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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

Fish and Aquatics Instream Flow Study
Study Plan Section 8.5

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

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

June 2014

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
ADCP	Acoustic Doppler Current Profiler
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
cfs	cubic feet per second
CIRWG	Cook Inlet Region Working Group
DO	dissolved oxygen
DSS	data storage system
EFC	Environmental Flow Component
EFM	Ecosystem Functions Model
FA	focus area
FERC	Federal Energy Regulatory Commission
fps	feet per second
FSP	Final Study Plan
ft/sec	feet per second
GIS	geographic information system
GPS	global positioning system
HRM	Historic River Mile
HSC	Habitat Suitability Criteria
HSI	Habitat Suitability Index
IFIM	Instream Flow Incremental Methodology
IFS	Instream Flow Study
IFS-FA	Instream Flow Study – Fish and Aquatics (8.5)
IHA	Indicators of Hydrologic Alteration
ISR	Initial Study Report

Abbreviation	Definition
LiDAR	Light Detection and Ranging
LR	Lower River
LWD	large woody debris
mg/L	milligrams per liter
MHz	megahertz
mph	miles per hour
MR	Middle River
MWH	MWH Global
NMFS	NOAA National Marine Fisheries Service
NTU	nephelometric turbidity unit
OS	Operating Scenario
QA/QC	quality assurance/quality control
PDO	Pacific Decadal Oscillation
PHABSIM	Physical Habitat Simulation
ppm	parts per million
PRM	Project River Mile
REFDSS	Riverine Environmental Flow Decision Support System
RIRP	Railbelt Integrated Resources Plan
RM	River Mile
RSP	Revised Study Plan
RTK	Real time kinematic
SOP	Standard Operating Procedure
SPD	Study Plan Determination
TM	Technical Memorandum
TNC	The Nature Conservancy

Abbreviation	Definition
TT	Technical Team
TWG	Technical Workgroup
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey
USR	Updated Study Report
WUA	Weighted Usable Area

1. INTRODUCTION

On December 14, 2012, AEA filed with the Federal Energy Regulatory Commission (FERC or Commission) its Revised Study Plan (RSP), which included 58 individual study plans (AEA 2012). Included within the RSP was the Fish and Aquatics Instream Flow Study (FA-IFS), Section 8.5. RSP Section 8.5 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.

Following submittal of the RSP, the FERC issued a Study Plan Determination (SPD) Schedule on January 17, 2013 (FERC 2013a) that specified deliverables of three IFS-related analyses: 1) results of the Open-water Flow Routing Model; 2) identification of all proposed Focus Areas with a description of habitat units within the Focus Areas for all aquatic studies to be implemented in the Middle Susitna River; and 3) identification of final Focus Areas for 2013 Middle and Lower River studies. Technical Memoranda (TM) pertaining to the first two deliverables were prepared and submitted to the FERC on January 31, 2013 (R2 Resource Consultants, Inc. [R2] et al. 2013; R2 2013a). The Final Middle and Lower River Focus Areas TM was filed with FERC on March 1, 2013 (R2 2013b).

On April 1, 2013, FERC issued its Study Plan Determination (April 1 SPD) for 14 of the 58 studies approving RSP Section 8.5 with modifications (FERC 2013b).

In its April 1 SPD, FERC recommended the following:

> *Microhabitat Types, HSC and HSI Development*
>
> > *- We recommend that AEA file with the Initial Study Report, a detailed evaluation of the comparison of fish abundance measures (e.g., number of individuals by species and age class) with specific microhabitat variable measurements where sampling overlaps, to determine whether a relationship between a specific microhabitat variable and fish abundance is evident. We expect the majority of locations where fish sampling and the eight additional microhabitat variable sampling efforts would overlap at a scale where they could be related would occur in focus areas where these sampling efforts are concentrated. If results from these initial comparisons indicate strong relationships may exist between a specific microhabitat parameter and fish abundance for a target species and life stage, expanded sampling may be necessary in 2014 to investigate these microhabitat relationships further. Accordingly, we recommend that AEA include in the evaluation to be filed with the Initial Study Report, any proposals to develop HSC curves for any of the 8 additional parameters as part of the 2014 study season.*
>
> *Upwelling and Downwelling*
>
> > *- We recommend that AEA test the feasibility of measuring vertical hydraulic gradient as a site-specific microhabitat variable using field measurements, and if determined feasible*

> *and effective at describing upwelling, incorporate the methods into the site-specific HSC development process. The results of the feasibility test (regardless of whether a feasible or infeasible finding is made) should be summarized in the Initial Study Report.*

Water Quality Monitoring at Salmon Spawning Locations

> *- We recommend that AEA monitor temperature, dissolved oxygen, and water level monitoring data at one or more select Chinook, pink, and coho spawning locations within Middle River focus areas.*

Instream Flow Study Areas and Study Sites

> *- We recommend that AEA: (1) consult with the TWG and select an appropriate focus area within MR-2 to eliminate from the study; (2) consult with the TWG and establish an additional focus area in geomorphic reach MR-7 that is sufficient for conducting interdisciplinary studies, possibly near Lower McKenzie Creek or below Curry on old Oxbow II; and (3) file a detailed description of the changes to the proposed focus area locations in MR-2 and MR-7 by May 31, 2013, and include in the filing documentation of consultation with NMFS, FWS, and Alaska DFG, including how the agency comments were addressed.*

In accordance with the April 1 SPD, an Instream Flow Technical Team meeting was held on April 26, 2013, and the AEA conferred with the TWG representatives concerning the changes to the Focus Area locations. On May 31, 2013, the AEA filed with FERC the Adjustments to Middle River Focus Areas TM (R2 2013c), providing the details requested in the April 1 SPD. Information in the Adjustments to the Middle River Focus Areas TM provides supplemental detail concerning the final selection of Focus Areas presented in the RSP and the Middle and Lower River Focus Areas TM filed with FERC on March 1, 2013 (R2 2013b).

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)) This Initial Study Report on the Fish and Aquatic Instream Flow Study has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP and as modified by FERC's April 1 SPD, the Open-water Flow Routing Model Technical Memo (R2 et al. 2013), the Final Middle and Lower River Focus Areas TM (R2 2013b), and the Adjustments to Middle River Focus Areas TM (R2 2013c) (collectively referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The goal of the Fish and Aquatics Instream Flow Study (FA-IFS) 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 study objectives are established in

RSP Section 8.5.1.2. Specific FA-IFS Study Plan objectives and associated companion studies include the following:

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 Characterization of Aquatic Habitats Study (Study 9.9) (Figure 2-1).
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. This objective will be completed via a collaborative process with the other resource studies (Riparian Instream Flow [Study 8.6], Groundwater [Study 7.5], Geomorphology [Studies 6.5 and 6.6], Water Quality [Studies 5.5 and 5.6], and Fish and Aquatics studies), and is described in ISR Study 8.5, Section 4.
3. Develop a mainstem Open-water Flow Routing Model that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternative operational scenarios. See ISR Study 8.5, Sections 4.4 and 5.3.
4. Develop site-specific Habitat Suitability Criteria (HSC) and Habitat Suitability Indices (HSI) for various species and life stages of fish for biologically relevant time periods selected in consultation with the TWG. Criteria will include observed physical phenomena that may be a factor in fish preference (e.g., depth, velocity, substrate, embeddedness, proximity to cover, groundwater influence, turbidity). 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. See ISR Study 8.5, Sections 4.5 and 5.5.
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. These metrics may include (but are not limited to) the following:

    - Water surface elevation at selected river locations
    - Water velocity within study areas subdivisions (cells or transects) over a range of flows during seasonal conditions
    - Length of edge habitats in main channel and off-channel habitats
    - Habitat area associated with off-channel habitats
    - Clear water area zones
    - Effective spawning and incubation habitats
    - Varial zone areas
    - Frequency and duration of exposure/inundation of the varial zone at selected river locations
    - Habitat suitability indices

    See ISR Study 8.5, Sections 4.6 and 5.6.

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. See ISR Study 8.5, Sections 4.3 and 5.4.
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), Groundwater (Study 7.5), Baseline Water Quality (Study 5.5), Fish Passage Barriers (Study 9.12), and Ice Processes (Study 7.6) (see Figure 2-1).
8. Develop a Decision Support System-type framework to conduct a variety of post-processing comparative analyses derived from the output metrics estimated under aquatic habitat models. These include (but are not limited to) the following:
    - Seasonal juvenile and adult fish rearing
    - Habitat connectivity
    - Spawning and egg incubation
    - Juvenile fish stranding and trapping
    - Ramping rates
    - Distribution and abundance of benthic macroinvertebrates

    See ISR Study 8.5, Sections 4.8 and 5.8.

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 Middle River Segment which extends from PRM 187.1 downstream to the Three Rivers Confluence at PRM 102.4 (Figure 3-2) and the Lower River Segment which extends from the Three Rivers Confluence to Cook Inlet (Figure 3-3). These river segments are described in ISR Study 8.5, Section 4.2.

4. METHODS

Evaluation of potential Project effects to Middle and Lower river habitats will consist of the following components:

- IFS Analytical Framework (ISR Study 8.5, Section 4.1)
- River Stratification and Study Area Selection (ISR Study 8.5, Section 4.2)
- Hydraulic Routing (ISR Study 8.5, Section 4.4)
- Hydrologic Data Analysis (ISR Study 8.5, Section 4.3)

- Habitat Suitability Criteria Development (ISR Study 8.5, Section 4.5)
- Habitat-Specific Model Development (ISR Study 8.5, Section 4.6)
- Temporal and Spatial Habitat Analyses (ISR Study 8.5, Section 4.7)
- Instream Flow Study Integration (ISR Study 8.5, Section 4.8)

Details concerning each of these components including proposed methodologies are provided below.

4.1. IFS Analytical Framework

4.1.1. Methodology

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

The Instream Flow Study (IFS) is designed to characterize the existing, unregulated flow regime and the relationship of instream flow to riparian and aquatic habitats under alternative operational scenarios. The instream flow framework is designed to integrate riverine processes, including geomorphology, ice processes, water quality, and groundwater-surface water interactions to quantify changes in indicators used to measure the integrity of aquatic resources. Figure 4.1-1 depicts the analytical framework of the IFS, which will be used to evaluate unregulated flows and alternative operational scenarios under average, wet, dry, and warm and cool hydrologic conditions. These conditions are defined further in ISR Study 8.5, Section 5.3. The overall framework includes analytical steps that are consistent with those described in the Instream Flow Incremental Methodology (IFIM) (Stalnaker et al. 1995), which will be used as a guide for completing the instream flow evaluation for the Project. The framework also generally follows the analytical steps that were applied for evaluating the effects of the proposed 1980s Susitna Hydroelectric Project on aquatic biota (Entrix 1986).

The proposed Project will alter streamflow and the transport of sediment and large woody debris (LWD) downstream of the proposed dam site. These stressors will affect channel morphology and the quantity, quality, and timing of downstream habitats. The IFS framework will be used to assess Project effects on downstream habitats under existing channel conditions, and will also provide for the evaluation of alternative operational scenarios under estimated future channel conditions. Changes in flow, ice processes, and sediment and LWD transport may cause channel degradation, avulsion, and other channel changes and may contribute to changes in the distribution and abundance of various habitat units (see page 2 of Figure 4.1-1). Integration of the Geomorphology studies (ISR Study 6.5 and 6.6) and other riverine process studies will allow future channel change to be evaluated at future time steps (e.g., current, 25 years, 50 years) within the expected term of the license.

Figure 4.1-1 depicts the analytical framework of the IFS that included for 2013 the initial development of a number of resource specific models. These included the Reservoir Operations Model that will be used to generate Project flow releases under alternative operational scenarios. The Reservoir Operations Model (see ISR Study 8.5, Section 4.4) will provide input data to the mainstem Open-water Flow Routing Model (see ISR Study 8.5, Section 4.4) and ice processes models (ISR Study 7.6) that will be used to predict hourly flow and water surface elevations at multiple downstream locations, taking into account accretion and flow attenuation. Coincident with the development of the Open-water Flow Routing Model, a series of biological and riverine process studies was initiated in 2013 to supplement the information collected in the 1980s, as necessary to assess the temporal and spatial relationships between riverine and biological functions. These analyses are being used to develop a series of flow-sensitive models that will quantify Project effects on indicators for each aquatic and riparian resource.

Resource and process effects will be location- and habitat-specific (e.g., responses are expected to be different in sloughs versus main channel versus split channel versus tributary delta versus riparian habitats), but there will also be a cumulative analysis that translates effects throughout the Susitna River. The IFS framework provides for the analysis of indicators that estimate flow-habitat response patterns for different species and life stages of fish and other aquatic biota. These models represent core tools that will be used for assessing changes in aquatic habitats under alternative operational scenarios. Additionally, a fish passage analysis (Study 9.12) will be used to develop the relationship between main channel flow and connectivity with side channel and off-channel areas. Data collection and modeling for Study 9.12 will be coordinated with the FA-IFS study, Fish and Aquatics studies, and Geomorphology studies 6.5 and 6.6 to ensure identification of potential fish passage barriers and hydraulic control points (see Figure 2-1).

Alternative operational scenarios will likely affect habitats and riverine processes on both a spatial and temporal scale. The habitat and process models will therefore be spatially discrete (e.g., by Focus Area, reach, and segment) and yet able to be integrated to allow for a holistic evaluation by alternative operational scenario. This will allow for an Integrated Resource Analysis of multiple resources for each operational scenario and provides feedback, leading to potential modifications of alternative operational scenarios (see ISR Study 8.5, Section 4.8).

The IFS framework (Figure 4.1-1) represents a measurement-oriented approach to assessing the relationship of hydrologic and geomorphic variables to the biological and ecological resources of concern. Stressors associated with Project effects include changes in the volume, timing, and quality of instream flow, and changes in ice processes and in sediment and large woody debris transport. The effects of these stressors on resources of concern will be evaluated using indicators that measure changes in habitat suitability, quality, and accessibility. Reference conditions establish the range of variation for each indicator and are defined by analysis of unregulated flows under average, wet, and dry hydrologic conditions and warm and cool Pacific Decadal Oscillation phases. Project effects under alternative operational scenarios are defined as departures from the reference conditions. The IFS framework provides the tools to identify operational scenarios that balance resource interests and quantify any loss of aquatic resources and their habitats that result from Project operations.

As part of the analytical framework, an Instream Flow Study–Technical Workgroup (IFS-TWG) was formed consisting of technical representatives. The IFS-TWG has provided and will continue to provide input into specific study design elements pertaining to the IFS, including selection of study areas, selection of methods and models, selection of HSC criteria, review and evaluation of hydrology and habitat-flow modeling results, and review of Project operations/habitat modeling results. For example, a TWG meeting occurred on September 14, 2012, and focused on the study area selection process. Since then, IFS-TWG meetings have occurred on October 24, 2012, February 7, 2013, February 14, 2013, March 27, 2013, June 25, 2013, September 24, 2013, and December 3, 2013. In addition, several IFS-Technical Team (IFS-TT) meetings have occurred outside of the TWG meetings as a means to address specific technical questions or issues central to IFS-related studies. For example, IFS-TT meetings have been held to discuss final selection of study sites (April 26, 2013), model selection (May 13, 2013), HSC/HSI sampling approaches (May 17, 2013 and June 11, 2013), and the integration of resource models (November 13-15, 2013). A site visit and methods review was conducted with TWG members on October 3-4, 2012. Results of the IFS-TT meetings are reported back to the larger TWG.

4.1.2. Variances

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

4.2. River Stratification and Study Area Selection

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (ISR Study 8.5, Section 4.2.2).

4.2.1. Methodology

4.2.1.1. River Stratification

The proposed Project would affect flows in mainstem and off-channel habitats in the Susitna River downstream of the dam site at PRM[1] 187.1. Two segments of the river are encompassed within this 187.1-mile section:

- Middle River Segment – Susitna River from Watana Dam site to confluence of Chulitna and Talkeetna rivers (Three Rivers Confluence) (PRM 187.1 to PRM 102.4)
- Lower River Segment – Susitna River extending below Three Rivers Confluence to mouth (PRM 102.4 to PRM 0)

The Middle River Segment represents the section of river below the proposed Project dam that is expected to experience the greatest effects of flow regulation caused by Project operations. Within this reach, the river flows from Watana Canyon into Devils Canyon, the narrowest and

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[1] The Project River Mile (PRM) system for the Susitna River was developed to provide a consistent and accurate method of referencing features along the Susitna River. During the 1980s, researchers often referenced features by river mile without identifying the source map or reference system. If a feature is described by river mile (RM) or historic river mile (HRM), then the exact location of that feature has not been verified. The use of PRMs provides a common reference system and ensures that the location of the feature can be verified. The PRM was constructed by digitizing the wetted width centerline of the main channel from 2011 Matanuska-Susitna Borough digital orthophotos. Project River Mile 0.0 was established as mean low water of the Susitna River confluence at Cook Inlet. A centerline corresponding to the channel thalweg was digitized upstream to the river source at Susitna Glacier using data collected as part of the 2012 flow routing transect measurements. The resultant line is an ArcGIS route feature class in which linear referencing tools may be applied. The use of RM or HRM will continue when citing a 1980s study or where the location of the feature has not been verified. Features identified by PRM are associated with an ArcGIS data layer and process, and signifies that the location has been verified and reproduced.

steepest gradient reach on the Susitna River. The Devils Canyon constriction creates extreme hydraulic conditions, including deep plunge pools, drops, and high velocities. Downstream of Devils Canyon, the Susitna River widens but remains essentially a single main channel with stable islands, numerous side channels, and sloughs.

The Lower River Segment receives inflow from three other large river systems. An abrupt, large-scale change in channel form occurs where the Chulitna and Talkeetna rivers join the Susitna River near the town of Talkeetna. The annual flow of the Chulitna River is approximately the same as the Susitna River at the confluence, though the Chulitna contributes much more sediment than the Susitna. The Talkeetna River also supplies substantial flow rates and sediment volumes. Farther downriver, the Susitna River becomes notably more braided, characterized by unstable, shifting gravel bars, and shallow subchannels. The Yentna River is a large tributary to the Lower Susitna River and supplies about 40 percent of the mean annual flow of the Susitna River at its mouth.

In order to characterize the existing and proposed flow regimes and potential Project-induced impacts to riverine habitats and organisms, the Susitna River was initially stratified into geomorphic reaches based in part on channel type, gradient, confinement, bed material, and tributary confluences.

This analysis was completed for both the Middle River and Lower River segments, confirming distinct variations in geomorphic attributes (e.g., channel gradient, confinement, channel planform types, and others) (see ISR Study 6.5; and Tetra Tech 2013b). That analysis resulted in the classification of the Middle River Segment into eight geomorphic reaches (Table 4.2-1, and Figure 3-2) and six geomorphic reaches in the Lower River Segment (Figure 3-3).

Further refinements to the stratification system were applied based on discussions during the August 16, 2012, September 14, 2012, October 2, 2012, February 14, 2013, and March 27, 2013, TWG meetings, and two interdisciplinary team meetings that were focused on study area selection and habitat mapping. This resulted in a more refined hierarchical stratification system that scales from relatively broad to more narrowly defined categories as follows:

Segment →

Geomorphic Reach→

M**acrohabitats (Mainstem, Off-channel, Tributary)→**

Mesohabitats (Mainstem, Off-channel and Tributary)

The highest level category is termed **Segment** and refers to the Middle River Segment and the Lower River Segment. The **Geomorphic Reach** level is next and consists of the eight categories *(MR-1 through MR-8)* for the Middle River Segment and six categories *(LR-1 through LR-6)* for the Lower River Segment (see Table 4.2-1 and ISR Study 6.5). The geomorphic reach breaks were based in part on the following five factors: 1) planform type (single channel, island/side channel, braided); 2) confinement (approximate extent of floodplain, off-channel features); 3) gradient; 4) bed material/geology; and 5) major river confluences. This level is followed by

Macrohabitat Types, which capture the same general categories applied during the 1980s studies but include additional sub-categories to provide a more refined delineation of habitat features (Table 4.2-2). Major categories and sub-categories under this level include: 1) Mainstem Habitats consisting of Main Channel, Split Main Channel, Multiple Split Main Channel, Side Channel, and Tributary Mouth (consisting of the segment of the tributary influenced by mainstem flow; 2) Off-channel Habitats that include Side Slough and Upland Slough; and 3) Tributary Habitats consisting of single channel, split channel, and channel complex. The next level in the hierarchy is **Mesohabitats,** which for the Mainstem and Off-channel classifies habitats into categories of Rapid, Riffle, Pool, Run/Glide, Clearwater plume, Backwater, and Beaver Complex; and for Tributaries classifies habitats into Falls, Cascade, Chute, Rapid, Boulder Riffle, Riffle, Run/glide, Pool (includes four subtypes), Beaver pond, Alcove, and Percolation channel. These are more fully described in ISR Study 9.9.

