Basic (VB) models and associated GIS tools to allow computation of HSC/HSI habitat evaluation metrics in MR Focus Areas over a range of flow conditions.
- Final calibration and refinement of the Effective Spawning/Incubation and Salmon Rearing models as described in ISR Study 8.5, Part A, Section 5.6.4.2, and presented during the IFS TT POC meeting on April 15-17, 2014.
- Development of varial zone models for each of the ten Focus Areas (RSP Section 8.5.4.6.1.6).
- Development of habitat evaluation metrics for priority species and life stages using hydraulic/habitat models developed for MR Focus Areas.
- Analyzing breaching flows to quantify habitat connectivity of side channels and sloughs within MR Focus Areas; breaching flows will also be analyzed at major side channel and slough within the MR to evaluate the representativeness of Focus Area data. The IFS breaching flow analysis will be complementary to Study 9.12 (Fish Passage Barriers) that is designed to evaluate existing and future potential barriers to fish movement.

- AEA will complete the development of habitat-specific models in the LR with specific efforts to include:
  - Finalization of open-water, 1-D hydraulic models in each of the six LR-1 PHABSIM sites that have already been surveyed: (PRM95, PRM96, PRM97, Trapper Creek, Birch Creek, and Deshka River).
  - Identification of transect locations within targeted habitats for Geomorphic Reach LR-2 in the vicinity of Sheep Creek and Caswell Creek.
  - Collection of open-water field data to support Fish Habitat Modeling at Geomorphic Reach LR-2 fish habitat sites.
  - Finalization of open-water, 1-D hydraulic models in the LR PHABSIM sites to be located in LR-2 between PRM 65 to PRM 70.
  - Identification of priority species, life stages and periodicity for LR-1 and LR-2 to use for HSC curve development to apply to the Fish Habitat Modeling.
  - Calculation of WUA curves for sites in LR-1 and LR-2 using calibrated PHABSIM models.
  - Calculation of WUA time series of open-water habitat for LR-1 and LR-2 sites based on species and life stage periodicity for existing conditions and Project operational scenarios.
  - Development of depth and velocity criteria for defining breaching, fish passage, and connectivity conditions for the tributary mouths.
  - Calculation of fish passage probabilities and percentage of time open-water connectivity is maintained to identify changes to timing, frequency or duration of conditions.

## 7.7. Temporal and Spatial Habitat Analyses

- AEA described the general approaches that will be used in completing the temporal habitat analysis in RSP Section 8.5.4.7.1.1, with further details provided in ISR Study 8.5, Part C, Section 7.7.1.1.1 and during the IFS TT Proof of Concept meeting on April 15-17, 2014. These include varial zone analysis, effective spawning/incubation habitat analysis, analysis of rearing habitats, breaching flow analysis, and analysis of other riverine processes (e.g., water quality, sediment deposition, ice) that may directly influence fish habitats.
- AEA will continue to work on development and finalization of methods for completing both the temporal and spatial analyses of data, and will apply those methods in evaluating Project operational effects.

## 7.8. Instream Flow Study Integration

- AEA reviewed potential options and benefits regarding DSS during the November 13-15, 2013 Riverine Modelers meeting. Based on an evaluation of several approaches, AEA elected to use the matrix method as the basis for the DSS, with the possible consideration of addressing uncertainties in a decision analysis framework (ISR Study 8.5, Part C, Section 7.8).
- Further discussion regarding the DSS occurred during the April 15-17, 2014 Proof of Concept meeting and the October ISR meetings during which Licensing Participants encouraged further development of the study integration components. The issue of addressing uncertainties associated with model outputs was explicitly raised during the October meetings. To further advance this analysis, AEA is currently developing an example to demonstrate how the issues of uncertainty can be addressed as part of the DSS process.
- AEA is planning on working in collaboration with the Licensing Participants in developing the final DSS that will be used for evaluating overall Project effects across resource disciplines and user groups.

# 8. LITERATURE CITED


Alaska Energy Authority (AEA). 2012. Revised Study Plan. Susitna-Watana Hydroelectric Project, FERC Project No. 14241 Submittal: December 14, 2012. http://www.susitna-watanahydro.org/study-plan.

Alaska Energy Authority (AEA). 2014. Initial Study Report. Susitna-Watana Hydroelectric Project, FERC Project No. 14241 Submittal: June 3, 2014. http://www.susitna-watanahydro.org/type/documents/.

Burnham, K.P., and D.R. Anderson. 2002. Model selection and multimodel inference: A practical information-theoretic approach. 2nd Edition. Springer-Verlag, New York

Federal Energy Regulatory Commission (FERC). 2013. Study Plan Determination on 14 remaining studies for the Susitna-Watana Hydroelectric Project. Susitna-Watana Hydroelectric Project, FERC No. P-14241. April 1, 2013. http://elibrary.FERC.gov/idmws/file_list.asp?accession_num=20130401-3022.

Geo-Watersheds Scientific (GWS) and R2 Resource Consultants (R2). 2014a. Preliminary Groundwater and Surface-Water Relationships in Lateral Aquatic Habitats within Focus Areas FA-128 (Slough 8A) and FA-138 (Gold Creek) in the Middle Susitna River. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 30, 2014, Attachment C, Study 7.5 Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/07.5_GW_GWS_T6_TM_Aquatic_Hydro_Final_Draft_20140925.pdf.

Geo-Watersheds Scientific (GWS) and R2 Resource Consultants (R2). 2014b. Groundwater and Surface-Water Relationships in Support of Riparian Vegetation Modeling. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 30, 2014, Attachment D, Study 7.5 Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/07.5_GW_GWS_T5_TM_Riparian_Final_Draft_20140926.pdf.

Hunter, M.A. 1992. Hydropower flow fluctuations and salmonids: a review of the biological effects, mechanical causes, and options for mitigation. Washington Department of Fisheries, Technical Report No. 119. 46 pp.

Manly, B.F.J., L.L. McDonald, and D.L. Thomas. 1993. Resource Selection by Animals: Statistical Design and Analysis for Field Studies. Chapman and Hall, London, United Kingdom, p. 192.

Mueller, D.S., C.R. Wagner, M.S. Rehmel., K.A. Oberg, and F. Rainville. 2013. Measuring discharge with acoustic Doppler current profilers from a moving boat. U.S. Geological Survey Techniques and Methods 3A-22, 95 p.

MWH Americas, Inc. (MWH). 2014. Susitna-Watana Hydroelectric Project Engineering Feasibility Report, AEA11-022, Report, 14-21-REP, v0.0. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: December 2014. Prepared for Alaska Energy Authority. http://www.susitna-watanahydro.org/type/documents/.

R2 Resource Consultants (R2). 2013. Selection of Focus Areas and Study Sites in the Middle and Lower Susitna River for Instream Flow and Joint Resource Studies – 2013 and 2014. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: March 1, 2013, Attachment C, Joint Resource Study Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2013/09/TechMemoSelectionOfFocusAreas.pdf.

R2 Resource Consultants, Inc. (R2). 2014a. Evaluation of Relationships between Fish Abundance and Specific Microhabitat Variables. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 17, 2014, Attachment G, Study 8.5 Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/08.5_IFS_R2_TM_FishAbundance-MicrohabitatVariables_FINAL.pdf.

R2 Resource Consultants, Inc. (R2). 2014b. 2013-2014 Instream Flow Winter Studies. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 17, 2014, Attachment H, Study 8.5 Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/08.5_IFS_R2_TM_2013-2014WinterStudies.pdf.

R2 Resource Consultants (R2). 2014c. Lower River Hydraulic Model Calibration. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part A, Appendix I. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/08.5_IFS_ISR_PartA_5_of_5_App_G-I.pdf.

R2 Resource Consultants (R2). 2014d. Hydrologic Data Collection Methods. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part A, Appendix A. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/08.5_IFS_ISR_PartA_3_of_5_App_A-C.pdf.

R2 Resource Consultants (R2). 2014e. Representative Years. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix J. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_1_of_2.pdf.

R2 Resource Consultants (R2). 2014f. Biological Cues Study. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part A, Appendix B. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/08.5_IFS_ISR_PartA_3_of_5_App_A-C.pdf.

R2 Resource Consultants (R2). 2014g. 2013 Moving Boat ADCP Measurements. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part A, Appendix C. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/08.5_IFS_ISR_PartA_3_of_5_App_A-C.pdf.

R2 Resource Consultants (R2). 2014h. Hydrology and Version 2 Open-water Flow Routing Model. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix K. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_1_of_2.pdf.

R2 Resource Consultants (R2). 2014i. Habitat Suitability Curve Development. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix M. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_2_of_2.pdf.

R2 Resource Consultants (R2). 2014j. Periodicity Tables. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part A, Appendix H. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/08.5_IFS_ISR_PartA_5_of_5_App_G-I.pdf.

R2 Resource Consultants, Inc. (R2). 2014k. 2012-2013 Instream Flow Winter Pilot Studies. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix L. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_2_of_2.pdf.

R2 Resource Consultants, Inc. (R2). 2014l. Fish Habitat Modeling in Lower River. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix O. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_2_of_2.pdf.

R2 Resource Consultants, Inc. (R2), Geo-Watersheds Scientific (GWS), Brailey Hydrologic, and Geovera. 2013. Open-water HEC-RAS Flow Routing Model. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: January 31, 2013, Attachment A, Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2013/02/Att-A-Flow-Routing-Model.pdf.

R2 Resource Consultants (R2) and LGL Alaska Research Associates (LGL). 2014a. Winter Sampling Report (2012-2013). Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 9.6, Part A, Appendix C. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/05/09.06_FDAML_ISR_PartA_4_of_5_App_C.pdf.

R2 Resource Consultants (R2) and LGL Alaska Research Associates (LGL). 2014b. 2013-2014 Winter Fish Study. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: September 17, 2014, Attachment D, Study 9.6 Technical Memorandum. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/09/09.06_FDAML_Winter_TM.pdf.

R2 Resource Consultants (R2), Miller Ecological Consultants, Tetra Tech, HDR, Geo-Watersheds Scientific, and Montgomery Watson Harza. 2014. Middle River Fish Habitat and Riverine Modeling Proof of Concept. Susitna-Watana Hydroelectric Project, FERC No. P-14241 Submittal: June 3, 2014, Initial Study Report, Study 8.5, Part C, Appendix N. Prepared for Alaska Energy Authority, Anchorage, Alaska. http://www.susitna-watanahydro.org/wp-content/uploads/2014/06/08.5_IFS_ISR_PartC_2_of_2.pdf.

United States Army Corps of Engineers (USACE). 2010a. HEC-RAS River Analysis System Applications Guide, CPD-70.

United States Army Corps of Engineers (USACE). 2010b. HEC-RAS River Analysis System Hydraulic Reference Manual, CPD-69.

United States Army Corps of Engineers (USACE). 2010c. HEC-RAS River Analysis System User's Manual, CPD-68.

United States Geological Survey (USGS). 2015. May 8, 2015. USGS real-time gage Susitna River at Gold Creek (No. 152920000). http://nwis.waterdata.usgs.gov/ak/nwis/uv/?site_no=15292000&PARAmeter_cd=00065,00060.

# 9. TABLES

**Table 4.3-1. Susitna Real-Time Reporting Network Stations. (Source: Modified ISR Study 8.5, Table 4.3-1.)**

| Site Name | Short Name | PRM | Parameters | Status |
|---|---|---|---|---|
| **Upper Segment AEA Gaging Stations** | | | | |
| 15291500 Susitna River Near Cantwell | ESS80 | 225.0 | discharge, water level, water and air temperature, camera | Maintained |
| **Middle Segment AEA Gaging Stations** | | | | |
| Susitna River Below Deadman Creek | ESS70 | 187.1 | discharge, water level, water and air temperature, camera | Maintained |
| Susitna River Below Fog Creek | ESS65 | 176.5 | discharge, water level, water and air temperature, camera | Removed 2015 |
| Susitna River Above Devil Creek | ESS60 | 168.1 | discharge, water level, water and air temperature, camera | Removed in June 2013 |
| Susitna River Below Portage Creek | ESS55 | 152.2 | discharge, water level, water and air temperature, camera | Maintained |
| Susitna River at Curry | ESS50 | 124.1 | discharge, water level, water and air temperature, camera | Removed 2015 |
| Susitna River Below Lane Creek | ESS45 | 116.6 | discharge, water level, water and air temperature, camera | Maintained |
| Susitna River Above Whiskers Creek | ESS40 | 107.2 | discharge, water level, water and air temperature, camera | Maintained |
| **Lower Segment AEA Gaging Stations** | | | | |
| Susitna River at Chulitna River | ESS35 | 102.1 | discharge, water level, water and air temperature, camera | Removed in July 2014 |
| Susitna River Below Twister Creek | ESS30 | 98.4 | discharge, water level, water and air temperature, camera | Removed 2015 |
| 15294350 Susitna River at Susitna Station | ESS20 | 29.9 | discharge, water level, water and air temperature, camera | Maintained |
| Susitna River Near Dinglishna Hill | ESS15 | 24.7 | water level, water and air temperature, camera | Removed 2015 |
| Susitna River Below Flat Horn Lake | ESS10 | 17.4 | water level, water and air temperature, camera | Removed 2015 |
| **Repeater Stations** | | | | |
| Mount Susitna Near Granite Creek | ESR1 | | air temperature | Maintained |
| Repeater, East of ESM1, First Potential Site | ESR2 | | air temperature | Maintained |
| Repeater, Dam Site to Glacial Repeater | ESR3 | | air temperature | Maintained |
| Curry Ridge near McKenzie Creek Repeater | ESR4 | | air temperature | Maintained |
| Curry Pt. to State Park Repeater | ESR5 | | air temperature, camera | Maintained |
| State Park over Devils Canyon Repeater | ESR6 | | air temperature, camera | Maintained |
| Portage Creek Repeater | ESR7 | | air temperature | Maintained |
| ESR2 to ESS80, ESM2 link | ESR8 | | air temperature | Maintained |
| **Base Stations** | | | | |
| Talkeetna Base Station | ESB2 | | N/A | Maintained |

Notes:

1 ESS = AEA Susitna River Surface-Water Station.

2 ESR = AEA Susitna River Repeater Station.

3 ESB = AEA Susitna River Base Station.

**Table 4.3-2. Focus Area pressure transducer site locations. (Source: SIR Study 8.5, Appendix B, Table 5.)**

| Focus Area | Name | PRM | Latitude | Longitude |
|---|---|---|---|---|
| 151 | Portage Creek – downstream | 151.8 | 62.829458 | -149.395588 |
| 144 | Slough 21 – upstream | 145.7 | 62.818930 | -149.576018 |
| 144 | Slough 21 – downstream | 144.3 | 62.803036 | -149.601279 |
| 141 | Indian River – downstream | 141.9 | 62.784096 | -149.662469 |
| 138 | Gold Creek - downstream | 138.5 | 62.753528 | -149.719407 |
| 128 | Slough 8A – Upstream | 129.7 | 62.671285 | -149.901254 |
| 128 | Slough 8 A - downstream | 128.2 | 62.660587 | -149.939926 |
| 115 | Slough 6A - Downstream | 115.4 | 62.507323 | -150.113471 |
| 113 | Oxbow 1 - Downstream | 113.6 | 62.485240 | -150.098638 |
| 104 | Whiskers Slough – upstream | 106 | 62.383478 | -150.142623 |
| 104 | Whiskers Slough – downstream | 104.8 | 62.370041 | -150.165218 |

**Table 4.3-3. Tributary gaging site information. (Source: SIR Study 8.5, Appendix B, Table 6.)**

| Tributary Name | Susitna PRM | Gage Site Type | Data Collection Years | Latitude | Longitude |
|---|---|---|---|---|---|
| Oshetna River | 235.1 | Continuous | 2013-2014 | 62.628520 | -147.369830 |
| Kosina Creek | 209.1 | Continuous with barologger | 2013-2014 | 62.755970 | -147.955150 |
| Tsusena Creek | 184.6 | Continuous | 2014 | 62.825689 | -148.609891 |
| Fog Creek | 179.3 | Spot | 2014, 2015 | 62.774199 | -148.705479 |
| Unnamed Tributary 174.3 | 174.3 | Spot | 2014 | 62.765622 | -148.842813 |
| Unnamed Tributary 173.8 | 173.8 | Spot | 2014 | 62.767920 | -148.857384 |
| Portage Creek | 152.3 | Continuous | 2014-2015 | 62.833177 | -149.378048 |
| Unnamed Tributary 144.6 | 144.6 | Spot | 2013, 2014 | 62.803980 | -149.591350 |
| Indian River | 142.1 | Continuous | 2013-2015 | 62.800881 | -149.664233 |
| Gold Creek | 140.1 | Continuous | 2014 | 62.762437 | -149.676828 |
| Skull Creek | 128.1 | Continuous with barologger | 2013-2014 | 62.657530 | -149.932540 |
| Unnamed Tributary 115.4 | 115.4 | Spot | 2013, 2014 | 62.508178 | -150.114503 |
| Gash Creek | 115 | Spot | 2013, 2014 | 62.504288 | -150.104018 |
| Slash Creek | 114.9 | Spot | 2013, 2014 | 62.503202 | -150.103737 |
| Unnamed Tributary 113.7 | 113.7 | Spot | 2013, 2014 | 62.486316 | -150.093785 |
| Whiskers Creek | 105.1 | Continuous with barologger | 2013-2014 | 62.378096 | -150.170806 |
| Trapper Creek | 95.4 | Continuous | 2013-2014 | 62.257540 | -150.172762 |
| Susitna River at Trapper Creek | 95.4 | Continuous stage only | 2013-2014 | 62.253622 | -150.168375 |
| Birch Creek | 93.3 | Continuous | 2013-2014 | 62.250468 | -150.089622 |
| Susitna River at Birch Creek Slough | 92.6 | Continuous stage only | 2013-2014 | 62.223373 | -150.116821 |
| Sheep Creek | 71.7 | Continuous | 2014-2015 | 61.996301 | -150.052516 |
| Susitna River at Sheep Creek | 68.3 | Continuous stage only | 2014-2015 | 61.979015 | -150.072249 |
| Caswell Creek | 67.3 | Spot | 2014, 2015 | 61.947736 | -150.056148 |
| Susitna River at Caswell Creek | 67.3 | Continuous stage only | 2014-2015 | 61.940156 | -150.081047 |
| Deshka River | 44.9 | Continuous with barologger | 2013-2014 | 61.754522 | -150.328552 |
| Susitna River at Deshka River | 44.9 | Continuous stage only | 2013-2014 | 61.696491 | -150.313659 |

**Table 4.4-1. Comparison of the content contained in the three versions of the hydraulic routing model. (Source: SIR Study 8.5, Appendix B, Table 1.)**

| Model Component | Version 1 | Version 2 | Version 2.8 | |
|---|---|---|---|---|
| Reach | NA | NA | Dam Site to Sunshine | Sunshine to Susitna Station |
| Extent | PRM 80-187.1 | PRM 29.9-187.1 | PRM 87.9-187.1 | PRM 29.9-87.9 |
| Number of Measured Cross-sections | 88 | 167 | 169 | 47 |
| WSE/Q Pairs | 120 | 387 | 194 Measured 204 Estimated | 13 Measured, 99 Estimated |
| Accretion | Hourly | Hourly | Hourly | Hourly |
| Diurnal Fluctuations | None | Measured where and when available, not estimated for missing gaps | Complete | Complete |
| Floodplain coverage | None | Extended using 2011 and 2013 LiDAR | Extended using 2011, 2013, and 2014 LiDAR | Extended using 2011 and 2013 LiDAR |
| Calibration/Validation Data | 6 gages<br>15291500<br>15291700<br>15292000<br>15292780<br>15292400<br>15292700 | 8 gages<br>15291500<br>15291700<br>15292000<br>15292780<br>15294350<br>15292400<br>15292700<br>15294345 | 8 gages<br>15291500<br>15291700<br>15292000<br>15292780<br>15294350<br>15292400<br>15292700<br>15294345 | 8 gages<br>15291500<br>15291700<br>15292000<br>15292780<br>15294350<br>15292400<br>15292700<br>15294345 |

**Table 4.4-2. Summary of 2012-2014 surface water data collected at selected ESS stations in the Susitna River. ESS = AEASusitnaSurface water measurements. Source: Modified ISR Study 8.5, Table 4.4-2.)**

| Station | PRM | Water Level Record Available | Water Temperature Record Available | Air Temperature Record Available | Camera Images | Land Access Granted | Studies Using Data |
|---|---|---|---|---|---|---|---|
| ESS80 | 225.0 | Complete | Complete | Complete | Yes | Yes | Engineering, Upper Basin DGGS, Glacier and Runoff Changes, Reservoir Modeling |
| ESS70 | 187.1 | Aug 2012 – Oct 2012<br>Aug 2014 – Nov 2014 | Aug 2012 – Oct 2012 | Complete | Yes | No | IFS, Ice Processes, Geomorphology, Water quality, Engineering, Upper Basin DGGS, Glacier and Runoff Changes, Groundwater |
| ESS65 | 176.5 | Oct 2012,<br>Jan – May 2013<br>Aug 2014 – Dec 2014 | Oct 2012,<br>Jan – May 2013 | Complete | Yes | No | IFS, Ice Processes, Geomorphology, Water Quality |
| ESS60 | 168.1 | Oct 2012 – May 2013 | Oct 2012 – May 2013 | Complete | Yes | No | IFS, Ice Processes, Geomorphology, Water Quality |
| ESS55 | 152.2 | Aug 2012 – May 2013 | Aug 2012 – May 2013 | Complete | Yes | No | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS50 | 124.1 | Aug 2013 – Oct 2012,<br>Aug 2013 – Dec 2013,<br>July 2014 – Dec 2014 | Aug – Oct 2012,<br>Aug – Dec 2013 | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS45 | 116.6 | Aug 2012 – May 2013,<br>Aug 2013– Dec 2013,<br>Aug 2014 – Dec 2014 | Aug 2012 – May 2013,<br>Aug – Dec 2013 | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS40 | 107.2 | Aug 2012 – May 2013,<br>Aug 2013 – Dec 2013,<br>Aug 2014 – Dc 2014 | Aug 2012 – May 2013,<br>Aug-Dec 2013 | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS35 | 102.1 | Aug 2012 – May 2013 | Aug 2012 – May 2013 | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS30 | 98.4 | Complete | Complete | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS20 | 29.9 | Sep 2012 – Dec 2013 | Complete | Complete | Yes | Yes | IFS, Ice Processes, Geomorphology, Water Quality, Groundwater |
| ESS15 | 24.7 | Complete | Complete | Complete | Yes | Yes | Ice Processes, Beluga |
| ESS10 | 17.4 | Aug 2012 – Oct 2012;<br>Oct 2013 – Dec 2013,<br>May 2014 – Dec 2014 | Aug – Oct 2012;<br>Oct – Dec 2013 | Complete | Yes | Yes | Ice Processes, Beluga |

**Table 5-1. Cumulative data files containing QC3'd data (as of October 2015) for Instream Flow Study 8.5 available on the Geographic Information Network of Alaska (GINA) at http://gis.suhydro.org/SIR/08-Instream_Flow/8.5-Fish_and_Aquatics_Instream_Flow/.**

| Component[1] | Data File Name | Description |
|---|---|---|
| Appendix A | SIR_8_5_IFS_2013-WinterStage-FA104-128_20151030.xlsx | Continuous water level data recorded in FA-104 and FA-128 during February-April 2013 |
| Appendix A | SIR_8_5_IFS_2013-WinterTemperature-FA104_20151030.xlsx | Continuous surface and intergravel water temperature data during February-April 2013 |
| Appendix A | SIR_8_5_IFS_2014-WinterStage-FA104_20151030.xlsx | Continuous water level data in representative habitats (i.e., main channel, side channel, side slough, upland slough and tributary) within FA-104 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_2014-WinterStage-FA128_20151030.xlsx | Continuous water level data in representative habitats (i.e., main channel, side channel, side slough, upland slough and tributary) within FA-128 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_2014-WinterStage-FA138_20151030.xlsx | Continuous water level data in representative habitats (i.e., main channel, side channel, side slough and upland slough) within FA-138 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_2014-WinterTemperature-FA104_20151030.xlsx | Continuous water temperature data in FA-104 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_2014-WinterTemperature-FA128_20151030.xlsx | Continuous water temperature data in FA-128 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_2014-WinterTemperature-FA138_20151030.xlsx | Continuous water temperature data in representative habitats (i.e., main channel, side channel, side slough and upland slough) within FA-138 during winter 2013-2014 |
| Appendix A | SIR_8_5_IFS_InstantaneousWQ_20151030.xlsx | Instantaneous water quality data recorded during 2012-2013, 2013-2014, and 2014-2015 IFS winter studies |
| Appendix A | SIR_8_5_IFS_IntergravelDO-FA128-138_20151030.xlsx | Continuous intergravel dissolved oxygen concentration recorded during 2012-2013 and 2013-2014 IFS winter studies |
| Appendix A | SIR_8_5_IFS_WinterStudies_GPS_20151030.xlsx | IFS winter studies spatial data |
| Appendix B | SIR_8_5_IFS_FocusAreaStageHydrographs_20151106.xlsx | Focus area pressure transducer data at upstream and downstream end of Focus Area |
| Appendix B | SIR_8_5_IFS_Gaging_SusitnaTributaryGagingHourlyRecords2013-2014_20151106.xlsx | Tributary gage coordinate location, measured stage data, and calculated hourly flow |
| Appendix B | SIR_8_5_IFS_ILF-1 Daily Reservoir Elevation Data_20151106.xlsx | ILF-1 scenario (data provided by MWH for 61 years) |
| Appendix B | SIR_8_5_IFS_ILF-1 Hourly Reservoir Outflow Data_20151106.xlsx | ILF-1 scenario (data provided by MWH for 61 years) |
| Appendix B | SIR_8_5_IFS_MainstemCrossSectionData_Q&WSE_20151106.xlsx | Measured Q/WSE data by transect for data collected in 2012-2014 |
| Appendix B | SIR_8_5_IFS_MSHydrology_Susitna Flows at Dam Site (PRM187.2)_20151106.zip | Mainstem hydrology, 62 files total, 61 files of the hourly streamflow of existing conditions at the dam site by year, 1 file of the daily flow at the dam site under existing conditions |
| Appendix B | SIR_8_5_IFS_OWFRM_CrossSectionAlignments_20151106.shp | GIS file of OWFRM cross-section alignments |

| Component[1] | Data File Name | Description |
|---|---|---|
| Appendix B | SIR_8_5_IFS_TribHydrology_Metadata_20151106.xlsx | Metadata for the tributary hydrology text files |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM100.3-95.4_20151106.zip | Tributary hydrology, 62 files total, 61 files of the hourly accretion by year for the subbasin identified, 1 file of the total daily accretion for the subbasin identified |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM100.3Talkeetna_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM102.5-100.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM102.5Chulitna_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM105.1-102.5_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM105.1WhiskersCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM128.1-105.1_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM128.1SkullCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM140.0-128.1_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM140.1-140.0_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM140.1GoldCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM142.1-140.1_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM142.1IndianRiver_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM152.3-142.1_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM152.3PortageCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM155.9-152.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM155.9CheechakoCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM160.5-155.9_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM160.5ChinookCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM164.8-160.5_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM164.8DevilCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM179.3-164.8_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM179.3FogCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM184.6TsusenaCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM187.2-184.6_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM31.4-29.9_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM31.4YentnaRiver_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM43.3-31.4_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM43.3RollyCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM44.9-43.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM44.9DeshkaRiver_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM52.1-44.9_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM52.1WillowCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM54.5-52.1_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM54.5LittleWillowCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM63.4-197.5MileCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM63.4-54.5_20151106.zip | |

| Component[1] | Data File Name | Description |
|---|---|---|
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM64.7-63.4_20151106.zip | Tributary hydrology, 62 files total, 61 files of the hourly accretion by year for the subbasin identified, 1 file of the total daily accretion for the subbasin identified |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM64.7KashwitnaRiver_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM67.3-64.7_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM67.3CaswellCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM71.7-67.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM71.7SheepCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM76.8-71.7_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM76.8GooseCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM81.0-76.8_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM81.0MontanaCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM87.2-81.0_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM87.2RabideuxCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM87.9-87.2_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM88.0-87.9_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM88.0SunshineCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM93.3-88.0_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM93.3BirchCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM95.4-93.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRM95.4TrapperCreek_20151106.zip | |
| Appendix B | SIR_8_5_IFS_TribHydrology_PRMPRM184.6-179.3_20151106.zip | |
| Appendix B | SIR_8_5_IFS_USGS15291700_2012-2015_20151106.txt | 15-minute data for the available data from 2012-2015 at USGS gage 15291700 (data provided by USGS) |
| Appendix B | SIR_8_5_IFS_USGS15292000_2012-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_USGS15292400_2012-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_USGS15292700_2012-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_USGS15292780_2012-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_USGS15294345_2012-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_USGS15294350_2013-2015_20151106.txt | |
| Appendix B | SIR_8_5_IFS_V2.8OWFRM_20151106.zip | OWFRM HEC-RAS model and input DSS files (13 files) |
| Appendix B | SIR_8_5_IFS_WinterGaging_QMeasurementSummaryTable_Jun2014ISR_20151106.xlsx | 2014 mainstem and tributary winter gaging measurements reported in the June 2014 ISR |
| Appendix B | SIR_8_5_IFS_WinterGaging_SusitnaMainstem_IceCrossSections_Jan2014_20151106.pdf | January 2014 winter gaging mainstem ice cross sections |
| Appendix B | SIR_8_5_IFS_WinterGaging_SusitnaMainstem_IceCrossSections_Mar2014_20151106.pdf | March 2014 winter gaging mainstem ice cross sections |
| Appendix D | SIR_8_5_IFS_HSC_Database2013-2014_20151030.xlsx | HSC/HSI fish utilization and availability data 2013-2014 |
| Appendix E | SIR_8_5_IFS_Cover_20151106.shp | GIS file of fish habitat model cover polygons |
| Appendix E | SIR_8_5_IFS_SalmonSpawning_20151106.shp | GIS file of salmon spawning areas |
| Appendix E | SIR_8_5_IFS_SalmonSpawning1980s_20151106.shp | GIS file of 1980s salmon spawning areas |

| Component[1] | Data File Name | Description |
|---|---|---|
| Appendix E | SIR_8_5_IFS_Substrate_20151106.shp | GIS file of fish habitat model surficial substrate polygons |

Notes:

Appendix A: 2014 Instream Flow Winter Studies.

Appendix B: Open-water Hydrology Data Collection and Open-water Flow Routing Model (Version 2.8).

Appendix D: Habitat Suitability Criteria Development.

Appendix E: Fish Habitat Modeling Data: Surficial Substrate and Cover Characterization and Salmon Spawning Observations by Focus Area.

**Table 5.3-1. Mainstem Transect Data Summary Table. (Source: SIR Study 8.5, Appendix B, Table 3.)**

UPPER RIVER (PRM 261.3 - 187.1)

| Project River | XS Profile | XS Profile | June/July 2012 | | | | | August 2012 | | | | | September/October 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | /Bathy Date | /Bathy Date 2 | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
| 225.0 | NA | | 6/14/2012 | 17:57 | 26,900 | Good | NA | 8/9/2012 | 15:03 | 11,300 | Excellent | NA | 10/18/2012 | NA | WSE only[5] | | 1906.26 |
| 187.2 | 6/17/2012 | | 6/17/2012 | 16:30 | 27,700 | Poor | 1466.42 | 8/6/2012 | 16:13 | 14,700 | Good | 1464.09 | 9/15/2012 | 13:17 | 7,840 | Good | 1461.81 |

| Project River | June/July 2013 | | | | | August 2013 | | | | | September/October 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 225.0 | | | | | | 8/8/2013 | 15:05 | 11,900 | Excellent | NA | 9/3/2013 | 13:32 | 14,700 | Good | NA |
| 187.2 | | | | | | | | | | | | | | | |

| Project River | June/July 2014 | | | | | August 2014 | | | | | September 2014 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 225.0 | 6/17/2014 | 13:40 | 14,400 | Fair | NA | | | | | | | | | | |
| 187.2 | 6/19/2014 | 15:14 | 20,300 | Fair | 1465.63 | | | | | | | | | | |

MIDDLE RIVER (PRM 187.1 - 102.4)

| Project River | XS Profile | XS Profile | June/July 2012 | | | | | August 2012 | | | | | September/October 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | /Bathy Date | /Bathy Date 2 | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
| **186.6** | 6/17/2014 | | | | | | | | | | | | | | | | |
| 186.2 | 6/18/2012 | | 6/18/2012 | 14:13 | 24,500 | Good | 1458.50 | 8/6/2012 | 17:05 | 14,400 | Good | 1457.07 | 9/15/2012 | 14:05 | 7,630 | Excellent | 1455.36 |
| 185.5 | 6/18/2012 | | 6/18/2012 | 16:10 | 25,400 | Good | 1452.14 | 8/6/2012 | 17:17 | WSE only[5] | | 1450.52 | 9/15/2012 | 14:28 | WSE only[5] | | 1449.17 |
| 185.2 | 6/19/2012 | | 6/19/2012 | 13:00 | 26,700 | Good | 1449.28 | 8/6/2012 | 17:43 | WSE only[5] | | 1447.37 | 9/15/2012 | 14:57 | WSE only[5] | | 1445.92 |
| 184.9 | 6/19/2012 | | 6/19/2012 | 15:49 | 27,600 | Good | 1446.04 | 8/6/2012 | 18:24 | 14,200 | Excellent | 1443.72 | 9/15/2012 | 14:57 | 7,710 | Excellent | 1442.10 |
| **184.7** | 6/18/2014 | | | | | | | | | | | | | | | | |
| 184.4 | 6/19/2012 | | 6/19/2012 | 16:51 | 27,900 | Fair | 1440.48 | 8/7/2012 | 12:38 | 14,800 | Good | 1437.43 | 9/15/2012 | 15:52 | 8,350 | Good | 1435.55 |
| **183.8** | 6/18/2014 | | | | | | | | | | | | | | | | |
| 183.3 | 6/20/2012 | | 6/20/2012 | 13:19 | 29,400 | Fair | 1424.86 | 8/7/2012 | 13:35 | 14,200 | Excellent | 1422.91 | 9/15/2012 | 16:41 | 8,310 | Excellent | 1421.75 |
| 182.9 | 6/20/2012 | | 6/20/2012 | 16:01 | 29,200 | Good | 1418.25 | 8/7/2012 | 13:40 | WSE only[5] | | 1416.49 | 9/15/2012 | 17:10 | WSE only[5] | | 1415.30 |
| **182.2** | 6/18/2014 | | | | | | | | | | | | | | | | |
| 181.6 | 6/20/2012 | | 6/20/2012 | 17:56 | 29,600 | Excellent | 1402.27 | 8/7/2012 | 14:44 | 14,700 | Good | 1400.11 | 9/15/2012 | 17:55 | 8,690 | Good | 1398.98 |
| **180.7** | 6/18/2014 | | | | | | | | | | | | | | | | |
| **180.1** | 6/19/2014 | | | | | | | | | | | | | | | | |
| 179.5 | 6/21/2012 | | 6/21/2012 | 12:28 | 30,900 | Fair | 1381.40 | 8/7/2012 | 15:41 | 14,300 | Excellent | 1377.74 | 9/14/2012 | 17:05 | 8,360 | Good | 1375.79 |
| **179.0** | 6/19/2014 | | | | | | | | | | | | | | | | |
| 178.5 | 6/16/2012 | | 6/16/2012 | 18:35 | 29,800 | Good | 1370.75 | 8/7/2012 | 16:37 | 14,800 | Excellent | 1367.82 | 9/14/2012 | 17:47 | 8,740 | Good | 1366.14 |
| **177.8** | 6/19/2014 | | | | | | | | | | | | | | | | |
| **177.3** | 6/19/2014 | | | | | | | | | | | | | | | | |
| 176.5 | 6/21/2012 | | 6/21/2012 | 14:40 | 31,200 | Excellent | 1346.56 | 8/8/2012 | 12:07 | 14,600 | Excellent | 1344.03 | 9/16/2012 | 14:50 | 10,800 | Excellent | 1343.18 |
| **175.9** | 6/19/2014 | | | | | | | | | | | | | | | | |
| 174.9 | 6/21/2012 | | 6/21/2012 | 16:12 | 31,200 | Good | 1329.91 | 8/8/2012 | 13:22 | WSE only[5] | | 1327.53 | 9/16/2012 | 16:00 | WSE only[5] | | 1326.88 |
| **173.5** | 6/20/2014 | | | | | | | | | | | | | | | | |
| **173.4** | 6/20/2014 | | | | | | | | | | | | | | | | |
| 173.1 | 6/21/2012 | | 6/21/2012 | 17:39 | 30,600 | Good | 1310.65 | 8/8/2012 | 14:28 | WSE only[5] | | 1307.89 | 9/16/2012 | 16:29 | 11,100 | Excellent | 1306.82 |
| **172.3** | 6/20/2014 | | | | | | | | | | | | | | | | |
| **171.6** | 6/20/2014 | | | | | | | | | | | | | | | | |
| **170.8** | 6/20/2014 | | | | | | | | | | | | | | | | |
| 170.1 | 6/22/2012 | | 6/22/2012 | 12:56 | 31,100 | Good | 1285.05 | 8/8/2012 | 15:16 | 14,600 | Excellent | 1282.38 | 9/16/2012 | 17:33 | 11,100 | Excellent | 1281.59 |
| **169.6** | 6/21/2014 | | | | | | | | | | | | | | | | |
| **168.8** | 6/21/2014 | | | | | | | | | | | | | | | | |
| 168.1 | 6/22/2012 | | 6/22/2012 | 14:33 | 32,300 | Good | 1259.50 | 8/8/2012 | 16:03 | 14,700 | Excellent | 1256.43 | 9/17/2012 | 15:19 | 14,600 | Good | 1256.46 |
| **167.4** | 6/21/2014 | | | | | | | | | | | | | | | | |
| **166.3** | 6/21/2014 | | | | | | | | | | | | | | | | |
| 153.7 | 6/25/2012 | | 6/25/2012 | 17:15 | 32,200 | Good | 862.57 | 8/10/2012 | 15:03 | 14,600 | Excellent | 858.93 | | | | | |
| **153.3** | 6/27/2014, 7/6/2014 | | | | | | | | | | | | | | | | |
| 152.9 | 6/26/2012 | | 6/26/2012 | 13:43 | 30,500 | Fair | 853.72 | 8/10/2012 | 15:14 | WSE only[5] | | 850.17 | | | | | |
| 152.1 | 6/26/2012 | 9/29/2012 | 6/26/2012 | 15:38 | 30,000 | Good | 843.65 | 8/10/2012 | 16:07 | 15,400 | Good | 840.96 | 9/29/2012 | 15:20 | 18,500 | Good | 841.61 |
| **151.8** | 6/27/2014 | | | | | | | | | | | | | | | | |
| **151.5** | 6/27/2014 | | | | | | | | | | | | | | | | |
| 151.1 | 6/25/2012 | | 6/25/2012 | 14:00 | 33,200 | Good | 832.09 | 8/10/2012 | 17:32 | WSE only[5] | | 827.79 | 9/29/2012 | 15:59 | WSE only[5] | | 829.13 |
| **150.6** | 6/28/2014 | | | | | | | | | | | | | | | | |
| **150.1** | 6/28/2014 | | | | | | | | | | | | | | | | |
| **149.3** | 6/28/2014 | | | | | | | | | | | | | | | | |
| **148.8** | 6/28/2014 | | | | | | | | | | | | | | | | |
| 148.3 | 6/26/2012 | | 6/26/2012 | 18:24 | 32,100 | Good | 796.39 | 8/10/2012 | 18:03 | 14,900 | Excellent | 793.54 | 9/29/2012 | NA | WSE only[5] | | 794.00 |
| **147.9** | 6/28/2014 | | | | | | | | | | | | | | | | |
| **147.5** | 6/28/2014 | | | | | | | | | | | | | | | | |
| **147.0** | 6/29/2014 | | | | | | | | | | | | | | | | |
| 146.6 | 6/27/2012 | | 6/27/2012 | 12:24 | 31,000 | Fair | 773.49 | 8/12/2012 | 12:54 | WSE only[5] | | 771.94 | 9/29/2012 | 16:36 | WSE only[5] | | 772.02 |
| 146.1 | 8/3/2013 | | | | | | | | | | | | | | | | |
| 145.7 | 6/27/2012 | 9/29/2012 | 6/27/2012 | 13:51 | 31,400 | Fair | 761.96 | 8/12/2012 | 13:12 | 17,400 | Excellent | 759.65 | 9/29/2012 | 16:51 | 18,100 | Good | 759.86 |
| 145.5 | 6/27/2012 | | 6/27/2012 | 14:40 | 31,900 | Fair | 760.04 | 8/12/2012 | 13:53 | WSE only[5] | | 757.93 | | | | | |
| 144.9 | 6/27/2012 | | 6/27/2012 | 17:01 | 31,900 | Fair | 751.50 | 8/12/2012 | 14:11 | WSE only[5] | | 749.46 | 9/29/2012 | 17:15 | WSE only[5] | | 749.80 |
| 144.3 | 6/27/2012 | | 6/27/2012 | 18:50 | 31,100 | Good | 742.52 | 8/12/2012 | 14:32 | WSE only[5] | | 740.68 | | | | | |
| 143.9 | 8/3/2013 | | | | | | | | | | | | | | | | |
| 143.5 | 6/28/2012 | | 6/28/2012 | 12:17 | 30,300 | Excellent | 732.35 | 8/12/2012 | 14:58 | 17,000 | Excellent | 730.64 | 9/29/2012 | 17:26 | WSE only[5] | | 730.72 |
| 143.0 | 6/28/2012 | | 6/28/2012 | 13:53 | 29,500 | Good | 725.04 | 8/12/2012 | 15:40 | WSE only[5] | | 723.49 | | | | | |
| 142.2 | 6/28/2012 | 9/29/2012 | 6/28/2012 | 15:15 | 29,800 | Good | 716.41 | 8/12/2012 | 16:29 | 16,800 | Excellent | 714.51 | 9/29/2012 | 17:45 | 18,300 | Excellent | 714.78 |

| Project River | June/July 2013 | | | | | August 2013 | | | | | September/October 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| **186.6** | | | | | | | | | | | | | | | |
| 186.2 | | | | | | | | | | | | | | | |
| 185.5 | | | | | | | | | | | | | | | |
| 185.2 | | | | | | | | | | | | | | | |
| 184.9 | | | | | | | | | | | | | | | |
| **184.7** | | | | | | | | | | | | | | | |
| 184.4 | | | | | | | | | | | | | | | |
| **183.8** | | | | | | | | | | | | | | | |
| 183.3 | | | | | | | | | | | | | | | |
| 182.9 | | | | | | | | | | | | | | | |
| **182.2** | | | | | | | | | | | | | | | |
| 181.6 | | | | | | | | | | | | | | | |
| **180.7** | | | | | | | | | | | | | | | |
| **180.1** | | | | | | | | | | | | | | | |
| 179.5 | | | | | | | | | | | | | | | |
| **179.0** | | | | | | | | | | | | | | | |
| 178.5 | | | | | | | | | | | | | | | |
| **177.8** | | | | | | | | | | | | | | | |
| **177.3** | | | | | | | | | | | | | | | |
| 176.5 | | | | | | | | | | | | | | | |
| **175.9** | | | | | | | | | | | | | | | |
| 174.9 | | | | | | | | | | | | | | | |
| **173.5** | | | | | | | | | | | | | | | |
| **173.4** | | | | | | | | | | | | | | | |
| 173.1 | | | | | | | | | | | | | | | |
| **172.3** | | | | | | | | | | | | | | | |
| **171.6** | | | | | | | | | | | | | | | |
| **170.8** | | | | | | | | | | | | | | | |
| 170.1 | | | | | | | | | | | | | | | |
| **169.6** | | | | | | | | | | | | | | | |
| **168.8** | | | | | | | | | | | | | | | |
| 168.1 | | | | | | | | | | | | | | | |
| **167.4** | | | | | | | | | | | | | | | |
| **166.3** | | | | | | | | | | | | | | | |
| 153.7 | | | | | | | | | | | | | | | |
| **153.3** | | | | | | | | | | | | | | | |
| 152.9 | | | | | | | | | | | | | | | |
| 152.1 | | | | | | | | | | | | | | | |
| **151.8** | | | | | | | | | | | | | | | |
| **151.5** | | | | | | | | | | | | | | | |
| 151.1 | | | | | | | | | | | | | | | |
| **150.6** | | | | | | | | | | | | | | | |
| **150.1** | | | | | | | | | | | | | | | |
| **149.3** | | | | | | | | | | | | | | | |
| **148.8** | | | | | | | | | | | | | | | |
| 148.3 | | | | | | | | | | | | | | | |
| **147.9** | | | | | | | | | | | | | | | |
| **147.5** | | | | | | | | | | | | | | | |
| **147.0** | | | | | | | | | | | | | | | |
| 146.6 | | | | | | | | | | | | | | | |
| 146.1 | | | | | | 8/3/2013 | 12:30 | WSE only[5] | | 766.45 | 9/5/2013 | 13:09 | WSE only[5] | | 767.62 |
| 145.7 | 6/20/2013 | 14:42 | WSE only[5] | | 761.43 | | | | | | 9/7/2013 | 13:18 | WSE only[5] | | 760.93 |
| 145.5 | 6/20/2013 | 12:10 | WSE only[5] | | 758.22 | 8/3/2013 | 9:38 | WSE only[5] | | 758.57 | 9/5/2013 | 13:33 | WSE only[5] | | 760.03 |
| 144.9 | 6/20/2013 | 16:12 | WSE only[5] | | 751.24 | | | | | | | | | | |
| 144.3 | | | | | | 8/3/2013<br>8/15/2013 | 16:25<br>15:28 | WSE only[5]<br>WSE only[5] | | 740.93<br>740.77 | 9/5/2013 | 9:21 | WSE only[5] | | 742.36 |
| 143.9 | | | | | | 8/3/2013 | 15:44 | WSE only[5] | | 736.31 | 9/5/2013 | 14:16 | WSE only[5] | | 737.47 |
| 143.5 | 7/30/2013 | 16:16 | WSE only[5] | | 730.63 | | | | | | | | | | |
| 143.0 | 6/23/2013 | 14:30 | WSE only[5] | | 725.33 | 8/4/2013 | 14:34 | WSE only[5] | | 725.07 | 9/5/2013 | 15:16 | WSE only[5] | | 726.11 |
| 142.2 | | | | | | | | | | | 9/8/2013 | 14:53 | WSE only[5] | | 716.21 |

| Project River | June/July 2014 | | | | | August 2014 | | | | | September 2014 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| **186.6** | 6/17/2014<br>6/19/2014 | 17:41<br>16:29 | WSE only[5]<br>20,700 | <br>Poor | 1460.50<br>1460.74 | | | | | | | | | | |
| 186.2 | | | | | | | | | | | | | | | |
| 185.5 | | | | | | | | | | | | | | | |
| 185.2 | | | | | | | | | | | | | | | |
| 184.9 | | | | | | 8/14/2014 | 14:32 | 14,500 | Good | NA | 9/12/2014<br>9/26/2014 | 15:22<br>14:48 | 12,800<br>9,600 | Good<br>Good | NA<br>NA |
| **184.7** | 6/18/2014<br>6/20/2014 | 12:35<br>11:23 | WSE only[5]<br>19,300 | <br>Good | 1441.86<br>1442.10 | 8/16/2014 | 16:31 | 16,400 | Good | 1441.16 | 9/13/2014 | 11:36 | 12,300 | Good | 1440.09 |
| 184.4 | | | | | | | | | | | | | | | |
| **183.8** | 6/18/2014 | 13:27 | WSE only[5] | | 1429.84 | | | | | | | | | | |
| 183.3 | | | | | | | | | | | | | | | |
| 182.9 | | | | | | | | | | | | | | | |
| **182.2** | 6/18/2014 | 14:19 | WSE only[5] | | 1408.89 | | | | | | | | | | |
| 181.6 | | | | | | | | | | | | | | | |
| **180.7** | 6/18/2014 | 19:11 | WSE only[5] | | 1390.70 | | | | | | 9/13/2014 | 13:30 | 13,100 | Good | 1389.73 |
| **180.1** | 6/19/2014 | 13:43 | WSE only[5] | | 1385.28 | | | | | | | | | | |
| 179.5 | | | | | | | | | | | | | | | |
| **179.0** | 6/19/2014 | 15:04 | WSE only[5] | | 1375.23 | | | | | | | | | | |
| 178.5 | | | | | | | | | | | | | | | |
| **177.8** | 6/19/2014 | 16:37 | WSE only[5] | | 1361.73 | | | | | | | | | | |
| **177.3** | 6/19/2014 | 17:30 | WSE only[5] | | 1354.38 | | | | | | 9/13/2014 | 14:59 | 13,500 | Good | 1352.73 |
| 176.5 | 6/20/2014 | 14:07 | 21,600 | Good | 1345.20 | 8/17/2014 | 11:10 | 18,700 | Good | 1344.69 | | | | | |
| **175.9** | 6/19/2014 | 18:07 | WSE only[5] | | 1339.06 | | | | | | | | | | |
| 174.9 | | | | | | | | | | | | | | | |
| **173.5** | 6/20/2014 | 15:28 | 21,700 | Good | 1314.04 | 8/17/2014 | 12:25 | 18,200 | Good | 1313.89 | 9/14/2014 | 12:03 | 14,500 | Good | 1313.13 |
| **173.4** | 6/20/2014 | 13:43 | WSE only[5] | | 1312.93 | | | | | | | | | | |
| 173.1 | | | | | | | | | | | | | | | |
| **172.3** | 6/20/2014 | 14:38 | WSE only[5] | | 1302.63 | | | | | | | | | | |
| **171.6** | 6/20/2014 | 15:26 | WSE only[5] | | 1296.50 | | | | | | | | | | |
| **170.8** | 6/20/2014 | 16:22 | WSE only[5] | | 1289.03 | | | | | | | | | | |
| 170.1 | | | | | | | | | | | | | | | |
| **169.6** | 6/21/2014 | 11:53 | WSE only[5] | | 1277.73 | | | | | | | | | | |
| **168.8** | 6/21/2014 | 13:29 | WSE only[5] | | 1266.24 | | | | | | 9/14/2014 | 13:28 | 14,400 | Good | 1264.47 |
| 168.1 | | | | | | | | | | | | | | | |
| **167.4** | 6/21/2014 | 14:47 | WSE only[5] | | 1250.43 | | | | | | | | | | |
| **166.3** | 6/21/2014 | 17:01 | WSE only[5] | | 1239.72 | | | | | | | | | | |
| 153.7 | | | | | | | | | | | | | | | |
| **153.3** | 6/27/2014 | 12:54 | WSE only[5] | | 859.93 | | | | | | | | | | |
| 152.9 | | | | | | | | | | | | | | | |
| 152.1 | 6/22/2014<br>7/6/2014 | 13:36<br>14:21 | 24,600<br>28,500 | Good<br>Good | 842.35<br>NA | | | | | | | | | | |
| **151.8** | 6/23/2014<br>6/27/2014 | 13:22<br>15:58 | 21,700<br>WSE only[5] | Good<br> | 837.35<br>839.99 | 8/12/2014 | 17:29 | 16,400 | Good | 836.59 | 9/16/2014 | 11:20 | 19,000 | Good | 837.08 |
| **151.5** | 6/27/2014 | 16:26 | WSE only[5] | | 836.57 | | | | | | | | | | |
| 151.1 | | | | | | | | | | | | | | | |
| **150.6** | 6/28/2014 | 12:25 | WSE only[5] | | 825.07 | | | | | | | | | | |
| **150.1** | 6/28/2014 | 14:14 | WSE only[5] | | 818.17 | | | | | | 9/16/2014 | 13:14 | 19,200 | Good | 816.87 |
| **149.3** | 6/28/2014 | 15:08 | WSE only[5] | | 807.59 | | | | | | | | | | |
| **148.8** | 6/28/2014 | 15:39 | WSE only[5] | | 803.19 | | | | | | | | | | |
| 148.3 | | | | | | | | | | | | | | | |
| **147.9** | 6/28/2014 | 16:55 | WSE only[5] | | 793.65 | | | | | | | | | | |
| **147.5** | 6/28/2014 | 17:20 | WSE only[5] | | 787.27 | | | | | | 9/16/2014 | 15:13 | 19,200 | Good [4] | 786.39 |
| **147.0** | 6/29/2014 | 11:04 | WSE only[5] | | 777.88 | | | | | | | | | | |
| 146.6 | | | | | | | | | | | | | | | |
| 146.1 | | | | | | | | | | | | | | | |
| 145.7 | | | | | | | | | | | | | | | |
| 145.5 | | | | | | | | | | | | | | | |
| 144.9 | | | | | | | | | | | | | | | |
| 144.3 | | | | | | 8/13/2014 | 13:12 | 17,100 | Good [4] | 740.43 | | | | | |
| 143.9 | | | | | | | | | | | | | | | |
| 143.5 | | | | | | | | | | | | | | | |
| 143.0 | | | | | | | | | | | | | | | |
| 142.2 | | | | | | | | | | | | | | | |

MIDDLE RIVER (PRM 187.1 - 102.4)

| Project River Mile (PRM) | XS Profile /Bathy Date | XS Profile /Bathy Date 2 | June/July 2012 | | | | | August 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
| 141.9 | 6/28/2012 | | 6/28/2012 | 16:27 | 30,600 | Good | 712.88 | 8/12/2012 | 17:13 | 16,800 | Excellent | 710.84 |
| 141.7 | 6/28/2012 | | 6/28/2012 | 17:41 | 30,600 | Excellent | 711.43 | 8/12/2012 | 17:13 | WSE only[5] | | 709.09 |
| **141.4** | 6/29/2014 | | | | | | | | | | | |
| 141.2 | 8/4/2013 | | | | | | | | | | | |
| 140.8 | 8/4/2013 | | | | | | | | | | | |
| 140.5 | 8/5/2013 | | | | | | | | | | | |
| **140.2** | 6/30/2014 | | | | | | | | | | | |
| 140.0 | 6/29/2012 | 9/30/2012 | 6/29/2012 | 14:48 | 30,400 | Excellent | 693.77 | 8/13/2012 | 12:54 | 16,400 | Excellent | 691.69 |
| 139.8 | 6/29/2012 | | 6/29/2012 | 16:21 | 29,100 | Excellent | 691.34 | 8/13/2012 | 13:10 | WSE only[5] | | 689.07 |
| 139.0 | 6/30/2012 | | 6/30/2012 | 13:56 | 28,000 | Good | 679.92 | 8/13/2012 | 13:58 | 16,400 | Good | 678.26 |
| 138.7 | 6/30/2012 | | 6/30/2012 | 14:51 | 28,200 | Excellent | 678.08 | 8/13/2012 | 14:48 | 16,300 | Excellent | 677.07 |
| 138.4 | 8/5/2013 | | | | | | | | | | | |
| 138.1 | 6/30/2012 | | 6/30/2012 | 16:33 | 28,200 | Good | 670.43 | 8/13/2012 | 15:07 | WSE only[5] | | 669.00 |
| **137.7** | 6/25/2014 | | | | | | | | | | | |
| 137.6 | 6/30/2012 | 9/30/2012 | 6/30/2012 | 18:13 | 27,900 | Good | 664.17 | 8/13/2012 | 16:14 | 16,400 | Excellent | 662.67 |
| 137.2 | 8/5/2013 | | | | | | | | | | | |
| **136.8** | 6/25/2014 | | | | | | | | | | | |
| 136.7 | 7/1/2012 | | 7/1/2012 | 13:35 | 26,800 | Good | 654.82 | 8/13/2012 | 16:34 | WSE only[5] | | 653.46 |
| 136.2 | 7/1/2012 | | 7/1/2012 | 16:06 | 26,900 | Good | 648.86 | 8/13/2012 | 17:06 | WSE only[5] | | 648.12 |
| 135.6 | 8/6/2013 | | | | | | | | | | | |
| **135.4** | 6/30/2014 | | | | | | | | | | | |
| **135.2** | 6/30/14, 7/1/14 | | | | | | | | | | | |
| 135.0 | 7/1/2012 | | 7/1/2012 | 18:33 | 26,500 | Excellent | 634.86 | 8/13/2012 | 17:41 | 15,600 | Excellent | 632.97 |
| 134.7 | 8/6/2013 | | | | | | | | | | | |
| 134.3 | 7/2/2012 | 10/1/2012 | 7/2/2012 | 12:16 | 25,500 | Good | 627.51 | 8/13/2012 | 18:21 | WSE only[5] | | 625.41 |
| 134.1 | 7/2/2012 | | 7/2/2012 | 13:18 | 26,200 | Good | 625.74 | 8/14/2012 | 13:14 | 16,500 | Excellent | 624.10 |
| 133.8 | 7/2/2012 | | 7/2/2012 | 14:30 | 25,700 | Good | 623.51 | 8/14/2012 | 14:05 | 16,300 | Excellent | 622.22 |
| 133.3 | 7/2/2012 | | 7/2/2012 | 16:22 | 25,700 | Excellent | 618.46 | 8/14/2012 | 14:41 | WSE only[5] | | 617.34 |
| 132.6 | 7/2/2012 | | 7/2/2012 | 17:57 | 25,000 | Excellent | 609.97 | 8/14/2012 | 15:17 | 16,000 | Good | 608.67 |
| 132.0 | 8/7/2013 | | | | | | | | | | | |
| 131.4 | 7/3/2012 | | 7/3/2012 | 15:27 | 28,600 | Good | 598.37 | 8/14/2012 | 16:05 | WSE only[5] | | 597.82 |
| 130.9 | 8/8/2013 | | | | | | | | | | | |
| 130.4 | 8/9/2013 | | | | | | | | | | | |
| **130.1** | 7/1/2014 | | | | | | | | | | | |
| 129.7 | 7/3/2012 | 10/1/2012 | 7/3/2012 | 17:33 | 28,200 | Good | 580.58 | 8/14/2012 | 17:00 | 16,300 | Excellent | 578.98 |
| 128.1 | 7/4/2012 | | 7/4/2012 | 15:40 | 26,700 | Good | 564.50 | 8/15/2012 | 12:50 | 15,900 | Excellent | 563.54 |
| 127.8 | 8/9/2013 | | | | | | | | | | | |
| **127.4** | 7/1/2014 | | | | | | | | | | | |
| 126.8 | 7/4/2012 | 10/1/2012 | 7/4/2012 | 17:22 | 27,600 | Excellent | 552.41 | 8/15/2012 | 13:40 | 16,100 | Excellent | 550.87 |
| 126.4 | 8/10/2013 | | | | | | | | | | | |
| 126.1 | 7/5/2012 | | 7/5/2012 | 14:24 | 27,200 | Good | 546.88 | 8/15/2012 | 13:41 | WSE only[5] | | 545.26 |
| **125.9** | 7/2/2014 | | | | | | | | | | | |
| 125.8 | 8/11/2013 | | | | | | | | | | | |
| 125.4 | 7/5/2012 | | 7/5/2012 | 16:38 | 26,400 | Excellent | 541.32 | 8/15/2012 | 14:12 | WSE only[5] | | 540.09 |
| 124.9 | 8/11/2013 | | | | | | | | | | | |
| **124.6** | 6/30/2014 | | | | | | | | | | | |
| 124.5 | 8/11/2013 | | | | | | | | | | | |
| 124.1 | 7/5/2012 | 10/1/2012 | 7/5/2012 | 18:11 | 26,100 | Good | 530.43 | 8/15/2012 | 14:27 | 16,200 | Excellent | 529.24 |
| **123.9** | 6/30/2014 | | | | | | | | | | | |
| 123.7 | 7/6/2012 | | 7/6/2012 | 12:18 | 23,900 | Excellent | 527.93 | 8/15/2012 | 15:54 | WSE only[5] | | 527.43 |
| 123.2 | 8/12/2013 | | | | | | | | | | | |
| 122.7 | 7/6/2012 | | 7/6/2012 | 14:23 | 23,300 | Excellent | 518.91 | 8/15/2012 | 17:15 | WSE only[5] | | 517.91 |
| 122.6 | 7/6/2012 | | 7/6/2012 | 15:59 | 22,900 | Good | 517.85 | 8/15/2012 | 16:13 | 16,300 | Excellent | 516.97 |
| 122.1 | 8/12/2013 | | | | | | | | | | | |
| 121.4 | 8/12/2013 | | | | | | | | | | | |
| 120.7 | 7/6/2012 | | 7/6/2012 | 17:19 | 22,700 | Good | 502.03 | 8/15/2012 | 17:27 | WSE only[5] | | 501.13 |
| 120.3 | 8/12/2013 | | | | | | | | | | | |
| 119.9 | 7/7/2012 | 10/3/2012 | 7/7/2012 | 12:19 | 20,700 | Excellent | 495.29 | 8/16/2012 | 12:54 | 16,000 | Excellent | 494.37 |
| **119.5** | 7/1/2014 | | | | | | | | | | | |
| 118.9 | 8/14/2013 | | | | | | | | | | | |
| 118.3 | 7/7/2012 | | 7/7/2012 | 14:06 | 20,700 | Excellent | 485.32 | 8/16/2012 | 13:04 | WSE only[5] | | 484.18 |
| **118.1** | 7/1/2014 | | | | | | | | | | | |
| 117.9 | 8/14/2013 | | | | | | | | | | | |
| 117.4 | 7/7/2012 | | 7/7/2012 | 16:15 | 20,700 | Excellent | 477.82 | 8/16/2012 | 13:39 | WSE only[5] | | 477.21 |
| 117.0 | 8/14/2013 | | | | | | | | | | | |