The mesohabitat level of classification is currently limited to the main channel and tributary mouths for which the ability to delineate these features was possible via aerial imagery and videography. Mesohabitat mapping in side channel and slough habitat types and in six tributaries of the Middle River Segment requires field surveys, which were initiated in 2013 (see ISR Study 9.9). These field surveys were also designed to ground-truth and evaluate the "classification type designations" that were made in 2013 and were based on remote aerial imagery (see ISR Study 9.9).

Overall, the goal of the stratification step was to define segments/reaches with effectively similar characteristics where, ideally, repeated replicate sampling would result in parameter estimates with similar statistical distributions. The stratification/classification system described above was designed to provide sufficient partitioning of sources of variation that can be evaluated through focused study efforts that target each of the habitat types, and from which inferences concerning habitat–flow responses in unmeasured sites can ultimately be drawn.

4.2.1.2. Selection of Study Areas/Study Sites

The selection of study areas/study sites differed between the Middle River Segment and Lower River Segment. Because Project operations are anticipated to affect the Middle River Segment the greatest, the selection of study areas and study sites within that segment received considerable attention and review with the TWG. The selection of study sites within the Lower River Segment was made subsequent to completion and review of the Open-water Flow Routing Model (R2 et al. 2013) and other hydrologic analysis that was presented and discussed during the February 14, 2013, TWG meeting. The site selection process for the Lower River Segment was less intense than for the Middle River Segment and concentrated on establishing habitat-flow relationships within visually determined representative sections of the river as well as selected side channels, side sloughs, and tributary mouths that were repeatedly used by fish as noted in the 1980s studies.

4.2.1.2.1. Middle River Study Area/Study Site Selection

In general (as noted by Bovee 1982), there are three characteristic approaches to instream flow studies that pertain to site selection, and which were considered for application in the Middle River Segment. These are representative sites/areas, critical sites/areas, and randomly selected sites/areas, and all three were employed to some degree in the selection of study areas and study sites.

Representative Sites

Representative sites are those where professional judgment or numerically and/or qualitatively derived criteria are relied on to select one or more sites/areas that are considered representative of the stratum or larger river. Representative sites typically contain all habitat types of importance. In general, the representative site approach can be applied fairly readily to simple, single thread channel reaches, where the attributes that are measured are extrapolated linearly based on stream length or area. In this case, the goal of stratification is to identify river segments that are relatively homogenous in terms of mesohabitat mixes, and the methods used for stratification tend to be classification-based. This approach typically requires completing some form of mapping up front, and using the results to select sites that encompass the range of habitat conditions desired. The results of such habitat mapping were not available during the initial study site/area selection, but since then, results of the aerial-based imagery habitat mapping of the Middle River Segment were completed and analyzed (HDR 2013) (see ISR Study 8.5, Section 5.2).

Critical Sites

Critical sites are those where available knowledge indicates that either i) a sizable fraction of the target fish population relies on a specific location; ii) a particular habitat type(s) is (are) highly important biologically; or iii) a particular habitat type is well known to be influenced by flow changes in a characteristic way, and the decision is made to focus on those areas. In the case of the Susitna River, historical fish studies repeatedly showed the importance of certain side slough, upland slough, and side channel areas for spawning and juvenile rearing. This information factored directly into the selection of certain side channel/side slough/upland slough complexes. Critical sites or areas are typically selected assuming that project effects to other areas are secondary in terms of implications to fish population structure, health, and size. This assumption can only really be tested if other sites are identified that are similar looking but not deemed critical, and sampling is performed on those sites as well to confirm the critical nature of the sites that were identified as such. This was likewise considered and resulted in the incorporation of other off-channel habitats (i.e., habitats for which nothing was known regarding fish use or for which previous studies indicated little fish use) into the overall study areas.

Randomly Located Sites

Randomly located sites are those sites, areas, or measurement locations selected randomly from each defined stratum or habitat type, and replicate sites or cross-sections are sampled to estimate variance (e.g., Williams 1996; Payne et al. 2004). Site selection based on random sampling tends to involve statistical multivariate grouping or stratification approaches, such as cluster analysis or ordination techniques. The approach is the least subject to potential for bias, because it relies on distinct rules and algorithms. However, the approach becomes increasingly difficult to apply in site selection when the sites become more complex, such as is the case on the Susitna River. In addition, the number of sites will be contingent on the variability within the universal dataset: the greater the number of clusters, the greater the potential number of sites. Strict random sampling was therefore not considered applicable for evaluating off-channel habitats and sloughs where the morphology of multiple channels varies substantially and in complex ways within and across sites. However, random sampling was applied with respect to selection of mainstem habitat types for HSC sampling (see ISR Study 8.5, Section 4.5) and fish distribution and abundance sampling (see ISR Study 9.6).

Focus Areas

During the September 11, 2012, TWG meeting, the concept of "intensive study areas" was introduced and discussed relative to sampling the Middle River Segment. This concept evolved around the realization that a prerequisite to determining the effects of Project development and operations on the Susitna River is the need to first develop an understanding of the basic physical, chemical, and ecological processes of the river, their interrelationships, and their relationships with flow. Two general paths of investigation were considered: 1) process and resource specific; and 2) process and resource interrelated. Under the first, process and resource specific, studies would focus on determining relationships of flow with specific resource areas (e.g., water quality, habitat, ice, groundwater) and at specific locations of the river without considering interdependencies of other resource areas at different locations. Under the second, process and resource interrelated, studies would be concentrated at specific locations of the river that would be investigated across resource disciplines with the goal of providing an overall understanding of interrelationships of river flow dynamics on the physical, chemical, and biological factors that influence fish habitat.

Because the flow dynamics of the Susitna River are complex, it was reasoned that concentrating study efforts across resource disciplines within specific locations would provide the best opportunity for understanding flow interactions and evaluating potential Project effects; therefore, major emphasis was placed on selecting those specific locations, termed Focus Areas. The Focus Area concept represents a combination of all three of the study site selection methods described above, inasmuch as 1) the areas contain habitat types representative of other areas; 2) the areas include certain habitat types repeatedly used by fish and therefore can be considered "critical areas"; and 3) sampling of certain habitat types within the areas is being completed via random sampling. As a corollary to the Focus Area approach, it was also reasoned there would be a need to collect information and data from other locations to meet specific resource objectives. As a result, the study site/area selection process used for the Middle River Segment represents a combination of both approaches.

Selection of Focus Areas

AEA's interdisciplinary water resources team identified ten candidate Focus Areas using a systematic review of aerial imagery within each of the Geomorphic Reaches (MR-1 through MR-8) for the entire Middle River Segment (Table 4.2-3). Selection criteria for the Focus Areas considered the following:

- All major habitat types (main channel, side channel, side slough, upland slough, tributary delta) will be sampled within each geomorphic reach. All major habitat types (main channel, side channel, side slough, upland slough, tributary mouth, clear water plume) within the selected geomorphic reaches will be sampled.

- At least one (and up to three) Focus Area(s) that is/are representative of other areas will be studied per geomorphic reach (excepting geomorphic reaches associated with Devils Canyon, i.e., MR-3 and MR-4).
- A replicate sampling strategy will be used for measuring habitat types within each Focus Area, which will include a random selection process of mesohabitat types.
- Areas that are known (based on existing and contemporary data) to be biologically important for salmon spawning/rearing in mainstem and lateral habitats (i.e., critical areas) will be sampled.
- Some areas for which little or no fish use has been documented or for which information on fish use is lacking will also be sampled.

Based on these criteria, Focus Areas were selected within Geomorphic Reach MR-1 (one Focus Area), Geomorphic Reach MR-2 (one Focus Area)[2], Geomorphic Reach MR-5 (one Focus Area), Geomorphic Reach MR-6 (four Focus Areas), Geomorphic Reach MR-7 (two Focus Areas)[3], and Geomorphic Reach MR-8 (one Focus Area) (R2 2013a, 2013b, 2013c). Focus Areas were not selected for Geomorphic Reaches MR-3 or MR-4 due to safety considerations related to Devils Canyon.

The Focus Areas were those deemed representative of the major features within each geomorphic reach and included mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies), as well as some locations (e.g., Slough 17) where previous sampling revealed few/no fish. Two of the Focus Areas in Geomorphic Reach MR-6 (FA-144 [Slough 21], FA-138 [Gold Creek], one in Geomorphic Reach MR-7 (FA-115 [Slough 6A]), and one in Geomorphic Reach MR-8 (FA-104 [Whiskers Slough]) contain specific habitat types that were found, during the 1980s studies, to be consistently used by salmon for spawning and/or rearing. Overall, 92 percent of the sockeye, 70 percent of the chum, and 44 percent of the slough-spawning pink salmon were found in just these four sloughs. The Focus Area in Geomorphic Reach MR-7 included Slough 6A which, based on the 1980s studies, provided primary juvenile rearing habitat; the Focus Area likewise included side channel and upland slough habitats that had been modeled in the earlier studies. By definition, these areas of known fish use represent “critical areas” and were included in the Focus Areas to allow some comparisons with the 1980s data. The upper two Focus Areas (one in Geomorphic Reach MR-1 and one in Geomorphic Reach MR-2) were selected based on their representativeness of the respective geomorphic reaches and the inclusion of a mix of side channel and slough habitat types. However, these areas were not sampled for fish in the 1980s. The Focus Areas range in length from 0.5 mile to 1.8 miles (Table 4.2-3). Details of each of the Focus Areas, including their identification number, common name, description, geomorphic reach assignment, location (PRM), length, habitat types included in the Focus Area, fish use and types of instream flow studies conducted in the 1980s, and the rationale for selection, are

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[2] MR-2 originally contained two Focus Areas – FA-171 (Stephan Lake, Simple Channel) and FA-173 (Stephan Lake Complex). Based on consultation with the TWG (see R2 2013c), FA-171 (Stephan Lake, Simple Channel) was deleted from MR-2.

[3] MR-7 originally contained one Focus Area – FA-115 (Slough 6a). Based on consultation with the TWG (see R2 2013c), a new Focus Area was established in MR-7 (FA-113[Oxbow 1]).

presented in Table 4.2-3; maps of each of the areas are depicted in Figure 4.2-1 through Figure 4.2-10.

The Focus Areas were assumed to have included side channels, side sloughs, upland sloughs, and tributary mouths that were representative of these habitat types in other portions of the river. This assumption has been initially evaluated using the results of the aerial imagery-based habitat mapping. The results of that analysis were presented in a Draft Middle and Lower River Focus Areas TM filed with FERC on January 31, 2013, and was subsequently presented and discussed during the TWG meeting on February 14, 2013. With consideration of the comments and suggestions received from licensing participants, a Final Middle and Lower River Focus Areas TM was filed with FERC on March 1, 2013 (R2 2013b). In accordance with the April 1 SPD, an Instream Flow Technical Team meeting was held on April 26, 2013, and AEA conferred with the TWG representatives concerning the changes to the Focus Area locations. On May 31, 2013, AEA filed with FERC the Adjustments to Middle River Focus Areas TM, providing the details requested in the April 1 SPD. Information in the Adjustments to the Middle River Focus Areas TM provides supplemental information concerning the final selection of Focus Areas. These results are summarized in ISR Study 8.5, Section 5.2. In addition, field surveys were initiated in 2013 to ground-truth the aerial imagery-based habitat mapping results (see ISR Study 9.9).

Detailed surveys were initiated on the lower seven of the ten Focus Areas in 2013; 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 Cook Inlet Regional Working Group (CIRWG) lands.

The data and information collected in 2013 from this study and other related investigations will be reviewed, and necessary refinements to existing selected study sites will be determined in 2014.

Middle River Segment Sites Outside of the Focus Areas

In addition to the identified Focus Areas, a total of 83 cross-sectional transects were established in 2012 and 2013 in the Middle River Segment and flow data collected to support development of the Open-water Flow Routing Model (see ISR Study 8.5, Section 5.4). These transects were primarily located across single thread sections of the river; however, some extend across more complex sections, including portions of Focus Areas. In most cases, two to three sets of flow measurements have been made at each transect. The resulting datasets of transects that traverse fish habitat will be identified and reviewed for possible use in evaluating velocity-depth distributions across the channel that can be related to biologically relevant criteria associated with various life stage requirements (e.g., spawning, adult holding, juvenile rearing). In some cases, it may be possible to develop actual habitat-flow relationships following a 1-D PHABSIM type analysis. However, the need for doing so will be determined based on results obtained from the Focus Area fish habitat-flow modeling. Once the main channel habitat mapping is completed (ISR Study 9.9), each of the transect locations will be assigned to specific mesohabitat types (e.g., riffle, run, glide, pool) that could be randomly selected for analysis. These additional transects may also be useful for extrapolating results/relationships from measured to unmeasured sites (see ISR Study 8.5, Section 4.7). Supplemental main channel transects may be established during the next year of study as needed to more fully characterize main channel habitats, either as part of the Focus Area analysis or at separate locations associated with specific mesohabitat types. The need for and number of supplemental transects will be determined based on results of the habitat mapping.

4.2.1.3. Lower River Study Area/Study Site Selection

The determination of whether, and the extent to which, studies would be extended into the Lower River Segment was presented in a March 1, 2013 TM (R2 2013b) and was based upon consideration of six criteria. Those criteria are listed below along with relevant information and data that formed the basis for extending studies into the Lower River Segment (portions of March 1, 2013 TM reproduced below).

- Criteria 1 - Magnitude of daily stage change due to load-following operations relative to the range of variability for a given location and time under existing conditions (i.e., unregulated flows)
    - Results of the Open-water Flow Routing Model were presented in R2 et al. (2013) and discussed during the February 14, 2013, TWG meeting. Results indicated that pre- versus post-Project stage changes varied by location and time and ranged at Gold Creek (Middle River Segment) from an increase in daily average water level of up to 2 to 3 feet in the winter and a reduction of daily average water level of as much as 5 feet in the summer during high natural flow conditions (Figures 5.4-2 and 5.4-3 of R2 et al. 2013). More typically the change would be about 3 feet in the summer. The predicted change in stage in the upper portion of the Lower River Segment at Sunshine ranged from an increase in daily average water level of up to 1 to 2 feet in the winter and a reduction in water level of as much as 3 feet in the summer during high flow conditions (Figures 5.4-4 and 5.4-5 of R2 et al. 2013). Daily and hourly changes in stage during the summer period at Sunshine were predicted to range from 0.6 to 0.8 feet, but accurate estimates for the winter period are contingent on completion of the winter flow routing model.
- Criteria 2 - Magnitude of monthly and seasonal stage change under Project operations relative to the range of variability under unregulated flow conditions
    - Results of a comparative hydrologic analysis considering existing and with-Project operations was completed by Tetra Tech and presented and discussed during the February 14, 2013, TWG meeting (Tetra Tech 2013a). These results were based on a 61-year extended discharge record that had been developed by the USGS. Comparisons were made of monthly flows and annual flows under pre-Project and a maximum load-following scenario. Results showed substantial changes in seasonal flows during both the summer (Project operational flows were lower) and winter (Project operational flows were higher) periods (as had been noted in the Pre-Application Document) with summer changes most pronounced in the upper portions of the river (pre-Project/post-Project flows at Gold Creek in July: 20,000 cubic feet per second (cfs) versus 6,980 cfs; and at Susitna Station 122,000 cfs versus 108,000 cfs) while winter changes were evident throughout the entire river length (pre-

Project/post-Project flows at Gold Creek in January: 1,280 cfs versus 8,840 cfs; and at Susitna Station – 7,910 cfs versus 15,500 cfs). Results of flow-duration analysis demonstrated the shifts in flow magnitudes that would occur with Project operations.

  - Flood frequency analysis likewise indicated there would be changes in return periods of specific flood magnitudes. For example, at Gold Creek, a two-year flood event (i.e., a flood that occurs on average once every two years) of 43,700 cfs would, under maximum load-following operations, occur once every 12 years. Likewise, at Susitna Station, a two-year flood of 170,300 cfs would occur once every five years.
  - Further hydrologic analysis will be completed as part of an Indicators of Hydrologic Alteration (IHA) analysis described in ISR Study 8.5, Section 4.3.
- Criteria 3 - Changes in surface area (as estimated from relationships derived from LiDAR and comparative evaluations of habitat unit area depicted in aerial digital imagery under different flow conditions) due to Project operations
  - Because the analysis of LiDAR data is still ongoing, inferences of surface areas were drawn from the previous work of R&M Consultants and Trihey and Associates (1985). Review of that document and the analysis presented indicated that changes in surface area with flows can be pronounced depending upon the range of flows considered, as well as on specific habitat types (e.g., side channel, side sloughs). As R&M Consultants and Trihey and Associates (1985) noted, surface area responses are a function of streamflow and channel geometry. Examples of flow responses to wetted surface areas for different locations in the Lower River Segment are found in Figures 3-1 through 3-4 of R&M Consultants and Trihey and Associates (1985). Inspection of those relationships indicates that surface areas of certain types of habitats can be quite sensitive to changes in main channel flows. Additional analysis of these data was completed and is presented in Tetra Tech (2013b).
- Criteria 4 - Anticipated changes in flow and stage to Lower River off-channel habitats
  - The flow and stage changes indicated by the results of the Open-water Flow Routing Model and hydrologic analysis cannot be directly related to off-channel habitats since results of the LiDAR analysis have not been completed and detailed bed topography of specific areas have not yet been acquired. However, reasonable inferences were made based on the timing, magnitude, and duration of flow and stage changes associated with the proposed Project operations on different types of lateral habitats. For example, it is reasonable to assume that some of the lateral habitats inundated under pre-Project flow conditions could become partially dewatered or disconnected from the main channel under summertime project operations due to reductions in flow and stage. Conversely, under wintertime operations, habitats that may normally be disconnected from the main channel and operate as clear water side slough habitats may become connected due to flow increases and breaching at the head end of the channel resulting in turbid water conditions.

- Criteria 5 - Anticipated Project effects resulting from changes in flow, stage, and surface area on habitat use and function, and fish distribution (based on historical and current information concerning fish distribution and use) by geomorphic reaches in the Lower River Segment
    - Based on the anticipated changes in stage and flows in the Lower River Segment, it was reasoned that there would likely be some effects on fish habitat and fish distribution resulting from Project operations.
- Criteria 6 - Initial assessment of potential changes in channel morphology of the Lower River based on Project-related changes to hydrology and sediment supply in the Lower River
    - The initial assessment of potential channel changes was performed and reported in three technical memoranda developed in the 2012 Geomorphology Study: Stream Flow Assessment (Tetra Tech 2013a), Development of Sediment-transport Relationships and an Initial Sediment Balance for the Middle and Lower Susitna River Segments (Tetra Tech 2013c), and Reconnaissance Level Assessment of Potential Channel Change in the Lower Susitna River Segment (Tetra Tech 2013d).Collectively, the conclusions from each analysis indicated that Project operations associated with changes in hydrology would likely influence the sediment balance in the Lower River Segment leading to changes in channel morphology and associated fish habitats.