| Project River Mile (PRM) | September/October 2012 | | | | | June/July 2013 | | | | | August 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 141.9 | | | | | | 6/22/2013 | 17:50 | WSE only[5] | | 712.34 | 8/4/2013 | 15:21 | WSE only[5] | | 711.25 |
| 141.7 | | | | | | | | | | | 8/4/2013 | 15:44 | WSE only[5] | | 710.00 |
| **141.4** | | | | | | | | | | | | | | | |
| 141.2 | | | | | | | | | | | 8/4/2013 | 17:16 | WSE only[5] | | 703.48 |
| 140.8 | | | | | | | | | | | 8/4/2013 | 18:41 | WSE only[5] | | 700.72 |
| 140.5 | | | | | | | | | | | 8/5/2013 | 10:55 | WSE only[5] | | 696.94 |
| **140.2** | | | | | | | | | | | | | | | |
| 140.0 | 9/30/2012 | 13:56 | 17,600 | Good | 691.94 | | | | | | 8/5/2013 | 12:08 | WSE only[5] | | 692.12 |
| 139.8 | | | | | | | | | | | 8/5/2013<br>8/10/2013 | 12:30<br>15:03 | WSE only[5]<br>WSE only[5] | | 689.52<br>688.92 |
| 139.0 | 9/30/2012 | 14:26 | WSE only[5] | | 678.50 | 6/7/2013<br>6/25/2013<br>7/28/2013 | 11:39<br>11:11<br>14:59 | WSE only[5]<br>WSE only[5]<br>WSE only[5] | | 680.77<br>678.93<br>678.28 | 8/10/2013 | 15:40 | 15,900 | Excellent | 678.03 |
| 138.7 | | | | | | | | | | | 8/5/2013<br>8/10/2013 | 12:50<br>15:48 | WSE only[5]<br>WSE only[5] | | 677.46<br>677.06 |
| 138.4 | | | | | | | | | | | 8/5/2013 | 15:34 | WSE only[5] | | 673.21 |
| 138.1 | 9/30/2012 | 14:52 | WSE only[5] | | 669.36 | | | | | | 8/5/2013<br>8/10/2013 | 13:21<br>16:12 | WSE only[5]<br>WSE only[5] | | 669.70<br>669.46 |
| **137.7** | | | | | | | | | | | | | | | |
| 137.6 | 9/30/2012 | 15:00 | 17,400 | Excellent | 662.58 | | | | | | 8/10/2013 | 16:51 | 15,700 | Excellent | 662.13 |
| 137.2 | | | | | | | | | | | 8/5/2013 | 17:22 | WSE only[5] | | 658.44 |
| **136.8** | | | | | | | | | | | | | | | |
| 136.7 | | | | | | | | | | | 8/5/2013 | 17:54 | WSE only[5] | | 653.47 |
| 136.2 | | | | | | | | | | | 8/6/2013 | 11:24 | WSE only[5] | | 648.21 |
| 135.6 | | | | | | | | | | | 8/6/2013 | 12:54 | WSE only[5] | | 640.17 |
| **135.4** | | | | | | | | | | | | | | | |
| **135.2** | | | | | | | | | | | | | | | |
| 135.0 | | | | | | | | | | | 8/6/2013 | 13:39 | WSE only[5] | | 633.09 |
| 134.7 | | | | | | | | | | | 8/6/2013 | 15:31 | WSE only[5] | | 631.40 |
| 134.3 | 10/1/2012 | 13:40 | 15,600 | Excellent | 625.68 | | | | | | 8/6/2013 | 14:45 | WSE only[5] | | 625.99 |
| 134.1 | | | | | | | | | | | 8/7/2013 | 10:45 | WSE only[5] | | 623.64 |
| 133.8 | | | | | | | | | | | 8/7/2013 | 11:01 | WSE only[5] | | 622.05 |
| 133.3 | | | | | | | | | | | 8/7/2013 | 5:45 | WSE only[5] | | 618.23 |
| 132.6 | | | | | | | | | | | 8/7/2013 | 12:00 | WSE only[5] | | 608.61 |
| 132.0 | | | | | | | | | | | 8/7/2013 | 13:18 | WSE only[5] | | 601.78 |
| 131.4 | | | | | | | | | | | 8/7/2013 | 14:34 | WSE only[5] | | 597.89 |
| 130.9 | | | | | | | | | | | 8/8/2013 | 13:27 | WSE only[5] | | 592.37 |
| 130.4 | | | | | | | | | | | 8/9/2013 | 6:49 | WSE only[5] | | 585.67 |
| **130.1** | | | | | | | | | | | | | | | |
| 129.7 | 10/1/2012 | 16:16 | 15,700 | Excellent | 579.02 | 6/27/2013 | 11:38 | WSE only[5] | | 580.28 | | | | | |
| 128.1 | | | | | | | | | | | 8/9/2013 | 15:02 | WSE only[5] | | 562.69 |
| 127.8 | | | | | | | | | | | 8/9/2013 | 15:44 | WSE only[5] | | 560.66 |
| **127.4** | | | | | | | | | | | | | | | |
| 126.8 | 10/1/2012 | 17:02 | 15,600 | Excellent | 551.04 | 7/9/2013 | 13:24 | 23,100 | Good | 552.15 | 8/11/2013 | 12:26 | 16,200 | Excellent | 550.96 |
| 126.4 | | | | | | | | | | | 8/10/2013 | 13:58 | WSE only[5] | | 547.78 |
| 126.1 | | | | | | | | | | | 8/11/2013 | 12:48 | WSE only[5] | | 544.76 |
| **125.9** | | | | | | | | | | | | | | | |
| 125.8 | | | | | | | | | | | 8/11/2013 | 14:10 | WSE only[5] | | 543.45 |
| 125.4 | | | | | | | | | | | 8/10/2013 | 15:15 | WSE only[5] | | 540.55 |
| 124.9 | | | | | | | | | | | 8/11/2013 | 12:56 | WSE only[5] | | 535.81 |
| **124.6** | | | | | | | | | | | | | | | |
| 124.5 | | | | | | | | | | | 8/11/2013 | 14:57 | WSE only[5] | | 531.40 |
| 124.1 | 10/1/2012 | 17:42 | 15,600 | Good | 529.40 | 7/9/2013 | 14:14 | 22,500 | Good | 530.21 | 8/11/2013 | 13:32 | 16,600 | Excellent | 529.32 |
| **123.9** | | | | | | | | | | | | | | | |
| 123.7 | | | | | | | | | | | 8/11/2013 | 16:15 | WSE only[5] | | 528.09 |
| 123.2 | | | | | | | | | | | 8/12/2013 | 12:45 | WSE only[5] | | 521.89 |
| 122.7 | | | | | | | | | | | 8/12/2013 | 1:09 | WSE only[5] | | 518.85 |
| 122.6 | | | | | | | | | | | 8/12/2013 | 12:26 | WSE only[5] | | 517.56 |
| 122.1 | | | | | | | | | | | 8/12/2013 | 6:30 | WSE only[5] | | 512.92 |
| 121.4 | | | | | | | | | | | 8/12/2013 | 15:04 | WSE only[5] | | 508.79 |
| 120.7 | | | | | | | | | | | 8/12/2013 | 16:34 | WSE only[5] | | 502.32 |
| 120.3 | | | | | | | | | | | 8/12/2013 | 8:40 | WSE only[5] | | 498.48 |
| 119.9 | 10/3/2012 | 14:47 | 14,000 | Excellent | 493.97 | 7/9/2013 | 17:10 | 22,700 | Excellent | 495.34 | 8/14/2013 | 11:38 | WSE only[5] | | 494.54 |
| **119.5** | | | | | | | | | | | | | | | |
| 118.9 | | | | | | | | | | | 8/14/2013 | 12:06 | WSE only[5] | | 489.01 |
| 118.3 | 10/3/2012 | 14:39 | WSE only[5] | | 484.62 | | | | | | 8/14/2013 | 13:27 | WSE only[5] | | 484.58 |
| **118.1** | | | | | | | | | | | | | | | |
| 117.9 | | | | | | | | | | | 8/14/2013 | 14:11 | WSE only[5] | | 481.58 |
| 117.4 | | | | | | | | | | | 8/14/2013 | 16:10 | WSE only[5] | | 477.65 |
| 117.0 | | | | | | | | | | | 8/14/2013 | 14:37 | WSE only[5] | | 471.85 |

| Project River Mile (PRM) | September/October 2013 | | | | | June/July 2014 | | | | | August 2014 | | | | | September 2014 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 141.9 | 9/5/2013 | 15:39 | WSE only[5] | | 712.73 | | | | | | 8/13/2014 | 14:49 | 17,400 | Good | 710.73 | | | | | |
| 141.7 | 9/5/2013 | 15:53 | WSE only[5] | | 711.76 | | | | | | | | | | | | | | | |
| **141.4** | | | | | | 6/29/2014 | 14:17 | WSE only[5] | | 706.46 | | | | | | | | | | |
| 141.2 | 9/6/2013 | 11:27 | WSE only[5] | | 705.26 | | | | | | | | | | | | | | | |
| 140.8 | 9/6/2013 | 11:39 | WSE only[5] | | 702.23 | | | | | | | | | | | | | | | |
| 140.5 | 9/6/2013 | 12:31 | WSE only[5] | | 698.50 | | | | | | | | | | | | | | | |
| **140.2** | | | | | | 6/30/2014 | 10:22 | WSE only[5] | | 694.52 | | | | | | | | | | |
| 140.0 | 9/6/2013 | 12:29 | WSE only[5] | | 693.56 | | | | | | | | | | | | | | | |
| 139.8 | 9/6/2013 | 12:39 | WSE only[5] | | 691.01 | | | | | | | | | | | | | | | |
| 139.0 | 9/6/2013 | 12:50 | WSE only[5] | | 679.90 | 6/23/2014 | 16:57 | 22,300 | Good | 678.89 | 8/13/2014 | 16:35 | 17,600 | Good | 678.19 | 9/17/2014<br>9/27/2014 | 11:15<br>14:11 | 21,000<br>12,000 | Good<br>Excellent | 678.75<br>NA |
| 138.7 | 9/6/2013 | 13:15 | WSE only[5] | | 678.55 | | | | | | | | | | | | | | | |
| 138.4 | 9/6/2013 | 13:27 | WSE only[5] | | 674.41 | 6/24/2014 | 12:40 | 20,900 | Good[4] | 673.61 | 8/18/2014 | 11:08 | 21,100 | Good[4] | 673.55 | 9/17/2014 | 13:04 | 20,700 | Good[4] | 673.47 |
| 138.1 | 9/6/2013 | 9:10 | WSE only[5] | | 670.74 | | | | | | | | | | | | | | | |
| **137.7** | | | | | | 6/25/2014 | 12:49 | WSE only[5] | | 664.64 | | | | | | | | | | |
| 137.6 | 9/6/2013 | 14:20 | WSE only[5] | | 663.95 | | | | | | | | | | | | | | | |
| 137.2 | 9/6/2013 | 17:07 | WSE only[5] | | 659.83 | | | | | | | | | | | | | | | |
| **136.8** | | | | | | 6/25/2014 | 14:55 | WSE only[5] | | 655.62 | | | | | | | | | | |
| 136.7 | 9/6/2013 | 17:21 | WSE only[5] | | 654.78 | | | | | | | | | | | | | | | |
| 136.2 | 9/6/2013 | 17:36 | WSE only[5] | | 649.06 | | | | | | | | | | | | | | | |
| 135.6 | 9/6/2013 | 17:51 | WSE only[5] | | 641.23 | | | | | | | | | | | | | | | |
| **135.4** | | | | | | 6/30/2014 | 11:47 | WSE only[5] | | 639.33 | | | | | | | | | | |
| **135.2** | | | | | | 7/1/2014 | 12:56 | WSE only[5] | | 637.15 | | | | | | | | | | |
| 135.0 | 9/6/2013 | 18:04 | WSE only[5] | | 635.01 | | | | | | | | | | | | | | | |
| 134.7 | 9/6/2013 | 18:14 | WSE only[5] | | 632.73 | | | | | | | | | | | | | | | |
| 134.3 | 9/6/2013 | 18:24 | WSE only[5] | | 628.13 | | | | | | | | | | | | | | | |
| 134.1 | 9/12/2013 | 13:24 | WSE only[5] | | 626.31 | | | | | | | | | | | | | | | |
| 133.8 | 9/12/2013 | 13:35 | WSE only[5] | | 624.06 | | | | | | | | | | | | | | | |
| 133.3 | 9/12/2013 | 13:52 | WSE only[5] | | 618.70 | | | | | | | | | | | | | | | |
| 132.6 | 9/12/2013 | 14:09 | WSE only[5] | | 610.90 | | | | | | | | | | | | | | | |
| 132.0 | 9/12/2013 | 14:25 | WSE only[5] | | 604.41 | | | | | | | | | | | | | | | |
| 131.4 | 9/10/2013 | 14:29 | WSE only[5] | | 598.97 | | | | | | | | | | | | | | | |
| 130.9 | 9/10/2013 | 13:57 | WSE only[5] | | 592.97 | | | | | | | | | | | | | | | |
| 130.4 | 9/10/2013 | 13:11 | WSE only[5] | | 587.41 | | | | | | | | | | | | | | | |
| **130.1** | | | | | | 7/1/2014 | 15:23 | WSE only[5] | | 583.92 | | | | | | | | | | |
| 129.7 | 9/10/2013 | 11:43 | WSE only[5] | | 580.53 | | | | | | | | | | | | | | | |
| 128.1 | | | | | | | | | | | 8/18/2014 | 14:22 | 21,600 | Good[4] | 562.47 | | | | | |
| 127.8 | | | | | | | | | | | | | | | | | | | | |
| **127.4** | | | | | | 7/1/2014 | 16:20 | WSE only[5] | | 558.37 | | | | | | | | | | |
| 126.8 | 9/12/2013 | 16:52 | 31,100 | Good | 552.79 | | | | | | | | | | | | | | | |
| 126.4 | | | | | | | | | | | | | | | | | | | | |
| 126.1 | | | | | | | | | | | | | | | | | | | | |
| **125.9** | | | | | | 7/2/2014 | 14:25 | WSE only[5] | | 546.78 | | | | | | | | | | |
| 125.8 | | | | | | | | | | | | | | | | | | | | |
| 125.4 | | | | | | | | | | | | | | | | | | | | |
| 124.9 | | | | | | | | | | | | | | | | | | | | |
| **124.6** | | | | | | 6/30/2014 | 12:48 | WSE only[5] | | 533.64 | | | | | | | | | | |
| 124.5 | | | | | | | | | | | | | | | | | | | | |
| 124.1 | 9/10/2013<br>9/12/2013 | 13:51<br>17:41 | WSE only[5]<br>30,600 | <br>Good | 530.81<br>531.16 | | | | | | | | | | | 9/17/2014 | 15:39 | 21,300 | Good | 529.81 |
| **123.9** | | | | | | 6/30/2014 | 15:06 | WSE only[5] | | 529.84 | | | | | | | | | | |
| 123.7 | 9/10/2013 | 11:38 | WSE only[5] | | 528.61 | | | | | | | | | | | | | | | |
| 123.2 | | | | | | | | | | | | | | | | | | | | |
| 122.7 | 9/9/2013 | 15:48 | WSE only[5] | | 520.10 | | | | | | | | | | | | | | | |
| 122.6 | 9/9/2013 | 15:33 | WSE only[5] | | 518.69 | | | | | | | | | | | | | | | |
| 122.1 | | | | | | | | | | | | | | | | | | | | |
| 121.4 | | | | | | | | | | | | | | | | | | | | |
| 120.7 | 9/9/2013 | 15:18 | WSE only[5] | | 503.32 | | | | | | | | | | | | | | | |
| 120.3 | | | | | | | | | | | | | | | | | | | | |
| 119.9 | 9/9/2013 | 9:59 | WSE only[5] | | 496.49 | | | | | | | | | | | | | | | |
| **119.5** | | | | | | 7/1/2014 | 13:13 | WSE only[5] | | 492.91 | | | | | | | | | | |
| 118.9 | | | | | | | | | | | | | | | | | | | | |
| 118.3 | 9/9/2013 | 13:45 | WSE only[5] | | 486.42 | | | | | | | | | | | | | | | |
| **118.1** | | | | | | 7/1/2014 | 14:03 | WSE only[5] | | 484.17 | | | | | | | | | | |
| 117.9 | | | | | | | | | | | | | | | | | | | | |
| 117.4 | 9/9/2013 | 13:18 | WSE only[5] | | 478.57 | | | | | | | | | | | | | | | |
| 117.0 | | | | | | | | | | | | | | | | | | | | |

MIDDLE RIVER (PRM 187.1 - 102.4)

| Project River | XS Profile | XS Profile | June/July 2012 | | | | | August 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | /Bathy Date | /Bathy Date 2 | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
| **116.9** | 7/2/2014 | | | | | | | | | | | |
| 116.6 | 7/7/2012 | | 7/7/2012 | 17:36 | 20,700 | Excellent | 468.98 | 8/16/2012 | 14:15 | 16,100 | Excellent | 468.16 |
| 116.3 | 7/8/2012 | | 7/8/2012 | 12:42 | 23,800 | Excellent | 467.39 | 8/16/2012 | 14:49 | WSE only[5] | | 466.24 |
| 115.7 | 7/8/2012 | | 7/8/2012 | 14:05 | 25,000 | Excellent | 461.95 | 8/16/2012 | 15:17 | WSE only[5] | | 461.01 |
| 115.4 | 7/8/2012 | | 7/8/2012 | 16:13 | 26,000 | Excellent | 458.41 | 8/16/2012 | 15:44 | WSE only[5] | | 456.99 |
| 114.4 | 7/8/2012 | | 7/8/2012 | 18:29 | 25,900 | Excellent | 450.21 | 8/16/2012 | 16:07 | WSE only[5] | | 448.97 |
| 113.6 | 7/9/2012 | 10/3/2012 | 7/9/2012 | 14:23 | 28,300 | Excellent | 444.75 | 8/16/2012 | 16:38 | 16,300 | Excellent | 443.10 |
| 113.1 | 8/15/2013 | | | | | | | | | | | |
| 112.5 | 8/15/2013 | | | | | | | | | | | |
| 111.9 | 7/9/2012 | | 7/9/2012 | 15:23 | 28,300 | Good | 429.73 | 8/17/2012 | 14:02 | WSE only[5] | | 427.98 |
| **111.2** | 7/2/2014 | | | | | | | | | | | |
| 110.5 | 7/9/2012 | 10/3/2012 | 7/9/2012 | 16:46 | 28,800 | Good | 417.55 | 8/17/2012 | 14:57 | 15,300 | Excellent | 415.70 |
| **109.7** | 7/3/2014 | | | | | | | | | | | |
| 109.0 | 8/15/2013 | | | | | | | | | | | |
| 108.3 | 8/18/2012 | | | | | | | 8/17/2012 | 17:55 | 16,400 | Good | 396.50 |
| 107.8 | 8/15/2013 | | | | | | | | | | | |
| **107.4** | 7/3/2014 | | | | | | | | | | | |
| 107.1 | 7/9/2012 | | 7/9/2012 | 18:26 | 28,400 | Good | 387.63 | 8/18/2012 | 13:12 | 15,500 | Excellent | 385.44 |
| **106.9** | 7/3/2014 | | | | | | | | | | | |
| 106.6 | 8/15/2013 | | | | | | | | | | | |
| 106.1 | 8/18/2012 | | | | | | | 8/18/2012 | 14:22 | 15,300 | Excellent | 377.95 |
| 105.3 | 8/18/2012 | | | | | | | 8/18/2012 | 15:52 | 15,400 | Excellent | 372.01 |
| 104.7 | 8/18/2012 | | | | | | | 8/18/2012 | 17:48 | 15,400 | Excellent | 367.05 |
| 104.1 | 8/19/2012 | | | | | | | 8/19/2012 | 12:49 | 15,300 | Excellent | 364.79 |
| 103.5 | 10/1/2012 | | | | | | | | | | | |
| 102.7 | 7/10/2012 | | 7/10/2012 | 13:53 | 26,600 | Good | 352.87 | 8/19/2012 | 15:05 | WSE only[5] | | 351.70 |

| Project River | September/October 2012 | | | | | June/July 2013 | | | | | August 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| **116.9** | | | | | | | | | | | | | | | |
| 116.6 | 10/3/2012 | 15:53 | 14,300 | Excellent | 467.97 | 7/9/2013 | 15:55 | 22,900 | Excellent | 469.33 | 8/14/2013 | 14:00 | 18,100 | Excellent | 468.71 |
| 116.3 | | | | | | 7/23/2013 | 10:40 | WSE only[5] | | 466.98 | 8/14/2013 | 12:50 | WSE only[5] | | 466.79 |
| 115.7 | | | | | | | | | | | 8/14/2013 | 12:30 | WSE only[5] | | 461.83 |
| 115.4 | | | | | | 7/5/2013<br>7/23/2013 | 15:46<br>15:20 | WSE only[5]<br>WSE only[5] | | 457.29<br>457.50 | 8/14/2013 | 12:17 | WSE only[5] | | 457.30 |
| 114.4 | | | | | | | | | | | 8/13/2013<br>8/14/2013 | 16:01<br>16:25 | WSE only[5]<br>WSE only[5] | | 449.42<br>449.39 |
| 113.6 | 10/3/2012 | 16:41 | 13,500 | Excellent | 442.90 | | | | | | 8/14/2013<br>8/14/2013 | 12:48<br>16:12 | WSE only[5]<br>18,100 | <br>Excellent | 443.28<br>443.45 |
| 113.1 | | | | | | | | | | | 8/14/2013<br>8/15/2013 | 17:30<br>11:00 | WSE only[5]<br>WSE only[5] | | 439.27<br>438.67 |
| 112.5 | | | | | | | | | | | 8/15/2013 | 13:07 | WSE only[5] | | 432.60 |
| 111.9 | | | | | | | | | | | 8/15/2013 | 14:05 | WSE only[5] | | 428.51 |
| **111.2** | | | | | | | | | | | | | | | |
| 110.5 | 10/3/2012 | 17:33 | 14,200 | Excellent | 415.49 | | | | | | 8/15/2013 | 14:32 | WSE only[5] | | 416.25 |
| **109.7** | | | | | | | | | | | | | | | |
| 109.0 | | | | | | | | | | | 8/15/2013 | 14:13 | WSE only[5] | | 403.26 |
| 108.3 | | | | | | | | | | | 8/15/2013 | 13:23 | WSE only[5] | | 397.46 |
| 107.8 | | | | | | | | | | | 8/15/2013 | 12:56 | WSE only[5] | | 391.77 |
| **107.4** | | | | | | | | | | | | | | | |
| 107.1 | 10/4/2012 | 14:10 | 14,600 | Excellent | 385.12 | 7/11/2013 | 16:50 | 19,700 | Excellent | 385.92 | 8/15/2013 | 15:53 | 18,900 | Excellent | 385.64 |
| **106.9** | | | | | | | | | | | | | | | |
| 106.6 | | | | | | | | | | | 8/15/2013 | 10:49 | WSE only[5] | | 382.41 |
| 106.1 | 10/4/2012 | 14:26 | WSE only[5] | | 377.75 | | | | | | 8/15/2013 | 10:08 | WSE only[5] | | 378.31 |
| 105.3 | | | | | | | | | | | 8/16/2013 | 10:05 | WSE only[5] | | 372.44 |
| 104.7 | 10/4/2012 | 14:58 | WSE only[5] | | 366.93 | | | | | | 8/16/2013 | 10:29 | WSE only[5] | | 367.15 |
| 104.1 | | | | | | | | | | | 8/16/2013 | 10:56 | WSE only[5] | | 365.31 |
| 103.5 | 10/4/2012 | 16:49 | 14,600 | Excellent | 359.89 | | | | | | 8/16/2013 | 11:24 | WSE only[5] | | 359.88 |
| 102.7 | | | | | | | | | | | 8/16/2013 | 10:32 | WSE only[5] | | 352.66 |

| Project River | September/October 2013 | | | | | June/July 2014 | | | | | August 2014 | | | | | September 2014 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| **116.9** | | | | | | 7/2/2014 | 16:58 | WSE only[5] | | 472.94 | | | | | | | | | | |
| 116.6 | 9/9/2013<br>9/13/2013 | 12:31<br>12:05 | WSE only[5]<br>30,800 | <br>Good | 470.52<br>470.62 | | | | | | | | | | | | | | | |
| 116.3 | | | | | | | | | | | | | | | | | | | | |
| 115.7 | | | | | | | | | | | | | | | | | | | | |
| 115.4 | | | | | | | | | | | | | | | | | | | | |
| 114.4 | | | | | | | | | | | | | | | | | | | | |
| 113.6 | | | | | | | | | | | | | | | | | | | | |
| 113.1 | | | | | | | | | | | | | | | | | | | | |
| 112.5 | | | | | | | | | | | | | | | | | | | | |
| 111.9 | | | | | | | | | | | | | | | | | | | | |
| **111.2** | | | | | | 7/2/2014 | 18:20 | WSE only[5] | | 423.99 | | | | | | | | | | |
| 110.5 | | | | | | | | | | | | | | | | | | | | |
| **109.7** | | | | | | 7/3/2014 | 12:08 | WSE only[5] | | 412.49 | | | | | | | | | | |
| 109.0 | | | | | | | | | | | | | | | | | | | | |
| 108.3 | 9/7/2013 | 13:51 | WSE only[5] | | 398.01 | | | | | | | | | | | | | | | |
| 107.8 | | | | | | | | | | | | | | | | | | | | |
| **107.4** | | | | | | 7/3/2014 | 12:48 | WSE only[5] | | 390.69 | | | | | | | | | | |
| 107.1 | 9/7/2013<br>9/15/2013 | 12:57<br>12:09 | WSE only[5]<br>21,700 | <br>Excellent | 387.46<br>386.36 | 7/3/2014 | 12:59 | 41,700 | Good | 389.00 | | | | | | | | | | |
| **106.9** | | | | | | 7/3/2014 | 13:31 | WSE only[5] | | 387.77 | | | | | | | | | | |
| 106.6 | | | | | | | | | | | | | | | | | | | | |
| 106.1 | 9/7/2013 | 12:40 | WSE only[5] | | 380.10 | | | | | | | | | | | | | | | |
| 105.3 | 9/7/2013 | 23:05 | WSE only[5] | | 374.10 | | | | | | | | | | | | | | | |
| 104.7 | | | | | | 7/3/2014 | 16:09 | 41,500 | Fair [4] | 369.85 | 8/18/2014 | 18:27 | 21,700 | Good [4] | 367.75 | | | | | |
| 104.1 | 9/6/2013 | 12:10 | WSE only[5] | | 366.38 | | | | | | | | | | | | | | | |
| 103.5 | 9/6/2013 | 11:54 | WSE only[5] | | 361.21 | | | | | | | | | | | | | | | |
| 102.7 | | | | | | | | | | | | | | | | | | | | |

LOWER RIVER (PRM 102.4 - 3.3)

| Project River | XS Profile | XS Profile | June/July 2012 | | | | | August 2012 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | /Bathy Date | /Bathy Date 2 | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
| 102.1 | 8/16/2013 | | | | | | | | | | | |
| 101.4 | 7/10/2012 | 10/15/2012 | 7/10/2012 | 16:28 | WSE only[5] | | 346.09 | 8/19/2012 | 15:54 | WSE only[5] | | 344.82 |
| 100.7 | 6/10/13 - 6/11/13,<br>7/17/2013 | | | | | | | | | | | |
| 99.9 | 6/10/13 - 6/11/13,<br>7/17/2013 | | | | | | | | | | | |
| 98.4 | 7/11/2012 | 10/5/2012 | 7/11/2012 | 14:09 | 46,500 | Good | 326.86 | 8/20/2012 | 14:51 | 40,600 | Good | 326.37 |
| 97.0 | 7/11/2012 | | 7/11/2012 | 18:27 | 45,100 | Good | 318.49 | 8/20/2012 | 17:03 | 40,300 | Excellent | 318.38 |
| 96.2 | 6/12/2013 | | | | | | | | | | | |
| **95.3** | 7/4/2014,7/5/2014 | | | | | | | | | | | |
| 94.8 | 6/12/2013,<br>7/18/2013 | | | | | | | | | | | |
| 94.0 | 6/13/2013 | | | | | | | | | | | |
| 93.2 | 6/13/2013 | | | | | | | | | | | |
| 92.3 | 6/13/2013,<br>7/18/2013 | | | | | | | | | | | |
| 91.6 | 8/21/2012 | | | | | | | 8/21/2012 | 14:55 | 46,300 | Excellent | 285.74 |
| 91.0 | 7/12/2012 | | 7/12/2012 | 15:39 | 43,900 | Good | 282.34 | 8/21/2012 | 16:51 | 46,200 | Excellent | 282.34 |
| 90.2 | 6/14/2013 | | | | | | | | | | | |
| 89.5 | 6/14/2013 | | | | | | | | | | | |
| 88.4 | 8/22/2012 | | | | | | | 8/22/2012 | 15:01 | 41,700 | Excellent | 268.25 |
| 88.0 | 6/15/2013 | | | | | | | | | | | |
| 87.6 | 6/15/2013 | | | | | | | | | | | |
| 87.1 | 7/12/2012 | | 7/12/2012 | 18:00 | 42,600 | Excellent | 263.24 | 8/22/2012 | 17:33 | WSE only[5] | | 262.89 |
| 86.3 | 7/13/2012 | | 7/13/2012 | 13:13 | 41,900 | Excellent | 258.59 | 8/22/2012 | 17:54 | WSE only[5] | | 258.39 |
| 85.4 | 8/22/2012 | | | | | | | 8/22/2012 | 18:01 | 40,500 | Excellent | 255.18 |
| 84.4 | 8/23/2012 | | | | | | | 8/23/2012 | 15:16 | 37,000 | Good | 251.19 |
| 83.0 | 7/13/2012 | | 7/13/2012 | 16:09 | 42,000 | Excellent | 245.29 | 8/23/2012 | 16:33 | WSE only[5] | | 244.93 |
| 82.3 | 8/23/2012 | | | | | | | 8/23/2012 | 17:52 | 37,900 | Good | 241.19 |
| 81.4 | 6/16/2013 | | | | | | | | | | | |
| 80.7 | 6/16/2013 | | | | | | | | | | | |
| 80.0 | 8/24/2012 | | | | | | | 8/24/2012 | 15:07 | 36,600 | Excellent | 229.51 |

| Project River | September/October 2012 | | | | | June/July 2013 | | | | | August 2013 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 102.1 | | | | | | | | | | | 8/16/2013 | 14:11 | WSE only[5] | | 348.19 |
| 101.4 | 10/15/2012 | 15:31 | WSE only[5] | | 344.68 | | | | | | | | | | |
| 100.7 | | | | | | 6/10/2013<br>7/17/2013 | 6:10<br>14:28 | WSE only[5]<br>WSE only[5] | | 341.09<br>342.11 | 8/1/2013 | 14:00 | WSE only[5] | | 341.54 |
| 99.9 | | | | | | 6/10/2013<br>6/11/2013 | 15:53<br>11:57 | WSE only[5]<br>WSE only[5] | | 337.43<br>338.15 | 8/1/2013 | 14:55 | WSE only[5] | | 336.51 |
| 98.4 | 10/5/2012 | 14:37 | 39,100 | Excellent | 326.08 | | | | | | 8/1/2013 | 15:15 | WSE only[5] | | 327.62 |
| 97.0 | 10/5/2012 | 15:18 | WSE only[5] | | 318.21 | | | | | | 8/1/2013 | 15:55 | WSE only[5] | | 319.19 |
| 96.2 | | | | | | 6/12/2013 | 11:06 | WSE only[5] | | 315.50 | 8/1/2013 | 16:23 | WSE only[5] | | 315.28 |
| **95.3** | | | | | | | | | | | | | | | |
| 94.8 | | | | | | 6/12/2013<br>7/18/2013 | 12:29<br>10:30 | WSE only[5]<br>WSE only[5] | | 307.57<br>305.77 | 8/1/2013<br>8/2/2013 | 15:40<br>11:49 | 53,800<br>WSE only[5] | Good [4]<br> | 306.38<br>306.16 |
| 94.0 | | | | | | 6/13/2013<br>7/18/2013 | 13:02<br>10:58 | WSE only[5]<br>WSE only[5] | | 301.54<br>300.72 | | | | | |
| 93.2 | | | | | | 6/13/2013 | 15:42 | WSE only[5] | | 297.59 | 8/2/2013 | 12:21 | WSE only[5] | | 296.23 |
| 92.3 | | | | | | 6/13/2013<br>7/18/2013 | 5:36<br>7:01 | WSE only[5]<br>WSE only[5] | | 292.79<br>291.17 | 8/2/2013 | 14:08 | WSE only[5] | | 291.73 |
| 91.6 | | | | | | | | | | | 8/2/2013 | 16:27 | WSE only[5] | | 286.54 |
| 91.0 | | | | | | | | | | | 8/2/2013 | 16:40 | WSE only[5] | | 283.58 |
| 90.2 | | | | | | 6/14/2013 | 13:24 | WSE only[5] | | 280.51 | 8/3/2013 | 13:00 | 51,900 | Good [4] | 279.73 |
| 89.5 | | | | | | 6/14/2013<br>7/18/2013 | 7:30<br>15:36 | WSE only[5]<br>WSE only[5] | | 276.16<br>274.24 | 8/2/2013 | 17:01 | WSE only[5] | | 275.58 |
| 88.4 | | | | | | | | | | | 8/3/2013 | 11:00 | WSE only[5] | | 269.39 |
| 88.0 | | | | | | 6/15/2013 | 11:18 | WSE only[5] | | 268.19 | 8/3/2013 | 13:20 | WSE only[5] | | 266.71 |
| 87.6 | | | | | | 6/15/2013 | 13:29 | WSE only[5] | | 267.00 | 8/3/2013 | 16:23 | 52,700 | Excellent | 265.99 |
| 87.1 | | | | | | | | | | | 8/3/2013 | 14:17 | WSE only[5] | | 264.23 |
| 86.3 | | | | | | | | | | | 8/3/2013 | 16:33 | WSE only[5] | | 259.92 |
| 85.4 | | | | | | | | | | | 8/3/2013 | 17:10 | WSE only[5] | | 256.22 |
| 84.4 | | | | | | | | | | | 8/3/2013 | 17:00 | WSE only[5] | | 252.05 |
| 83.0 | | | | | | | | | | | 8/4/2013 | 14:30 | WSE only[5] | | 245.63 |
| 82.3 | | | | | | | | | | | 8/4/2013 | 14:00 | WSE only[5] | | 242.01 |
| 81.4 | | | | | | 6/16/2013 | 11:47 | WSE only[5] | | 238.57 | 8/4/2013 | 13:33 | WSE only[5] | | 237.22 |
| 80.7 | | | | | | 6/16/2013 | 13:44 | WSE only[5] | | 235.84 | 8/4/2013 | 11:02 | WSE only[5] | | 234.64 |
| 80.0 | | | | | | | | | | | 8/4/2013 | 12:56 | WSE only[5] | | 230.55 |

| Project River | September/October 2013 | | | | | June/July 2014 | | | | | August 2014 | | | | | September 2014 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mile (PRM) | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] | Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
| 102.1 | | | | | | | | | | | | | | | | | | | | |
| 101.4 | | | | | | | | | | | | | | | | | | | | |
| 100.7 | | | | | | | | | | | | | | | | | | | | |
| 99.9 | | | | | | | | | | | | | | | | | | | | |
| 98.4 | | | | | | 7/4/2014 | 13:39 | 74,600 | Good [4] | 328.46 | | | | | | 9/18/2014 | 15:53 | 50,600 | Good [4] | 326.97 |
| 97.0 | | | | | | | | | | | | | | | | | | | | |
| 96.2 | | | | | | | | | | | | | | | | | | | | |
| **95.3** | | | | | | 7/4/2014,<br>7/5/2014 | over 2<br>days | WSE only[5] | | 309.73 | | | | | | | | | | |
| 94.8 | | | | | | | | | | | | | | | | | | | | |
| 94.0 | | | | | | | | | | | | | | | | | | | | |
| 93.2 | | | | | | | | | | | | | | | | | | | | |
| 92.3 | | | | | | | | | | | | | | | | | | | | |
| 91.6 | | | | | | | | | | | | | | | | | | | | |
| 91.0 | | | | | | | | | | | | | | | | | | | | |
| 90.2 | | | | | | | | | | | | | | | | | | | | |
| 89.5 | | | | | | | | | | | | | | | | | | | | |
| 88.4 | | | | | | | | | | | | | | | | | | | | |
| 88.0 | | | | | | | | | | | | | | | | | | | | |
| 87.6 | | | | | | | | | | | | | | | | | | | | |
| 87.1 | | | | | | | | | | | | | | | | | | | | |
| 86.3 | | | | | | | | | | | | | | | | | | | | |
| 85.4 | | | | | | | | | | | | | | | | | | | | |
| 84.4 | | | | | | | | | | | | | | | | | | | | |
| 83.0 | | | | | | | | | | | | | | | | | | | | |
| 82.3 | | | | | | | | | | | | | | | | | | | | |
| 81.4 | | | | | | | | | | | | | | | | | | | | |
| 80.7 | | | | | | | | | | | | | | | | | | | | |
| 80.0 | | | | | | | | | | | | | | | | | | | | |

**LOWER RIVER (PRM 102.4 - 3.3)**

| Project River Mile (PRM) | XS Profile /Bathy Date | XS Profile /Bathy Date 2 | June/July 2012 Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | August 2012 Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] | September/October 2012 Date | Time | Q, cfs[1] | Q Rating[2] | WSE[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79.0 | 6/17/2013 | | | | | | | | | | | | | | | | |
| 78.0 | 6/17/2013 | | | | | | | | | | | | | | | | |
| 77.0 | 6/18/2013 | | | | | | | | | | | | | | | | |
| 75.9 | 6/18/2013,<br>8/20/2013 | | | | | | | | | | | | | | | | |
| 75.0 | 6/19/2013 | | | | | | | | | | | | | | | | |
| 74.1 | 6/19/2013,<br>8/20/2013 | | | | | | | | | | | | | | | | |
| 73.1 | 6/20/2013 | | | | | | | | | | | | | | | | |
| 71.0 | 6/20-6/22,<br>8/26/2013 | | | | | | | | | | | | | | | | |
| 69.2 | 6/23/2013 | | | | | | | | | | | | | | | | |
| 68.2 | 6/24/2013-<br>6/25/2013 | | | | | | | | | | | | | | | | |
| 67.2 | 6/25/2013 | | | | | | | | | | | | | | | | |
| 66.1 | 6/25/2013-<br>6/26/2013 | | | | | | | | | | | | | | | | |
| 64.6 | 6/26/2013 | | | | | | | | | | | | | | | | |
| 62.7 | 6/27/2013 | | | | | | | | | | | | | | | | |
| 60.3 | 6/27/2013 | | | | | | | | | | | | | | | | |
| 59.1 | 6/28/2013 | | | | | | | | | | | | | | | | |
| 57.8 | 6/28/2013 | | | | | | | | | | | | | | | | |
| 55.4 | 6/29/2013 | | | | | | | | | | | | | | | | |
| 54.2 | 6/30/2013 | | | | | | | | | | | | | | | | |
| 52.1 | 7/2/2013 - 7/3/2013 | | | | | | | | | | | | | | | | |
| 49.0 | 7/4/2013, 7/6/2013 | | | | | | | | | | | | | | | | |
| 47.9 | 7/4/2013, 7/6/2013 | | | | | | | | | | | | | | | | |
| 47.1 | 7/5/2013 | | | | | | | | | | | | | | | | |
| 46.3 | 7/5/2013, 7/7/2013 | | | | | | | | | | | | | | | | |
| 45.6 | 7/7/2013 | | | | | | | | | | | | | | | | |
| 44.5 | 7/7/2013 | | | | | | | | | | | | | | | | |
| 41.3 | 7/8/2013 | | | | | | | | | | | | | | | | |
| 40.4 | 7/8/13 - 7/10/2013 | | | | | | | | | | | | | | | | |
| 39.5 | 7/10/13 - 7/12/2013 | | | | | | | | | | | | | | | | |
| 38.3 | 7/11/13 - 7/13/2013 | | | | | | | | | | | | | | | | |
| 36.4 | 7/11/2013 -<br>7/13/2013 | | | | | | | | | | | | | | | | |
| 34.8 | 7/14/2013 | | | | | | | | | | | | | | | | |
| 33.7 | 7/14/2013 | | | | | | | | | | | | | | | | |
| 32.4 | 7/15/2013 | | | | | | | | | | | | | | | | |
| 31.6 | 7/15/2013 | | | | | | | | | | | | | | | | |
| **30.8** | 7/14/2014 | | | | | | | | | | | | | | | | |
| 29.9 | 7/15/2013 | | | | | | | | | | | | 9/11/2012 | 15:05 | WSE only[5] | | 40.16 |

| Project River Mile (PRM) | June/July 2013 Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
|---|---|---|---|---|---|
| 79.0 | 6/17/2013 | 12:21 | WSE only[5] | | 226.66 |
| 78.0 | 6/17/2013 | 13:38 | WSE only[5] | | 221.54 |
| 77.0 | 6/18/2013 | 10:08 | WSE only[5] | | 215.46 |
| 75.9 | 6/18/2013 | 8:33 | WSE only[5] | | 209.14 |
| 75.0 | 6/19/2013 | 12:07 | WSE only[5] | | 205.04 |
| 74.1 | 6/19/2013 | 14:29 | WSE only[5] | | 200.98 |
| 73.1 | 6/20/2013 | 13:54 | WSE only[5] | | 194.77 |
| 71.0 | 6/20/2013<br>6/21/2013 | 15:12<br>13:41 | WSE only[5]<br>WSE only[5] | | 182.36<br>182.89 |
| 69.2 | 6/23/2013 | 12:38 | WSE only[5] | | 171.39 |
| 68.2 | 6/25/2013 | 0:48 | WSE only[5] | | 166.79 |
| 67.2 | 6/25/2013 | 13:02 | WSE only[5] | | 161.48 |
| 66.1 | 6/25/2013 | 15:09 | WSE only[5] | | 155.90 |
| 64.6 | 6/27/2013 | 13:41 | WSE only[5] | | 150.46 |
| 62.7 | 6/27/2013 | 12:17 | WSE only[5] | | 141.33 |
| 60.3 | 6/27/2013 | 13:39 | WSE only[5] | | 131.89 |
| 59.1 | 6/28/2013 | 11:35 | WSE only[5] | | 126.07 |
| 57.8 | 6/28/2013 | 9:55 | WSE only[5] | | 120.33 |
| 55.4 | 6/29/2013 | 12:48 | WSE only[5] | | 110.65 |
| 54.2 | 6/30/2013 | 8:51 | WSE only[5] | | 104.51 |
| 52.1 | 7/2/2013<br>7/3/2013 | 16:39<br>12:52 | WSE only[5]<br>WSE only[5] | | 96.88<br>98.97 |
| 49.0 | 7/4/2013 | 12:26 | WSE only[5] | | 83.55 |
| 47.9 | 7/4/2013 | 14:34 | WSE only[5] | | 79.97 |
| 47.1 | 7/5/2013 | 12:38 | WSE only[5] | | 77.10 |
| 46.3 | 7/5/2013<br>7/7/2013 | 11:21<br>11:02 | WSE only[5]<br>WSE only[5] | | 72.84<br>72.15 |
| 45.6 | 7/7/2013 | 12:13 | WSE only[5] | | 71.35 |
| 44.5 | 7/7/2013 | 13:42 | WSE only[5] | | 68.30 |
| 41.3 | 7/8/2013 | 12:41 | WSE only[5] | | 61.84 |
| 40.4 | 7/8/2013 | 13:07 | WSE only[5] | | 60.14 |
| 39.5 | 7/10/2013 | 15:10 | WSE only[5] | | 58.48 |
| 38.3 | 7/12/2013<br>7/18/2013 | 12:46<br>15:43 | WSE only[5]<br>WSE only[5] | | 55.34<br>55.56 |
| 36.4 | 7/13/2013 | 2:18 | WSE only[5] | | 50.82 |
| 34.8 | 7/14/2013 | 12:57 | WSE only[5] | | 47.35 |
| 33.7 | 7/14/2013 | 14:13 | WSE only[5] | | 46.41 |
| 32.4 | 7/15/2013 | 10:58 | WSE only[5] | | 45.33 |
| 31.6 | 7/15/2013 | 13:24 | WSE only[5] | | 44.64 |
| **30.8** | | | | | |
| 29.9 | 7/15/2013 | 13:18 | WSE only[5] | | 42.42 |

| Project River Mile (PRM) | August 2013 Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
|---|---|---|---|---|---|
| 79.0 | 8/4/2013 | 12:33 | WSE only[5] | | 225.93 |
| 78.0 | 8/4/2013 | 12:32 | 52,100 | Good [4] | 220.90 |
| 77.0 | | | | | |
| 75.9 | 8/5/2013<br>8/20/2013 | 12:40<br>6:05 | WSE only[5]<br>WSE only[5] | | 207.19<br>208.22 |
| 75.0 | | | | | |
| 74.1 | 8/5/2013<br>8/20/2013 | 13:12<br>13:02 | WSE only[5]<br>WSE only[5] | | 199.62<br>199.48 |
| 73.1 | 8/5/2013 | 13:28 | 51,100 | Good [4] | 193.41 |
| 71.0 | 8/26/2013 | 16:06 | WSE only[5] | | 181.26 |
| 69.2 | 8/5/2013 | 16:09 | WSE only[5] | | 170.71 |
| 68.2 | 8/5/2013 | 16:54 | WSE only[5] | | 166.43 |
| 67.2 | 8/6&7/2013 | NA | 45,400 | Fair [4] | 160.18 |
| 66.1 | 8/6/2013 | 12:46 | WSE only[5] | | 155.12 |
| 64.6 | 8/6/2013 | 13:30 | WSE only[5] | | 149.75 |
| 62.7 | 8/6/2013 | 13:57 | WSE only[5] | | 141.07 |
| 60.3 | 8/6/2013 | 14:51 | WSE only[5] | | 130.95 |
| 59.1 | | | | | |
| 57.8 | 8/6/2013<br>8/27/2013 | 15:19<br>13:40 | WSE only[5]<br>WSE only[5] | | 119.04<br>119.21 |
| 55.4 | 8/27/2013 | 14:37 | WSE only[5] | | 109.84 |
| 54.2 | 8/27/2013 | 15:54 | WSE only[5] | | 102.80 |
| 52.1 | 8/28/2013 | 16:14 | WSE only[5] | | 94.06 |
| 49.0 | 8/28/2013 | 14:49 | WSE only[5] | | 82.58 |
| 47.9 | 8/28/2013 | 14:27 | WSE only[5] | | 79.22 |
| 47.1 | 8/28/2013 | 14:12 | WSE only[5] | | 76.06 |
| 46.3 | 8/28/2013 | 17:01 | WSE only[5] | | 72.16 |
| 45.6 | 8/29/2013 | 12:25 | WSE only[5] | | 71.59 |
| 44.5 | 8/29/2013 | 13:00 | WSE only[5] | | 68.73 |
| 41.3 | 8/29/2013 | 14:40 | WSE only[5] | | 62.10 |
| 40.4 | 8/29/2013 | 14:20 | WSE only[5] | | 60.76 |
| 39.5 | 8/29/2013 | 14:55 | WSE only[5] | | 58.71 |
| 38.3 | 8/29/2013 | 15:15 | WSE only[5] | | 55.49 |
| 36.4 | 8/30/2013 | 14:30 | WSE only[5] | | 51.05 |
| 34.8 | | | | | |
| 33.7 | 8/30/2013 | 13:30 | WSE only[5] | | 46.17 |
| 32.4 | 8/30/2013 | 12:56 | WSE only[5] | | 45.03 |
| 31.6 | | | | | |
| **30.8** | | | | | |
| 29.9 | 8/30/2013 | 12:31 | WSE only[5] | | 41.43 |

| Project River Mile (PRM) | September/October 2013 Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
|---|---|---|---|---|---|
| 79.0 | | | | | |
| 78.0 | 9/20/2013 | 16:59 | WSE only[5] | | 219.48 |
| 77.0 | | | | | |
| 75.9 | 9/20/2013 | 15:49 | WSE only[5] | | 206.23 |
| 75.0 | | | | | |
| 74.1 | | | | | |
| 73.1 | 9/20/2013 | 14:43 | WSE only[5] | | 192.32 |
| 71.0 | 9/20/2013 | 9:14 | WSE only[5] | | 180.38 |
| 69.2 | 9/20/2013 | 13:07 | WSE only[5] | | 170.12 |
| 68.2 | | | | | |
| 67.2 | 9/20/2013 | 12:42 | WSE only[5] | | 159.69 |
| 66.1 | | | | | |
| 64.6 | 9/20/2013 | 11:51 | WSE only[5] | | 148.97 |
| 62.7 | 9/20/2013 | 11:31 | WSE only[5] | | 139.84 |
| 60.3 | 9/18/2013 | 12:28 | WSE only[5] | | 130.98 |
| 59.1 | | | | | |
| 57.8 | 9/18/2013 | 8:56 | WSE only[5] | | 118.63 |
| 55.4 | 9/18/2013 | 13:52 | WSE only[5] | | 109.09 |
| 54.2 | 9/16&17/2013<br>9/18/2013 | NA<br>9:26 | 50,600<br>WSE only[5] | Fair [4] | 103.00<br>102.48 |
| 52.1 | | | | | |
| 49.0 | 9/12/2013<br>9/18/2013 | 14:08<br>12:26 | WSE only[5]<br>44,100 | <br>Good [4] | 84.95<br>82.72 |
| 47.9 | | | | | |
| 47.1 | | | | | |
| 46.3 | 9/12/2013<br>9/18/2013 | 14:46<br>11:07 | WSE only[5]<br>WSE only[5] | | 76.91<br>71.93 |
| 45.6 | | | | | |
| 44.5 | 9/12/2013<br>9/18/2013 | 15:28<br>11:24 | WSE only[5]<br>WSE only[5] | | 72.70<br>68.28 |
| 41.3 | | | | | |
| 40.4 | 9/19/2013 | 12:34 | 44,500 | Good [4] | 60.03 |
| 39.5 | 9/12/2013<br>9/19/2013 | 15:55<br>8:37 | WSE only[5]<br>WSE only[5] | | 61.22<br>58.11 |
| 38.3 | | | | | |
| 36.4 | 9/20/2013 | 13:17 | 40,900 | Good [4] | 50.05 |
| 34.8 | 9/12/2013<br>9/15/2013<br>9/19/2013<br>9/21/2013 | 16:24<br>14:58<br>13:00<br>12:18 | WSE only[5]<br>WSE only[5]<br>WSE only[5]<br>38,100 | <br><br><br>Excellent [4] | 52.09<br>47.76<br>46.79<br>46.15 |
| 33.7 | | | | | |
| 32.4 | | | | | |
| 31.6 | | | | | |
| **30.8** | | | | | |
| 29.9 | 9/9/2013<br>9/19/2013 | 17:19<br>9:42 | WSE only[5]<br>WSE only[5] | | 46.03<br>40.65 |

| Project River Mile (PRM) | June/July 2014 Date | Time | Q, cfs | Q Rating[2] | WSE[3] | August 2014 Date | Time | Q, cfs | Q Rating[2] | WSE[3] | September 2014 Date | Time | Q, cfs | Q Rating[2] | WSE[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 79.0 | | | | | | | | | | | | | | | |
| 78.0 | | | | | | | | | | | | | | | |
| 77.0 | | | | | | | | | | | | | | | |
| 75.9 | | | | | | | | | | | | | | | |
| 75.0 | | | | | | | | | | | | | | | |
| 74.1 | | | | | | | | | | | | | | | |
| 73.1 | | | | | | | | | | | | | | | |
| 71.0 | | | | | | | | | | | | | | | |
| 69.2 | | | | | | | | | | | | | | | |
| 68.2 | | | | | | | | | | | | | | | |
| 67.2 | | | | | | | | | | | | | | | |
| 66.1 | | | | | | | | | | | | | | | |
| 64.6 | | | | | | | | | | | | | | | |
| 62.7 | | | | | | | | | | | | | | | |
| 60.3 | | | | | | | | | | | | | | | |
| 59.1 | | | | | | | | | | | | | | | |
| 57.8 | | | | | | | | | | | | | | | |
| 55.4 | | | | | | | | | | | | | | | |
| 54.2 | | | | | | | | | | | | | | | |
| 52.1 | | | | | | | | | | | | | | | |
| 49.0 | | | | | | | | | | | | | | | |
| 47.9 | | | | | | | | | | | | | | | |
| 47.1 | | | | | | | | | | | | | | | |
| 46.3 | | | | | | | | | | | | | | | |
| 45.6 | | | | | | | | | | | | | | | |
| 44.5 | | | | | | | | | | | | | | | |
| 41.3 | | | | | | | | | | | | | | | |
| 40.4 | | | | | | | | | | | | | | | |
| 39.5 | | | | | | | | | | | | | | | |
| 38.3 | | | | | | | | | | | | | | | |
| 36.4 | | | | | | | | | | | | | | | |
| 34.8 | | | | | | | | | | | | | | | |
| 33.7 | | | | | | | | | | | | | | | |
| 32.4 | | | | | | | | | | | | | | | |
| 31.6 | | | | | | | | | | | | | | | |
| **30.8** | 7/14/2014 | 14:34 | WSE only[5] | | 46.11 | | | | | | | | | | |
| 29.9 | | | | | | | | | | | | | | | |

extra Q mmt at Sunshine (June/July 2014)

extra Q mmt at Sunshine and at FA151 (September 2014)

[1] Data approved by HDR Alaska, Inc. (See HDR, 2013)

[2] Q measurement rated according to guidance of U.S. Geological Survey, Office of Surface Water (see USGS OSW, 2012)

[3] WSE = water surface elevation (feet, NAVD 88). WSE was measured during, or within 2 hours of, the flow measurement, typically at left and right banks of all channels . The average WSE of the main channel is reported here.

[4] 2013/2014 multiple channel measurement. Q rating methodology adapted for summing multiple channel Q measurements (see ISR Section 8.5, Appendix C)

[5] Only water surface elevation (WSE) was measured at these cross sections. Flows to be estimated by interpolating/synthesizing from nearby stations.

Not measured concurrently with Q (or reasonably close in time). Pairing of Q and WSE may not be appropriate.

Known channel change affects WSE measurements.

In post processing transects for calibration, the designation of the main channel was changed. Therefore, by the new designation, these WSE measurements are on a side channel.

Following the 2012 flood, measurements show noteworthy change in the channel cross section. The post flood bathymetry has been adopted, therefore these measurements **might not** reflect the current channel geometry.

NA WSE not provided.

**Table 5.5-1. Priority ranking of fish species for development of site-specific Habitat Suitability Curves for the Susitna River, Alaska. (Presented to TWG during Q2 2013 meeting.) (Source: SIR Study 8.5, Appendix D, Table 5.1-1.)**

| Common Name | High | Moderate | Low |
|---|---|---|---|
| Chinook salmon | X | | |
| Chum salmon | X | | |
| Coho salmon | X | | |
| Pink salmon | X | | |
| Sockeye salmon | X | | |
| Arctic grayling | X | | |
| Arctic lamprey | | | X |
| Bering cisco | | | X |
| Burbot | | X | |
| Dolly Varden | | X | |
| Eulachon | | X | |
| Humpback whitefish | | X | |
| Lake trout | | | X |
| Longnose sucker | | X | |
| Northern pike | | | X |
| Rainbow trout | X | | |
| Round whitefish | | | X |
| Sculpin | | | X |
| Threespine stickleback | | | X |

**Table 5.5-2. Updated priority ranking of fish species and life stages for development of Habitat Suitability Criteria for the Susitna River, Alaska. (Presented to Technical Team during Q2 2014 meeting.) (Source: SIR Study 8.5, Appendix D, Table 5.1-2.)**

| | Priority Ranking | | |
|---|---|---|---|
| | High | Moderate | Low |
| Life Stage | Multivariate Preference Curves | Univariate Utilization / 1980s Curves | Literature Based / Expert Panel |
| Spawning | Chum | | |
| | Sockeye | | |
| | Pink | | |
| Adult | Whitefish[1] | Rainbow trout | Bering cisco |
| | Arctic grayling | Dolly Varden | Eulachon |
| | Longnose sucker | Burbot | |
| Juvenile | Coho | Arctic grayling | |
| | Chinook | | |
| | Longnose sucker | | |
| Fry | Coho | Whitefish[1] | |
| | Chinook | Arctic grayling | |
| | Sockeye | Longnose sucker | |

Notes:

1 To eliminate potential for miss identification, no distinction was made between whitefish species (humpback and round).

**Table 5.5-3. Number of individual sampling events by Focus Area, habitat type, and sampling session during 2013 - 2014 HSC sampling in the Middle and Lower River segments of the Susitna River, Alaska. (Source: SIR Study 8.5, Appendix D, Table 5.2-1.)**

| Focus Area | Number of Sample Sites | Habitat Type[1] | Number of Sample Sites | Sample Session | Number of Sampling Events |
|---|---|---|---|---|---|
| Lower River[2] | 16 | Bar Island Complex | 3 | June 18-22, 2013 | 12 |
| FA-104 (Whiskers Slough) | 17 | Main Channel | 21 | July 10-30, 2013 | 49 |
| FA-113 (Oxbow 1) | 9 | Split Main Channel | 6 | Aug 6-27, 2013 | 64 |
| FA-115 (Slough 6A) | 5 | Multi-Split Main Channel | 1 | Sep 10-29, 2013 | 42 |
| FA-128 (Slough 8A) | 13 | Side Channel | 27 | May 20-31, 2014 | 30 |
| FA-138 (Gold Creek) | 15 | Side Channel Complex | 2 | June 1-7, 2014 | 20 |
| FA-141 (Indian River) | 10 | Side Slough | 30 | July 15-22, 2014 | 27 |
| FA-144 (Slough 21) | 8 | Upland Slough | 25 | Sep 17-24, 2014 | 23 |
| FA-151 (Portage Creek) | 3 | Tributary Mouth | 8 | | |
| FA-173 (Stephan Lake) | 9 | Tributary | 6 | | |
| FA-184 (Watana Dam) | 3 | | | | |
| Outside Focus Area | 21 | | | | |
| **Total** | **129** | | **129** | | **267** |

Notes:

1 Habitat types defined in ISR Study 9.9 (AEA 2014a).

2 Lower River (Susitna River downstream of Talkeetna including the Trapper-Birch and Sheep-Caswell complexes).

**Table 5.5-4. Number of microhabitat use measurements used in HSC model development by Focus Area and habitat type for all species and life stages observed during 2013 - 2014 HSC surveys of the Middle and Lower River segments of the Susitna River, Alaska. (Source: SIR Study 8.5, Appendix D, Table 5.2-2.)**

| | Life | Lower | Middle River Focus Areas | | | | | | | | | | | | Habitat Type[2] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Species** | **Stage** | **River[1]** | **104** | **113** | **115** | **128** | **138** | **141** | **144** | **151** | **173** | **184** | **NFA** | **Total** | **MC** | **SC** | **SS** | **SMC** | **MSMC** | **Trib** | **TM** | **US** | **BIC** | **SCC** | **Total** |
| Chinook | Fry | 32 | 51 | 15 | 7 | 14 | 13 | 45 | 3 | 35 | | | 2 | 217 | 33 | 17 | 52 | 15 | | 38 | 35 | 21 | 5 | 1 | **217** |
| | Juv | 18 | 11 | 2 | 3 | 8 | 10 | 5 | | 7 | | | 3 | 67 | 13 | 18 | 16 | 2 | | 1 | 4 | 9 | 2 | 2 | **67** |
| Chum | Fry | 77 | 65 | 36 | 8 | 18 | 4 | 30 | 15 | | | | | 253 | 48 | 59 | 52 | 27 | | 16 | 11 | 14 | 14 | 12 | **253** |
| | Juvenile | | | | | 1 | | | | | | | 1 | 2 | 1 | 1 | | | | | | | | | **2** |
| | Spawning | | | | | 71 | 71 | 19 | 76 | | | | 160 | 397 | 51 | 129 | 124 | 25 | | | 7 | 61 | | | **397** |
| Coho | Fry | 33 | 119 | 22 | 7 | 21 | 15 | 42 | 4 | 3 | | | 8 | 274 | 8 | 21 | 98 | 17 | | 36 | 28 | 65 | | 1 | **274** |
| | Juv | 7 | 30 | 10 | 16 | 3 | 6 | 3 | 2 | 5 | | | 5 | 87 | 4 | 6 | 16 | 2 | | 10 | 3 | 45 | | 1 | **87** |
| | Spawning | | | | | 3 | | | | | | | | 3 | | 3 | | | | | | | | | **3** |
| Pink | Fry | 1 | 1 | | | 2 | | 34 | 1 | | | | | 39 | | 4 | 1 | | | 23 | 11 | | | | **39** |
| | Spawning | | | | | | | 17 | | | | | 36 | 53 | | | | | | 17 | 36 | | | | **53** |
| Sockeye | Fry | 44 | 69 | 26 | 15 | 71 | 46 | 56 | 20 | 2 | | | 8 | 357 | 8 | 46 | 166 | 13 | | 32 | 18 | 65 | 7 | 2 | **357** |
| | Juv | 2 | 6 | 2 | | 1 | 6 | 2 | | | | | 2 | 21 | | 5 | 13 | | | | | 3 | | | **21** |
| | Spawning | | | | | 51 | 68 | 19 | 82 | | | | 24 | 244 | | 65 | 123 | | | 7 | 12 | 37 | | | **244** |
| Arctic Grayling | Fry | | 10 | 6 | 11 | 21 | 11 | 35 | 11 | | 6 | 1 | 8 | 120 | 14 | 22 | 37 | 3 | | 1 | 17 | 26 | | | **120** |
| | Juv | | 4 | 3 | | 9 | 3 | 15 | 4 | 1 | 26 | 9 | 4 | 78 | 36 | 21 | 12 | 3 | | 1 | 1 | 4 | | | **78** |
| | Adult | | 1 | | | | | 4 | | | 3 | 7 | | 15 | 10 | 5 | | | | | | | | | **15** |
| Arctic lamprey juv | | | 1 | | | | | | | | | | | 1 | | | 1 | | | | | | | | **1** |
| Lamprey (undiff) juv | | 1 | | | | | | | | | | | | 1 | | | | | | 1 | | | | | **1** |
| Burbot | Fry | | | 1 | | | | | | | | | | 1 | | | | 1 | | | | | | | **1** |
| | Juv | | 1 | 3 | | | | 1 | | | | | | 5 | 2 | | | 3 | | | | | | | **5** |
| | Adult | 1 | 7 | 1 | 5 | 2 | 2 | | 1 | 2 | 1 | | | 22 | 6 | 8 | 1 | 1 | | | | 5 | | 1 | **22** |
| Dolly Varden | Fry | | 2 | 7 | | | | 10 | | 1 | | | 1 | 21 | 1 | | | | | 10 | 4 | 6 | | | **21** |
| | Juv | | | | | | 1 | | | | 1 | | | 2 | | | 1 | | | | | 1 | | | **2** |
| | Adult | | | | | | 1 | | | 1 | 1 | | | 3 | 1 | | 2 | | | | | | | | **3** |
| Longnose sucker | Fry | 12 | 13 | 20 | 6 | 1 | | 9 | 1 | 1 | 22 | 1 | 2 | 88 | 6 | 17 | 33 | 4 | | | 8 | 18 | 2 | | **88** |
| | Juv | 7 | 16 | 7 | 6 | 3 | 10 | 7 | 1 | 3 | 31 | 2 | 4 | 97 | 15 | 20 | 45 | 2 | 1 | | | 12 | 1 | 1 | **97** |
| | Adult | 2 | 16 | 8 | 4 | 7 | 14 | 6 | 3 | | 1 | | 10 | 71 | 19 | 22 | 13 | 7 | 2 | | | 7 | | 1 | **71** |
| Rainbow trout | Fry | | | 2 | | | | | | 2 | | | | 4 | 1 | | | | | 2 | 1 | | | | **4** |
| | Juv | | 4 | 2 | | | | 1 | | | | | | 7 | 1 | 1 | | | | 2 | | 3 | | | **7** |
| | Adult | | 4 | | | 1 | | | 1 | 1 | | | 1 | 8 | 2 | 2 | 1 | | | | | 3 | | | **8** |
| Whitefish | Fry | 25 | 5 | 5 | 5 | 3 | 12 | 8 | 1 | 1 | 21 | 15 | 4 | 105 | 24 | 30 | 29 | | | | 2 | 14 | 4 | 2 | **105** |
| | Juv | 9 | 5 | 6 | 2 | 9 | 5 | 8 | 1 | 2 | 23 | 28 | 3 | 101 | 46 | 23 | 14 | 4 | | | 1 | 11 | 2 | | **101** |
| | Adult | 2 | 2 | 3 | 1 | 6 | 5 | 6 | 1 | 4 | | 1 | 4 | 35 | 19 | 8 | 2 | 3 | | | | 3 | | | **35** |
| **TOTAL** | | **273** | **443** | **187** | **96** | **326** | **303** | **382** | **228** | **71** | **136** | **64** | **290** | **2,799** | **369** | **553** | **852** | **132** | **3** | **197** | **199** | **433** | **37** | **24** | **2,799** |

Notes:

1 Lower River: Susitna River downstream of Talkeetna including the Trapper-Birch and Sheep-Caswell complexes.

2 Habitat Types defined in ISR Study 9.9 (AEA 2014a): MC=Main Channel, SC=Side Channel, SS=Side Slough, SMC=Split Main Channel, Multi-Split Main Channel, Trib=Tributary, TM=Tributary Mouth, US=Upland Slough, BIC=Bar Island Complex, SCC=Side Channel Complex.

**Table 5.5-5. Total number of HSC observations recorded during electrofish sampling in each winter season of 2012-2013 and 2013-2014, by fish species and life stage. (Source: SIR Study 8.5, Appendix D, Table 5.2-3.)**

| Winter Season | Species | Life stage[1] | FA-104 (Whiskers Slough) | FA-128 Slough 8A) | FA-138 (Gold Creek) | FA-141 (Indian River) | Total |
|---|---|---|---|---|---|---|---|
| 2012-2013 | Chinook salmon | Fry | 1 | 2 | 0 | 0 | **3** |
| | | Juvenile | 13 | 10 | 0 | 0 | **23** |
| | Coho salmon | Fry | 2 | 0 | 0 | 0 | **2** |
| | | Juvenile | 1 | 0 | 0 | 0 | **1** |
| 2013-2014 | Chinook salmon | Fry | 13 | 0 | 0 | 1 | **14** |
| | | Juvenile | 2 | 3 | 1 | 0 | **6** |
| | Sockeye salmon | Fry | 1 | 30 | 4 | 0 | **35** |
| | | Juvenile | 0 | 0 | 33 | 0 | **33** |
| | Chum salmon | Fry | 0 | 17 | 25 | 0 | **42** |
| | Coho salmon | Fry | 25 | 7 | 2 | 1 | **35** |
| | | Juvenile | 47 | 7 | 32 | 2 | **88** |
| | Rainbow trout | Juvenile | 2 | 0 | 2 | 0 | **4** |
| | Arctic grayling | Juvenile | 1 | 0 | 0 | 0 | **1** |
| | Longnose sucker | Juvenile | 2 | 0 | 0 | 0 | **2** |
| | Arctic lamprey | Juvenile | 2 | 0 | 0 | 0 | **2** |
| **2012-2013 Total** | | | **17** | **12** | **0** | **0** | **29** |
| **2013-2014 Total** | | | **95** | **64** | **99** | **4** | **262** |
| **Cumulative Total** | | | **112** | **76** | **99** | **4** | **291** |

Notes:

1 Fry consist of fish less than 60 mm fork length; juvenile life stage represents fish between 60 mm and 150 mm fork length.