Mainstem Habitat types in the Lower River Segment include main channel, side channels and sloughs, backwater, and tributary mouths (Tetra Tech 2013b). In comparison to the Middle River, the Lower River channel exhibits much lower gradient with a wider floodplain containing numerous subchannels. As noted above, a Focus Area study approach has been employed for the Middle River segment to describe existing conditions and the response of habitats to proposed Project releases. Modeling of the Middle River Focus Areas will integrate studies of fisheries, geomorphology, groundwater, riparian, ice processes, and water quality. Hydraulic conditions within these Middle River Segment Focus Areas will be based on 2-D modeling that will be integrated into a PHABSIM-type analysis of potential fish habitat. However, the size and complexity of the Lower River Segment renders a 2-D modeling approach of specific areas infeasible. Rather, study sites in the Lower River Segment were selected in Geomorphic Reaches LR-1 and LR-2 based on a combination of representative and critical study sites. Instream flow sites were limited to these upper two geomorphic reaches in the Lower River Segment since Project effects become more attenuated downstream (based on results of the Open-water Flow Routing Model). Study areas were initially identified by AEA's interdisciplinary team of representatives from geomorphology, instream flow-fish, instream flow-riparian, and groundwater. One area was selected in each of the upper two geomorphic reaches to describe the mix of thalweg channel, major subchannels, alluvial island complexes, side channels, and sloughs observed in aerial photos of the Lower River Segment channel. The area around Trapper Creek near PRM 95.4 was selected as representative of the habitat types in LR-1 (Figure 4.2-11), and the area around Caswell Creek near PRM 67.3 was selected as representative of habitat types in LR-2 (Figure 4.2-12).

Fish habitats in the Lower River Segment will be modeled using a 1-D approach involving transects selected to represent major habitat types within each geomorphic reach. Data collection and modeling efforts were conducted in LR-1 in 2013 (see ISR Study 8.5, Section 4.6) and will be completed in LR-2 during the next year of study.

In addition to describing representative habitat types in LR-1 and LR-2, tributary mouths were identified as potential critical sites. During the 1980s, the primary salmon spawning areas within the Lower River Segment appeared to be clearwater tributaries (R&M Consultants, Inc. and Trihey & Associates 1985), although 1980s sampling limitations may have overlooked some mainstem salmon spawning. Low velocity backwater areas near tributary mouths were used as holding areas by adult salmon during upstream migration into the tributaries, and tributary mouths became a major component of Lower River studies during the 1980s. In addition to evaluating potential effects of Project flow releases on adult salmon holding areas at Lower River Segment tributary mouths, 1980s studies included analyses of salmon access into tributaries and the geomorphic stability of tributary mouths. Thirteen Lower River Segment tributary mouths were selected for study in the 1980s (Table 4.2-4) (R&M Consultants, Inc. and Trihey & Associates 1985).

Results from 2012 and 2013 biological studies support the continued importance of Lower River Segment tributary mouths as salmonid habitat. During 2012, habitats in LR-1 and LR-2 were opportunistically surveyed to collect HSC. Of the 69 HSC observations of adult, juvenile, and fry life stages, 42 percent were located in tributary mouth macrohabitats. Of the 13 tributary mouths studied in the 1980s, five were selected for study during 2013. Trapper Creek and Birch Creek are located in the vicinity of the LR-1 study area, and Sheep Creek and Caswell Creek are located in the vicinity of the LR-2 study area. The Deshka River was identified as an important adult salmon holding area during the February 14, 2013, TWG meeting, and the Deshka River mouth was added to the list of 2013 study areas. The mouth of the Kashwitna River is located near the LR-2 study area, but it was not selected for study in 2013 because it does not appear to be heavily influenced by potential Project flow releases (Table 4.2-4). Studies were completed in Trapper and Birch creeks in 2013; Sheep Creek, Caswell Creek, and Deshka River will be sampled during the next year of study.

4.2.2. Variances from Study Plan

AEA implemented the methods as described in the Study Plan with the exception of the variance explained below. While land access was not available for the three upper Focus Areas adjacent to Cook Inlet Regional Working Group (CIRWG) lands in 2013, this was not considered a variance because this study was designed to collect data over multiple years.

Sampling of LR-2 was originally scheduled for 2013 but not completed and is now scheduled for the next year of study (see ISR Study 8.5, Section 4.6.2). However, this variance will not have a substantive effect on the completion of this study since all field work, data analysis and modeling will be completed prior to submittal of the license application.

4.3. Hydrologic Data Analysis[4]

AEA implemented the methods as described in the Study Plan with the exception of the variances explained below (ISR Study 8.5, Section 4.3.2).

AEA's 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 are summarized below; more detailed information regarding data collection and analytical techniques is provided in ISR Study 8.5, Appendix A.

4.3.1. Methodology

4.3.1.1. Hydrologic Data Collection

In 2013, AEA continued the collection and analysis of hydrologic data at a number of existing mainstem gaging stations, collected winter flow measurements at selected USGS gages, and installed and monitored gages at ten tributary gages.

The mainstem Susitna River hydrologic data collection included stage and discharge measurements, cross-sectional and areal bathymetric surveys, velocity mapping, and roughness determinations.

Surveying was completed using several methods depending on survey objectives. This included Global Positioning System (GPS) surveying that applied both high accuracy methods and the use of hand-held GPS systems for reconnaissance surveying, as well as, in some locations, optical level surveying to determine water level elevations and to set up temporary benchmarks at hydrology stations. In all cases where accuracy was important, the surveying of points and locations was completed using Real Time Kinematic (RTK) GPS with reference to the geodetic control network (ISR Study 8.5, Appendix A). RTK surveying is the method by which a single reference station is used to provide real-time carrier phase corrections by radio link to one or more roving GPS receivers, providing up to centimeter-level accuracy under ideal conditions. In this study, RTK surveys used two or more GPS units. Data points such as temporary benchmark elevations, which require a level of accuracy greater than RTK methods can provide, were tied using static GPS observations. Instantaneous stage measurements were performed using either RTK GPS methods or optical levels, using benchmarks and geodetic control points that are part of the control network. All AEA gaging or water level stations had RTK or control point surveys established as well as temporary benchmarks installed to allow efficient optical-level loop surveys. Surveys to check the accuracy of existing Light Detection and Ranging (LiDAR) information needed for defining floodplain and dry channel topography were made at 25 locations in the Lower Susitna River Segment and 125 locations in the Middle and Upper Susitna

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[4] Note – this section followed the Open-water Flow Routing Model and Reservoir Operations Model section in the RSP. It was moved ahead of that section in this ISR to reflect proper sequencing of data collection and analysis.

River Segments. Over 19,000 ground survey shots were collected in 2013 that can be used to spot-check the LiDAR DEM for accuracy. Additional information concerning the LiDAR validation is found in Geomorphology ISR Study 6.6.

During open-water conditions, mainstem discharge measurements were performed using ADCPs following current USGS guidance (Mueller and Wagner 2009). Relying on the Doppler principle, ADCPs measure water velocity using acoustic reflections from suspended particles (ISR Study 8.5, Appendix A). The cross-sectional bathymetric surveys were performed as part of discharge measurements completed using the Sontek M9 ADCP. The Sontek M9 is equipped with a 0.5-megahertz (MHz) vertical-beam depth sounder and RTK GPS positioning. Together with shore-based RTK GPS surveys, the digital elevation model is used to develop cross-sections for use in the Open-water Flow Routing Model.

Stage, discharge and bathymetric surveys were collected at various cross-sections and within Focus Areas (including inlets and outlets) using the surveying and ADCP methods. The cross-sections were either surveyed using ADCPs or single-beam depth sounders. In either case, bathymetric data were referenced to the Project geodetic control network using RTK GPS survey methods. A description of the Focus Area measurements is also provided in Geomorphology ISR Study 6.6.

Continuous stage measurements (along with temperature and meteorological data) were recorded at AEA hydrology stations at 15-minute intervals and made available to studies via the real-time reporting data network (ISR Study 8.5, Section 4.4). Continuous stage measurements were made using vented pressure transducers accurate to within about 0.02 feet. The hydrology stations required periodic water elevation surveys, either performed by RTK surveying or by optical-level loop survey methods. Table 4.3-1 shows a listing of the stations in the real-time reporting data network. Pressure transducers and water temperature sensors were added at hydrology stations to provide the Groundwater (Study 7.5) and Ice Processes (Study 7.6) study teams with winter pressure (water pressures under ice, water levels in ice-free or partial ice-covered reaches) and water temperature measurements. Sensors lost during spring break-up were replaced as soon as it was safe and practical to install. All data were recorded on Campbell Scientific CR1000 data loggers, with internal memory backup.

Winter streamflow measurements provide valuable information for understanding hydraulic conditions in the mainstem Susitna River during seasons when groundwater plays a more prominent role in aquatic habitat functions. Periodic winter discharge measurements (January and March) were completed (using a combination of ADCP and current meter methods) at selected hydrology stations in winter 2013. These measurements were made in coordination with USGS winter measurement programs to allow collection of synoptic data sets. The 2013 winter discharge measurement occurred at the AEA hydrology stations ESS70 (PRM 187.1), ESS65 (PRM 176.5), ESS60 (PRM 168.1), ESS50 (PRM 124.1), ESS45 (PRM 116.6), and ESS40 (PRM 107.2) (Table 4.3-2). The methods and results of winter measurements can be found in the Ice Processes ISR Study (7.6). The mainstem discharge measurements will help assess gaining and losing river reaches during winter conditions.

4.3.1.1.1. Tributaries to the Susitna River

Twelve tributary gaging stations were installed at selected tributaries in 2013 to provide additional data for hydrologic and fisheries studies (Table 4.3-3; Figure 4.3-1). Ten of the twelve stations have continuous recording pressure transducers and two had spot discharge measurements collected. The gaging stations were installed in spring/early summer of 2013 to help measure the spring snowmelt peaks. Three of the tributaries had a companion stage-only site located in the downstream slough of the mainstem of the Susitna River. The stations report data similar to the existing mainstem AEA gages. Details concerning the installation, monitoring, and data analysis procedures of the tributary gages are presented in ISR Study 8.5, Appendix A.

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 throughout 2013 as a means to provide real time updates on hydrology and other meteorological parameters at locations throughout the river (Table 4.3-1 and Table 4.3-2). 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 network system includes a naming convention that serves to identify station locations and the primary purpose of the station. The convention is of the form: $EX_1X_2X_3$ where E represents AEA, X_1 indicates the river drainage (S = Susitna, C = Chulitna, T = Talkeetna), X_2 is the primary station purpose (B = base station; C = camera station; F = Pit tag array; G = groundwater station; M = meteorological station; R = repeater station; and S = surface water station), and X_3 = station sequence number, or specific Focus Area number and PRM (e.g., FA-104). For example, station ESS80 represents Alaska Energy Authority station on the **S**usitna River for **S**urface water and is station 80. More details concerning the network system are described in ISR Study 7.5.

4.3.1.2. Hydrologic Data Analyses

The primary activities associated with hydrologic data analysis completed in 2013 included data compilation and QA/QC reviews of flow and stage data collected from the AEA mainstem and tributary gage stations, compilation and review of winter gaging data, correction of pressure transducer records and conversions to station gage height records, rating curve development, stream flow computations, and cross-section and bathymetric data post-processing. Data analysis is ongoing and will include the development of daily and hourly inflow routing to Focus Areas from the Susitna River Open-water Flow Routing Modeling and analysis for selected tributaries. Analysis will also include calculations of hydrologic data statistics for the Susitna River and selected tributaries.

Efforts in 2012 already established the 61-year period extending from Water Years 1950 through 2010 (October 1, 1949 to September 30, 2010) as the hydrologic period of record for the Project. This record was based on a series of USGS gages in the Susitna River Basin that were measured over different time periods (Table 4.3-4 and Table 4.3-5). The periods of record of measured flows at each of the sites listed in Table 4.3-4 and Table 4.3-5 were extended to cover the 61-year period (Water Years 1950 through 2011) by synthesizing the missing daily flow records to fill in the gaps (Curran 2012).

Work was also completed in 2013 on selecting representative years to reflect wet, average and dry conditions and warm and cool Pacific Decadal Oscillations. The selection of representative year types is needed so that a range of climatic and hydrologic conditions can be considered when evaluating Project alternatives. An update on the process AEA is applying in the selection of representative years was provided during the November 13-15, 2013 IFS-TT Riverine Modelers Meeting and also at the Q4 2013 TWG Meeting.

4.3.1.3. Indicators of Hydrologic Alteration and Environmental Flow Components

The assessment of hydrologic data will include the calculation of summary statistics that will be useful for describing the seasonal and short-term and long-term hydrologic characteristics of the Susitna River. This will include daily, monthly, and annual summaries, and exceedance summaries and recurrence intervals of small and large floods. This analysis was initiated in 2012 and continued in 2013 as more data were added to the hydrologic record. In addition to the computation of summary statistics, AEA will utilize the Indicators of Hydrologic Alteration (IHA) and Range of Variability models developed by The Nature Conservancy (TNC 2009) for computing additional baseline hydrologic characteristics. The IHA models are components of an analytical software package designed to assess the impacts of a project on unregulated hydrologic conditions (TNC 2009).

In 2013, AEA applied the IHA models to the hydrology of the Stikine and Taku rivers as part of the Biological Cues Analysis described in ISR Study 8.5, Section 4.5, and presented in Appendix B. AEA will develop and finalize the IHA approach that will be used for the Susitna River with input from the TWG.

4.3.2. 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.

4.3.2.1. 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."

Ten continuous gage sites and two spot measurement sites were established on tributaries of the Susitna River in 2013. Indian River was one of these gage sites, but Fog Creek and Portage Creek were not gaged due to land access issues. Gaging of Fog Creek and Portage Creek is proposed in the second year of study (ISR Study 8.5, Section 7.4). Tributary inputs in the Open-water Flow Routing Model will be estimated based on drainage area and then adjusted using available tributary gaging data. Data gaps associated with the lack of gage sites on Fog Creek and Portage Creek in 2013 will not significantly affect accretion calculations used in the Open-water Flow Routing Model.

4.3.2.2. 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 has occurred in the schedule of the selection of representative years. The selection of representative years will address multiple resource interests including geomorphology and ice processes. The topic of representative years was discussed at both the November 13-15, 2013 IFS-TT Riverine Modelers Meeting, and at the Q4 2013 TWG meeting. A technical meeting is also scheduled for 2014. Finalization of the selection of representative years will not be needed until IFS-related modeling begins. The schedule identified in the Study Plan was an effort to stagger development of supporting information; however, delaying selection of representative years until 2014 will not affect the ability to meet study objectives. An initial proposal and rationale for the selection of representative years is included in ISR Study 8.5, Section 5.3.

4.3.2.3. Indicators of Hydrologic Alteration and Environmental Flow Components

The RSP states that "In consultation with the TWG, the IHA/EFC or HEC-EFM programs will be used to evaluate existing conditions and alternative operational scenarios for the Susitna-Watana 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."

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 has continued through Q4 of 2013. The study objectives will be achieved as the development of the IHA analysis is ongoing in conjunction with the determination of representative years. A description of an initial proposed methodology is provided in ISR Study 8.5, Section 5.4. This methodology will undergo continued discussion and coordination with the TWG. It is anticipated that a fully developed and implementable methodology will be available for use prior to the USR.

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 explained below (ISR Study 8.5, Section 4.4.2).

Project operations will cause hourly, daily, and seasonal changes in the Susitna River flows downstream of the proposed dam as compared to existing conditions. Seasonally, Project operations will likely include storing water during the snowmelt season (May through August) and releasing it during the winter (October through April) (AEA 2011). This would reduce flows downstream of the proposed dam site from May through August and increase flows October through April. To evaluate those changes, two models were developed in 2013 to simulate existing and Project conditions; a Reservoir Operations Model to simulate the storage and release of water within the Project reservoir, and an Open-water Flow Routing Model to simulate the movement of releases from the proposed dam to downstream locations. These models and their development are described in the sections below.

4.4.1. Methodology

4.4.1.1. Reservoir Operations Model

The HEC reservoir system simulation model, HEC-ResSim (USACE 2007) Version 3.0, was adapted and utilized for the Project in 2012 and 2013 to forecast a range of reservoir outflows associated with different operational scenarios that will ultimately be evaluated as part of the IFS. The HEC-ResSim is a general-purpose, sequential stream flow routing model that is free and in the public domain. The HEC-ResSim model has an hourly time increment of operation. HEC-ResSim includes a graphical user interface, and graphics and reporting facilities. The HEC Data Storage System (HEC-DSS) is used for storage and retrieval of input and output time-series data.

HEC-ResSim incorporates a reservoir water balance that is governed by a set of operating rules such that inflow minus all outflows, including turbines, valves, and spillway, equals the change in reservoir storage for a given time period. Required input data to the model includes long-term reservoir inflow time-series data. For the proposed Watana Dam, the reservoir inflow was provided from the continuous 61-year record of daily flows for Water Years 1950 through 2010. The USGS provided the basis for the continuous long-term daily flows with a Susitna River watershed record extension study (Curran 2012) that includes both recorded and correlated flows. Two of the USGS gages included in the study were Susitna River at Gold Creek (Gage No. 15292000), which has a drainage area of 6,160 square miles, and Susitna River near Cantwell (Gage No. 15291500), which has a drainage area of 4,140 square miles. The proposed Watana Dam has a drainage area of 5,180 square miles, about halfway between these two USGS gages. Inflows to Watana Reservoir were based on proportioning the USGS flows based on drainage area.

As was also the case in the 1980s studies, providing environmental flows at the Gold Creek USGS gage will presumably be one of the a primary reservoir operating criterion. With the proposed Watana Dam, a majority of the flow tributary to the Gold Creek USGS gage will be regulated, but significant natural inflows between Watana Dam and Gold Creek must also be included. To provide the local inflows below the proposed dam, a 61-year daily record was constructed from the Gold Creek USGS gage flows minus the calculated Watana Reservoir inflows. This provided a time-series of natural local inflow data that can be used as input to the model.

The HEC-ResSim model will provide results for many parameters such as the simulated reservoir elevation and powerhouse generation. Data can be plotted or output provided in standard or user-customized reports. One of the key parameters, total reservoir outflow, will serve as the primary input to the HEC-RAS model that will be used in the IFS analysis. Total reservoir outflow is the summation of all outlets, including the powerhouse, spillway, and fixed-cone outlets. The extent of data analysis will be determined based on needs of other resource models, the number and types of representative years identified for analysis (e.g., wet, dry, and average years), potentially for both the warm and cool phases of the Pacific Decadal Oscillation (PDO) (ISR Study 8.5, Section 4.4), as well as the number of operational scenarios specified by AEA.

In addition to HEC-ResSim, AEA also applied a reservoir operation model developed by MWH for making some preliminary operational runs. The MWH model can perform an automated iteration to maximize firm energy to specified reliability criteria, which then form the input generation requirements for the HEC-ResSim model. Execution times in the MWH reservoir operation model are several times faster than for HEC-ResSim, and the MWH model can be programmed to simulate unique or complex operation requirements.

4.4.1.2. Open-water Flow Routing Model

Steady-state flow models assume that velocity or flow at a given location remains constant. Unsteady flow models are used when flows change rapidly and when the consideration of time is an additional variable. One-dimensional unsteady flow hydraulic models are commonly used to route flow and stage fluctuations through rivers and reservoirs. The HEC-RAS model (USACE 2010a, 2010b, and 2010c) was selected as the Open-water Flow Routing Model for routing 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 ISR and a winter model to route flows under ice-covered conditions described in ISR 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 break-up.

Version 1 of the Open-water Flow Routing Model was developed in 2013 to analyze the impacts of alternative Project operational scenarios that include load following, on changes in flow and stage downstream of the proposed Watana Dam site. This model 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 Open-water Flow Routing Model was developed using river cross-sections and streamflow gaging stations established on the Susitna River. A total of three versions of the model will be developed and provided for distribution with Version 1 developed and distributed in Q1 2013 and Version 2 in early 2014. Each successive version of the model will be refined and will contain more detail based on additional information available. A comparison of the three versions and the content contained in each is provided in Table 4.4-1.

Cross-sectional data were collected in 2012 and 2013 in accordance with U.S. Geological Survey (USGS) procedures and as described in ISR Study 8.5, Appendix C). This entailed surveying of ground surface and water surface elevations at each cross-section using Real Time Kinematic (RTK) GPS instrumentation. River bathymetry and flow velocities were measured using an Acoustic Doppler Current Profiler (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.