**Table 5.5-6. Total number of HSC observations recorded during electrofish sampling in each winter season of 2012-2013 and 2013-2014, by fish species and life stage. (Source: SIR Study 8.5, Appendix D, Table 1-1.)**

| Species [1] | Life Stage | Number of Microhabitat Measurements | Multivariate Preference HSC Model | Univariate Utilization HSC | Non-site Specific HSC | Field Data Collection Complete? | Targeted Future Data Collection |
|---|---|---|---|---|---|---|---|
| **High Priority Species** | | | | | | | |
| Chinook salmon | Fry-summer | 217 | X | | | Yes | |
| | Fry-winter | 17 | | X | | | X |
| | Juv-summer | 67 | X | | | Yes | |
| | Juv-winter | 28 | | X | | | X |
| Chum salmon | Fry [2] | 253 | N/A | N/A | N/A | Yes | |
| | Spawning | 397 | X | | | Yes | |
| Coho salmon | Fry-summer | 274 | X | | | Yes | |
| | Fry-winter | 36 | | X | | | X |
| | Juv-summer | 87 | X | | | Yes | |
| | Juv-winter | 88 | | X | | | X |
| | Spawning | 3 | | | X | Yes | |
| Pink salmon | Fry[2] | 39 | N/A | N/A | N/A | Yes | |
| | Spawning | 53 | | X | | | X |
| Sockeye salmon | Fry-summer[2] | 357 | N/A | N/A | N/A | Yes | |
| | Fry-winter | 35 | | X | | | X |
| | Spawning | 244 | X | | | Yes | |
| Arctic grayling | Fry | 120 | X | | | Yes | |
| | Juv | 78 | X | | | Yes | |
| | Adult | 15 | | X | | | X |
| Rainbow trout | Fry | 4 | | | X | Yes | |
| | Juvenile | 7 | | | X | Yes | |
| | Adult | 8 | | X | | | X |
| **Moderate Priority Species** | | | | | | | |
| Burbot | Fry | 1 | | | X | Yes | |
| | Juvenile | 5 | | | X | Yes | |
| | Adult | 22 | | X | | | X |
| Dolly Varden | Fry | 21 | | | X | Yes | |
| | Juvenile | 2 | | | X | Yes | |
| | Adult | 3 | | | X | Yes | |
| Eulachon | Spawning | | | X | | | X [3] |
| Longnose sucker | Fry[4] | 88 | | X | | Yes | |
| | Juvenile | 97 | X | | | Yes | |
| | Adult | 71 | X | | | Yes | |
| Whitefish (undiff) | Fry | 105 | X | | | Yes | |
| | Juvenile | 101 | X | | | Yes | |
| | Adult | 35 | | X | | | X |

Notes:

Juv=Juvenile, undiff=undifferentiated

1 HSC will not be developed for low priority species northern pike, round whitefish, sculpin, three-spine stickleback, Arctic lamprey, Bering cisco, and lake trout.

2 N/A – Not applicable since HSC will not be developed for fry that outmigrate shortly after emergence.

3 Data collection activities will be conducted under Study 9.16 (Eulachon Run timing, Distribution, and Spawning in the Susitna River).

4 Considered for multivariate model development.

**Table 5.5-7. Proposed minimum and maximum threshold values for use with individual HSC/HSI model variables and life stages. (Source: SIR Study 8.5, Appendix D, Table 5.5-1.)**

| Variable | Life Stage | Time Period | Threshold Range Minimum | Threshold Range Maximum | Comments |
|---|---|---|---|---|---|
| Depth | Fry | All Year | 0.1 ft | Model/non-limiting | If descending limb does not extend to zero preference, set probability constant from last (deepest) utilization point to outer extend of depth range |
| | Juv. | All Year | 0.2 ft | Model/non-limiting | If descending limb does not extend to zero preference, set probability constant from last (deepest) utilization point to outer extend of depth range |
| | Adult | All Year | 0.25 ft | Model/non-limiting | If descending limb does not extend to zero preference, set probability constant from last (deepest) utilization point to outer extend of depth range |
| | Spawning | Summer | 0.3 ft | Model/non-limiting | If descending limb does not extend to zero preference, set probability constant from last (deepest) utilization point to outer extend of depth range |
| Velocity | Fry | Summer | 0.0 fps | Model or 3.0 fps | If descending limb does not extend to zero preference, use maximum threshold to set upper extent of velocity preference. Last utilization point at 2.9 fps |
| | Juv. | Summer | 0.0 fps | Model or 3.0 fps | If descending limb does not extend to zero preference, use maximum threshold to set upper extent of velocity preference. Last utilization point at 2.9 fps |
| | Adult | Summer | 0.0 fps | Model | Last utilization point at 2.9 fps |
| | Spawning | Summer | 0.0 fps | Model or 4.5 fps | Last utilization point at 3.47 fps, similar to maximum spawning velocity used in 1980s HSC study |
| | Fry | Winter | 0.0 fps | 1.5 fps | Last utilization point at 0.93 fps (winter) |
| | Juv. | Winter | 0.0 fps | 1.5 fps | Last utilization point at 1.15 fps (winter) |
| pH | Fry | All Year | 6.5 | 8.5 | Alaska DEC (2012) |
| | Juv. | All Year | 6.5 | 8.5 | Daily minimum and maximum values |
| | Adult | All Year | 6.5 | 8.5 | |
| | Spawning | All Year | 6.5 | 8.5 | |
| DO | Fry | Winter | 7 mg/l | 17 mg/l | Daily minimum and maximum values |
| | Juv. | Winter | 7 mg/l | 17 mg/l | |
| | Adult | Winter | 7 mg/l | 17 mg/l | |
| | Incubation | Winter | 7 mg/l | 17 mg/l | Assume 2 mg/l depression for intergravel (Alaska DEC, 2012) |
| | Fry | Summer | 7 mg/l | 17 mg/l | If D.O. pre-project <7 mg/l, no greater than 2 mg/l reduction from background, but no lower than 3 mg/l regardless of pre-project level. |
| | Juv. | Summer | 7 mg/l | 17 mg/l | |
| | Adult | Summer | 7 mg/l | 17 mg/l | |
| | Spawning | Summer | 7 mg/l | 17 mg/l | |
| Temp. | Fry | Summer | 3.0°C | 20.0°C | Alaska DEC (2012) |
| | Juv. | Summer | 3.0°C | 20.0°C | Daily minimum and maximum values |
| | Adult | Summer | 3.0°C | 20.0°C | |
| | Spawning | Summer | 3.0°C | 13.0°C | Aug. 15 – Sep. 30; applied to only those areas with >0.0 spawning preference |
| Distance to Water's Edge | Fry | Summer | none | 75.0 ft | Based on maximum distance from bank observed during 2013-2014 surveys |
| | Juv. | Summer | none | 75.0 ft | Based on maximum distance from bank observed during 2013-2014 surveys |
| | Adult | Summer | none | None | |
| | Spawning | Summer | none | None | |

**Table 5.5-8. Utilization of categorical habitats as a percent of total samples (including availability) for chum salmon spawning. (Source: SIR Study 8.5, Appendix D, Table 5.6-7.)**

| Factor | Group | Number of Samples[1] | Percent Utilization |
|---|---|---|---|
| Substrate | All Gravel | 159 | 63% |
| | Gravel Dominant Mix | 293 | 58% |
| | Gravel Subdominant Mix | 226 | 45% |
| | Cobble Dominant / No Gravel | 103 | 23% |
| Upwelling | Upwelling | 722 | 52% |
| | Downwelling | 32 | 28% |

Note:
1 Number of samples includes availability + utilization observations.

**Table 5.5-9. AIC model comparisons testing random effects and interaction between spawning site type (random vs. select) and each predictor variable. (Source: SIR Study 8.5, Appendix D, Table 5.6-8.)**

| Predictor | Model[1,2] | AICc | deltaAIC | Conclusion |
|---|---|---|---|---|
| Depth | 3rd order Depth with Site Type | 1051.9 | 3.4 | Some evidence that select sites have no depth preference; potential impact would be that relationship with depth is understated by including select sites. |
| | 3rd order Depth with Site Type and Interaction | 1048.5 | 0.0 | |
| | Fixed Model: 3rd order Depth with Site Type and Interaction | 1067.0 | 18 | |
| Velocity | 3rd order Vel with Site Type | 1052.7 | 0.0 | No evidence of interaction. |
| | 3rd order Vel with Site Type and Interaction | 1053.7 | 1.0 | |
| | Fixed Model: 3rd order Vel with Site Type and Interaction | 1062.0 | 9.3 | |
| Water Temperature | Quadratic Temp with Site Type | 1063.7 | 0.0 | No evidence of interaction. |
| | Quadratic Temp with Site Type and Interaction | 1064.6 | 0.9 | |
| | Fixed Model: quadratic Temp with Site Type and Interaction | 1083.0 | 19 | |
| Substrate Group | Substrate Group with Site Type | 1024.6 | 0.0 | No evidence of interaction. |
| | Substrate Group with Site Type and Interaction | 1024.7 | 0.1 | |
| | Fixed effects: Substrate Group with Site Type and Interaction | 1048.4 | 24 | |
| Upwelling | Upwelling with Site Type | 1026.6 | 0.0 | No evidence of interaction. |
| | Upwelling with Site Type and Interaction | 1028.3 | 1.7 | |
| | Fixed effects: Upwelling with Site Type and Interaction | 1044.1 | 18 | |
| Dissolved Oxygen | Quadratic DO with Site Type | 1052.8 | 0 | No evidence of interaction. |
| | Quadratic DO with Site Type and Interaction | 1054.2 | 1.5 | |
| | Fixed effects: quadratic DO with Site Type and Interaction | 1071.1 | 18 | |

Notes:

1 Displayed models are mixed/random effects models unless noted.

2 Interaction is added to the univariate model including all predictors.

**Table 5.5-10. Chum salmon spawning univariate model AIC comparisons used to select relationships for multivariate analysis. (Source: SIR Study 8.5, Appendix D, Table 5.6-9.)**

| Predictor | Model | AICc | Difference From Null Model | Selected Model | Reason for Model Selection |
|---|---|---|---|---|---|
| Depth | Null (No covariates) | 1065 | 0 | | Linear and quadratic have similar AIC |
| | Linear Depth | 1049.2 | -16 | ** | |
| | Quadratic Depth | 1050.1 | -15 | ** | |
| | 3rd order Depth | 1051.5 | -14 | | |
| Velocity | Null (No covariates) | 1065 | 0 | | Lowest AIC |
| | Linear Velocity | 1066.1 | 1.1 | | |
| | Quadratic Velocity | 1051.6 | -13 | ** | |
| | 3rd order Velocity | 1053.6 | -11 | | |
| Water Temperature | Null (No covariates) | 1065 | 0 | | Lowest AIC |
| | Linear Temperature | 1063.4 | -1.6 | ** | |
| | Quadratic Temperature | 1065.1 | 0.1 | | |
| Upwelling | Null (sites with upwelling measured) | 1027.2 | 0 | | Lowest AIC |
| | Categorical | 1025.8 | -1.4 | ** | |
| Substrate Group | Null (No covariates) | 1065 | 0 | | Lowest AIC |
| | Categorical | 1024.1 | -41 | ** | |
| Dissolved Oxygen | Null (sites with DO measured) | 1049.7 | 0 | ** | Null has lowest AIC |
| | Linear DO | 1050.2 | 0.50 | | |
| | Quadratic DO | 1051.7 | 2.0 | | |

**Table 5.5-11. AIC results for chum salmon spawning multivariate models. (Source: SIR Study 8.5, Appendix D, Table 5.6-10.)**

| Intercept | Substrate | Depth | Depth² | Temp | Velocity | Velocity² | Substrate: Depth | Substrate: Velocity | Substrate: Temperature | Depth: Velocity | Depth: Temperature | Velocity: Temperature | Degrees of Freedom | AICc | Delta AIC[1] | Notes[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| x | x | x | | x | x | x | | | | | | x | 10 | 997.1 | 0.0 | |
| x | x | x | x | x | x | x | | | | | | x | 11 | 998.3 | 1.2 | S |
| x | x | x | | x | x | x | | | | | | | 9 | 999.1 | 2.0 | BME |
| x | x | x | | x | x | x | x | | | | | | 12 | 999.4 | 2.3 | |
| x | x | x | | | x | x | | | | | | | 8 | 1000.1 | 3.0 | |
| x | x | x | x | x | x | x | | | | | | | 10 | 1000.3 | 3.2 | |
| x | x | x | x | x | x | x | x | | | | | | 13 | 1000.7 | 3.7 | |
| x | x | x | | x | x | x | | | | | x | | 10 | 1000.9 | 3.8 | |
| x | x | x | x | | x | x | | | | | | | 9 | 1001.0 | 3.9 | |
| x | x | x | | x | x | x | | | | x | | | 10 | 1001.1 | 4.0 | |
| x | x | x | | x | x | x | | | x | | | | 12 | 1001.9 | 4.8 | |
| x | x | x | x | x | x | x | | | | | x | | 11 | 1002.2 | 5.1 | |
| x | x | x | x | x | x | x | | | | x | | | 11 | 1002.3 | 5.3 | |
| x | x | x | x | x | x | x | | | x | | | | 13 | 1003.0 | 6.0 | |
| x | x | x | | x | x | x | | x | | | | | 12 | 1004.9 | 7.8 | |
| x | x | x | x | x | x | x | | x | | | | | 13 | 1006.1 | 9.0 | |
| x | x | x | | x | | x | | | | | | | 8 | 1007.2 | 10.1 | |
| x | x | x | | | | x | | | | | | | 7 | 1007.7 | 10.6 | |
| x | x | x | x | x | | x | | | | | | | 9 | 1008.3 | 11.2 | |
| x | x | x | x | | | x | | | | | | | 8 | 1008.5 | 11.4 | |
| x | x | x | | x | | | | | | | | | 7 | 1008.9 | 11.8 | |
| x | | | | | | | | | | | | | 2 | 1065.0 | 67.9 | NULL |

Notes:

1 Models other than the null model with deltaAIC > 12 are not displayed for brevity.

2 Quadratic term.

3 S = Selected Model; BME = Best main-effects model (i.e., no interactions); NULL = model with no predictors.

**Table 5.5-12. Coho fry utilization of habitats with and without each cover type, including turbidity (>30 NTU) as a cover type (last two rows), or as an interacting factor (last four columns). (Source: SIR Study 8.5, Appendix D, Table 5.6-11.)**

| Type of Cover | | All | | Turbidity≤30[1] | | Turbidity>30[1] | |
|---|---|---|---|---|---|---|---|
| | | Cover Absent | Cover Present | Cover Absent | Cover Present | Cover Absent | Cover Present |
| Boulder | Number of Observations | 1168 | 106 | 933 | 87 | 198 | 18 |
| | Percent Utilization | 22% | 21% | 23% | 24% | 11% | 0% |
| Wood | Number of Observations | 1143 | 131 | 913 | 107 | 199 | 17 |
| | Percent Utilization | 18% | 50% | 20% | 55% | 10% | 12% |
| Aquatic Vegetation | Number of Observations | 1006 | 268 | 778 | 242 | 199 | 17 |
| | Percent Utilization | 18% | 34% | 20% | 36% | 10% | 12% |
| Overhead Vegetation | Number of Observations | 1219 | 55 | 968 | 52 | 214 | 2 |
| | Percent Utilization | 20% | 45% | 22% | 48% | 10% | 0% |
| Undercut Bank | Number of Observations | 1246 | 28 | 992 | 28 | 216 | 0 |
| | Percent Utilization | 20% | 75% | 22% | 75% | 10% | na |
| Any (Non-Turbidity) | Number of Observations | 760 | 514 | 576 | 444 | 165 | 51 |
| | Percent Utilization | 14% | 33% | 14% | 36% | 10.9% | 7.8% |
| Turbidity (>30 NTU) | Number of Observations | 1020 | 216 | | | | |
| | Percent Utilization | 23% | 10% | | | | |

Note:

na = not applicable

1 Turbidity was not recorded at each coho fry utilization measurement point.

**Table 5.5-13. Coho salmon fry univariate model AIC comparisons used to select relationships for multivariate analysis. (Source: SIR Study 8.5, Appendix D, Table 5.6-12.)**

| Predictor | Model[1] | AICc | Difference From Null Model | Selected Model | Reason for Model Selection |
|---|---|---|---|---|---|
| Depth | Null (No covariates) | 1284.9 | 0 | | Lowest AIC |
| | Linear Depth | 1285.3 | 0.4 | | |
| | Quadratic Depth | 1266 | -19 | ** | |
| | 3rd order Depth | 1266.8 | -18 | | |
| | Fixed effects: 3rd order Depth | 1307.6 | 23 | | |
| Velocity | Null (No covariates) | 1284.9 | 0 | | Lowest AIC |
| | Linear Velocity | 1260.3 | -25 | ** | |
| | Quadratic Velocity | 1262.3 | -23 | | |
| | 3rd order Velocity | 1264.3 | -21 | | |
| | Fixed effects 3rd order Velocity | 1296.6 | 12 | | |
| Water Temperature | Null (No covariates) | 1277.5 | 0 | ** | Null model has lowest AIC |
| | Linear Temperature | 1279.5 | 2.0 | | |
| | Quadratic Temperature | 1280.1 | 2.5 | | |
| | Fixed effects quadratic Temperature | 1323.7 | 46 | | |
| Cover and Turbidity | Null (where turbidity available) | 1234 | 0 | | Lowest AIC |
| | Cover | 1179.4 | -55 | | |
| | Cover:Turbidity | 1172.8 | -61 | ** | |
| | Fixed effects Cover:Turbidity | 1190.7 | -43 | | |
| Dissolved Oxygen | Null (sites with DO measured) | 1264.9 | 0 | ** | Linear decreasing relationship with DO is not ecologically reasonable |
| | Linear DO | 1243.8 | -21 | | |
| | Quadratic DO | 1245.8 | -19 | | |
| | Fixed effects quadratic DO | 1286.9 | 22 | | |

Notes:

1 Displayed Models are Mixed/Random effects models except where noted.

**Table 5.5-14. AIC results for coho salmon fry multivariate models. (Source: SIR Study 8.5, Appendix D, Table 5.6-13.)**

| Intercept | Cover/ Turbidity | Depth | Depth² | Velocity | Cover/Turbidity: Depth | Cover/Turbidity: Velocity | Depth: Velocity | Degrees of Freedom | AICc | deltaAIC[1] | Notes[3] |
|---|---|---|---|---|---|---|---|---|---|---|---|
| x | x | x | x | x | x | | | 9 | 1122.4 | 0 | S |
| x | x | x | x | x | | | x | 8 | 1129.6 | 7.2 | |
| x | x | x | x | x | | | | 7 | 1133.6 | 11.2 | BME |
| x | x | x | x | x | | x | | 9 | 1134.3 | 11.9 | |
| x | x | x | x | | | | | 6 | 1151.7 | 29 | |
| x | x | | | x | | | | 5 | 1155.8 | 33.4 | |
| x | x | x | | x | | | | 6 | 1157.6 | 35.2 | |
| x | x | | | | | | | 4 | 1170.9 | 48.5 | |
| x | x | x | | | | | | 5 | 1172.5 | 50.1 | |
| x | | | | | | | | 2 | 1234 | 111.6 | NULL |

Notes:

1 Models other than the null model with deltaAIC > 50 are not displayed for brevity.

2 Quadratic term.

3 S = Selected Model; BME = Best main-effects model (i.e., no interactions); NULL = model with no predictors.

**Table 5.5-15. Evaluation of FERC requested variables and recommendations for inclusion in future HSC curve development. (Source: SIR Study 8.5, Appendix D, Table 5.4-1.)**

| Variable | Relationship with Fish Abundance Measures (Strong, Weak, None) | Direct Link to Fish Habitat Use | Modeled at Focus Area Scale | Recommended for Future HSC Analysis |
|---|---|---|---|---|
| Macronutrients: Total Phosphorus, Total Nitrogen | Insufficient Data | Unknown | No | No |
| pH | Strong | Yes | Yes | Yes |
| Dissolved Organic Carbon | None | No | Yes | No |
| Alkalinity | Weak | No | No | No |
| Chlorophyll-a | Strong | No | Yes | No[1] |

Notes:

1 Chlorophyll-a showed a strong relationship to non-salmonid species only and was not recommended for further analysis.

# 10. FIGURES

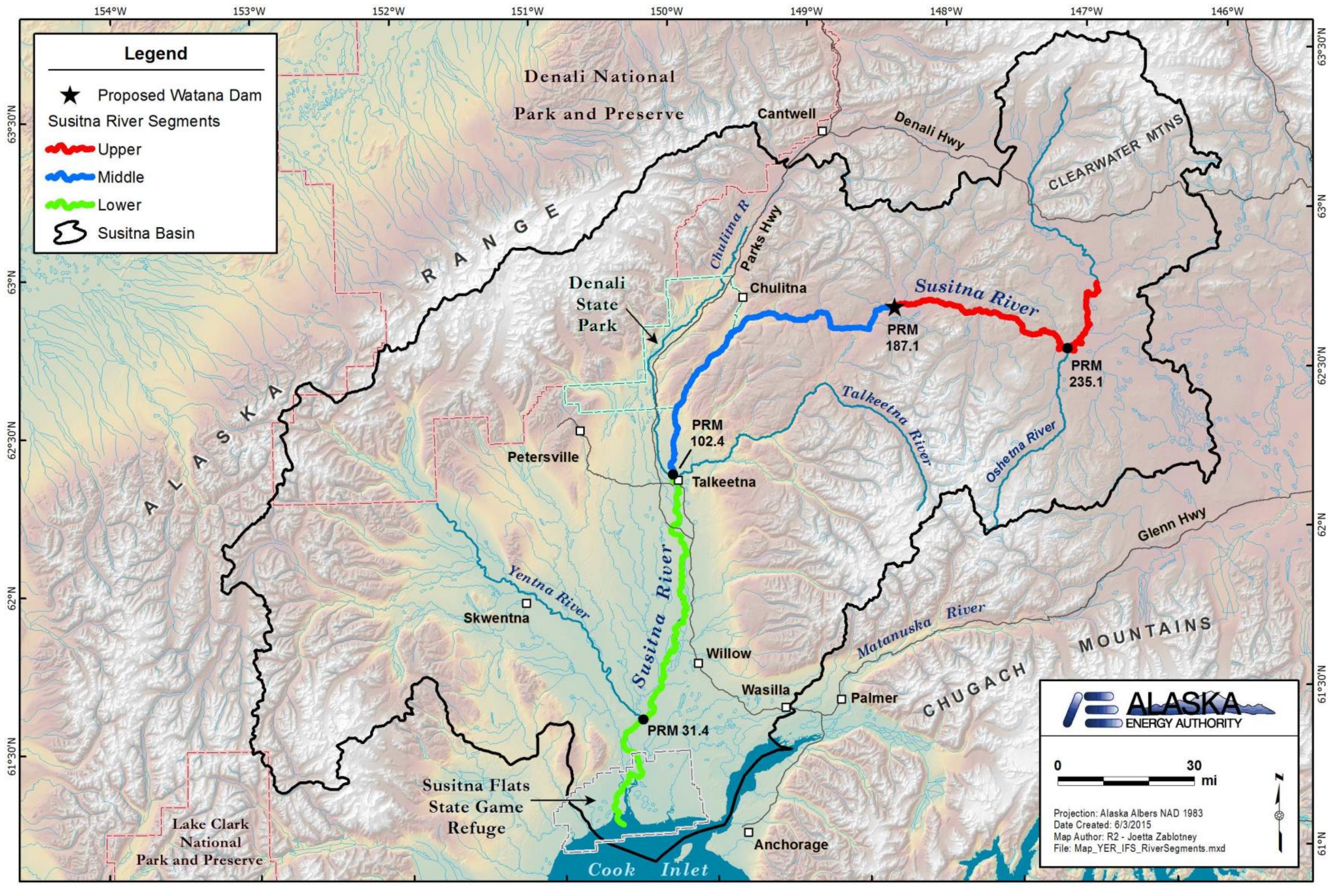


**Figure 3-1. Map depicting the Upper, Middle and Lower Segments of the Susitna River potentially influenced by the Susitna-Watana Hydroelectric Project.**

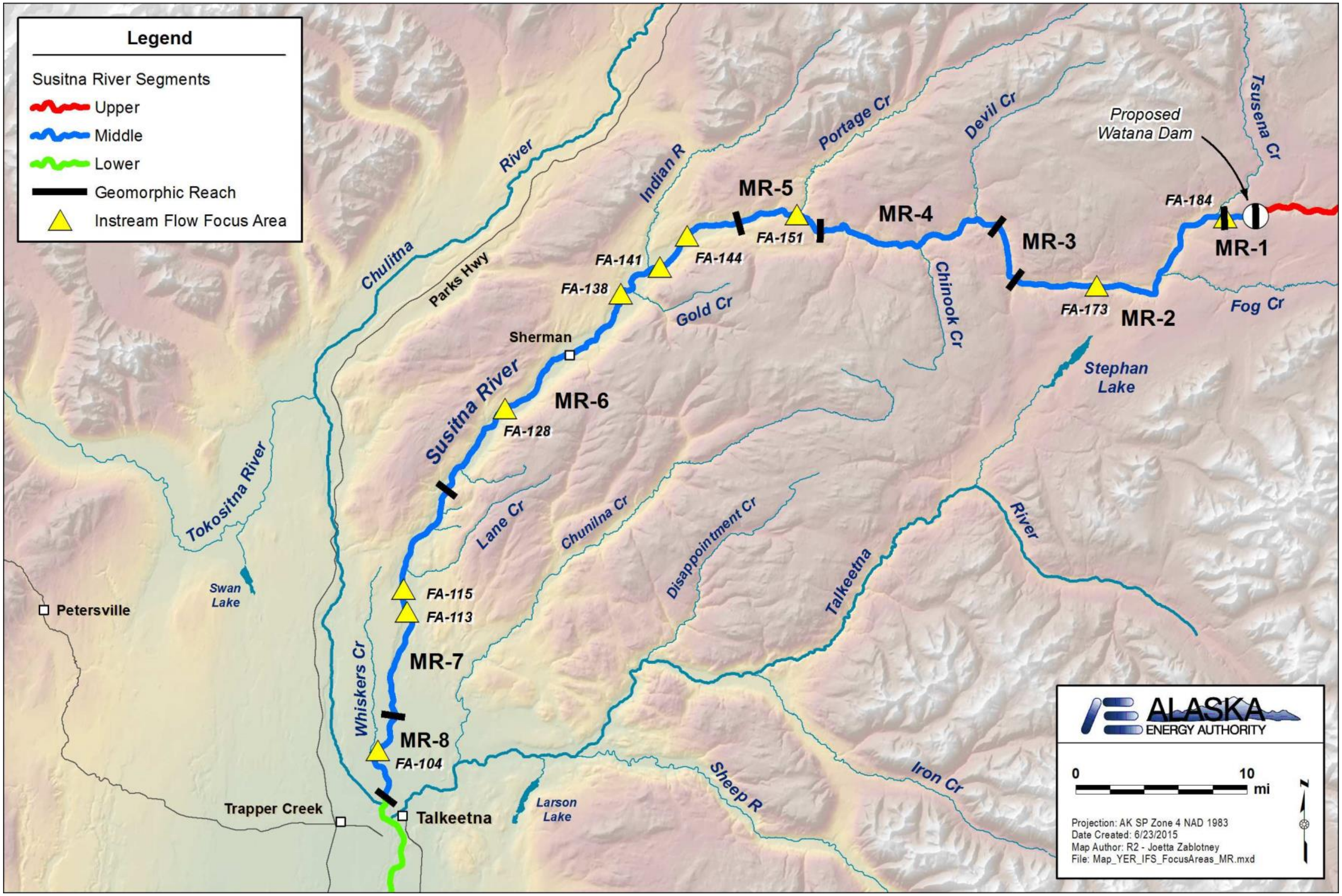


**Figure 3-2. Map of the Middle Segment of the Susitna River depicting the eight Geomorphic Reaches and locations of ten Focus Areas. No Focus Areas were located in MR-3 and MR-4 due to safety issues related to sampling within or proximal to Devils Canyon.**

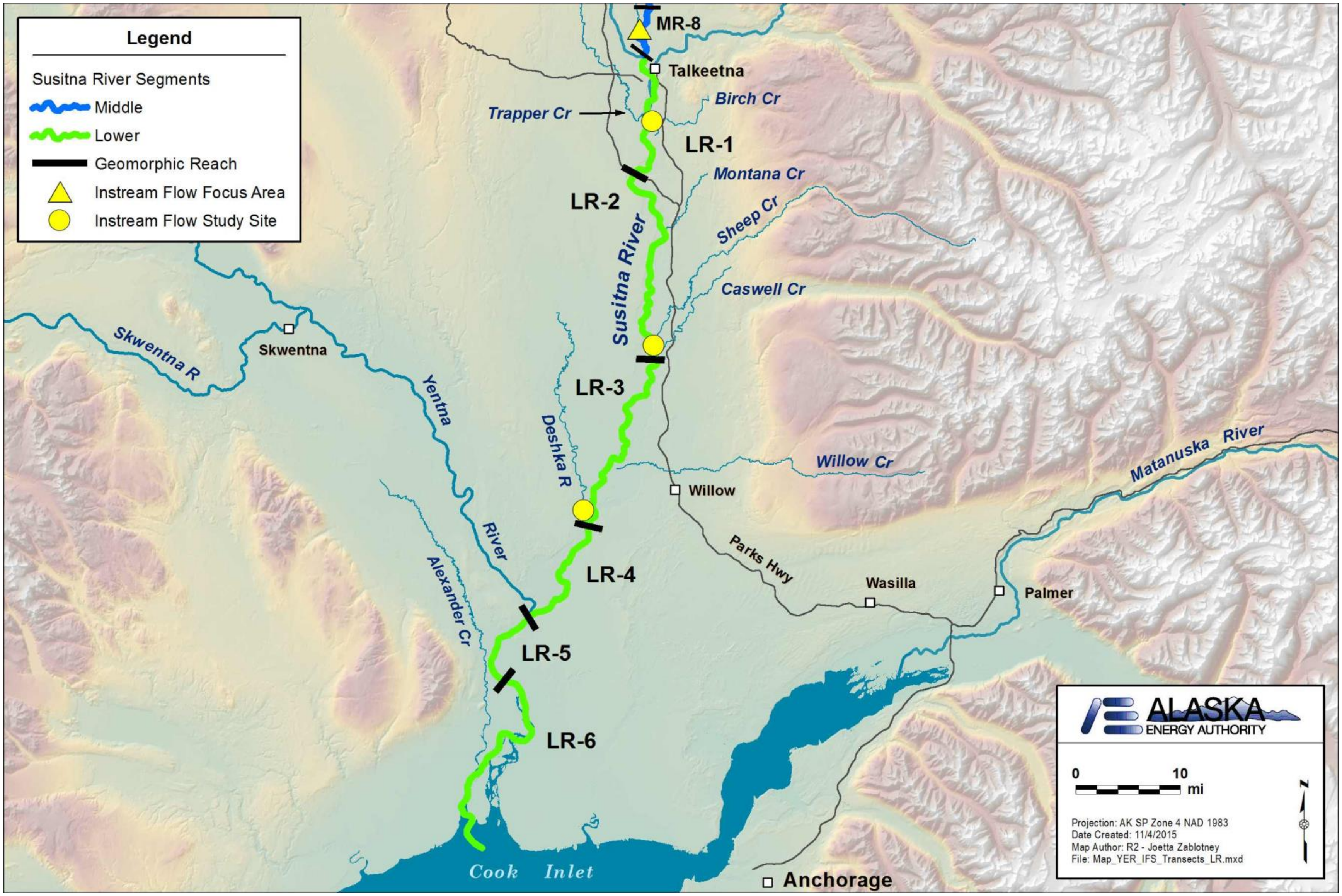


**Figure 3-3. Map of the Lower Segment of the Susitna River depicting the six Geomorphic Reaches.**

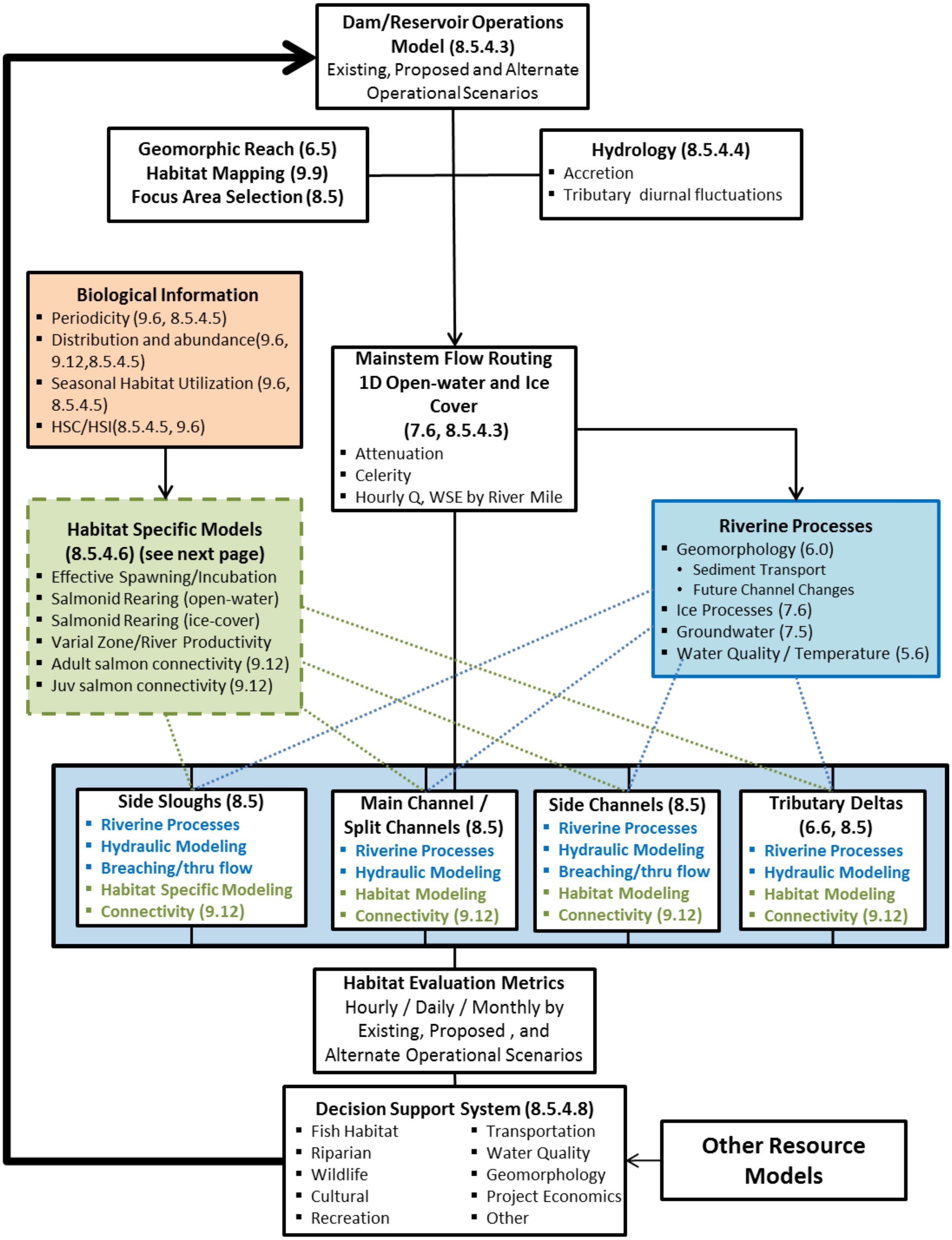


**Figure 4.1-1a. Conceptual framework for the Susitna-Watana Instream Flow Study depicting integration of habitat specific models and riverine processes to support integrated resource analyses. (Source: ISR Study 8.5, Figure 4.1-1.)**

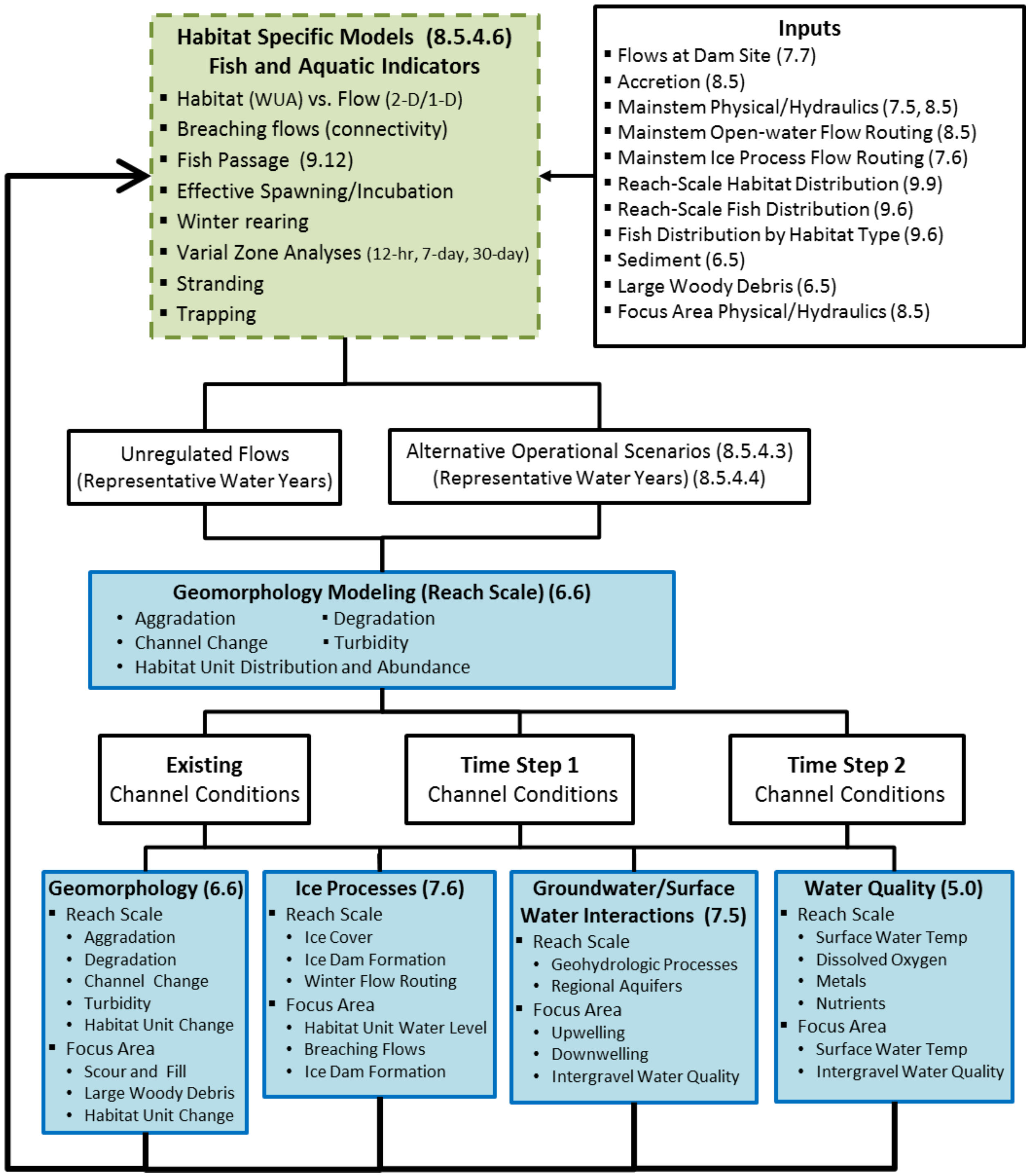


**Figure 4.1-1b. Conceptual framework for the Susitna-Watana Instream Flow Study depicting integration of riverine processes to develop fish and aquatic habitat specific models. (Source: ISR Study 8.5, Figure 4.1-1.)**

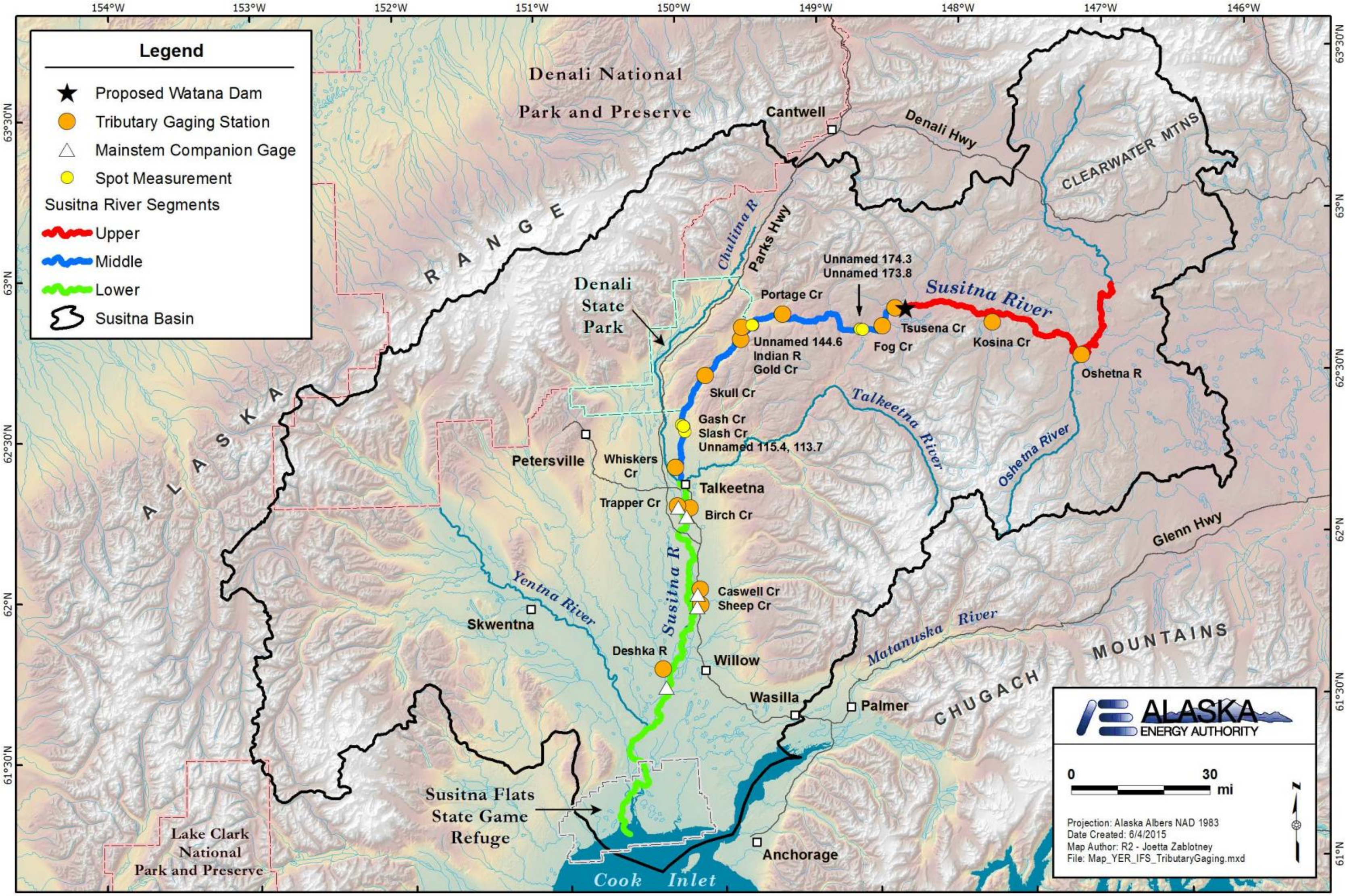


**Figure 4.3-1. Location of tributary gage sites. (Source: SIR Study 8.5, Appendix B, Figure 1.)**

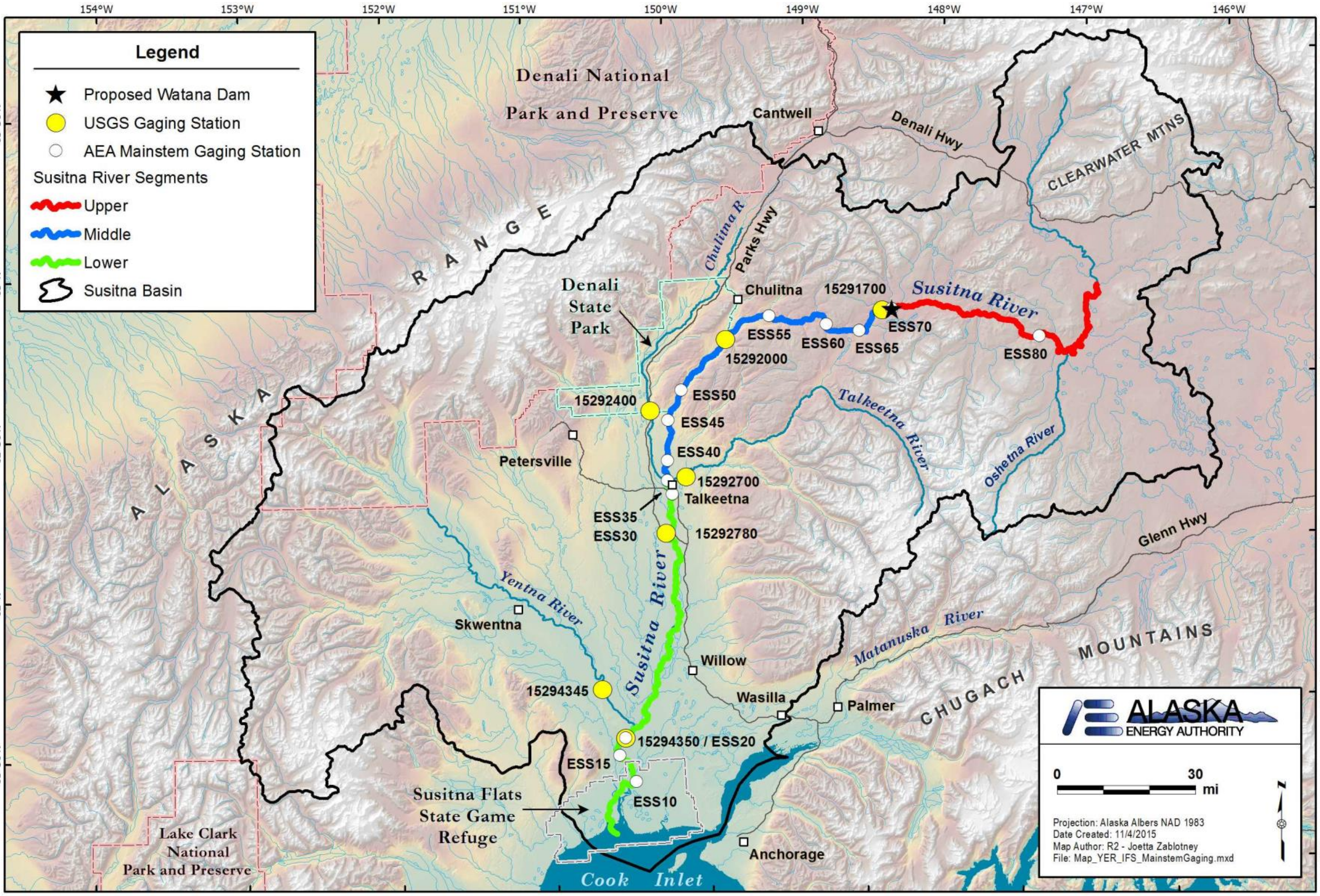


**Figure 4.4-1. Mainstem gaging locations.**

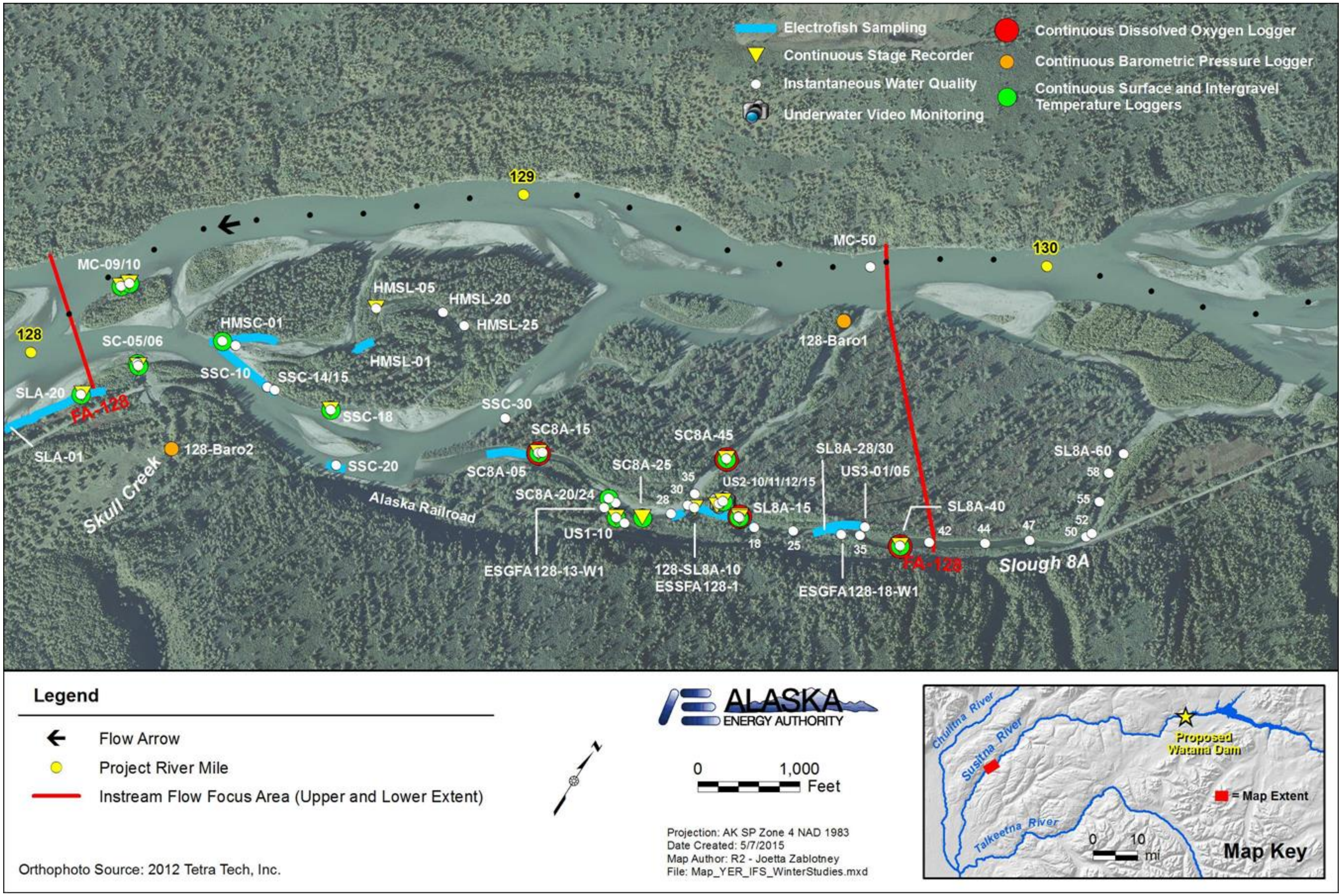


**Figure 4.5-1. Locations of IFS winter studies sites used for continuous and instantaneous water quality monitoring, water level monitoring, and fish sampling in FA-104 (Whiskers Slough) during the winter seasons of 2012-2013, 2013-2014 and 2014-2015. (Source: SIR Study 8.5, Appendix D, Figure 5.2-13.)**

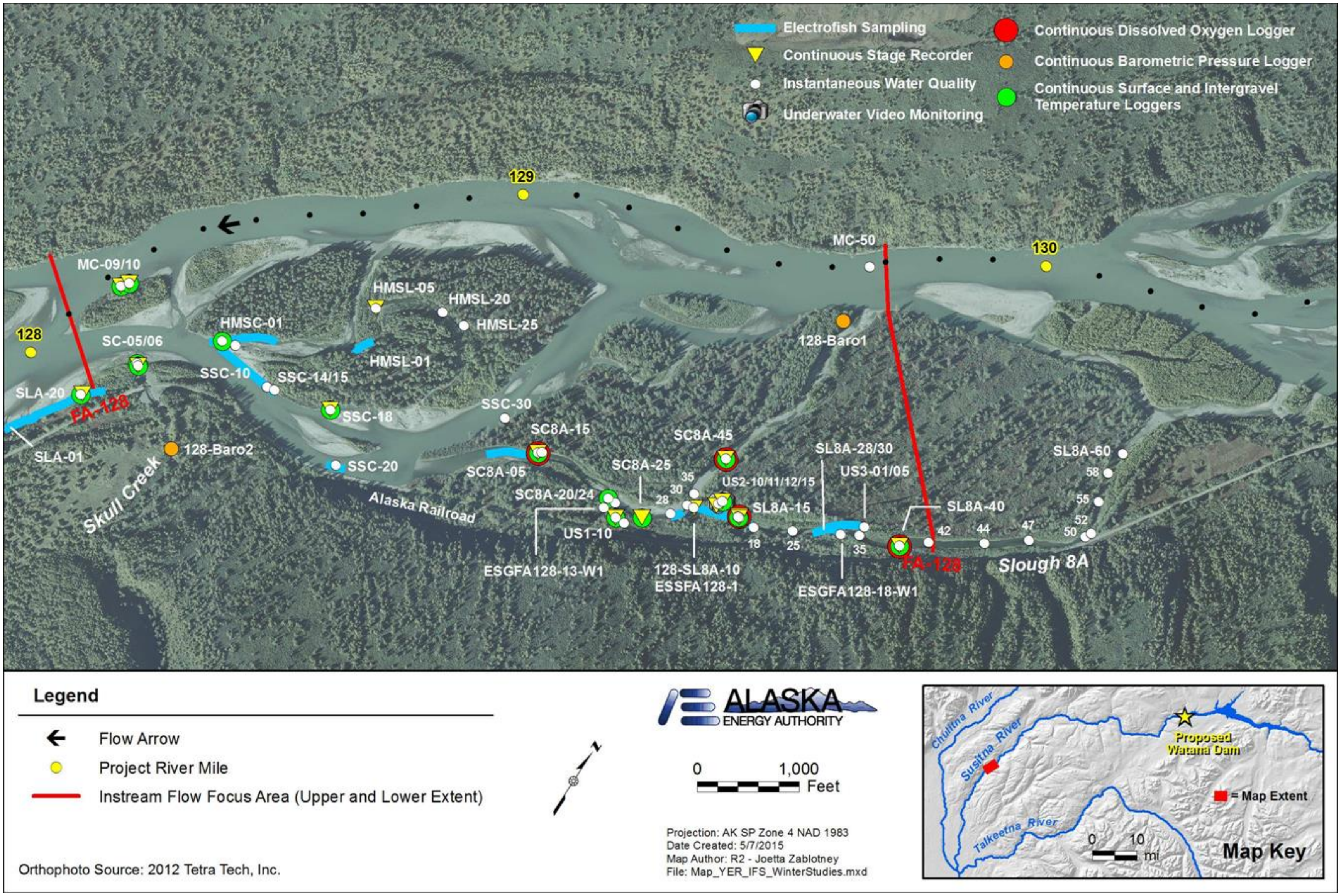


**Figure 4.5-2. Locations of IFS winter studies sites used for continuous and instantaneous water quality monitoring, water level monitoring, and fish sampling in FA-128 (Slough 8A) during the winter seasons of 2012-2013, 2013-2014 and 2014-2015. (Source: SIR Study 8.5, Appendix D, Figure 5.2-14.)**

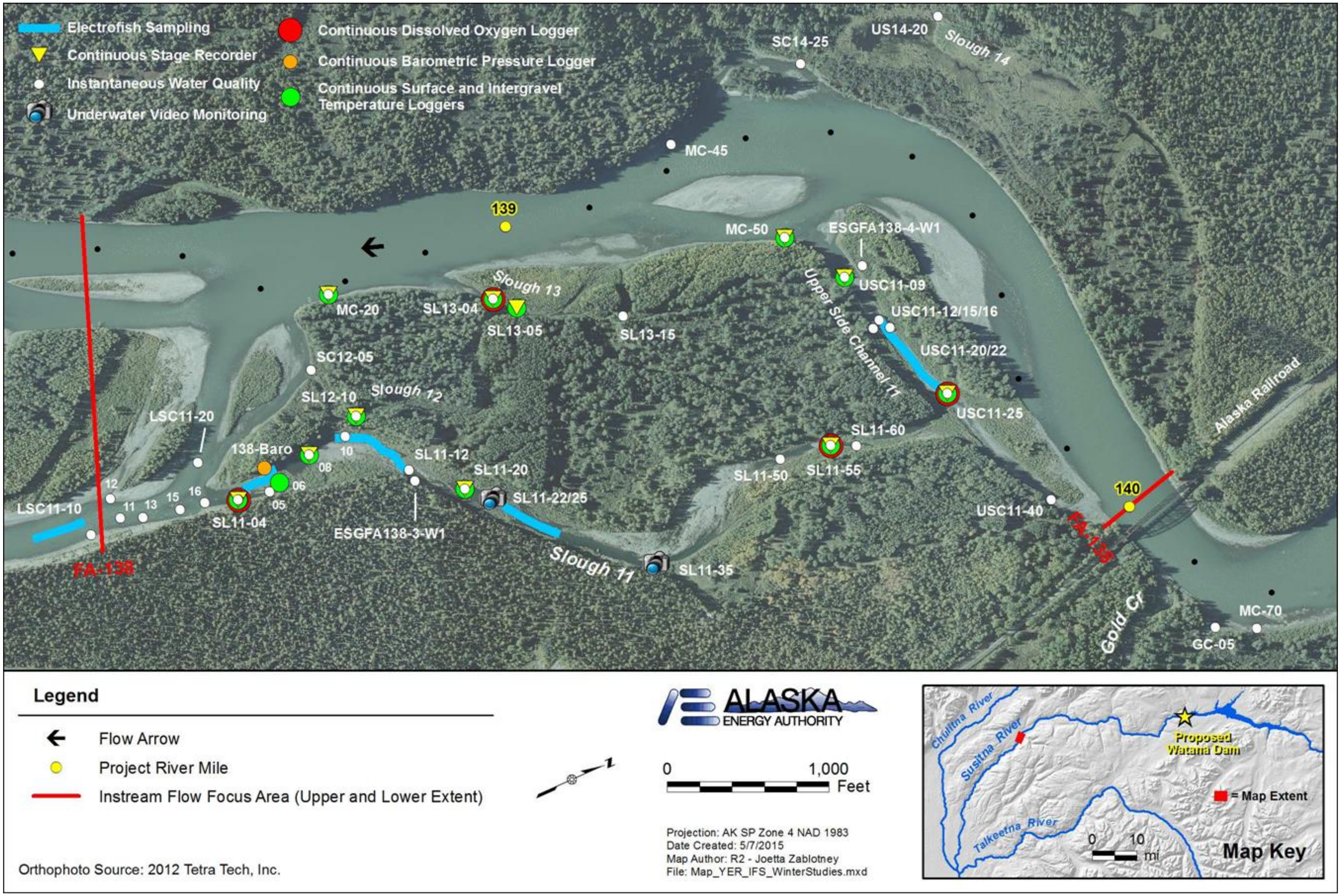


**Figure 4.5-3. Locations of IFS winter studies sites used for continuous and instantaneous water quality monitoring, water level monitoring, and fish sampling in FA-138 (Gold Creek) during the winter seasons of 2013-2014 and 2014-2015. (Source: SIR Study 8.5, Appendix D, Figure 5.2-15.)**

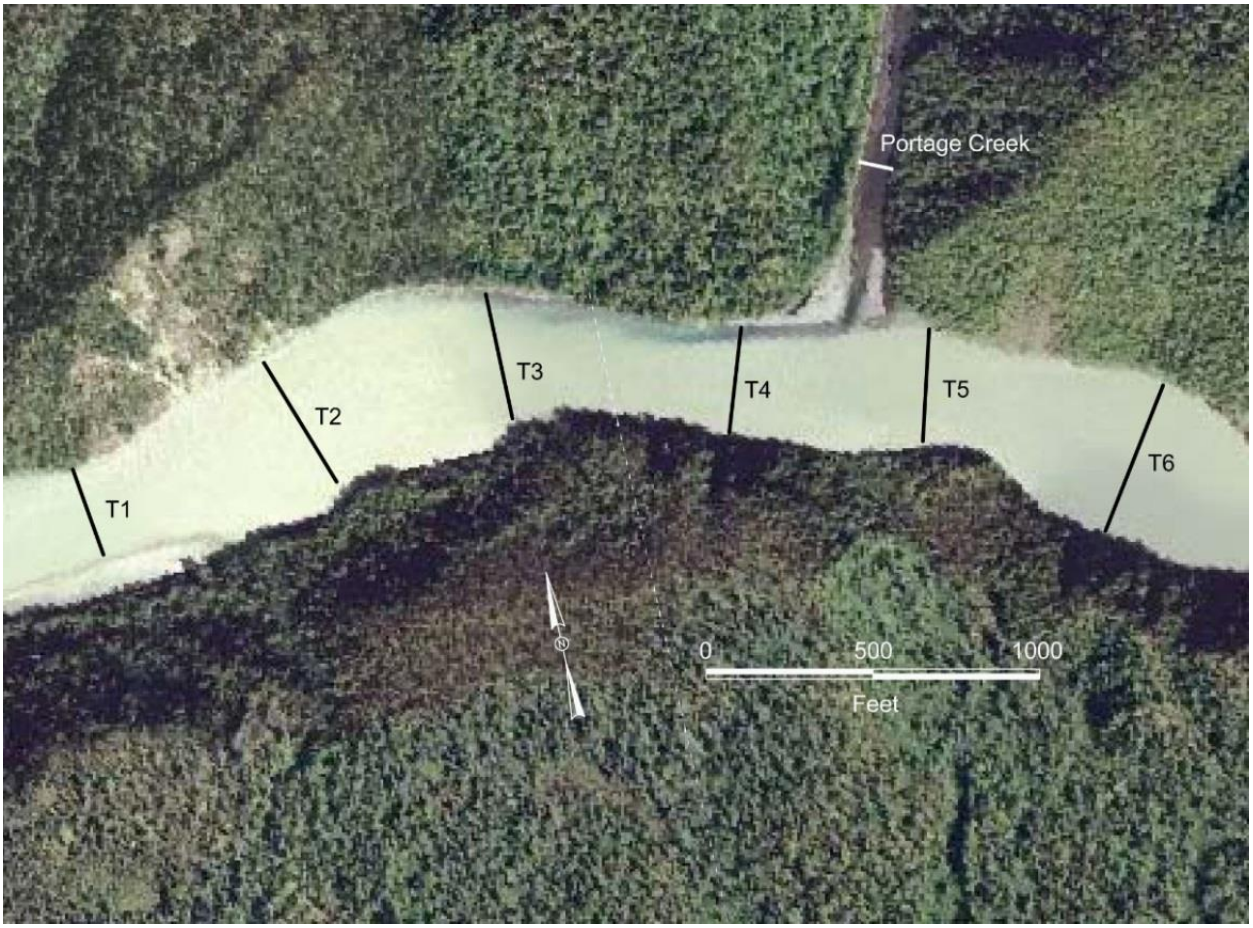


**Figure 4.6-1. 2-D Model calibration transects at FA-151 (Portage Creek). (Source: SIR Study 8.5, Appendix C, Figure 4.)**

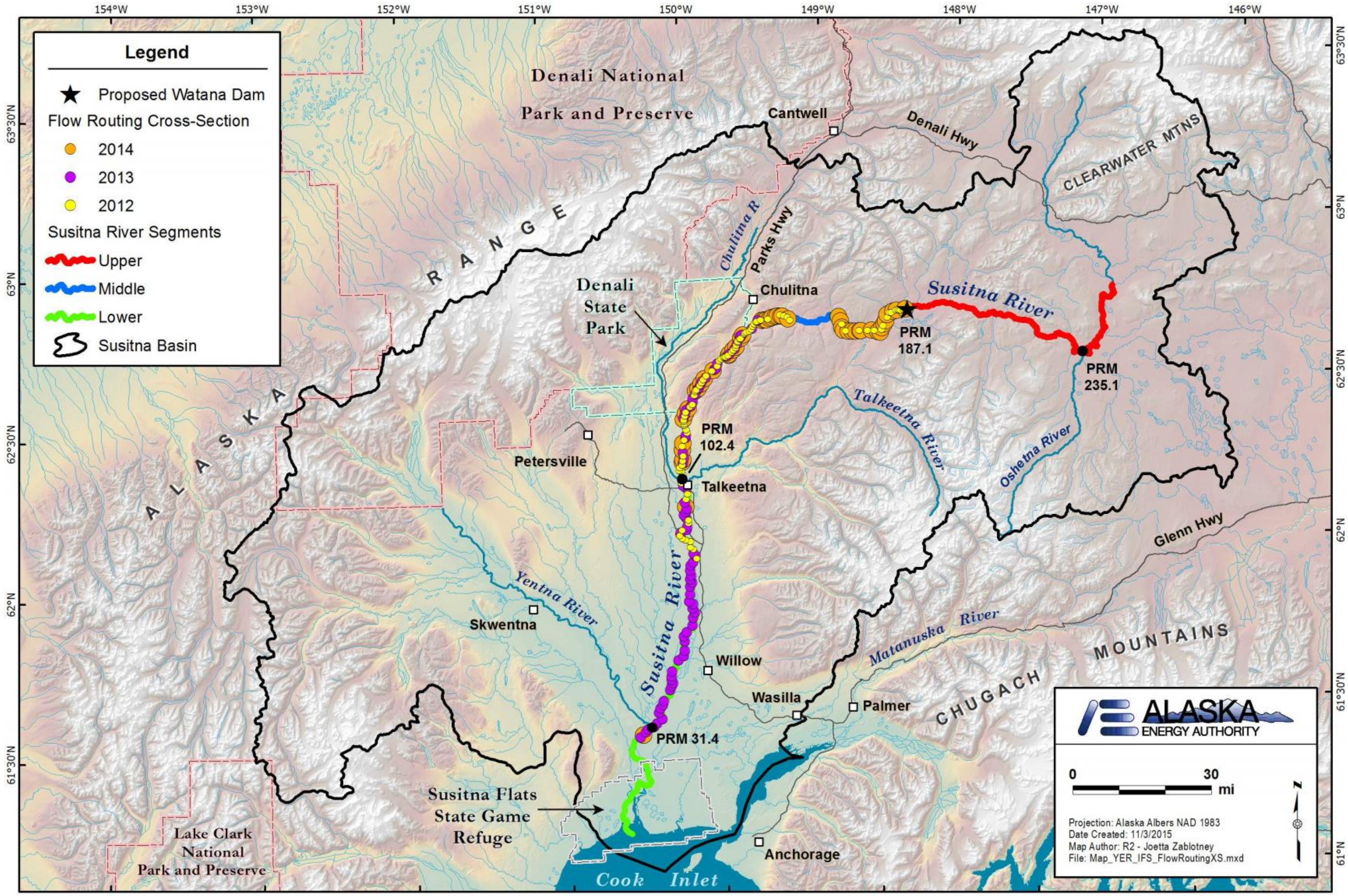


**Figure 5.3-1 Location of 2012, 2013, and 2014 measured flow-routing cross-sections. (Source: Modified ISR Study 8.5, Figure 5.3-1.)**