A total of 88 cross-sections was surveyed in 2012 (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) and an additional 80 cross-sections surveyed in 2013 between PRM 29.9 and PRM 146. 1. The 2012 cross-sections were measured during three field trips intended to capture high-flow (28,000 cfs), medium-flow (16,000 cfs), and low-flow (8,000 cfs) conditions corresponding to the USGS gaging station at Gold Creek (Gage No. 15292000). The 2013 cross-sections were surveyed to improve the Open-water Flow Routing Model, 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 riparian analysis (Study 8.6).

The hourly flow records from USGS gaging stations on the Susitna River were also utilized to help develop Version 1 of the Open-water Flow Routing Model. An additional 13 new mainstem gaging stations (Table 4.3-2) were established on the Susitna River in 2012 and maintained in 2013 to measure stage every 15 minutes. Water temperature, air temperature, and time-laps photographic (camera) images of river conditions were also collected at each station. Data recorded at these stations will be used to calibrate flow pulse arrival time in the Open-water Flow Routing Model, based on measured diurnal glacial melt pulses and rainstorm-generated flood peaks. These stations also monitored water pressure under winter ice covered conditions.

During the development and calibration of Version 1 of the Open-water Flow Routing Model, the drainage areas of ungaged tributaries were quantified and used to help estimate accretion flows to the Susitna River between locations where flows are measured. The flow estimates developed for ungaged tributaries will be refined based on flows that were measured in those tributaries in 2013 (ISR Study 8.5, Section 4.4).

Because the results of the ice processes model are not yet available (Study 7.6), the downstream extent of Project effects on flow and stage during the winter will be initially assessed by routing winter-flow releases identified by the Reservoir Operations Model (ISR Study 8.5, Section 4.3) downstream using the Open-water Flow Routing Model. Although stage and flow projections during the winter will not be robust, they will provide sufficient information on downstream flow and stage effects to support initial analyses.

Output from the Open-water Flow Routing Model provides the fundamental input data to habitat-specific and riverine process-specific models described in ISR Study 8.5, Section 4.6; ISR Study 8.6, and ISR Study 6.6.

4.4.2. Variances from Study Plan

AEA implemented the methods as described in the Study Plan with the exception of the variance 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 Open-water Flow Routing Model (R2 et al. 2013) was developed in January 2013 following submittal of the RSP. During development of the Open-water Flow Routing Model 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). Eight of the original 13 sites were identified as high priority based in part upon their locations in the river, the stability of the channel proximal to the stations, and accessibility; other sites were considered low priority due to location or erosional changes in the channel profile during 2013. As a result, some data gaps of water stage exist for the original 13 surface-water stations locations. Three stations ((ESS80 (PRM 225), ESS30 (PRM 98.4), and ESS20 (PRM 29.9)) have complete or near complete data sets. Six stations ((ESS65 (PRM 176.5), ESS55 (PRM 152.2), ESS50 (PRM 124.1), ESS45 (PRM 116.6), ESS40 (PRM 107.2), and ESS35 (PRM 102.1)) have partial data sets. Stations ESS70 (PRM 187.1) and ESS60 (PRM 168.1) were not operating during much of 2013. Stations ESS15 (PRM 24.7) and ESS10 (PRM 17.4) are downstream of the lower extent of the Open-water Flow Routing Model and were installed to provide basic hydrology data for supporting studies in the lower river. These data along with available data from USGS at four additional sites along the mainstem of the Susitna River will be used in calibration of Version 2 of the model. Given the availability of complete data sets at seven locations (three ESS stations and four USGS stations), it is not anticipated that data gaps at the other ESS stations will hinder achieving study objectives.

4.5. Habitat Suitability Criteria Development

AEA implemented the methods as described in the Study Plan with the exception of the variances explained below (ISR Study 8.5, Section 4.5.2.

Habitat suitability criteria (HSC) curves and habitat suitability index (HSI) models have been utilized by natural resources scientists for over two decades to assess the effects of habitat changes on biota. HSC curves are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC curves describe the instream suitability of habitat variables (typically depth, velocity, substrate and cover) related to stream hydraulics and channel structure. HSC curves can also be developed for other variables influenced by flow including water quality (temperature, dissolved oxygen, turbidity) and presence of groundwater upwelling/downwelling. HSI models were originally designed for application with the Habitat Evaluation Procedures (HEP) (U.S. Fish and Wildlife Service 1980) which could be applied to both terrestrial and aquatic habitats. However, in the 1980s a series of HSI models were developed for a variety of fish species including most salmonids to provide for a means to predict or evaluate the effects of anthropogenic factors on different fish species. These models describe how well each particular habitat variable meets the habitat requirements of the target species and life stage, as described by a suite of environmental variables (e.g., percentage fine sediments, water temperature, pH, dissolved oxygen, pool-riffle ratio, and others (see Raleigh et al. 1986 for examples). Both HSC and HSI models are scaled to produce an index between 0 (unsuitable habitat) and 1 (optimal habitat). Both models are hypotheses of species-habitat relationships and are intended to provide indicators of habitat change, not to directly quantify or predict the abundance of target organisms. In this ISR Study 8.5, HSC and HSI are considered together and are reported hereafter as HSC/HSI.

For the Susitna-Watana Hydroelectric Project aquatic habitat studies, data for developing both HSC (i.e., depth, velocity, and substrate/cover) and HSI (e.g., turbidity, groundwater upwelling, colonization rate, dewatering mortality) curves were collected in 2013. These data, in combination with data collected in 2012 and data that will be collected during the next year of study, will be used to develop final HSC/HSI curves that will be used with the hydraulic and habitat models (ISR Study 8.5, Section 4.6) to estimate the effects of alternative operational scenarios.

4.5.1. Methodology

Work completed by AEA in 2013 that was focused on development of HSC/HSI curves included: 1) selection of target species and life stages; 2) development of draft HSC curves using existing information; and 3) collection of site-specific HSC/HSI data from selected areas. This information and these data will be used in combination with data collected during the next year of study to develop both habitat utilization and preference curves for target fish species.

4.5.1.1. Select Target Species and Life Stages

Survey results from the 1980s technical studies were reviewed in 2013 and used to determine the list of target fish species for potential development of HSC/HSI curves (Table 4.5-1). In collaboration with the TWG (Q1 and Q2 2013 TWG meetings), a ranking of priority (high, moderate, and low) fish species for which HSC/HSI curve development is targeted was developed based on management status and/or potential sensitivity to potential Project operations (Table 4.5-2). The highest priority species were generally considered the most sensitive to habitat loss through manipulation of flows and are the highest management priority in the Susitna River. The list of species and their priority ranking will continue to be evaluated following review of the 2013 sampling results.

4.5.1.2. Development of Draft HSC/HSI Curves Using Existing Information

Although the first priority in development of HSC/HSI curves is through the use of site-specific field data, a review and comparison of HSC/HSI curves developed as part of the 1980s assessment and non-Susitna River literature-based HSC/HSI curves sets was completed in 2013. This review relied heavily on information obtained as part of the 1980s assessments, in particular, the Instream Flow Relationships Report (Trihey & Associates and Entrix 1985a, 1985b) and a four-volume series on the aquatic habitat and instream flow assessment (Hilliard et al. 1985; Klinger-Kingsley et al. 1985; Steward et al. 1985; Aaserude et al. 1985). This information was synthesized and compared with more contemporary curve sets developed for similar river systems (R2 2013e). In addition, the HSC/HSI data collected in 2012 was compared with existing curve sets to see if patterns of microhabitat use were similar (R2 2013e).

A summary of the 1980s datasets available and reviewed to date is presented in Table 4.5-3. The draft HSC/HSI curves reviewed as part of this effort are presented in the 2012 Compendium of Technical Memoranda completed during Q1 2013 (R2 2013e).

4.5.1.3. HSC/HSI Study Area Selection

For the 2013 HSC/HSI sampling, a stratified random sampling approach based on macrohabitat composition within each Focus Area (ISR Study 8.5, Section 4.2) and relative fish use, was used for selecting sampling locations, with some adjustments made to final locations based on access and safety considerations. This approach enabled representative sampling of the range of macrohabitat types available to fishes within Focus Areas. In addition, HSC/HSI study sites were also selected in four areas outside of the Focus Areas, two within geomorphic reach MR-6 and two in MR-7 (Figure 4.5-1). These areas were identified as areas of high fish use during the 1980s and 2012 surveys and were selected in consultation with the Fish Distribution and Abundance (FDA) studies (ISR Study 9.6). All sample sites outside of the Focus Areas were given a unique identifier, with the site name beginning with NFA (Non-Focus Area).

There are 10 Focus Areas located in the Middle River Segment of the Susitna River (Figure 3-1) (see ISR Study 8.5, Section 4.2). The HSC/HSI sampling in Focus Areas in 2013 was limited to seven Focus Areas including 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). Due to access issues related to adjacent Cook Inlet Regional Working Group (CIRWG) lands, no HSC/HSI sampling sites were located in FA-184 (Watana Dam), FA-173 (Stephan Lake Complex), or FA-151 (Portage Creek). For the Focus Areas sampled, macrohabitats were first split into defined linear habitat units. For main and side channel macrohabitats, these units were defined as 500-meter-long (1,640 feet) thalweg segments. Off-channel macrohabitat units were similarly split into 200-meter-long (656 feet) segments. These units were then stratified into areas of known fish use versus unknown fish use based on studies conducted in the 1980s and in 2012 (R2 2013e). If this stratification resulted in multiple segments within a stratum or grouping, random segments were selected for sampling. The number and distribution of selected habitat units within each Focus Area are displayed in Table 4.5-4.

For main channel habitats, a single 100-meter (328 feet) sampling site was selected from within each of the randomly selected habitat units (i.e., 500-meter [1,640 feet] main channel units). The sample site was placed within the habitat unit, in an area that visually appeared to have the greatest diversity of microhabitat types (i.e., fast and slow, deep and shallow water) and could be safely worked. The width of the sampling site was determined in the field based on the sampling method employed and on safety concerns. In all other habitat types (side channels, sloughs, tributary mouths, backwaters, and plumes), a 50-meter (164 feet) sampling site was placed within each randomly selected habitat unit using the same considerations discussed above for the main channel. The general location of each sampling site within the Middle River Segment is presented in Figure 4.5-1.

4.5.1.4. Collect Site-Specific Habitat Suitability Information

Collection of HSC/HSI data was initiated in the Susitna River during a pilot effort in 2012. The primary goals of the 2012 pilot effort were to evaluate various sampling techniques, assess logistical aspects of site access, and begin collection of site-specific habitat suitability data for target species (R2 2013e). Information gathered during the 2012 sampling effort was used to help guide development of the 2013 field studies. The 2013 effort included the collection of both fish microhabitat utilization and availability data. The collection of habitat availability data along with habitat utilization data will allow the development of both habitat preference curves, as well as habitat utilization curves.

For 2013, a total of 68 HSC/HSI data collection sites were randomly selected (includes both 50- and 100-meter sampling sites [164 and 328 feet, respectively]) for collection of field data to define microhabitat use by spawning and freshwater ‘rearing’ (juvenile resident or anadromous fish) or ‘holding’ (adult resident fish) life stages of target fish species. As previously stated, specific sampling sites were located based on professional judgment within randomly selected macrohabitat units to capture the greatest diversity of microhabitat (slow and fast, deep and shallow water) and in areas with known concentrations of high fish use. In general, the same sample sites were visited two to three times during the summer (June-September) to detect any temporal changes in habitat use. Fish-use observation methods included pedestrian and underwater (snorkel) fish observations, single-pass backpack electrofishing, pole/beach seining, and backpack electrofishing with a mobile downstream blocking seine. Observation methods varied depending on environmental conditions, and were subject to ADF&G Fishery Resource Collection Permit requirements.

During each survey, microhabitat data (water depth, velocity, substrate composition and embeddedness, and cover) 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), 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. A more detailed description of each of the methods used during 2013 field sampling is presented below.

Prior to conducting any fish surveys within a sample site, turbidity samples were taken at the upstream and downstream ends of each sample site. Additional samples were taken if there were visible differences (e.g., clear water plumes, upwelling) in turbidity level between the upstream and downstream extent of the sampling site.

Additionally, vertical hydraulic gradient measurements were recorded at a minimum of three locations (downstream most, center, and upstream most end) within the length of each sampling site following procedures described by the USGS 2000 Fact Sheet. Additional measurements were collected near clusters of spawning redds/nest if large differences were noted between any of the three measurements within the sampling site. The vertical hydraulic gradient device was tested early during the survey period and found to be effective in detecting positive (upwelling) and negative (downwelling) hydraulic gradients. Although visual and temperature indications of groundwater upwelling were also noted, the vertical hydraulic gradient device was used extensively for detecting the presence of groundwater upwelling or downwelling within sampling sites, which will be important in developing HSC/HSI curves.

4.5.1.5. Spawning/Redd Surveys

The timing and location of spawning/redd surveys were based in part on fish distribution and periodicity data obtained from the 1980s studies and 2012 surveys of the Susitna River. This information was helpful in identifying sample timing and areas with the highest concentrations of spawning activity.

Because redds can often be inconspicuous and superimposed over one another, spawning site observations were made by experienced fish biologists. When actively spawning or guarding adults were located, HSC/HSI spawning surveys were conducted using snorkeling and pedestrian-based observations. The presence of at least one actively spawning or guarding fish of known species was required to qualify as an individual fish-use spawning site or redd. If a redd was located without a fish either spawning on or guarding a specific channel location, it was not used as an HSC/HSI fish spawning site. If a site was designated a spawning HSC/HSI site then one snorkeler or pedestrian surveyor entered the downstream end of the sampling site, stopping at each individual redd to first record the salmon species associated with the redd and then record the following information:

- Redd location (Lat/Long GPS coordinates) and distance from downstream end of sample site and distance from water's edge (nearest foot)
- Water depth at upstream end of the redd (nearest 0.1 foot), using a top setting rod
- Mean water column velocity at upstream end of redd (feet per second to nearest 0.05 fps), using a Price AA current meter
- Substrate size (dominant, sub-dominant, percent composition and embeddedness within the redd) characterized in accordance with a Wentworth grain size scale modified to reflect English units (Table 4.5-5)
- Water temperature (to nearest 0.1°C), dissolved oxygen (ppm), and conductivity (µS) measurements were made at the lower, middle, and upper ends of each sampling site and at a subset of the individual redds and/or clusters of redds
- In addition, if the redd was located proximate to habitat structure or cover features, then the cover type was noted: boulder, wood debris, aquatic vegetation, undercut bank, and overhanging vegetation)

The accuracy of water velocity meters and water quality probes was assessed before each survey (Table 4.5-6). Price AA current meter accuracy was tested by performing a timed spin test in accordance with USGS (1999) protocols with results recorded in a current meter accuracy test log. Accuracy of hand-held temperature probes was tested prior to field use in controlled water baths using a National Institute of Standards and Technology thermometer as a control (Dunham et al. 2005). Dissolved oxygen and conductivity probe accuracy was tested using known 0 percent oxygen (sodium sulfite) and 100 percent oxygen (water-saturated air) solutions as per the instrument manufacturer. Turbidity meters were checked for accuracy prior to each use using multiple turbidity standards that encompass a wide range of turbidity values (< 0.1 NTU to 800

NTU). All data were recorded on waterproof data sheets to ensure consistent data collection between surveys.

4.5.1.6. Juvenile Rearing and Resident Holding Utilization Surveys

To ensure the accurate detection of microhabitat use of rearing and holding fish, a combination of active and passive fish observation methods were employed during the 2013 surveys. These methods included snorkel surveys, pole/beach seining single-pass backpack electrofishing, and backpack electrofishing combined with a mobile downstream block seine. Active capture techniques were mainly used in reaches with turbid water (main channels and side channels) where underwater visibility was limited to less than 4 feet, whereas snorkel surveys were conducted if underwater visibility exceeded 4 feet. Fish rearing and holding observation surveys were conducted by teams of two or three individuals with extensive experience in using fish capture methodologies, identifying juvenile fish species, and conducting habitat and water quality surveys. A general description of each of the sampling methods used is presented below.

4.5.1.6.1. Snorkel Surveys

Snorkel surveys were conducted at sampling sites with good (>4 feet) underwater visibility. Prior to each survey underwater sight distance was evaluated to determine the visibility corridor for sampling. An object was held underwater by the data recorder, and a tape measure extended from the snorkeler to a point where the object was no longer clearly visible. As a general rule, when visibility conditions were less than 4 feet, no underwater sampling occurred.

To ensure accurate estimation of fish size underwater, snorkelers calibrated their sights to a ruler held underwater at various distances. Ruler marks were made on diving gloves to maintain accuracy in the underwater estimation of fish length. Observation sites consisted of individual fish holding in one location, but could contain a school of holding fish if the school was composed of one species and life stage, and was thought to be using a homogenous microhabitat site. Starting at the lower/downstream point within a longitudinal sample transect, one snorkeler moved in an upstream direction toward the upstream end of the sample site, but making lateral movements or zigzags as needed to cover the channel width. At each fish-use observation site, the snorkeler placed a weighted flag and communicated the following information to the data recorder:

- Fish species
- Fork length (mm)
- Number of fish observed for schooled-fish observations (schools categorized by life stage and species). (Note: only one observation of microhabitat use was recorded for each species of fish observed regardless of the number present.)

A trailing crew member then followed behind the snorkeler, being careful not to interfere with snorkel observations, and recorded the following measurements at each fish-use observation site:

- Fish location (Lat/Long GPS location for individual or groups of measurements) and distance from downstream end of sample site and distance from water’s edge (nearest foot)

- Water depth (nearest 0.1 foot) using a top setting rod
- Mean column velocity (feet per second to nearest 0.05 fps) measured using a Price AA current meter
- Distance to water's edge (feet)
- Substrate composition (dominant, sub-dominant, percent dominant, and percent embedded) characterized in accordance with a Wentworth grain size scale modified to reflect English units (Table 4.5-5).
- Water temperature (ºC)
- Dissolved oxygen (ppm)
- Conductivity (µS)
- Presence (within 1 meter) of habitat structure/cover features (e.g., boulder, wood debris, aquatic vegetation, undercut bank, and overhanging vegetation)

All data were recorded on waterproof data sheets to ensure consistent data collection between surveys. Accuracy of instruments used in association with snorkel observations was tested as described for equipment used in spawning observations (see ISR Study 8.5, Section 4.5).

4.5.1.6.2. Pole/Beach Seining

Pole seining was generally used in turbid water areas that could not be sampled with underwater techniques due to visibility limitations. Pole/beach seine nets (40 x 4 feet, 3/16 in body mesh, 1/8 in cod end mesh) were used in relatively shallow (<3.0 feet), low-moderate velocity (0 to 2 fps) locations to capture fish and determine their microhabitat use. The seine was worked upstream and to the stream margin where captured fish were separated into species and life stage, then released downstream after being measured.

Seine operators worked carefully to ensure that the lead line was pulled flush along the bottom of the stream to prevent fish from escaping under the net, and to keep the cod end open. The field crew lead estimated the point within the seine sample quadrant at which captured fish were assumed to be holding, and thus where fish use microhabitat variables were to be measured. In general, fish holding points were estimated as the approximate center point of the quadrant. The area of each quadrant varied for each sampling location, but ranged from approximately 50 to 200 square feet.

4.5.1.6.3. Single-pass Backpack Electrofishing

Single-pass backpack electrofishing was used in shallow water habitats (<2.5 feet) in areas associated with woody debris or aquatic vegetation where seining would not have been an effective method to capture fish. The electrofishing unit was operated and configured with settings consistent with guidelines established by NMFS (2000) and Smith-Root (2009) for safe and effective capture of fish. One crew member electrofished approximately 10- to 25-square-foot quadrants set approximately 10 to 30 lineal feet apart in an upstream direction. A second crew member was positioned downstream of the electrodes with a dip net to capture stunned fish. Captured fish were separated by species and life stage, and released downstream after being measured to total length. Microhabitat measurements were collected at each observation site using methods similar to seining; however, the electrofished quadrant generally did not exceed 25 square feet.