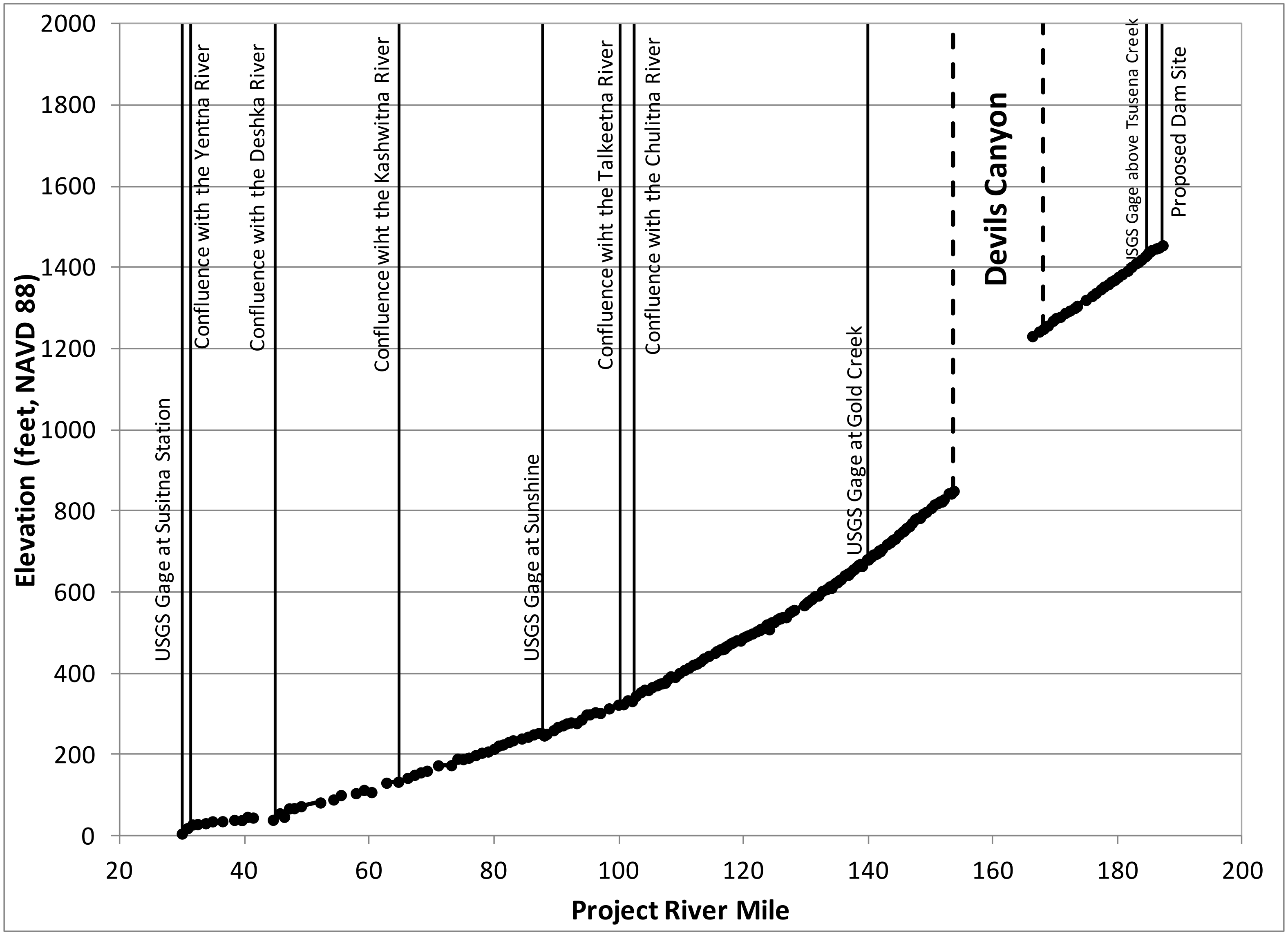


**Figure 5.4-1 Longitudinal thalweg profile of the Susitna River extending from PRM 29.9 to PRM 187.2. (Source: SIR Study 8.5, Appendix B, Figure 14.)**

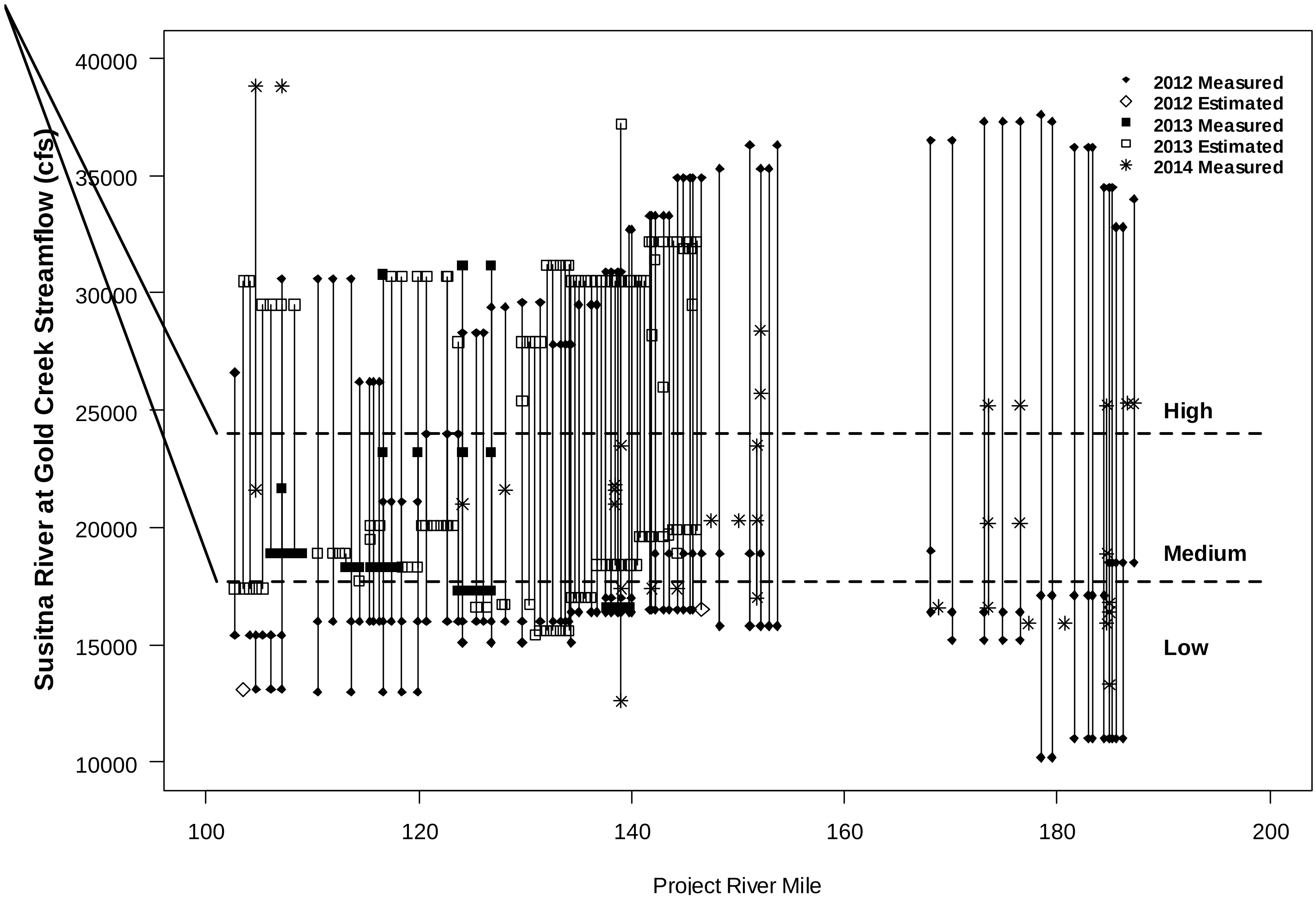


**Figure 5.4-2. Locations of flow measurements in the upper Susitna River in 2012-2014, and classification of flows as low, medium, or high based on concurrent measurements in the Susitna River at Gold Creek (USGS No. 15292000). (Source: SIR Study 8.5, Appendix B, Figure 15.)**

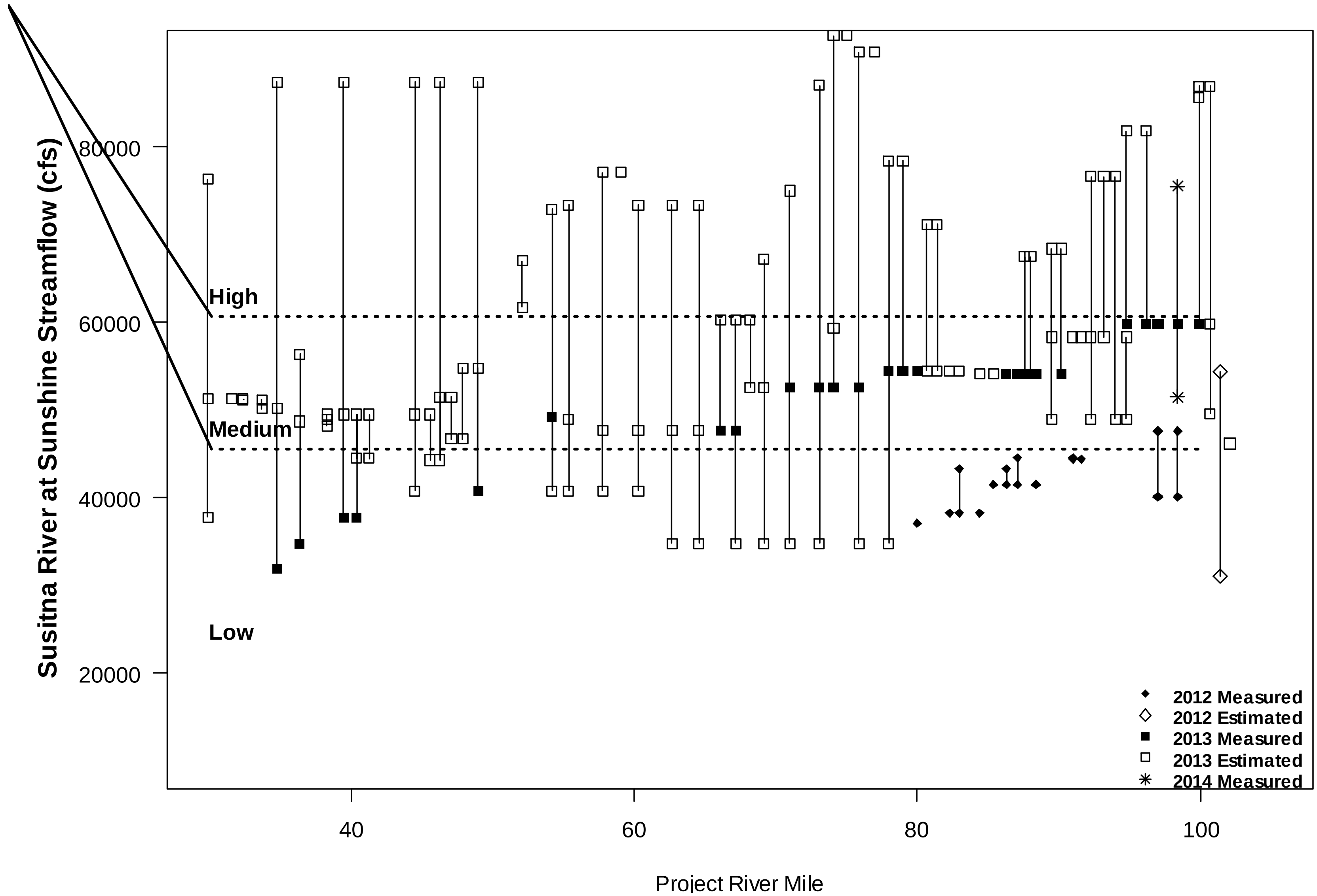


**Figure 5.4-3. Locations of flow measurements in the lower Susitna River in 2012-2014, and classification of flows as low, medium, or high based on concurrent measurements in the Susitna River at Sunshine gage (USGS No. 15292780). (Source: SIR Study 8.5, Appendix B, Figure 16.)**

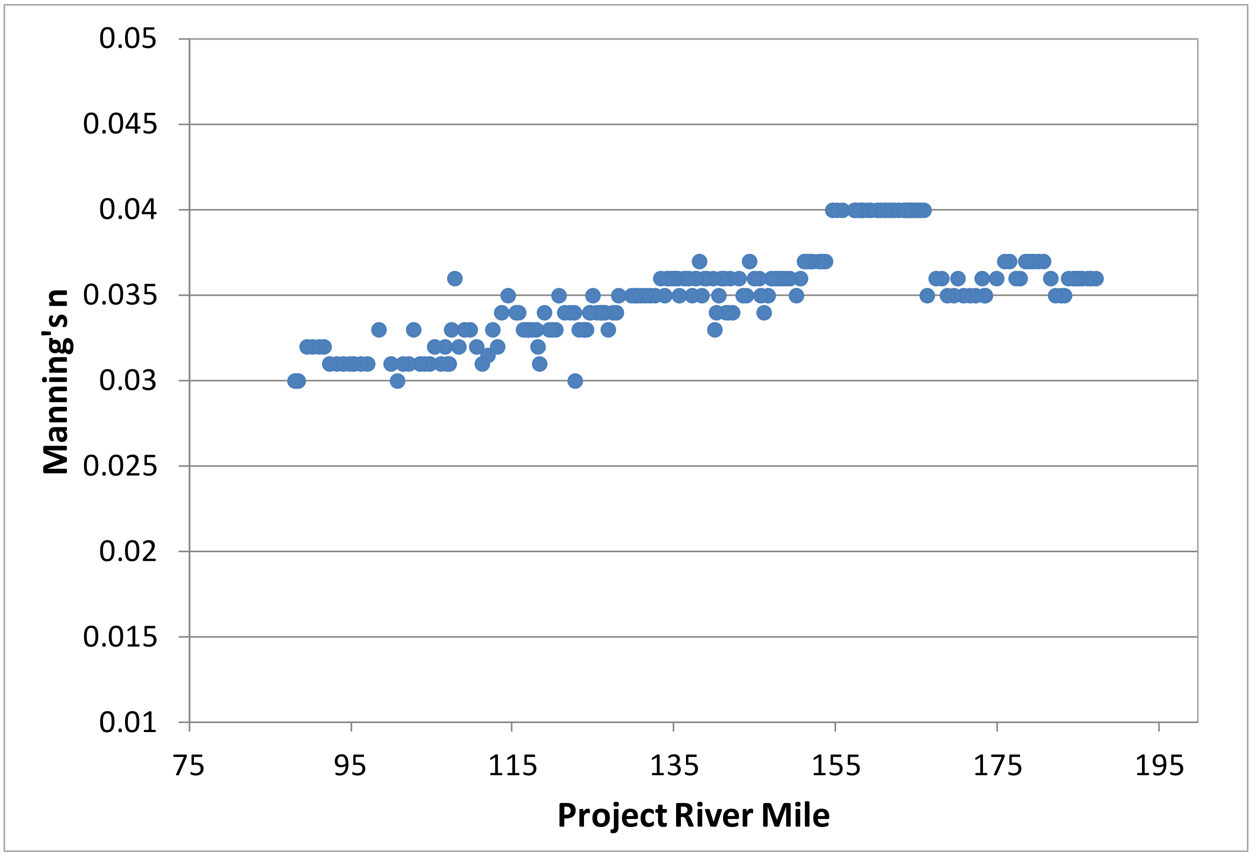


**Figure 5.4-4. Manning's *n* channel roughness coefficients derived from steady-state calibration of flow routing model for 216 cross-sections of the Susitna River surveyed between 2012 and 2014. (Source: SIR Study 8.5, Appendix B, Figure 17.)**

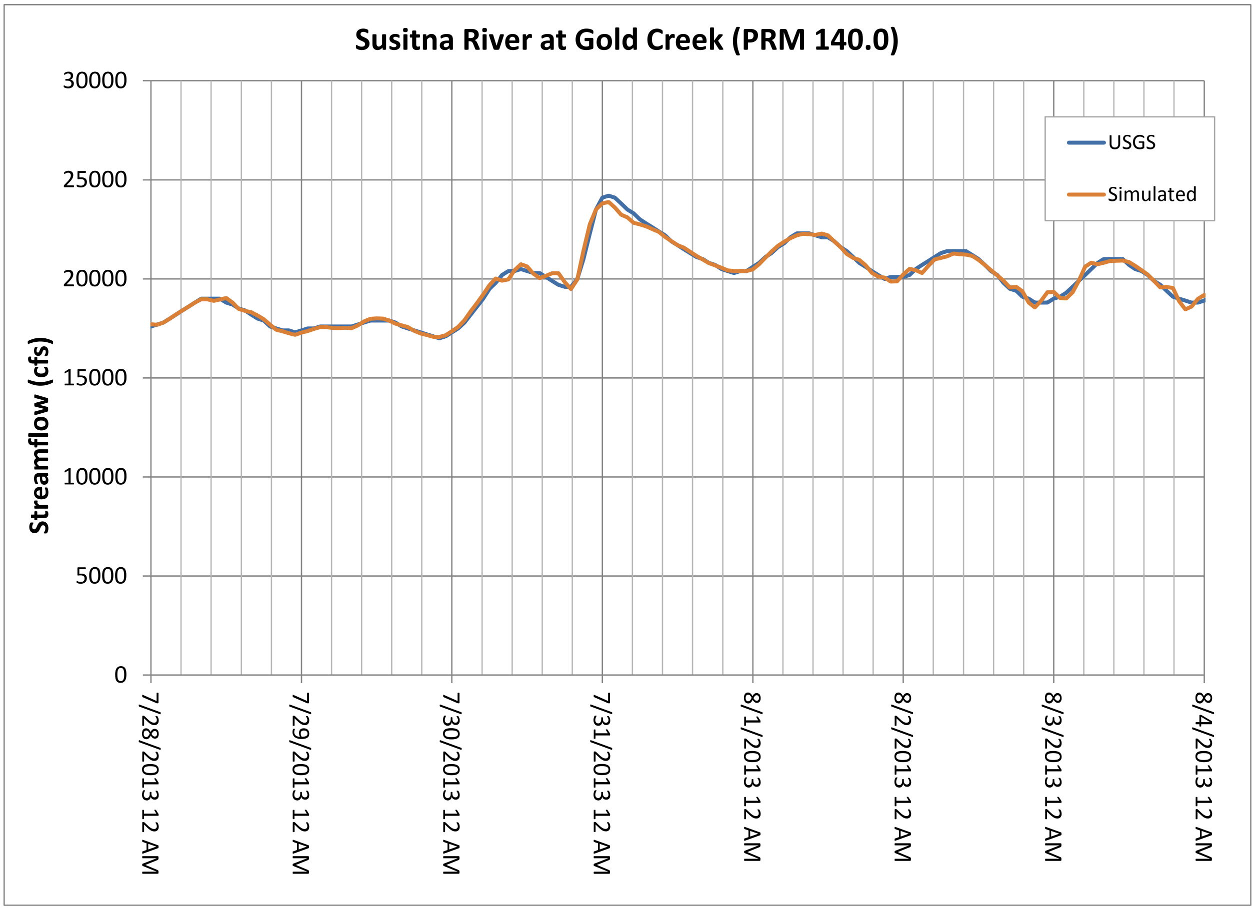


**Figure 5.4-5. Comparison of measured versus simulated flow hydrographs in the Susitna River at Gold Creek (USGS No. 15292000) during the period from July 28 to August 3, 2013. (Source: SIR Study 8.5, Appendix B, Figure 18.)**

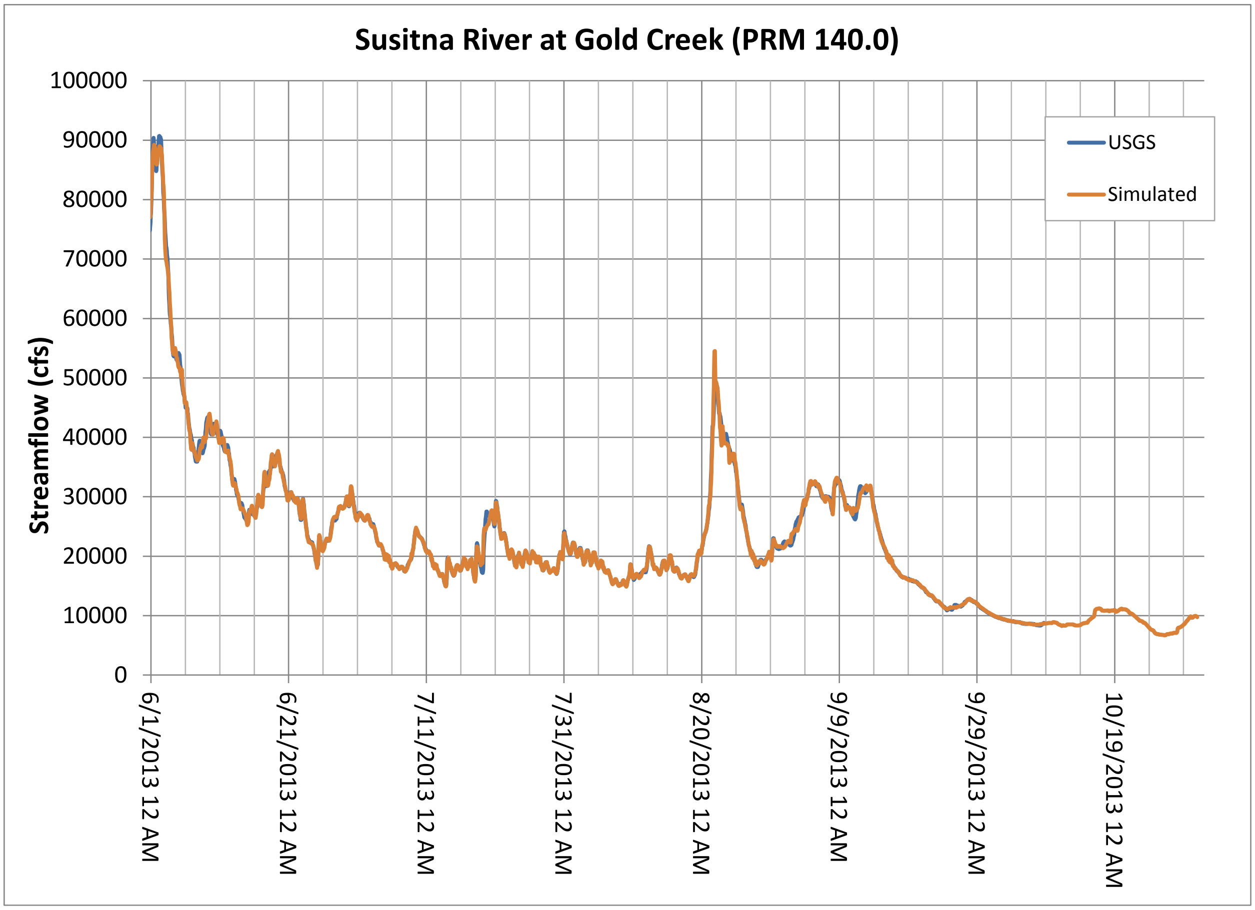


**Figure 5.4-6. Comparison of measured versus simulated flow hydrographs in the Susitna River at Gold Creek (USGS No. 15292000) during the 2013 open-water period. (Source: SIR Study 8.5, Appendix B, Figure 19.)**

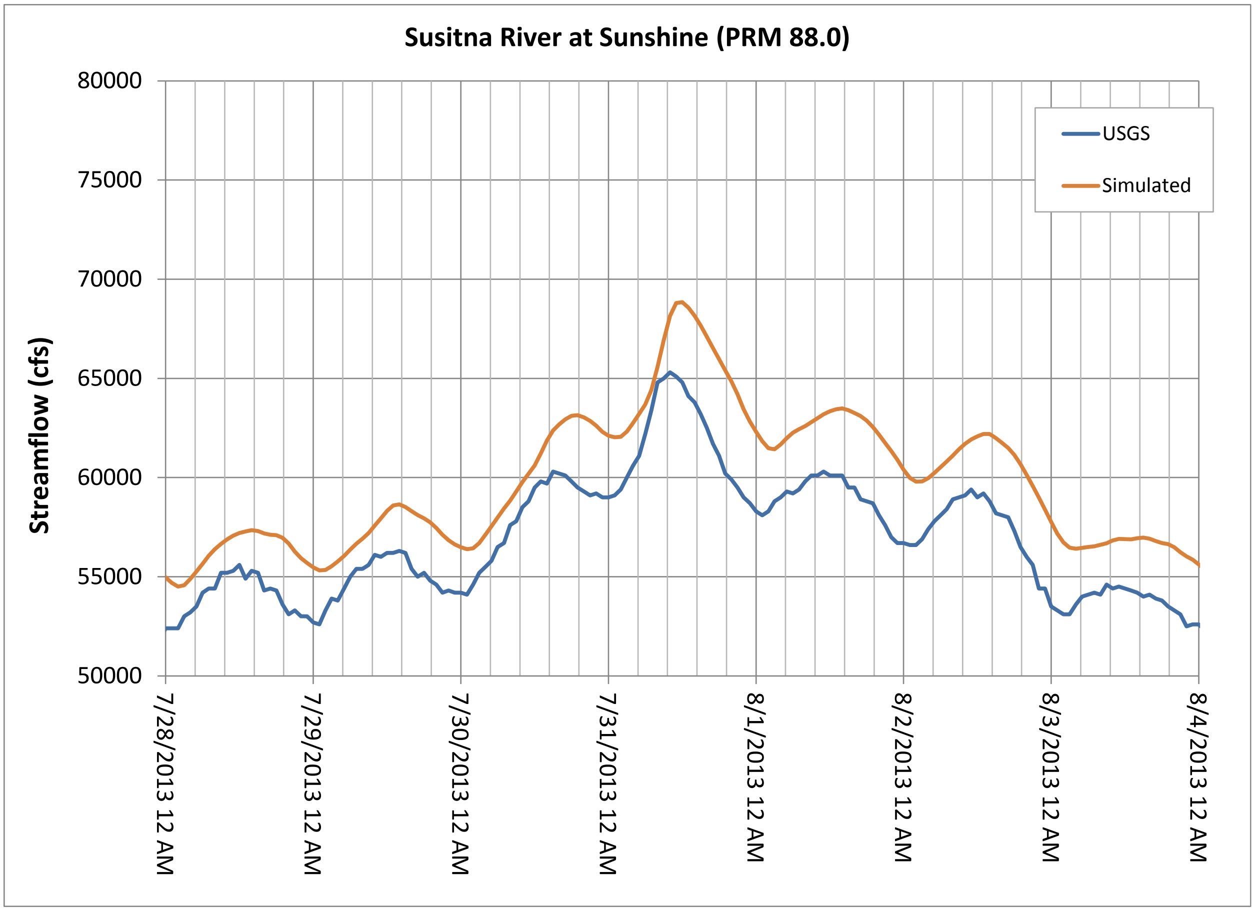


**Figure 5.4-7. Comparison of measured versus simulated flow hydrographs in the Susitna River at Sunshine (USGS No. 15292780) during the period from July 28 to August 3, 2013. (Source: SIR Study 8.5, Appendix B, Figure 20.)**

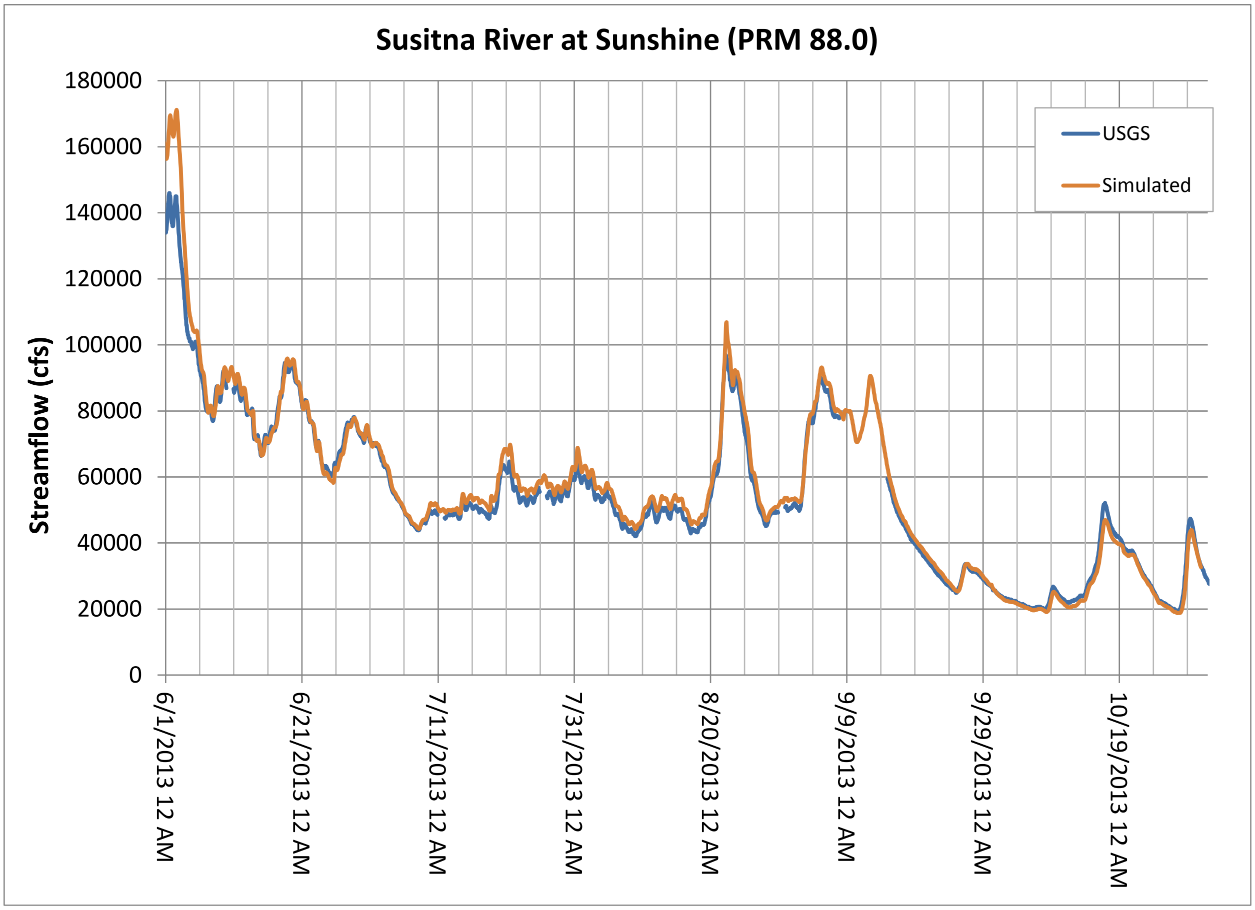


**Figure 5.4-8. Comparison of measured versus simulated flow hydrographs in the Susitna River at Sunshine (USGS No. 15292780) during the 2013 open-water period. (Source: SIR Study 8.5, Appendix B, Figure 21.)**