4.5.1.6.4. Backpack Electrofishing with a Mobile Downstream Block Seine

Backpack electrofishing with a mobile downstream block seine was used in relatively deep (0.5 to 2.5 feet) and moderately high velocity (0.5 to 1.5 fps) habitats located within the sample site to capture fish and determine their microhabitat use. One crew member electrofished approximately 25- to 50-square-foot quadrants upstream of the blocking seine net that was set up to capture stunned fish floating or moving downstream. Captured fish were separated by species and life stage, then released downstream after being measured. Habitat measurements were collected at each observation site using methods similar to seining surveys.

4.5.1.7. Habitat Availability Data Collection

After fish sampling was complete, habitat availability measurements were completed within each sampled site. Cross-channel transects were marked every 10 meters (32.8 feet) along the edge of the sampling site so that there would be 10 transects in each 100-meter (328-foot) site and 5 transects in each 50-meter (164-foot) site. At each transect, microhabitat measurements were collected at three random stations across the sampled width of the channel. A random number table was used to determine the location of each measurement across the transect. The following measurements were made at each station across the transect:

- Water depth (nearest 0.1 foot) using a top setting rod
- Mean column velocity (feet per second to nearest 0.05 fps) measured using a Price AA current meter
- Substrate composition (dominant, sub-dominant, percent dominant, and percent embedded) characterized in accordance with a Wentworth grain size scale modified to reflect English units)
- Habitat structure or cover types (if present) were noted (boulder, wood debris, aquatic vegetation, undercut bank, and overhanging vegetation)
- Vertical hydraulic gradient, water temperature (to nearest 0.1°C), dissolved oxygen (ppm), and conductivity (µS) measurements were made at the lower, middle, and upper ends of each sampling site

4.5.1.8. Habitat Utilization Frequency Histograms/HSC/HSI Curve Development

The HSC/HSI habitat data collected from each site were entered into spreadsheets and checked for data entry accuracy. For each species and life stage, frequency distributions were then generated for mean velocity, depth, and dominant substrate type for each species and then normalized to the maximum values of each parameter. Histogram plots of depth and mean column velocity utilization were developed using bin sizes of 0.2 for both water depth and velocity microhabitat data. The frequency of fish observations in each of the bins was then normalized by dividing by the maximum value observed, to create probability histograms with values between 0 and 1. These histograms were then compared to 2012 utilization histograms and to the 1980s HSC/HSI curves, which were based on utilization and presented in R2 (2013e).

Where possible, the 2013 HSC/HSI utilization data, along with additional utilization data collected during the next year of study will be combined with habitat availability observations to compute habitat preference curves (ISR Study 8.5, Section 4.5). This analysis will evaluate the probability of observing a fish of a given species and life stage in a particular location, given the depth, velocity, substrate, and other microhabitat variables available at that location. These relationships will be modeled using logistic regression, and where appropriate univariate and multivariate statistical methods.

4.5.1.9. Other Methods for HSC/HSI Curve Development

For some species and life stages, the 2013 site-specific HSC/HSI curves discussed above may be used as final curves. However, additional HSC/HSI sampling is planned for the next year of study and it is anticipated that most HSC relationships will be updated. For species and life stages that are rarely observed, final HSC curves may be based on additional data, including utilization data from 2012 and the 1980s studies on the Susitna River. However, there may still be some species where few or no empirical HSC/HSI data were able to be collected. In those cases, AEA will consider other methods for developing curves. This may include the use of literature based curves, developing envelope curves (see, for example, Jowett et al. 1991, and GSA BBEST 2011), guilding (e.g., creating a combined HSC/HSI curve representing multiple species and/or life stages; see, for example, Vadas, Jr. and Orth 2001, GSA BBEST 2011), developing curves based on expert opinion/round table discussions) and the use of Bayesian statistical methods for updating data distributions (see, for example, Hightower 2012). Bootstrapping may be used as one technique for estimating variability around these types of combined curves. Bootstrapping is a data-based simulation method for assigning measures of accuracy to statistical estimates and can be used to produce inferences such as confidence intervals (Efron and Tibshirani 1993).

The site-specific HSC/HSI curves developed based on the 2013 data will be presented in 2014 as part of the Proof of Concept discussions and will include estimates of uncertainty based on standard errors from the logistic regression model. Data collected during the next year of study will include availability data and will be combined with the 2013 data to refit the logistic regressions, with potential consideration of different time periods.

4.5.1.10. Winter Habitat Use Sampling

Pilot IFS winter studies were completed during 2012–2013 to monitor water quality and stage conditions at salmon spawning locations and to record fish habitat use. These studies were done as a collaborative effort with the FDA study (Study 9.6) and Groundwater Study (Study 7.5). The winter IFS 2012–2013 pilot study was comprised of three components: 1) monitoring of intergravel temperature, dissolved oxygen, and surface water levels; 2) fish behavior and habitat use observations; and 3) winter fish capture. One of the primary purposes of the pilot study was to evaluate and test different instruments, methods, and approaches for safely conducting winter studies within the Middle River Segment of the Susitna River, with the goal of taking that information and applying it to develop a more robust winter study program for 2013-2014.

The 2012-2013 pilot winter studies were comprised of two primary components: 1) water level and water quality monitoring and 2) fish behavior and habitat use observations. Data collection occurred during three trips in early 2013: February 1-7, March 19-25 and April 8-13. The initial work on the 2012–2013 pilot study consisted of a focused review of literature from 1980s studies and of more recent research to identify potential methods for each study component.

Water level and water quality were continuously monitored at nine sites in FA-104 (Whiskers Slough) during February – April 2013 (Figure 4.5-2). Continuous monitoring sites in FA-104 (Whiskers Slough) were established in early February 2013 in the Susitna River within a variety of macrohabitat types. These included main channel, side channel, side slough, upland slough and tributary habitats. The areas selected were comprised of areas with known or suspected groundwater upwelling, bank seepage and lateral intergravel flow from the main channel, areas of mixing between upwelling and bank seepage, areas with no intergravel discharge, areas where fish had been observed spawning. In FA-128 (Slough 8A), continuous water level and water quality sites were established during March 2013 in side slough and upland slough habitats (Figure 4.5-3). Salmon spawning was observed during fall 2012 at FA-104 (Whiskers Slough) sites WSC-30, WSL-20 and WC-10 and at FA-128 (Slough 8A) Site SL8A-15 (Figure 4.5-2 and Figure 4.5-3). Habitat designations (e.g., side channel, slough) used during 2012-2013 winter studies were based on 2012 Middle River Segment remote line habitat mapping (HDR 2013). Most water level and water quality instruments were downloaded and removed prior to completion of the April 2013 trip, however, a subset of water level and temperature instruments were downloaded and redeployed in April 2013 to record hydrologic and temperature conditions through spring ice breakup.

Pressure transducers (Solinst leveloggers) were used to record changes in stage at continuous monitoring sites. Transducers were deployed at the substrate surface at each site. To prevent shifting during the deployment period, transducers were anchored with weights and attached to metal stakes driven into the substrate. All transducers were removed during the final data collection period in April 2013, with the exception of instruments in Whiskers Slough) (WSL-20) and Slough 3A (SL3A) in FA-104 (Whiskers Slough) and both sites in FA-128 (Slough 8A) (SL8A-10 and US2-10) (Figure 4.5-2 and Figure 4.5-3). In FA-104 (Whiskers Slough), comparisons between stage in side channel and off-channel habitats relative to the Susitna River main channel were completed using pressure transducer data normalized to zero at the common start time for all instruments within the FA. At FA-128 (Slough 8A), main channel stage data were not available so stage data recorded at the USGS gage at Gold Creek (No. 15292000) after ice breakup were used for comparison of main channel and off-channel stage. Pressure data recorded at each continuous monitoring site was compensated with barometric pressure data recorded at FA-104 (Whiskers Slough) and FA-128 (Slough 8A) (Figure 4.5-2 and Figure 4.5-3).

Surface and intergravel water temperatures and intergravel dissolved oxygen concentrations were continuously recorded in FA-104 (Whiskers Slough) and FA-128 (Slough 8A) (Figure 4.5-2 and Figure 4.5-3). Surface water temperature was recorded by pressure transducers at the substrate surface. Intergravel water temperature loggers (Hobo Tidbit v2) were deployed at three separate intergravel depths: 5 centimeters (cm) (2 in), 20 cm (7.9 in), and 35 cm (13.8 in) beneath the substrate surface. These depths reflect observed burial depth ranges of chum and sockeye eggs (Bigler and Levesque 1985; DeVries 1997). Intergravel temperature probes were attached to stainless steel cable and deployed into the gravel using a steel installation device (*sensu*

Zimmerman and Finn 2012). Dissolved oxygen loggers (HOBO U26-001), which also recorded water temperature, were bolted within a perforated PVC tube and likewise inserted into the gravel to a depth of approximately 20 cm adjacent to known or historic salmon spawning areas. All intergravel temperature and dissolved oxygen instruments were removed in April 2013 except intergravel temperature loggers at Whiskers Slough (WSL-20) and Whiskers side channel (WSC-30) in FA-104 (Whiskers Slough), which were recovered in June 2013 and October 2013, respectively.

The relationship between main channel stage and water temperature was evaluated at three sites in FA-104 (Whiskers Slough) that were observed to support salmon spawning in 2012 (WSC-30, WSL-20, and WC-10). The stage records for each spawning site and the main channel were normalized to zero at the start of data collection and compared to surface and intergravel temperatures.

Instantaneous measurements of surface water quality were recorded at continuous monitoring sites in addition to other main channel and off-channel areas in FA-104 (Whiskers Slough) and FA-128 (Slough 8A) during January, March, and April 2013 using a hand-held water quality meter (YSI Pro 30) (Figure 4.5-2 and Figure 4.5-3). Measurements of water temperature, dissolved oxygen concentration and specific conductance were recorded on the water surface and at mid-column depth. Instantaneous water quality data were used to characterize surface water quality in each Focus Area and to help discern qualitative differences in groundwater composition among habitats based on water temperature and specific conductance (Rosenberry and LaBaugh 2008).

Fish observation and capture efforts occurred in each Focus Area during monthly trips between February-April 2013. Fish observation sites were located in open-water and ice-covered areas within off-channel and tributary habitats (Figure 4.5-2 and Figure 4.5-3). Underwater video was used consistently by FDA and IFS staff during each trip and in each Focus Area to monitor behavior in fish communities and evaluate the effectiveness of different camera types, power supplies, and lighting conditions. Dual Frequency Identification Sonar (DIDSON) was utilized opportunistically by FDA staff in FA-104 (Whiskers Slough) to gauge its applicability for monitoring fish behavior and habitat utilization during winter. When used in ice-covered areas, the video camera or DIDSON unit was lowered through auger holes drilled through the ice. Where possible, video cameras were used to characterize winter habitat attributes such as the presence of anchor ice, hanging dams, and substrate type.

Electrofishing surveys were performed during 2012-2013 IFS winter studies to collect site-specific habitat suitability criteria (HSC) data and augment observations of fish behavior. Electrofishing surveys were conducted at four sites in open-water areas of FA-104 (Whiskers Slough) and FA-128 (Slough 8A) during day and night surveys in March and April 2013 (Figure 4.5-2 and Figure 4.5-3). HSC/HSI data (e.g., velocity, water depth, substrate and cover) were measured at the point of fish capture during electrofishing sampling and in association with underwater video monitoring provided fish species and size could be determined during underwater surveys and target fish were observed maintaining a stationary position. Water velocity and depth measurements were made either through holes drilled in the ice or in open-water leads using a wading rod and Price AA water velocity meter. Instantaneous measurements of water temperature, dissolved oxygen and specific conductance were recorded using a hand-held water quality meter (YSI Pro 30) to describe water quality conditions at the location of fish observations.

4.5.1.11. Stranding and Trapping

No formal stranding and trapping surveys were conducted during the 2013 field season. The need for, and if warranted the type of, such surveys to be completed during the next year of study will be determined.

4.5.1.12. River Productivity

Development of HSC/HSI for macroinvertebrates and algae followed a similar general approach to that for fish, and included a literature search for available information, field studies to supplement literature-based information and to provide site-specific data, and use of a panel of TWG participants to finalize the HSC/HSI curves. The development of HSC/HSI information for macroinvertebrates and algae is one part of the more comprehensive River Productivity Study (Study 9.8).

In 2013, macroinvertebrate sampling was stratified by reach and mainstem macro-habitat type (mainstem, tributary confluences, side channels, and sloughs). Sampling stations were located at FA-104 (Whiskers Slough), FA-141 (Indian River), FA-173 (Stephan Lake Complex), and FA-184 (Watana Dam). One additional station was located in the Lower River Segment near Montana Creek (RP 81). Sampling occurred at five stations, with 3-5 sites each (depending on the number of macrohabitats present in the Focus Areas) for a total of 20 sites. See ISR Study 9.8 for locations of sample sites. Measurements of depth (measured with top-set rod), mean water column velocity (Pygmy current meter), and substrate composition (visual assessment) were taken concurrently with benthic macroinvertebrate sampling.

Data collected in 2013 will be used to develop histograms (i.e., bar charts) for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of dewatering) for macroinvertebrates and algae. The histograms developed using field observations from 2013 will then be compared to the literature-based HSC/HSI curves to validate applicability of the literature-based HSC/HSI curves for aquatic habitat modeling.

4.5.1.13. Periodicity

Fish periodicity describes the temporal and spatial utilization of mainstem, off-channel, and tributary habitats in the Susitna River by individual fish species and life stages and is necessary to evaluate potential effects of Susitna River streamflow fluctuations on fish communities. In 2013, AEA developed 14 separate species and life-stage-specific periodicity tables applicable to different segments and macrohabitat types of the Susitna River (see Tables 5.1-1 through 5.1-14 in R2 2013e). The species covered included Chinook, coho, sockeye, chum, and pink salmon; rainbow trout; Arctic grayling; Dolly Varden; burbot; round and humpback whitefish; longnose sucker; Bering cisco; and eulachon. These tables were based on information provided in the 1980s studies as well as more contemporary information from ADF&G reports (e.g., Merizon et al. 2010). Additional species periodicity information has been collected in 2013 as part of the IFS HSC/HSI studies (ISR Study 8.5, Section 4.5.1.13) and a number of fish studies including Fish Distribution and Abundance in the Middle and Lower River (Study 9.6), Salmon

Escapement (Study 9.7), Eulachon (Study 9.16). Updates and/or revisions to the draft periodicity tables will be completed in cooperation with fisheries resource leads and the TWG in 2014.

4.5.1.14. Biological Cues Study

Climatic and hydrologic patterns are important considerations in determining salmon distribution and abundance. Large-scale climatic changes (e.g., Pacific Decadal Oscillation) affect regional weather conditions that subsequently influence hydrologic conditions (Hartmann and Wendler 2005). Changes in river hydrology can influence the stability and persistence of aquatic habitats and can determine fish distribution and abundance (Connor and Pflug 2004). The objective of this exploratory analysis was to look for general relationships between temporal patterns in environmental conditions and salmon distribution, abundance, and migration timing. Analyses of these flow-dependent biological cues, such as possible relationships between climatic, hydrologic, and fish habitat indices and salmon abundance and migration timing, were to be based on available long-term datasets for Deshka River Chinook salmon and Yentna River sockeye salmon. Other Susitna River Basin long-term datasets pertaining to salmon migration timing and abundance were to also be included if available.

After examination of data reports and available hydrologic data, and discussions with ADF&G personnel, the Deshka River and the Yentna River were ruled out as plausible datasets to examine relationships between hydrology and biological response relevant to Susitna River salmon stocks. Through further discussions with ADF&G, AEA selected the Taku River and Stikine River Chinook salmon stocks for this study. These two systems were selected because both are glacial fed systems like the Susitna, both support populations of Chinook salmon that have been monitored by ADF&G for several decades, and both have a long hydrologic record from which to test for biologically relevant hydrologic metrics.

Biological data focused on Chinook salmon harvest levels and smolt and adult abundance levels for the Taku and Stikine rivers that were acquired from ADF&G (R. Phillips, ADF&G biologist, personal communication, September 6-12, 2013). Data collection methods are described in McPherson et al. (2010) for the Taku River and in Richards et al. (2012) for the Stikine River. For each river, annual data consisted of the following:

- Harvest levels downstream of the fish-counting station
- Harvest levels upstream of the counting station
- Inriver run size at the counting station
- Inriver age structure (percent of run in ages 3-7)
- Smolt abundance by brood year

Hydrologic data focused on daily flow values acquired from USGS gages located in the lower Stikine and lower Taku rivers (Gage No. 15024800 and Gage No. 14041200). PDO data were acquired from the University of Washington Joint Institute for the Study of the Atmosphere and Ocean (UWJISAO 2013). The hydrologic data were initially analyzed using The Nature Conservancy's (TNC) Indicators of Hydrologic Alteration (IHA) and Environmental Flow Component (EFC) software (TNC 2009). This resulted in the calculation of 33 IHA metrics and

34 EFC metrics for each system. The outputs were subsequently post-processed in Excel to compute flow metrics specific to the life history characteristics of Chinook salmon.

For Chinook salmon productivity, daily flow values were summarized over periods considered potentially critical for survival during egg incubation, winter rearing, summer rearing, out-migration, and early ocean rearing (see Table 2 from Biological Cues ISR Study 8.5, Appendix B). In addition, Mantua et al. (1997) demonstrated a relationship between the PDO in sea surface temperatures with the productivity of salmon stocks in Alaska and the west coast of North America. Consequently, a PDO index was also included in the pool of potential covariates. For median run timing two potential flow indices were considered as potential covariates while three indices were considered for run duration (see Table 3 from Biological Cues ISR Study 8.5, Appendix B).

If relationships among these variables exist, they are likely to be highly complex and interactive. This study was based on available data only, and is not meant to be exhaustive. Rather, AEA looked for moderate correlations and evaluated relationships visually and using regression analysis. Linear and local regression analysis was used to visually discern potential linear and non-linear relationships between select biological and hydrologic variables. Correlation estimates were obtained for each paired relationship with a potentially meaningful causal mechanism based upon an understanding of mechanisms observed in other systems. For relationships that had moderate correlations, we examined relationships further with single or multiple linear regressions, including two-way interactions, and described the best-fitting model. A detailed description of the methods used as part of this analysis is provided in ISR Study 8.5, Appendix B (Biological Cues Study).

4.5.1.15. Relationship between Microhabitat Use and Fish Abundance

In the April 1, 2013 Study Plan Determination (FERC 2013b), 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.

AEA initiated this evaluation in Q4 2013 by first identifying and reviewing the extent and completeness of the data necessary to complete the analysis. This review revealed that the following information was already or would be soon available to be used in the analysis, organized by study:

- River Productivity – data have been collected during three separate sampling events (spring, summer, fall) within FA-104 (Whiskers Slough), FA-141 (Indian River), FA-173 (Stephan Lake Complex), and FA-184 (Watana Dam). Finalized turbidity, photosynthetic active radiation, and temperature data available Q4 2013.
- Groundwater – spot and continuous records collected during winter and summer sampling events within FA-104 (Whiskers Slough), FA-115 (Slough 6A), FA-128

(Slough 8A), and FA-138 (Gold Creek). Limited availability of finalized water quality data in Q4 2013. Remaining data finalized next year of study.

- Water Quality – collected during three separate sampling events (July 28, August 11, and August 23) within seven Focus Areas located downstream of Portage Creek. Limited availability of finalized water quality data in Q4 2013. Remaining data finalized next year of study.
- Fish Distribution and Abundance - collected during three separate sampling events (July 7-August 12, August 13-September 4, September 4-October 4) from representative habitat types within each FA. Limited availability of finalized fish distribution and abundance data in Q4 2013. Remaining data finalized next year of study.

Once all data are compiled, AEA will complete a statistical analysis of the data to detect possible relationships between one or more of the variables and fish distribution and abundance information. The analysis proposed for completing this evaluation is described in ISR Study 8.5, Section 7.5.

4.5.2. Variances from Study Plan

AEA implemented the methods as described in the Habitat Suitability Criteria Development section of the Study Plan with the exception of the variances explained below.

- Due to access restrictions, the distribution of HSC sampling sites in the Middle River Segment was limited to habitat areas between Portage Creek (PRM 151.8) and Three Rivers (PRM 102.4). The Study Plan states: “sample sites will be stratified and randomly selected from within the Middle River Segment (RM 98-RM 184) and Lower River Segment (RM 77¬RM 98) of the Susitna River”. However, no HSC sampling sites were selected within the Lower River due to delays in completing habitat composition surveys and the desire to concentrate the 2013 sampling effort within the Middle River. These changes are not anticipated to adversely impact achieving Project objectives assuming that these areas will be sampled during the next year of data collection.
- Spawning redd dimensions were not collected as part of the 2013 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 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 FA-IFS 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 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.
- Mesohabitat type was not recorded for fish observation/capture points. Mesohabitat mapping was completed as part of RSP 9.9 and the data are currently being analyzed (Study 9.9). After the mesohabitat mapping task is complete, 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 "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 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. 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, this change is not expected to adversely impact achieving Project objectives. AEA will discuss the need for stranding and trapping surveys with the resource agencies during TWG meetings. If stranding and trapping surveys are not needed, 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.
- According to the Study Plan for winter sampling, results of the 2012-2013 winter effort were to be distributed to TWG participants by Q3 2013. Although condensed results from winter data collection were communicated to TWG participants during IFS presentations at quarterly TWG meetings in June, September and December 2013, detailed results were not distributed due to IFS data collection and analysis activities that occurred during Q3 and Q4 2013. AEA will distribute a technical memorandum that describes the results of the IFS pilot winter studies to the stakeholders for review and comment in 2014.
- 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, 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 FERC-approved Study Plan, 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 is still being processed and/or undergoing quality assurance checks and is not available at this time. AEA initiated this task in Q4 2013 and will complete the analysis in the next year of study. This change in schedule is not expected to adversely impact achieving Project objectives since there will be adequate time for agency review and comment prior to the start of the next year of data collection.

4.6. Habitat-Specific Model Development

AEA implemented the methods related to habitat model development for both the Middle and Lower River segments of the Susitna River as described in the Study Plan. There were no variances pertaining to the Middle River Segment, but a few variances occurred relative to the Lower River Segment that are described in ISR Study 8.5, Section 4.6.2. As described in the Study Plan schedule of activities, most habitat modeling activities will occur after the ISR is submitted in 2014. Thus, the work completed in 2013 consisted largely of activities associated with the selection of specific models to be used, coordination with other resource model leads in the completion of surveying and collection of field data necessary to support model development, preliminary model development, and completion of preliminary model test-runs to illustrate draft habitat evaluation metrics and linkages with other resource models.

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. The RSP 8.5 (Section 8.5.4.6) provided background information on the types and intended uses of the habitat models that will be applied in this analysis and is not repeated in this ISR. The methods and models include a combination of approaches that vary depending on habitat types (e.g., mainstem, side channel, slough, etc.) and the biological importance of those types, as well as the particular instream flow issue (e.g., connectivity/fish passage into the habitats, provision of suitable habitat conditions in the habitats, etc.) Importantly, the habitat-specific models are only one of a number of resource models that will be used for evaluating Project effects on aquatic and fish habitats. Other models are being developed to address issues related to:

- Water quality: models include – (3-D) Reservoir Water Quality Model, (2-D) River Water Quality Model, and (2-D) River Water Quality Model with Enhanced Resolution Focus Areas (Study 5.6),
- Sedimentation and channel morphology: models include – 1-D Bed Evolution Model, 2-D Bed Evolution Model (Study 6.6)
- Ice processes and under ice conditions: models include – River1D Ice Processes Model, River2D Focus Area Ice Models (Study 7.6), and
- Groundwater and surface water interactions: models include – empirical models based on groundwater level-surface water level monitoring, MODFLOW for selected Focus Areas (Study 7.5).

As will be described in ISR Study 8.5, Section 4.8, the habitat-specific models will depend on outputs from the Reservoir Operations Model and the Open-water Flow Routing Model and River 1D/2D Ice Processes Models to evaluate project effects on physical habitats during open-water and ice-covered conditions. The other resource models will be integrated into the analysis as needed to address specific biologically relevant questions.

4.6.1. Methodology

The development of the habitat-specific models was tailored around the study sites and transect locations identified in ISR Study 8.5, Section 4.2. These sites consisted of the ten Focus Areas selected in the Middle River Segment (Table 4.2-3), and the study sites and transect locations selected in the Lower River Segment (Figure 4.2-11 and Figure 4.2-12). The Lower River sites were selected following an aerial reconnaissance (completed on May 16, 2013) of the tributary mouths and main channel habitat areas around Trapper Creek (PRM 95.4), Birch Creek (PRM 93.3), Caswell Creek (PRM 67.3), and Sheep Creek (PRM 71.7). Fish habitat transects were identified in the vicinity of Trapper Creek and Birch Creek to capture the habitat conditions at the tributary mouth and within adjacent mainstem macrohabitats. Fish habitat transects were also identified between PRM 95 and PRM 97 to capture mainstem macrohabitat types for the Lower River. Transect selection and measurements for the Deshka River and boundary condition transects for Trapper Creek were collected as part of the Fluvial Geomorphology Study (ISR Study 6.6).

4.6.1.1. Habitat Model Selection

The selection of specific habitat models was made following discussions with the agencies and stakeholders that began in 2012 as part of the August 16, September 14, and October 2-3 TWG meetings. During the latter meeting, AEA reviewed a variety of instream flow methods and models for potential applicability on the Project (

Table 4.6-1). As part of the October meeting AEA completed a two-day site reconnaissance with personnel from state and federal agencies, Alaska Native entities, and other TWG members to review river reaches and habitat types, visit several proposed Focus Areas, and discuss options for model development. Participants reconvened for a field reconnaissance debrief on the final day of the trip to discuss observations and assessment of different modeling methods. At that time, consideration was being given to the application of either 1-D or 2-D hydraulic models coupled with habitat models that would be used within a Physical Habitat Simulation (PHABSIM) based framework, as well as several other models (Table 4.6-1). Based on further internal discussions between resource leads, it was decided that 2-D hydraulic modeling would provide the greatest resolution for defining habitat-flow relationships and sediment transport relationships within Focus Areas of the Middle River Segment. This was discussed during the February 14, 2013 TWG meetings (Tetra Tech 2013e) and AEA subsequently proceeded with data collection to support development of 2-D models in the Focus Areas. However, due to the complexity of the channel network in the Lower River Segment, AEA selected the 1-D hydraulic model HEC-RAS Version 4.1 to simulate water surface elevations coupled with PHABSIM for modeling habitats at discrete locations, and proceeded with data collection for those models (R2 2013b). Details concerning the collection of data to support development of these models are provided in the following sections.

4.6.1.2. Field Coordination and Collection of Physical and Hydraulic Data

Once Focus Areas (Middle River Segment) and transect locations (Lower River Segment) were identified, and the habitat-specific models selected, detailed field surveys were conducted. These surveys occurred in 2013 and were closely coordinated between and among the different resource leads to ensure that data necessary for developing the respective models was being collected. This was especially important relative to the surveying and data collection in the Focus Areas for the development of the 2-D hydraulic models. Those data were collected as part of the FA-IFS program but are being analyzed for development of the 2-D hydraulic models by the Geomorphology program (Study 6.6). Once the 2-D hydraulic models are developed, FA-IFS will then apply the models in a 2-D PHABSIM framework to define habitat – flow relationships and other habitat metrics (ISR Study 8.5, Section 4.6.1.4).

During 2013, physical and hydraulic data collection within the Middle River Segment included measurement of hydraulic boundary conditions, stage and discharge measurements, bathymetric surveys, velocity mapping, and roughness (channel substrate) determinations 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), and FA-144 (Slough 21). Data were also collected from Middle River cross-sections established to support development of the Open-water Flow Routing Model (ISR Study 8.5, Section 4.4).

For the Lower River Segment, each transect was initially flagged and marked with a hand-held GPS to identify the headpin location for the survey crew. Data collection included single transect surveys consisting of ADCP measurements for discharge determinations, stage measurements, and bathymetric surveys. completed using the protocols described in ISR Study 8.5, Appendix A.

4.6.1.2.1. Boundary Condition Transects

The upstream and downstream boundaries as well as the lateral extents of the Focus Areas were established by the Geomorphology Study (RSP Section 6.6.4.1.2.4) in 2013 so that appropriate boundary condition transects could be established for the 2-D hydraulic modeling.

Data were collected at each of the boundary condition transects as part of the hydrologic data collection field activities described in ISR Study 8.5, Section 4.3. The primary field data collected at each of the transects included:

- Completion of a cross-section survey to define channel topography and hydraulic controls at the upstream- and downstream-most portion of each Focus Area using RTK GPS instrumentation.
- Velocity and discharge measurements collected using an ADCP system consisting of a Sontek M9 equipped with RTK GPS positioning to generate the necessary discharge and velocity distribution data (ISR Study 8.5, Appendix C).
- Measurement of the water surface elevation during discharge measurements, and documentation of the substrate type, groundcover, habitat type, and woody debris in the flood-prone area for the purposes of developing roughness estimates.
- Measurement of stage and discharge during a high and low flow condition.

Data collected at each of the boundary condition transects will be used to compute the energy slope, velocity, depth, and other hydraulic variables at each cross-section for use in development of the 2-D hydraulic models.

4.6.1.2.2. 2-D Modeling

In 2013, AEA collected bathymetric data within each of the seven measured Focus Areas as part of the hydrologic data collection activities described in ISR Study 8.5, Section 4.3. The data were collected with a Sontek M9 ADCP and vertical-beam depth sounder and RTK GPS positioning systems. These data will serve as input to the 2-D hydraulic models that are being developed and described in the Geomorphology study (ISR Study 6.6). AEA performed cross-sectional bathymetric surveys as part of discharge measurements completed in 2012 and 2013 using the AEA used the results of these surveys to prepare a digital elevation model of the streambed., AEA used the digital elevation model together with shore-based RTK GPS surveys to develop cross-sections for use in the Open-water Flow Routing Model.

The bathymetric surveys were conducted in both deep (via boat) and shallow (by wading) water areas along pre-planned survey lines throughout the seven Focus Areas. An example of the pattern and density of the measurements is presented in ISR Study 6.6. The survey lines were selected using recent imagery and hydrographic data acquisition software (e.g., HyPack); the density of survey lines was commensurate with the minimum model grid spacing needed for 2-D hydraulic or other IFS models (ISR Study 6.6).

The bathymetric data were QA/QC checked and post-processed using hydrographic data software to obtain a digital terrain model from which a Triangulated Irregular Network (TIN) was derived. The digital terrain models and TIN were used to develop cross-sections or as input to the 2-D hydraulic models and other instream flow models. The ADCP files were post-processed to develop cross-sectional or plan-view velocity maps for calibration of hydraulic models.

As part of the surveys, AEA visually estimated substrate size and composition by wading in shallow areas or probing in deeper water main channel areas. The same substrate categories as used for the HSC data collection were applied during the surveys. Visual calibration of the size classes was made prior to the data collection by having each observer estimate substrate size classes within a given area and then measuring the substrate. This calibration procedure was repeated periodically each day by all observers at each Focus Area. The substrate categories (dominant particle size, subdominant and percent dominant) were recorded on laminated enlarged aerial photographs as polygons or point values on cross-sections. AEA categorized main channel substrate in cross-sections by probing with a long rod over the side of a jet boat. Cross-sections were repeated at regular intervals in each Focus Area. The combined data collection of shoreline crews and boat crews resulted in a complete substrate survey of each Focus Area.

4.6.1.2.3. Single Transect Data Collection

Single transect cross-sections were located and measured in 2012 and 2013 in both the Middle and Lower River segments as described in the hydrologic data analysis section of ISR Study 8.5, Section 4.3. Data collected from these transects has and will continue to be used to support development of the Open-water Flow Routing Model as well as for collecting discharge and stage information. Data from some of these cross-sections may also be used in a 1-D PHABSIM type analysis.

The need for doing so in the Middle River Segment will be determined based on results obtained from the Focus Area 2-D habitat-flow modeling. The 2-D hydraulic model domain includes the entire riverine (wetted) spatial area of each Middle River Focus Area and therefore can be used to evaluate features and attributes using single transect modeling. If 1-D, single transect modeling is required in the Focus Areas, the data can be extracted from the 2-D model domain and the field survey data used to construct those models. The transects outside of the Focus Areas can also be brought into this analysis if supplemental information is needed.

In the Lower River Segment, in addition to the cross-sections established for discharge measurements and the Open-water Flow Routing Model, single transects were located across a range of macrohabitat types at five sites established between PRM 92.9 and PRM 97 to support development of 1-D hydraulic models and completion of a 1-D PHABSIM analysis. Data collection at those sites consisted of three site visits (June, August and September 2013) to coincide with high, moderate and low flow conditions. Flow conditions for each field visit were assessed based on real-time flows reported for the Susitna River at the Sunshine gage (USGS Gage No. 15292780). The flow target for collecting field data under high flow conditions was greater than 80,000 cfs, the moderate flow target was around 50,000 cfs and the low flow target was less than 25,000 cfs. Each of the three surveys was completed near the targeted flow ranges.

From 3 to 17 cross-sectional transects were established per site in June 2013 (Figure 4.2-11). Data collection was completed in accordance with methods described in ISR Study 8.5, Section

4.3 and ISR Study 8.5, Appendix C and included ground surveying using an RTK GPS, and bathymetric surveys and velocity measurements using an ADCP. Field protocols specified the collection of one complete set of velocity profiles, bathymetry and water surface elevation data at each transect and representative discharge measurements to establish boundary conditions for a single flow condition. The field survey protocols for the remaining two flow conditions involved the collection of water surface elevation data at each transect and completion of substrate and cover mapping. This approach assumes that the same bed topography will be applied for each discharge condition and as part of the data analysis required the flow routing model results and USGS discharge data for the mainstem and tributary gages to establish boundary conditions to support the field data collected during the two follow-up field surveys. Representative photographs were taken during each of the three flow conditions at each transect showing views upstream, downstream and facing both banks.

The high flow survey was completed from June 10 to June 15, 2013 at flows ranging between approximately 70,000 cfs and 90,000 cfs as measured at the Susitna River at the Sunshine gage (USGS Gage No. 15292780) (provisional). During the June survey, initial site set-up was completed with installation of transect headpins. The bathymetric survey, velocity profile measurements and water surface elevation survey were completed for high flow conditions at each transect. Transects were marked on both banks with re-bar pins, labelled survey lath and flagging tape. An additional marker pin was installed approximately 300 meters upstream of the PRM 96 site on the right bank of the main channel to serve as a main channel water level reference at the time of the survey. The RTK GPS topographic survey was conducted in June to collect location and elevation of water level data at wetted edges, marker pins, bank characteristics and streambed sections that were dry or too shallow to be captured by the boat-mounted ADCP crew. Discharge and bathymetry data were collected with ADCP for each transect in June 2013, with the exception of a single transect within the Trapper Creek site that was too shallow to survey by boat. At this location, depths and velocities were measured using a Sontek FlowTracker velocimeter mounted to a top-set wading rod. The distances along the transect were established using a tape measure and were identified relative to the headpin locations. A single discharge was collected at an appropriate transect location within at least one single channel area to define boundary conditions and the remaining transects were surveyed using a single pass with the ADCP to define the velocity profile.

The moderate flow survey was completed from August 18 to August 20, 2013 at flows ranging between approximately 43,000 cfs and 60,000 cfs at the Susitna River at Sunshine gage (provisional). The August 2013 field visit consisted of RTK GPS surveying of water level at wetted edges for each transect, measuring flow at selected transects and classifying substrate for each transect. Where possible, discharge was measured for each channel within each site at locations that were wadeable to define model boundary conditions. Discharge was measured using a handheld Sontek FlowTracker velocimeter with a top-set wading rod. Substrate was visually assessed for each transect where visibility permitted and classified into dominant and sub-dominant types using a modified Wentworth grain size scale. A percentage distribution was estimated and assigned to the dominant substrate type. Where substrate composition could not be determined visually, a long pole was dragged across the deep section of the transect to identify general substrate category (boulder, cobble/gravel, fines).

The low flow survey was completed from September 23 to September 25, 2013 at flows ranging between approximately 25,000 cfs and 28,000 cfs at the Susitna River at Sunshine gage (provisional). During the September 2013 visit, water levels and flow were measured as in the August survey and substrate was reviewed and modified where better visual observations could be made. Fish cover was inventoried for each transect and recorded as percent cover across channel width and location on the cross-section for boulder, aquatic vegetation, overhanging vegetation, undercut banks and woody debris.

4.6.1.3. Preliminary Model Development

4.6.1.3.1. 2-D Modeling

In 2013, data from the topographic ground surveys, ADCP bathymetric and velocity surveys, LiDAR coverages, and substrate characterization surveys were QA/QC'd and transmitted to the Geomorphology program to begin development of the 2-D hydraulic models. As part of the Geomorphology Study (Study 6.6), two 2-D models are being considered including the Bureau of Reclamation’s SRH2-D and the suite of River2D models (see ISR Study 6.6 for a description of various 2-D model attributes and references). These two models have slightly different capabilities relative to applications necessary for the Geomorphology program to model channel bed evolution dynamics and are being evaluated accordingly. This evaluation will result in the selection of a single 2-D hydraulic model to meet the needs of both the Geomorphology analysis and the IFS Focus Area fish habitat analysis. Details of data QA/QC, 2-D model development steps, and the comparative evaluation of the two models are provided in ISR Study 6.6.

Some preliminary, conceptual model results from the SRH-2D hydraulic model were presented for FA-104 (Whiskers Slough) during the November 13-15, 2013, IFS-TT Riverine Modelers Meeting (Tetra Tech 2013f).

4.6.1.3.2. 1-D Single Transect Modeling

In 2013, data from the ground surveys, LiDAR coverages, ADCP bathymetric and velocity surveys, and substrate characterization surveys collected from the Lower River Segment transects were QA/QCd and used in the initial development of the 1-D hydraulic models. This involved the merging of electronic data sets from the RTK and ADCP surveys into a single digital elevation model that could be used for generating cross-sectional profiles that extended into the floodplain. Bathymetric and discharge field data were processed from the raw Sontek RiverSurveyorLive data files that were collected during the ADCP field survey along with the appropriate field notes from field crew. The RTK files were processed as described in ISR Study 8.5, Section 4.34 prior to merging with the ADCP files. The locations and elevations of the RTK survey were treated as the reference points and the ADCP survey data were adjusted, as required, to match the RTK data. The ADCP data were reviewed and processed as follows:

- Discharge transect pairs were identified using the field notes and geo-referenced data location (transects originating at opposing start banks were selected);
- GPS position references were applied to discharge transect pair files (as opposed to bottom track positional referencing);

- The appropriate heading correction was applied to each file to account for any minor compass bias introduced by ferrous material on the water craft or magnetic declination inaccuracy (generally less that 10 degrees was applied), and
- A discharge summary for each transect pair was created.

There were some measured transects that did not have transects at opposing banks. In these cases it was necessary to use transects that originated on the same bank. Discharges were calculated and relevant summary sheets were produced for these locations .

The RTK system used to provide positional information to the RiverSurveyorLive program in the field did not allow for a base position to be entered. This resulted in ADCP data points collected to an accuracy of 0.06 ft (2 cm) to one another, but georeferenced to an accuracy of approximately 3 ft–6 ft (1-2 m). To resolve this issue, calibrations were performed by the field team to calculate offsets based on the accurately georeferenced RTK survey points (approximately 0.06 ft) recorded at the same time and location by the RTK survey team. These calculated offsets were then applied to the exported ADCP datasets. In cases where an RTK fix was not achieved, the positional information collected loses accuracy, but the depth measurements of the ADCP instrument remain accurate and suitable for developing cross-sectional profiles. To resolve this, GIS was used to create a water surface based on the surveyed RTK water level points. The depth parameter of the ADCP files was then used to calculate a bottom elevation at each position. With this correction, the two horizontal components had an accuracy of approximately 1 m ~ 2 m but the vertical component, the most important component for one dimensional hydraulic modeling, had a survey instrument accuracy of approximately +/- 0.06 to 0.16 ft (3-5 cm). When boat movement and wave action was considered relative to the assigned “flat” water surface elevation, the combined survey accuracy for the bottom topography was approximately 0.33 ft (10 cm).