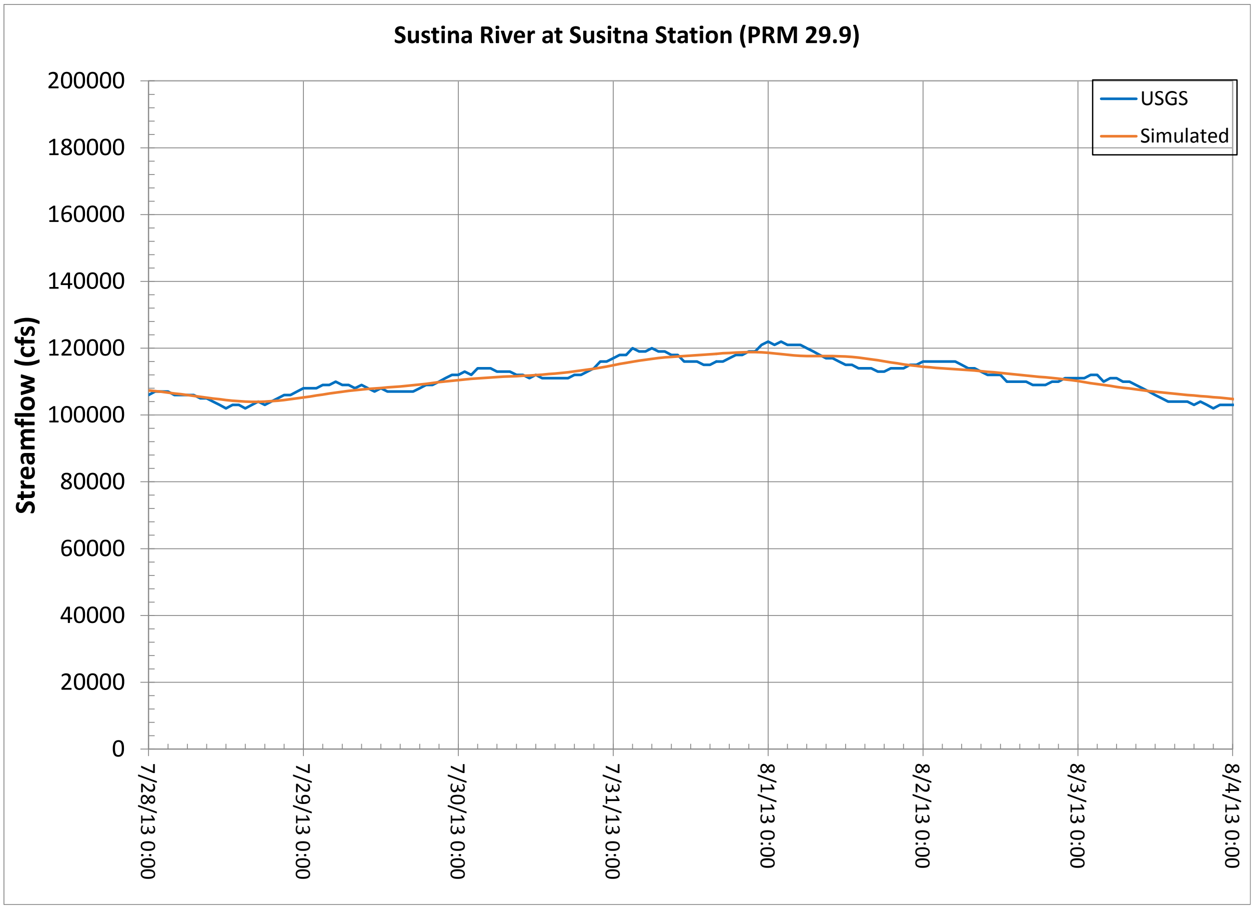


**Figure 5.4-9. Comparison of measured versus simulated flow hydrographs in the Susitna River at Susitna Station (USGS No. 15294350) during the period from July 28 to August 3, 2013. (Source: SIR Study 8.5, Appendix B, Figure 22.)**

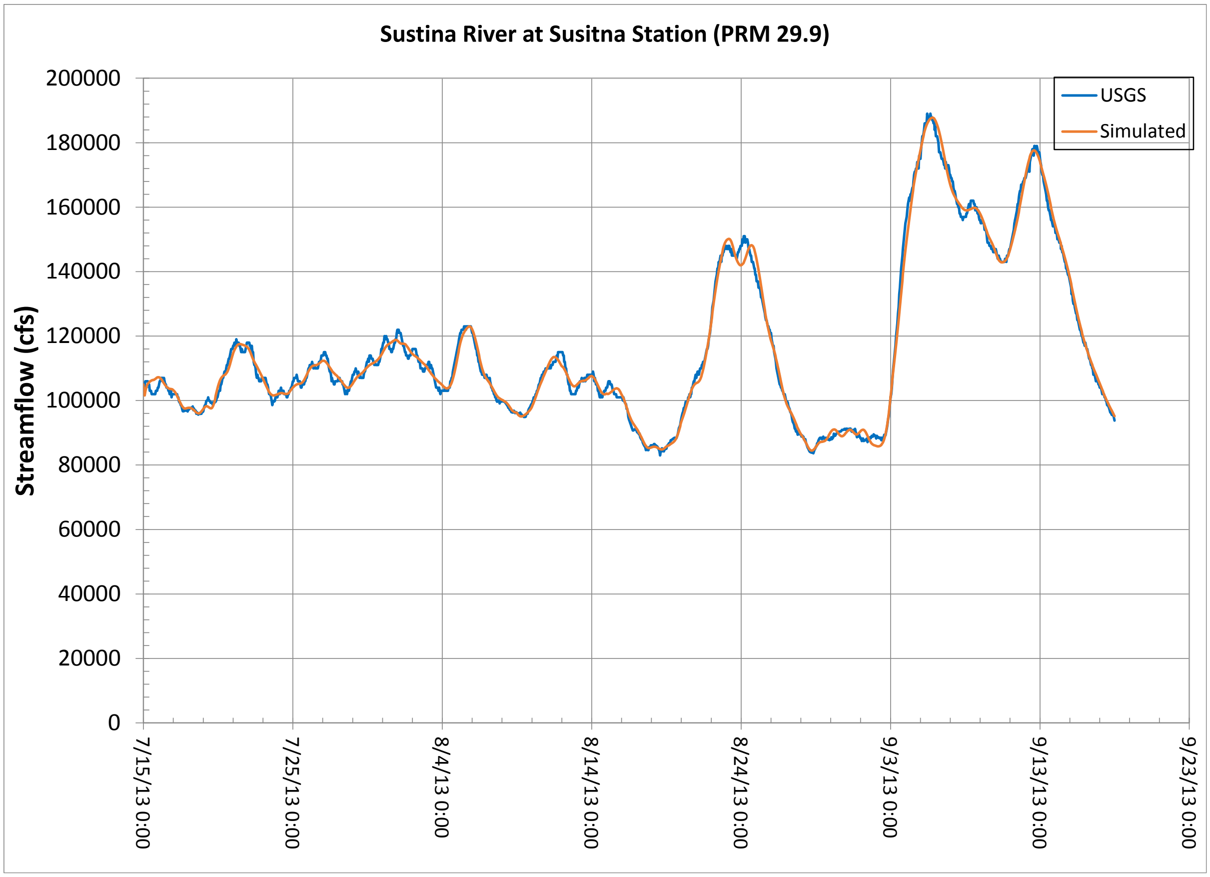


**Figure 5.4-10. Comparison of measured versus simulated flow hydrographs in the Susitna River at Susitna Station (USGS No. 15294350) during the 2013 open-water period. (Source: SIR Study 8.5, Appendix B, Figure 23.)**

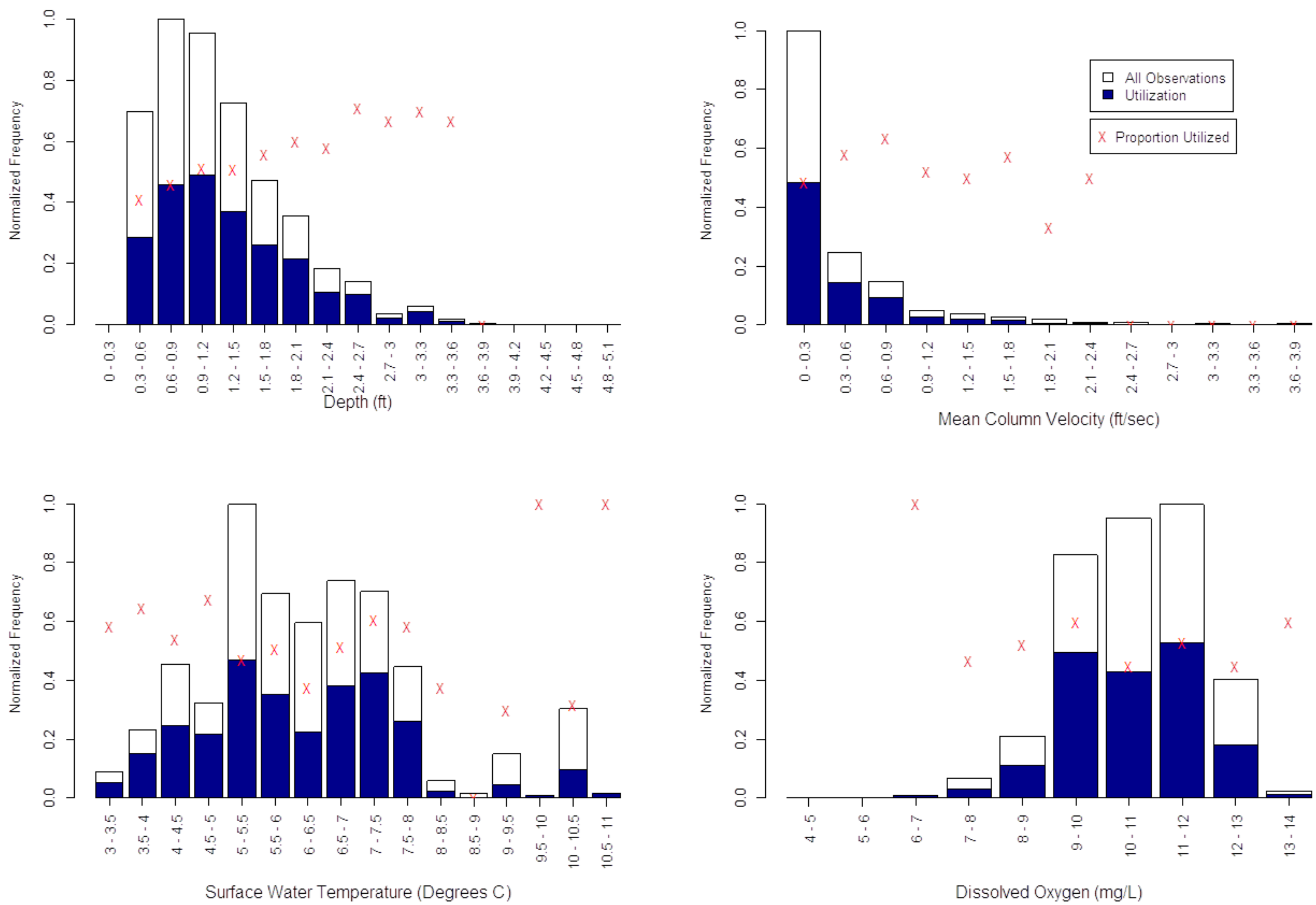


**Figure 5.5-1. Normalized utilization for four continuous habitat variables for spawning chum salmon. (Source: SIR Study 8.5, Appendix D, Attachment 5, Figure D5-3.)**

Note: Utilization data are normalized to availability of habitat for sites where fish were observed only.

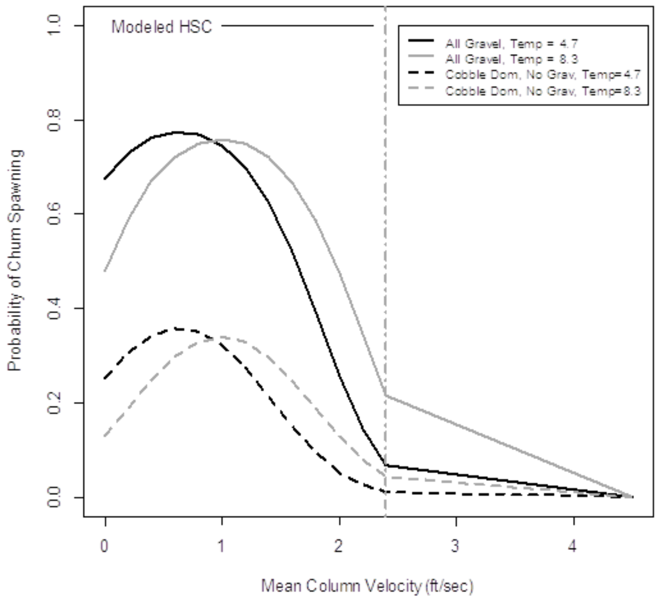


**Figure 5.5-2. Chum spawning HSC as a function of velocity for two substrate types and surface water temperatures, with depth fixed at 1.2 feet. (Source: SIR Study 8.5, Appendix D, Figure 5.6-5.)**

Note: Estimated preference for velocity > 2.4 fps is based on linear decline to 0 probability at threshold value of 4.5 fps.

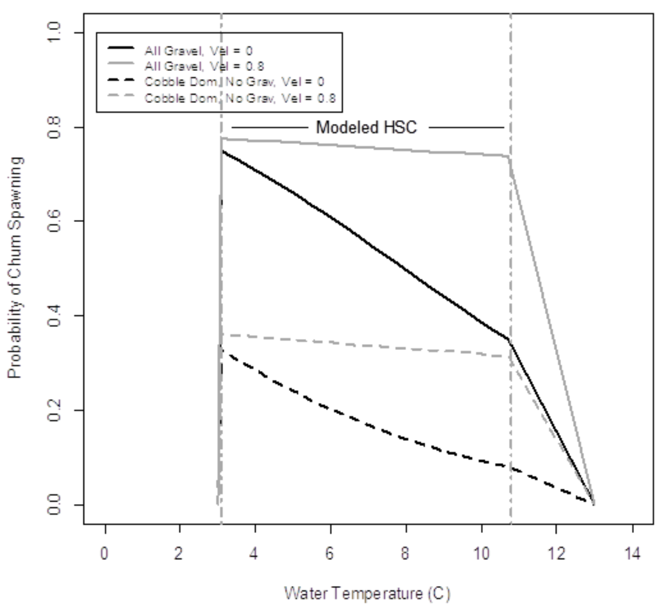


**Figure 5.5-3. Chum spawning HSC as a function of surface water temperature for two substrate types and velocities, with depth fixed at 1.2 feet. (Source: SIR Study 8.5, Appendix D, Figure 5.6-6.)**

Note: Estimated preference for temperatures less than 3.1 and greater than 9.3 are based on linear decline to 0 probability at threshold values of 3 and 13 degrees C, respectively.

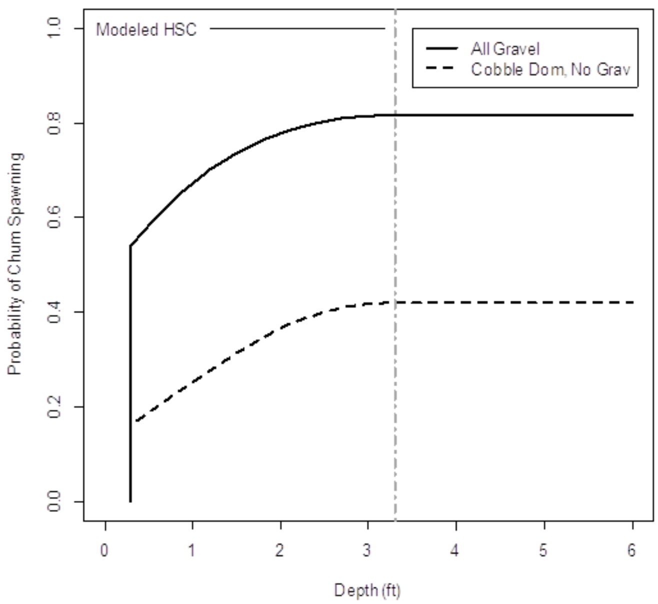


**Figure 5.5-4. Chum spawning HSC as a function of depth for two substrate types, with velocity fixed at 0.2 fps, and water temperature fixed at 5.5 degrees C. (Source: SIR Study 8.5, Appendix D, Figure 5.6-7.)**

Note: Estimated preference for depth < 0.3 feet is zero, and estimated preference for depth > 3.3 feet is non-limiting (i.e., fixed at the highest modeled value).

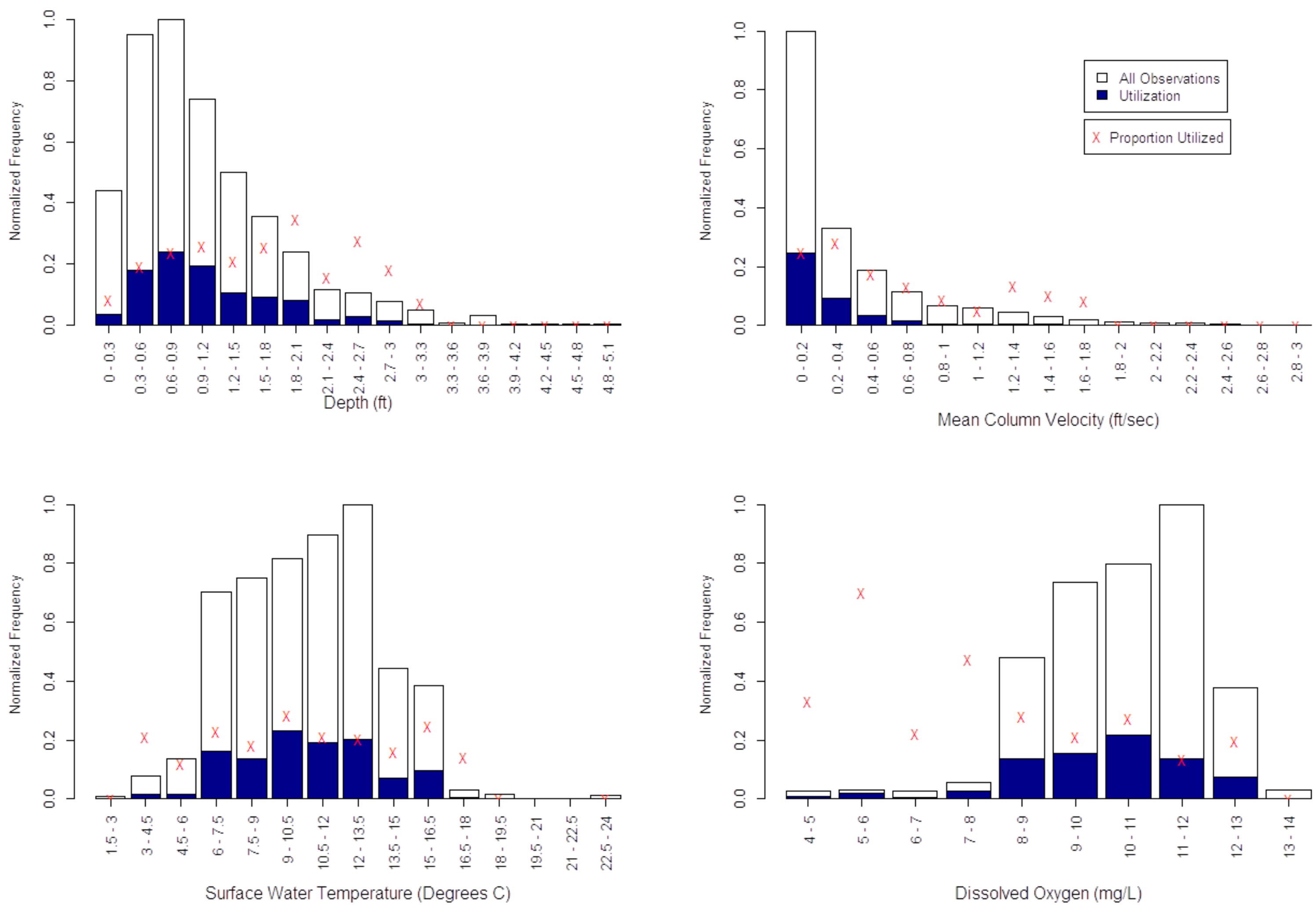


**Figure 5.5-5. Normalized utilization for four continuous habitat variables for coho salmon fry. (Source: SIR Study 8.5, Appendix D, Attachment 5, Figure D5-4.)**

Note: Utilization data are normalized to availability of habitat for sites where fish were observed only.

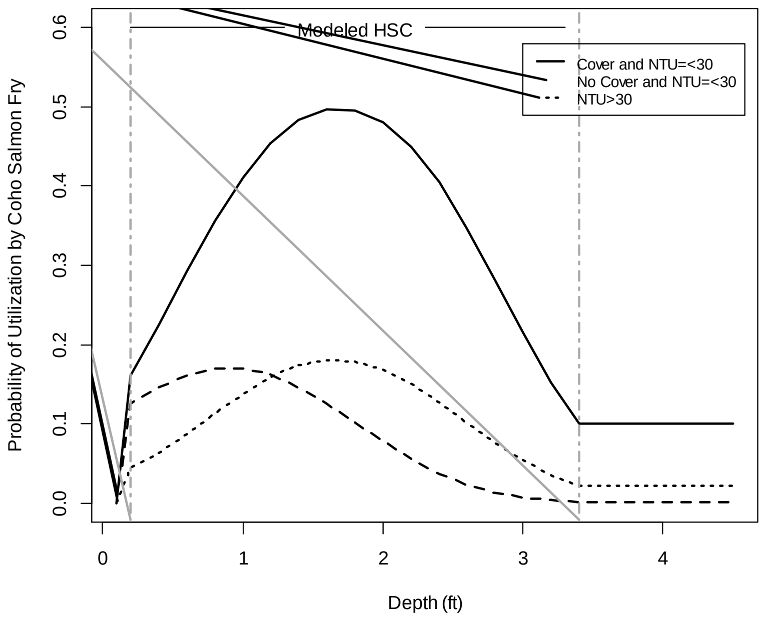


**Figure 5.5-6. HSC model for coho salmon fry as a function of depth for fixed velocity of 0.4 fps for three different substrate/turbidity groups. (Source: SIR Study 8.5, Appendix D, Figure 5.6-8.)**

Note: Estimated preference for depth < 0.2 feet (first observed fish) is linear decreasing to the threshold of 0.05 feet, and estimated preference for depths > 3.4 feet (last observed fish) is non-limiting (i.e., fixed at the highest modeled value).

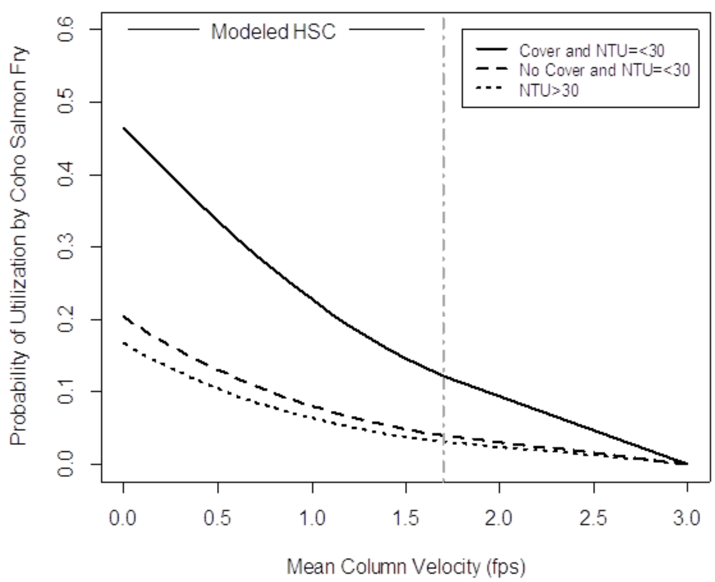


**Figure 5.5-7. HSC model for coho salmon fry as a function of velocity for fixed depth of 1 foot for three different substrate/turbidity groups. (Source: SIR Study 8.5, Appendix D, Figure 5.6-9.)**

Note: Estimated preference for velocity > 1.7 fps (last observed fish) is based on linear decline to 0 probability at threshold value of 3 fps.

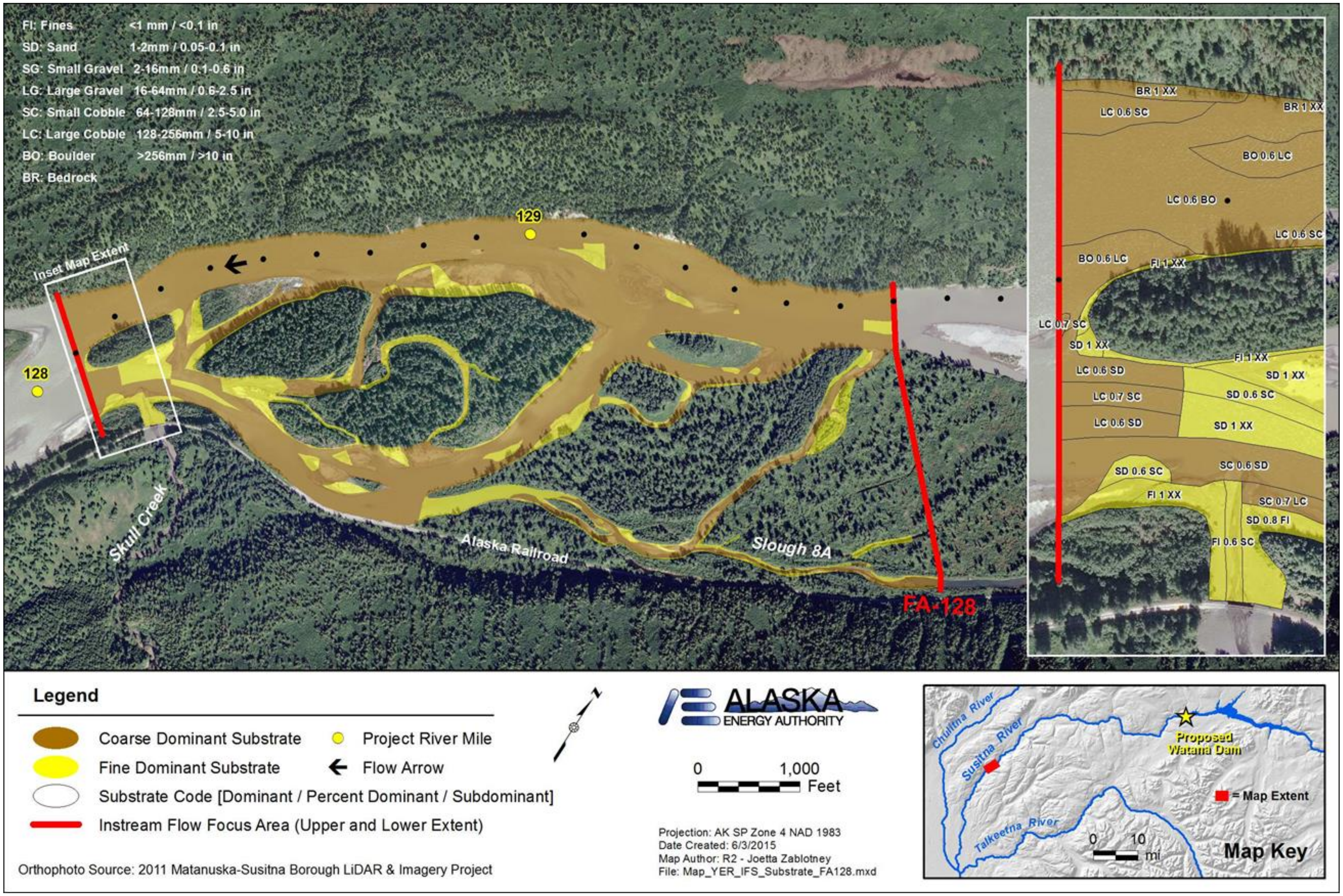


**Figure 5.6-1. Substrate characterization mapping in FA-128 (Slough 8A) on September 21, 2013. For display purposes, the figure shows the distribution of coarse and fine substrate within the Focus Area; however, the dominant and subdominant particle size and the percent composition of each substrate polygon is used for habitat modeling purposes (see enlargement of the lower end of the Focus Area). (Source: SIR Study 8.5, Appendix E, Figure 5.)**


**Figure 5.6-2. Cover polygons in FA-128 (Slough 8A) mapped during September 2013 habitat surveys. (Source: SIR Study 8.5, Appendix E, Figure 13.)**

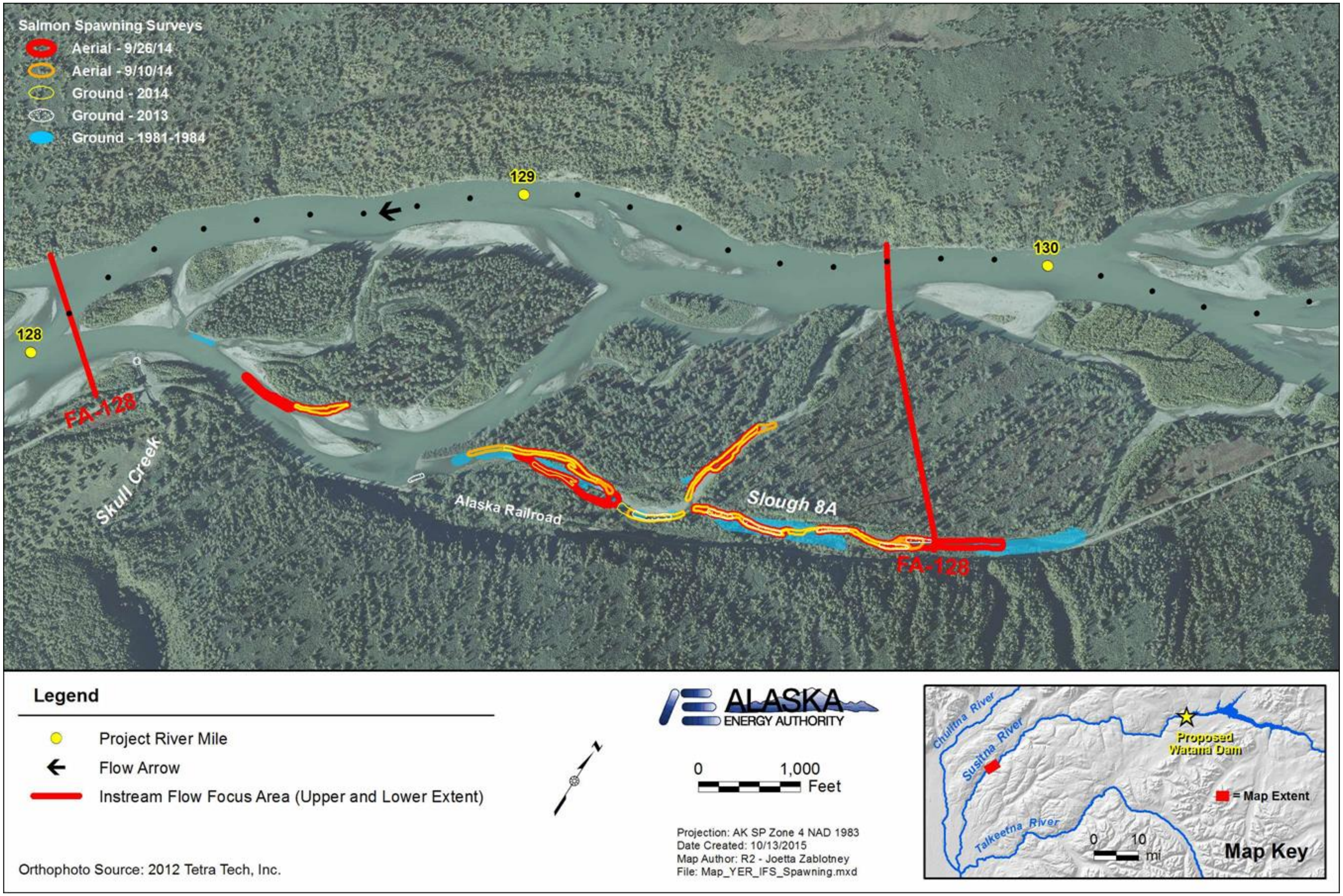


**Figure 5.6-3. Salmon spawning areas mapped within FA-128 (Slough 8A) during 2013 and 2014 IFS aerial and ground spawning surveys and in association with 1981-1984 monitoring efforts in the Middle River Segment of the Susitna River. (Source: SIR Study 8.5, Appendix E, Figure 20.)**

# APPENDIX A: 2014 INSTREAM FLOW WINTER STUDIES

[See separate file for Appendix.]

# APPENDIX B: OPEN-WATER HYDROLOGY DATA COLLECTION AND OPEN-WATER FLOW ROUTING MODEL (VERSION 2.8)

[See separate file for Appendix.]

# APPENDIX C: 2014 MOVING BOAT ACOUSTIC DOPPLER CURRENT PROFILER (ADCP) MEASUREMENTS

[See separate file for Appendix.]

# APPENDIX D: HABITAT SUITABILITY CRITERIA DEVELOPMENT

[See separate file for Appendix.]

# APPENDIX E: FISH HABITAT MODELING DATA: SURFICIAL SUBSTRATE AND COVER CHARACTERIZATION AND SALMON SPAWNING OBSERVATIONS BY FOCUS AREA

[See separate file for Appendix.]