Water surface elevations for the Lower River Segment transects were simulated using the one-dimensional HEC-RAS hydraulic model (Version 4.1, USACE 2010a, 2010b, 2010c). The general steps used in the development of the HEC-RAS models included preparation of model input data for the study reaches, calibrations of hydraulic models using available survey data collected in June, August and September 2013, and sensitivity analysis of the hydraulic models.

The HEC-RAS hydraulic model was set up using the processed and merged field data files as described above. The surveyed RTK and bathymetric data were combined with the SuWa LiDAR topographic data to extend transects beyond the top of bank that was directly surveyed during the RTK survey. These integrated survey data were used to generate the cross-section profile at each river/creek station in the HEC-RAS hydraulic model. The same channel geometric data created from the June 2013 survey were used for three model runs under high, moderate and low flow conditions as represented by the June, August and September 2013 field surveys, respectively.

The values of Manning’s roughness coefficient (n) were initially assumed and assigned to each cross-section based on the observed dominant substrate materials in the channel as documented during the field surveys. The initial estimated Manning’s n values ranged from 0.025 to 0.05 based on the published data for similar channel bed conditions (FHWA 1984 and Chow 1959). The estimated Manning’s n values were subsequently adjusted during the model calibration based on the surveyed flow and water level data. A sensitivity analysis was then conducted by increasing and decreasing the Manning's n values by 15% from the calibrated n values to evaluate changes in water level relative to changes in roughness. The energy losses associated with changes of channel cross-sections were accounted for during calibration by assigning estimated expansion and contraction coefficients of 0.3 and 0.1, respectively.

The calibrated HEC-RAS models are being used to model cross-sectional depths and velocities that will be used as input for PHABSIM modeling for the single transect locations in the Lower River Segment.

4.6.2. Variances from Study Plan

AEA implemented the methods as described in the Study Plan pertaining to Middle River fish habitat modeling with no variances. As described in the Study Plan schedule of activities, most habitat modeling activities will occur after the ISR.

AEA implemented the methods as described in the Study Plan pertaining to Lower River fish habitat modeling with the exception of the variance explained below:

- Two of the five sites identified for study in 2013 (R2 2013b) were not completed. Sheep Creek and Caswell Creek within geomorphic reach LR-2 were deferred to the next study year prior to the start of the 2013 field season. This approach will allow AEA to assess the effectiveness of model outputs from the other three sites in the Lower River to assess the need for additional fish habitat study sites in the next study year. Field studies have been planned for the Sheep Creek and Caswell Creek sites as part of the next study year, if required, as described in ISR Study 8.5, Section 7.6. The field execution plan and schedule for 2013 was presented at an IFS Technical Team meeting on April 26, 2013 and progress updates on the field program were provided during each TWG meeting. Delaying collection of field data to the next study year at Sheep Creek and Caswell Creek is not anticipated to adversely impact achieving Project objectives.

4.7. Temporal and Spatial Habitat Analyses

AEA implemented the methods as described in the Study Plan with the exception of the variance explained below (ISR Study 8.5, Section 4.7.2).

The IFS will result in the collection of data and the development of different types of habitat-flow relationships from spatially distinct locations within each of the Focus Areas, and possibly from selected cross-sectional transects outside of the Focus Areas that contain a variety of habitat types. Types of relationships will include but not be limited to: 1) those founded on PHABSIM that depict WUA or habitat versus flow by species and life stage; 2) effective habitat-versus-discharge relationships that define how spawning and incubation areas respond to flow changes; 3) varial zone analysis that quantifies areas of stranding and trapping relative to flow change; and 4) groundwater-surface water flow relationships relative to upwelling and spawning habitats. Additional components that will factor into the habitat-flow relationships will include those associated with breaching flows, upwelling, water temperature, and turbidity. Further, the IFS will provide important information (e.g., 2-D hydraulic models and bathymetry data) that will be used in the Fish Barriers (ISR Study 9.12) analysis relative to habitat connectivity. These relationships will be part of the analytical framework and conceptual models that will be used in evaluating the operational effects of the Project (ISR Study 8.5, Section 4.8) on different habitats. This evaluation will include both a temporal analysis that focuses on how the various habitat response variables change with flow over biologically important time periods (i.e., periodicity), and a spatial analysis that can be used not only for evaluating specific relationships on a site/transect specific or Focus Area basis, but also for expanding or extrapolating results from measured to unmeasured habitats within the Susitna River. This latter analysis is needed in order to assess system-wide Project effects.

4.7.1. Methodology

Completion of the temporal and spatial analyses is contingent on the acquisition and analysis of data and subsequent development of models that will be used to assess both temporal and spatial effects of Project operations. IFS-related data acquisition was initiated in Q2 2013 and will continue during a next year of study; model development activities are ongoing and will be completed during the next year of study prior to the USR. As a result, this ISR is limited primarily to presenting potential methods and approaches for conducting the temporal and spatial analyses. These were initially provided in the Study Plan, were discussed briefly during the November 13-15 IFS TT Riverine Modelers Meeting and are presented in more detail in ISR Study 8.5, Section 7.6. Further discussion with the TWG will occur in 2014 and will be presented as part of the Proof of Concept presentations.

4.7.2. Variances from Study Plan

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

The final approach and details concerning the methods that will be used for conducting the temporal analysis, including the time steps (hourly, daily, monthly, etc.), indicator parameters (spawning period, incubation, substrate composition, water temperature, and other biologically relevant indicators), and Project operational scenarios were scheduled to be worked out in consultation with the TWG in Q4 2013, with the final approaches for both the temporal and spatial analysis to be provided to the TWG in 2014 (see ISR Study 8.5, Section 7.9). Although the general approaches to be used for the spatial analysis of the fish habitat models and the temporal analysis for the different resource models were discussed as part of the November 13-15, 2013 IFS TT Riverine Modelers Meeting, there was no specific TWG meeting in Q4 2013 that focused exclusively on those methods. Rather, the emphasis in Q4 2013 was on providing the agencies and stakeholders with more information concerning each of the resource models and how they would be used in addressing biological questions. However, AEA provides more details concerning these methods in this ISR Study 8.5, Section 7.6 which will be demonstrated during the Proof of Concept discussions in 2014. Thus, not having a specific meeting to discuss spatial and temporal methods with the agencies in Q4 2013 will not affect the study objectives or change the plans for completing the study.

4.8. Instream Flow Study Integration

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

The overall evaluation of Project effects on Susitna River resources will be accomplished via the development of a suite of flow-sensitive resource specific models including those related to fish habitat (Study 8.5), riparian ecology (Study 8.6), geomorphology (Study 6.5), water quality (Study 5.6) groundwater (Study 7.5), and ice processes (Study 7.6), as well as numerous studies focused on fish and fish habitats. These models are described in each of the respective ISR sections just noted and were also discussed during the November 13-15 IFS TT Riverine Modelers Meeting (AEA 2013). These models will be used both individually to address resource specific questions as well as in an integrated fashion whereby outputs from various models serve as inputs to other models that are designed to evaluate different biological questions. This integration is described in the IFS Analytical Framework (ISR Study 8.5, Section 4.1) and displayed in Figure 4.1-1. That figure also lists the Decision Support System (DSS) which will consider Project effects resulting from different operational scenarios across a variety of resource interests that go beyond fish habitat (e.g., wildlife, cultural, recreation, project economics, etc.). AEA is in the process of developing a DSS to assist in the interpretation and evaluation of the multitude of study results in preparation for evaluating Project effects. The DSS will aid in interpretation by providing a consistent framework for each process, leading to an evaluation metric. Evaluation metrics are also being developed for each resource area, which will provide the basis for comparing alternatives for operational scenarios. The overall goal of the DSS is to reduce the complexity of information and focus attention on trade-offs involved in the decision. Progress during 2013 in development of the DSS was limited and is provided in ISR Study 8.5, Section 5.8.

4.8.1. Methodology

Development of the DSS and completion of an integrated resource analysis is contingent on the acquisition and analysis of data and subsequent development of resource specific models that will be used to assess Project operations. Resource specific data acquisition was initiated in Q2 2013 and will continue during a next year of study; model development activities are ongoing and will be completed during the next year of study prior to the USR. As a result, this ISR is limited primarily to presenting potential methods and approaches for developing the DSS and conducting the integrated resource analyses. These approaches were initially provided in the Study Plan (RSP Section 8.5.4.8), and were discussed briefly during the November 13-15 IFS TT Riverine Modelers Meeting. Further discussion with the TWG will occur in 2014 and will be presented as part of the Proof of Concept.

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 initial model calibration information, are available on the GINA website (http://gis.suhydro.org/reports/isr) and presented in this Results section and Appendix D.

5.1. IFS Analytical Framework

The analytical framework described in ISR Study 8.5, Section 4.1 and depicted in Figure 4.1-1 was introduced at the August 16, 2012, TWG meeting and further discussed at the October 24, 2012, TWG meeting. Essentially all of the IFS-related resource studies developed and implemented in 2013 were structured to fit within the context of this framework and were designed to address specific questions related to Project operations. This framework was presented again and discussed in detail during the November 13-15, 2013, IFS-TT Riverine Modelers Meeting where it served as the backdrop for all of the flow-specific resource models discussed during the meeting. The framework also served to introduce the Decision Support System that will be used for comparing operational scenarios across resource interests. 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

5.2.1. Stratification

A hierarchical stratification system was developed for the Susitna River in 2013 that scaled from relatively broad to more narrowly defined categories that included: Segment → Geomorphic Reach → Macrohabitats → Mesohabitats (ISR Study 8.5, Section 4.2). This system differed slightly from the original scale presented in the RSP, which included categories of Segment – Geomorphic Reach – Mainstem Habitat Type – Main Channel Habitats and Off Channel Habitats – Mesohabitat Types – Edge Habitat Types. The current designation simply collapsed mainstem and off-channel habitats under Macrohabitats (which is consistent with the habitat mapping studies (ISR Study 9.9) and removed Edge Habitats from the classification system as recommended by FERC in the April 1 Study Plan Determination (see page B-208, FERC 2013b). Specific details of the stratification approach are described in ISR Study 8.5, Section 4.2.

5.2.2. Study Area Selection

As noted in ISR Study 8.5, Section 4.2, the selection of study areas/study sites differed between the Middle River Segment and Lower River Segment. Because Project operations are anticipated to affect the Middle River Segment the greatest, the selection of study areas and study sites within that segment received considerable attention and review with the TWG in 2013. The selection of study sites within the Lower River Segment was made subsequent to completion and review of the Open-water Flow Routing Model (R2 et al. 2013) and other hydrologic analyses that were presented and discussed during the February 14, 2013, TWG meeting. The site-selection process for the Lower River Segment was less rigorous than for the Middle River Segment and concentrated on selecting sites within visually determined representative sections of the river as well as selected side channels, side sloughs, and tributary mouths that were repeatedly used by fish as noted in the 1980s studies.

5.2.3. Middle River Study Area/Site Selection

In the Middle River Segment, ten Focus Areas were identified, reviewed, and discussed with the TWG and, with TWG input, finalized for detailed investigation in 2013. The distribution of these Focus Areas included one in Geomorphic Reach MR-1, one in Geomorphic Reach MR-2[5], one in Geomorphic Reach MR-5, four in Geomorphic Reach MR-6, two in Geomorphic Reach MR-7[6], and one in Geomorphic Reach MR-8. Focus Areas were not selected for Geomorphic Reaches MR-3 or MR-4 due to safety considerations related to Devils Canyon (Table 4.2-3). Field studies were successfully conducted in 2013 at seven of the ten Focus Areas, with the upper three areas not sampled due to access restrictions. The Focus Areas provide a common geographic area within which multidisciplinary studies are being conducted. However, not all Focus Areas were studied by all disciplines, depending upon the complexity and individual characteristics of the Focus Area. For example, Groundwater (Study 7.5), Ice Processes (Study 7.6), and Riparian IFS (Study 8.6) studies were not conducted at all Focus Areas but were limited to those areas in which these resource characteristics could be meaningfully influenced by Project operations. In addition to the Focus Areas, 83 cross-sectional transects have been established in the Middle River Segment in conjunction with development of the Open-water Flow Routing Model. These transects will be evaluated for potential use in evaluating fish habitat-related hydraulic characteristics.

5.2.3.1. Evaluation of Focus Areas

The Focus Areas were deemed representative of the major features within each geomorphic reach and included mainstem habitat types of known biological significance (i.e., where fish have been observed based on previous and/or contemporary studies), as well as some locations (e.g., Slough 17) where previous sampling revealed few/no fish. The representativeness of the Focus Areas was initially evaluated in 2013 using results of the aerial imagery-based habitat mapping. Further analysis will be completed once results from the field habitat mapping exercise are finalized (Study 9.9). The results of the initial analysis were presented in the March 1, 2013, Technical Memorandum (R2 2013b), discussed during the February 14, 2013, TWG meeting and are briefly summarized below.

The initial habitat mapping of the Middle River Segment of the Susitna River was completed using a combination of geo-rectified aerial imagery (Mat-Su Borough 2011) in combination with high definition aerial videography taken of the river in August 2012 (flow conditions during the videography were ≈ 10,000 cfs) (HDR 2013). The results of the habitat mapping provided a spatial depiction of the distribution of habitat types and features throughout the entire length of the Middle River Segment. Specific habitat types were digitized using ARC GIS and lineal distances computed for each discrete habitat feature. Results of the habitat mapping were used to evaluate the "representativeness" of the Focus Areas with respect to other areas of the river. In this context, representativeness specifically refers to how well habitat units within the Focus

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[5] MR-2 originally contained two Focus Areas – FA-171 (Stephan Lake, Simple Channel) and FA-173 (Stephan Lake Complex). Based on consultation with the TWG (R2 2013c), FA-171 (Stephan Lake, Simple Channel) was deleted from MR-2.

[6] MR-7 originally contained one Focus Area – FA-115 (Slough 6a). Based on consultation with the TWG (R2 2013c), a new Focus Area was established in MR-7 (FA-113 [Oxbow 1]).

Areas represent habitat units outside of these areas within the same geomorphic reach. For this initial evaluation, representativeness was examined by 1) comparing the representation of habitat types within the Focus Areas to the representation of habitat types in the entire geomorphic reach; 2) determining if the habitat types have been proportionately represented (Focus Area vs. non-focus areas); 3) determining if there was a bias in the habitat types that were selected in the Focus Areas; and 4) evaluating whether a random systematic approach in the selection of Focus Areas would yield results different from the selection process and criteria applied to the current Focus Areas.

5.2.3.1.1. Evaluation of Representativeness – Representation and Proportionality

Because the length of river that is included in the Focus Areas is less than that not included in the areas, some scaling of counts and lengths of the habitat types was necessary for proportional comparisons. For this, a suite of scaled metrics was developed and used in a comparative analysis of the representativeness of habitat types within and outside of Focus Areas. These metrics included the major habitat categories specified in the classification, and consisted of percentages or proportions of lineal distances, and of densities (length per mile) (Table 5.2-1).

Values for these metrics were compared graphically by geomorphic reach to determine whether 1) each habitat type contained in the geomorphic reach was represented in the Focus Areas within the reach; and 2) the representation was proportional. The metrics could not be statistically compared within geomorphic reaches (focus area vs. non-focus area) because they do not represent multiple independent random samples. Thus, there was no estimation of variance determined.

Main channel proportionality metrics are displayed graphically in Figure 5.2-1. Geomorphic Reach MR-1 was all single main channel, while Geomorphic reaches MR-2, MR-5, and MR-6 contained small amounts of split main channel, which was not represented within the Focus Area. In Geomorphic Reach MR-7, the split main channel was represented, but at a higher proportion than exists in the full reach. In Geomorphic Reach MR-8, the braided main channel was not represented in the Focus Area, and the split main channel was represented at a lesser proportion in the Focus Area.

Side channel and slough proportionality metrics are displayed graphically in Figure 5.2-2. Side channels were represented in Geomorphic Reach MR-1. In Geomorphic Reach MR-2, Focus Areas exhibited all habitats, with a higher proportion of side sloughs than were contained in the full reach. The small amounts of side slough habitat in Geomorphic Reaches MR-5 and MR-7 were not represented in Focus Areas. Geomorphic Reach MR-6 was well represented by side channels and side sloughs present in Focus Areas. Geomorphic Reach MR-7 side channels and upland sloughs were likewise represented in Focus Areas within that reach. In Geomorphic Reach MR-8, all habitats were represented in the Focus Areas, but there was proportionately more side channel and side slough habitat than in the reach at large. Additional results for beaver complex, backwater, and tributary categories are presented in R2 2013b.

Overall, the results of the analysis indicated that the Focus Areas captured the majority of habitat types present in each Geomorphic Reach.

5.2.3.1.2. Evaluation of Representativeness – Bias

Bias in the method in which Focus Areas were selected was examined by considering the geomorphic reaches as independent replicates of potential bias, and testing if the average bias is different from zero using a t-test or a non-parametric equivalent. For example, if the Focus Areas selection consistently under-represented upland sloughs, the analysis would highlight that result.

Results of the bias estimates are displayed in Table 5.2-2. A negative number indicates that a habitat was over-represented in the Focus Areas, and a positive number indicates that a habitat was under-represented. Because there is a fairly even distribution of cases where habitat was under-represented and over-represented across reaches, there was no strong evidence (i.e., no statistically significant results at an alpha level of 0.10) of bias in the habitat types that were selected within the Focus Areas.

5.2.3.1.3. Evaluation of Representativeness – Random/Systematic Approach

As a fourth evaluation of representativeness, a set of simulated random Focus Areas was selected based on a random systematic sampling approach. These areas were selected from each geomorphic reach, matching the number and total coverage of focus areas for each geomorphic reach. For example, in Geomorphic Reach MR-2, there are two Focus Areas with a total length equal to 3.2 miles. For simplicity, the simulation selected two equally sized focus areas, also totaling 3.2 miles. The process in Geomorphic Reach MR-2 began with a random start and the formation of eight contiguous 1.6-mile reaches. Then one of the four paired equally spaced reaches [(1,5), (2,6), (3,7), (4,8)] was selected at random. A similar process was applied to the remaining five geomorphic reaches. Both the current Focus Area location(s) as well as the randomly selected counterparts are displayed in Table 5.2-3. The habitat features of this simulated set of focus areas was then evaluated in the same manner as the current Focus Areas, and comparisons were made.

The simulated selection of a set of random systematic Focus Areas resulted in a different balance of habitat units. For some habitat types in some geomorphic reaches, the random Focus Areas appear to be more representative. For example, the main channel types (main, split, braided) in Geomorphic Reach MR-8 were proportionally similar in the random Focus Areas and in the reach as a whole. However, in some areas the random Focus Areas miss the same habitat types, as for off-channel habitats in Geomorphic Reach MR-5. In other areas, the random Focus Areas are less representative, as in off-channel habitats in Geomorphic Reach MR-8.

Bias estimates for random Focus Areas are displayed in Table 5.2-4. A negative number in this table indicates that a habitat was over-represented in the random Focus Areas, and a positive number indicates that a habitat was under-represented. These results show that the random Focus Areas consistently over-represented side channels and consistently under-represented riffles (with alpha = 0.10). This analysis again indicated that although the selected Focus Areas do not perfectly represent every habitat in every geomorphic reach, the results are similar to what would be expected with a random systematic sampling scheme.

5.2.3.1.4. Selection of Final Focus Areas

Overall, the results of the habitat mapping and statistical analysis completed in 2013 indicated that the ten Focus Areas selected in the Study Plan are generally representative of habitat types found in other portions of the river. As a result, those ten Focus Areas were selected for study in accordance with the respective resource-specific study plans.

A caveat to the above is that the analysis did show that some habitat types within individual geomorphic reaches were not represented in the reach-specific Focus Areas or captured in the existing transects. The Study Plan described several considerations that were made relative to adding supplemental sites in 2013. No adjustments were made in 2013, but this will be evaluated further once results of the habitat characterization analysis are completed (ISR Study 9.9).

5.2.4. Lower River Study Area/Study Site Selection

In the Lower River Segment, study sites were selected in Geomorphic Reaches LR-1 and LR-2 based on a combination of representative and critical study sites. Instream flow sites were limited to these upper two geomorphic reaches since Project effects become more attenuated downstream (as demonstrated by results of open-water hydraulic flow model). One area was selected in each of the two geomorphic reaches, with the area in Geomorphic Reach LR-1 located around Trapper Creek near PRM 95.4 (Figure 4.2-11) and the area in Geomorphic Reach LR-2 located around Caswell Creek near PRM 67.3 (Figure 4.2-12).

5.3. Hydrologic Data Analysis

5.3.1. Mainstem Susitna River

Results from the stage and discharge surveys are summarized in Table 5.3-1 and locations are provided in Figure 5.3-1. The table includes data collected in both 2012 and 2013 and indicates for each cross-section measured, whether or not a bathymetry profile was collected, the date of the measurement, and the corresponding discharge and water surface elevation. In many cases, only a water surface elevation was collected in which case blank values occur under the discharge heading. Each discharge measurement has an associated rating of poor, fair, good, or excellent (see ISR Study 8.5, Appendix C for more detail). Of the 184 discharge measurements, 1 was rated as poor, 8 as fair, 77 as good, and 98 as excellent. A technical memorandum, dated December 2013 and prepared by Brailey Hydrologic, provides 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 (ISR Study 8.5, Appendix C). AEA is aware of a velocity profile QA/QC processing issue documented by the newly released USGS Office of Surface Water Technical Memo 2014.02 (USGS 2013) and discussions are ongoing as to whether some modification of the flow data is warranted. At this time, some minor changes resulting in an approximately 1 to 6 percent increase in flow values are anticipated.

There were ten discharge measurements in the lower river (located at PRMs 94.8, 90.2, 78, 73.1, 67.2, 54.2, 49, 40.4, 36.4, and 34.8) that were based on multiple channel measurements In these cases, the discharge rating methodology was correspondingly modified as described in ISR Study 8.5, Appendix C.

Two high-flow events occurred during data collection efforts, one on September 21, 2012, with a peak flow of 72,900 cfs at Gage No. 15292000 at Gold Creek, and the other on June 2, 2013, with a peak flow of approximately 90,700 cfs (based on provisional USGS data for Gage No. 15292000 at Gold Creek). Because high flows can move and transport sediments and modify channel form, a second set of bathymetry data was collected at 14 cross-sections in 2012 after the September 21, 2012 flood event. This enabled a comparison of channel cross-sectional profiles pre- and post-flood (Figure 5.3-2 and Figure 5.3-3).

Full bathymetry datasets were not collected again in 2013 and therefore it was not possible to complete a similar pre-post comparison after the June 2, 2013 flood. However, discharge data were collected at six sites in 2013 that were at or proximal to sites that had been surveyed in 2012. Because the ADCP acquires a channel profile as part of a discharge measurement, those profiles can be used for making pre-post June 2, 2013 channel conditions. At each of the six cross-sections, four ADCP passes were made resulting in four profiles for each cross-section. For comparative purposes, these profiles are graphically displayed along with profiles obtained for both pre-, and for five of the cross-sections, post-2012 flood conditions (Figure 5.3-4).

Stage recording measurements collected at the 13 ESS sites in the mainstem of the Susitna River are displayed in Figure 5.3-5 and Figure 5.3-6, Finalized data were only available through October 31, 2012. Once available data have been finalized, figures will be updated similar to that provided in Figure 5.3-7 for station ESS20.

Winter discharge measurements were also collected on the mainstem of the Susitna River. The results of this data collection effort are provided in Ice Processes, Section 7.6.

Flow measurements associated with the development of 2-D-hydraulic models were collected in seven Focus Areas within the Middle River Segment. These included measurements in 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). Measurement locations were selected to quantify flow splits among various channels and sloughs, resulting in 10 to 14 measurements per Focus Area. Moving bed tests were performed at representative main channel locations, with each measurement consisting of at least two reciprocal tests. The uncertainty of 2D-model flow measurements was evaluated using streamwise summations of riverwide flow. A final summary of the Focus Area measurements is provided in Table 5.3-2. This table includes a section for each of the seven Focus Areas measured with data organized by transect and date. Each measurement includes the portion of the channel measured in each transect and the total flow. More detailed data processing and results such as the compass calibration, loop test, measurement duration, mean velocity, extrapolation settings, percent top, bottom, and edge estimates, and the coefficient of variation can be found in ISR Study 8.5, Appendix C.

5.3.2. Tributaries to Susitna River

Site schematics are provided in ISR 8.5, Appendix E for all continuous tributary gaging sites. These schematics include the location of the benchmarks, transect profile, staff gage, and water level recorder. Representative site photographs are provided in ISR Study 8.5, Appendix F. Streamflow and staff gage measurements for the data collected in 2013 are provided in Table 5.3-3. The 15-minute streamflow data are provisional and not provided in the ISR. These data will be provided once additional data are collected and rating curves updated.

5.3.3. Realtime Hydrologic Data and Network

A summary of the types of data collected at the 13 surface water 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.

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. An initial evaluation of representative years was completed in 2013 and was based on defining wet, average, and dry conditions during periods of warm or cool PDO phases. AEA’s Fluvial Geomorphology Studies (ISR Study 6.6) provided an initial evaluation of representative years that identified a 50-year period of record from the 61 years included in the Streamflow Record Extension Study (USGS 2012). From this record, candidate years were identified for representative wet, average, and dry conditions during periods of warm or cool PDO. The methods and results of this analysis can be found in ISR Study 6.6, Appendix: Evaluation of 50-Year Simulation Period, Pacific Decadal Oscillation, and Selection of Representative Annual Hydrographs. This analysis compared years using a rank of both annual and monthly average flow volumes. The PDO analysis revealed no identifiable influence of warm or cool PDO periods on wet, average, and dry conditions, except during the winter. Higher winter flows were associated with warm PDO and lower winter flows were associated with cool PDO. Ultimately, four years were evaluated for each of the wet, average, and dry conditions (12 total) (Figure 5.3-8) and from this total, three years were preliminarily recommended. Year 1981 was recommended to represent wet conditions, 1985 to represent average conditions, and 1950 to represent dry conditions.

AEA completed additional analysis of the open-water period (May to September) from a habitat modeling perspective. For this, an average monthly and range in average monthly flow from May through September were evaluated. The average monthly flow was calculated from the same 50-year period of record. First, each month from May through September was ranked using the monthly flow for all 50 years.The lowest and highest ranks for the 5-month period were then identified and used to calculate an average for that period. This average was then used to rank the 50 years again, andthe difference in the highest and lowest rank for that 5-month period calculated. The 5-month average rank and 5-month difference in rank were then used to review the 50 years. A wet year was identified as one with a low average and a low difference between ranks. A dry year was identified as one with a high average and a low difference between ranks. An average year was identified as one with a medium average and low difference between ranks.

The monthly hydrographs of the four potential years for each of the wet, average, and dry conditions identified in ISR Study 6.6 are shown on a linear scale in Figure 5.3-8 and on a logarithmic scale in Figure 5.3-9. The linear scale can be used to compare the summertime flows while the logarithmic scale can be used to compare the wintertime flows. Additional input on representative years was also provided from the ice processes studies, which involved consideration of the temperature conditions of the winter period, rate and extent of freeze-up, and amount of snow cover.

Overall, AEA's analysis resulted in the selection of three candidate years to represent wet, average and dry conditions consisting of 1981, 1985,and 1970, respectively. The year selected to represent the dry year, 1970 was different than the one originally selected by the geomorphology analysis, 1950. This change to 1970 was based on input from fish habitat and ice processes considerations and was selected since it had a lower wintertime flow as shown in the bottom plot of Figure 5.3-9.

These three candidate years will be presented to the agencies and discussed with the TWG in 2014. Once finalized, the hydrology associated with the three representative years will be used in multiple resource modeling efforts. Both the Reservoir Operations Model and the Open-water Flow Routing Model will have the ability to simulate the 61-year period of record, but these representative years may be used first to evaluate and consider specific operational conditions. Both the ice-processes flow routing and the sediment transport 1-D modeling will have the ability to simulate the abridged 50-year period of record. These three representative years may also be used for initial simulations to evaluate Project operations.

Additional years may be selected for the ice processes modeling to represent specific severe breakup ice jamming years; the candidate representative wet, average, and dry years do not include incidence of breakup ice jamming.

5.3.5. Indicators of Hydrologic Alteration and Environmental Flow Components

As noted in ISR Study 8.5, Section 4.4, AEA's application of the IHA models in 2013 were limited to the hydrology of the Stikine and Taku rivers as part of the Biological Cues Analysis described in ISR Study 8.5, Section 4.5. AEA has developed a proposed IHA approach for analysis of Susitna River hydrology data. The approach will be discussed with the TWGand completed during the next year of study.

5.4. Reservoir Operations and Open-water Flow Routing Modeling

5.4.1. Reservoir Operations Model

Input in terms of daily inflows to the Reservoir Operations Model was based on the USGS Susitna River watershed record extension study (Curran 2012). The 61 years of monthly average flows at Gold Creek are shown on Table 5.4-1, with a similar table for the calculated monthly inflows to Watana Reservoir presented in Table 5.4-2.

The output of the Reservoir Operations Model can be used to provide an indication of powerhouse discharge variability. This output serves as input into the Open-water Flow Routing

Model that can be used to predict stage and flow conditions resulting from a given powerhouse discharge at locations downstream (ISR Study 8.5, Section 5.4.2). For efficient operation of the whole interconnected Railbelt system, powerhouse discharges are expected to normally vary over a 24-hour period to serve the electricity load variability in the Railbelt region. However, it is difficult to characterize typical powerhouse operations before production modeling simulation of the Railbelt is complete. Nevertheless, AEA completed a simulation model run that assumed that the generation requirements for the Project for the year included the entire seasonal, weekly, daily, and hourly load fluctuations of the entire Railbelt; Railbelt electricity loads for this scenario were taken from the 2010 Railbelt Regional Integrated Resource Plan (RIRP). This run was termed the Maximum Load Following Operational Scenario-1 (OS-1). This scenario was presented for illustration purposes at two TWG meetings, the first on October 24, 2011 (MWH 2011) and the second on October 23-25, 2012 (MWH 2012). As noted, OS-1 represents an extreme condition that would rarely if ever occur since AEA would also rely on other projects (e.g., Bradley Lake) to meet load fluctuations.

For illustration purposes, minimum instream flows were included at Gold Creek as part of the Maximum Load Following OS-1 operating plan; these flows were those specified under Case E-VI from the 1985 FERC License Application (FERC No. 7114). Those criteria specified a minimum wintertime flow of 2,000 cfs at Gold Creek, increasing to a minimum flow of as much as 9,000 cfs from June 3 through September 1. However, for planning purposes, AEA adjusted the 2,000 cfs minimum winter flows to 3,000 cfs at Gold Creek. The relevant results from the Reservoir Operations Model for the IFS are the total reservoir outflows. For OS-1, these results are plotted in Figure 5.4-1.

5.4.2. Open-water Flow Routing Model

This section provides the results of the field data collection in 2012, the calibration and validation steps used for Version 1 of the Open-water Flow Routing Model, and results of some preliminary model runs based on the Maximum Load Following scenario, OS-1 described above. A complete description of the development of Version 1 of the model is provided in R2 et al. (2013).

5.4.2.1. Field Data Collection

Version 1 of the Open-water Flow Routing Model relied on field data that were collected in 2012. These data included:

- Cross-sections of the Susitna River surveyed between PRM 80.0 and PRM 187.2
- Flow measurements and concurrent water surface elevation surveys at the river cross-sections as described in ISR Study 8.5, Section 4.4 and ISR Study 8.5, Appendix A and C.
- Stage hydrographs measured at gaging stations established on the Susitna River

Additional field data were collected in 2013; data collection methods are described in ISR Study 8.5, Section 4.4, Hydrologic Data Analysis. A summary of the cross-sectional profile data collected in 2012 and 2013 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 location of the 2012 and 2013 cross-sections are shown in Figure 5.3-1, and examples of two of the river cross-sections (PRM 173.1 and PRM 80) shown in Figure 5.4-2. At PRM 173.1 (between the proposed dam site and Devils Canyon), the channel had a single thread width of about 600 feet. At PRM 80 (downstream from the Three Rivers Confluence), the channel was multi-threaded with a total width of about 1 mile. An example of the output from one of the June 21, 2012 passes at PRM 173.1 is shown in Figure 5.4-3.

5.4.2.2. Model Development and Calibration

Version 1 of the Open-water Flow Routing Model was developed from the 88 cross-sections surveyed in 2012 For numerical stability under unsteady conditions, additional river cross-sections were interpolated at 1,000-foot intervals. This was necessary to route flows through Devils Canyon, a 14-mile-long reach of the Susitna River where for safety reasons no cross-sections were surveyed. With the interpolated cross-sections added to the model, the average drop in elevation between cross-sections was about 2 feet. A longitudinal thalweg profile of the Susitna River was then developed from the 88 cross-sections (Figure 5.4-4). The channel gradient was steepest through Devils Canyon (0.52 percent) with a gradual reduction in channel gradient downstream.

5.4.2.2.1. Steady State Model

The Open-water Flow Routing Model was first calibrated under steady-state conditions using 170 pairs of flow/water surface elevation measurements obtained at the 88 cross-sections in 2012. The relative magnitude of these flow measurements was assessed by using the concurrent flows in the Susitna River at Gold Creek (USGS Gage No. 15292000) as a common reference point (Figure 5.4-5). This calibration provided for the calculation of water surface elevations to within plus or minus 0.2 feet of the observed water surface elevation. 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 5.4-6. The Manning’s “n” coefficients ranged from 0.030 to 0.045. Unsteady State Model.

Flow hydrographs measured in 2012 by the USGS were used to calibrate the flow routing model under unsteady-state conditions. Hydrology data for the week of August 11 to 17, 2012, were selected for model calibration. This week was selected because it demonstrated a distinct pattern of diurnal flow pulses associated with glacial melt (Figure 5.4-7 and Figure 5.4-8). By examining the 15-minute flow hydrographs in the Susitna River above Tsusena Creek and at Gold Creek, it was found that the two hydrographs could be synchronized if the flow hydrograph in the Susitna River above Tsusena Creek was shifted forward by 6.4 hours (Figure 5.4-9). The travel time of the pulses over the 47.2-mile-long distance between the two gages is therefore 6.4 hours. The speed of propagation of the pulses, also referred to as the celerity, was estimated to be 7.4 miles per hour (mph) (10.8 feet per second (fps)). The difference in magnitude of flows from Figure 5.4-9 was used to estimate a hydrograph of the ungaged lateral inflow to the Susitna River between Tsusena Creek and Gold Creek. A similar process was used to estimate hydrographs of ungaged lateral inflow to the Susitna River between Gold Creek and Sunshine. However, the process, which is more fully described in R2 et al. (2013) was complicated by the diurnal fluctuations observed in the Susitna River at Sunshine which were influenced by the fluctuations observed in the Susitna River at Gold Creek, the Chulitna River, and the Talkeetna River. The resultant flow hydrographs for the ungaged lateral inflow to the Susitna River are shown in Figure 5.4-10.

The goal of calibration under unsteady-state conditions was to match the arrival time of pulses from upstream sources in the Susitna River at Gold Creek and also at Sunshine. If it was necessary to accelerate the arrival time of pulses from upstream sources, then interpolated cross-sections that were not used for steady-state calibration were made narrower to increase the celerity. If it was necessary to decelerate the arrival time of pulses from upstream sources, then interpolated cross-sections that were not used for steady-state calibration were made wider to decrease the celerity. Initial analysis of the data predicted that the diurnal pulses would arrive late in the Susitna River at Gold Creek (USGS Gage No. 15292000). To accelerate the arrival of the pulses, the interpolated cross-sections in Devils Canyon were made narrower. After this adjustment, there was good agreement between measured and simulated hydrographs in the Susitna River at Gold Creek (Figure 5.4-11).

Finally, the celerity that was derived from the August 2012 diurnal pulses in the Susitna River between the proposed Watana Dam site and the Gold Creek gage (USGS Gage No. 15292000) was used to help select a computational time step in the Open-water Flow Routing Model. For numerical stability and accurate results, the computational time step should be less than the distance between river cross-sections divided by the celerity. With the surveyed and interpolated cross-sections combined, the distance between cross-sections is about 1,000 feet. This distance divided by the celerity (10.8 fps) yields a time increment of 93 seconds. Thus, a computational time step of one minute (60 seconds) was adopted for the Open-water Flow Routing Model.

5.4.2.3. Model Validation

The Open-water Flow Routing Model, that was calibrated under both steady and unsteady- state conditions, was then validated using the available hydrologic dataset for the June 4 through October 14, 2012, period. Input to the model was based on the flow hydrographs illustrated in Figure 5.4-12, Figure 5.4-13, and Figure 5.4-14. Validation consisted of comparing simulated versus measured hydrographs in the Susitna River at Gold Creek and Sunshine. A comparison of measured and simulated hydrographs for this validation period is shown in Figure 5.4-15 for the Susitna River at Gold Creek (USGS Gage No. 15292000) and in Figure 5.4-16 for the Susitna River at Sunshine (USGS Gage No. 15292780). Good agreement was found between measured and simulated hydrographs at both locations over a wide range of flow conditions.

5.4.2.4. Preliminary Model Runs – OS-1

Potential downstream changes in flow and water surface elevations were assessed by comparing Pre-Project conditions with a Maximum Load Following Operational Scenario 1 (OS-1) conditions for calendar year 1984. Calendar year 1984 was selected because historical gage records were available from the USGS, and because 1984 represents an average hydrological condition on both an annual and monthly basis.

The two scenarios (i.e., Pre-Project and OS-1) represent different flow hydrograph releases from the proposed Watana Dam and were used as input to the Open-water Flow Routing Model (Figure 5.4-1). Under Maximum Load Following OS-1, higher flows would generally be released during winter, and lower flows would be released during the spring and summer until the reservoir fills to capacity. During periods when the reservoir is not full, flow releases under the Maximum Load Following OS-1 would exhibit daily and weekly flow fluctuations in response to power generation requirements.

Daily flow records for 1984 were available from the USGS for the following locations:

- Susitna River above Tsusena Creek, USGS Gage No. 15291700
- Susitna River at Gold Creek, USGS Gage No. 15292000
- Chulitna River near Talkeetna, USGS Gage No. 15292400
- Talkeetna River near Talkeetna, USGS Gage No. 15292700
- Susitna River at Sunshine, USGS Gage No. 15292780

These daily flows were converted to 15-minute flows in a manner as illustrated in Figure 5.4-17. With the 15-minute flow hydrograph, the daily average was preserved each day and the hydrograph was smooth and continuous. No attempt was made during these Version 1 Open-water Flow Routing Model runs to account for diurnal glacial melt fluctuations. The 15-minute flow hydrographs, thus derived, are illustrated in Figure 5.4-18, Figure 5.4-19, and Figure 5.4-20.

The calibrated model was then used to assess downstream stage changes associated with Pre-Project and Maximum Load Following OS-1 scenarios for calendar year 1984. The analysis considered changes in stage and flow at locations just below the Watana Dam Site, at Gold Creek, and at Sunshine. Analyses were completed and results graphically displayed at each of these locations for three time periods; the entire year, a summer period consisting of the week of July 23 to July 29, 2012, and a winter period consisting of the week of January 8 to January 14, 2012. Summer and winter analysis were also completed at a river location at PRM 87.1 just downstream of Sunshine that was deemed more representative of channel characteristics than at the Sunshine gage site. The detailed results of these analysis including figures that compare predicted flows and stage changes for Pre-Project and OS-1 conditions are provided in R2 et al. (2013) (see Section 5 and Figures 5.4-1 through 5.4-21 of R2 et al. 2013). Two of these figures depicting stage changes for the July 23 to July 29. 2012 period for Gold Creek and Sunshine are reproduced here as Figure 5.4-21 and Figure 5.4-22, respectively. During the summer, hourly stage fluctuations within each day were predicted to range from 0.7 to 1.0 feet at Gold Creek and from 0.2 to 0.4 feet at Sunshine. As noted above, the OS-1 Scenario represents an extreme condition that was for illustration purposes only and does not reflect how AEA would normally operate the Project.

5.5. Habitat Suitability Criteria Development

This section provides information on the preliminary results of the HSC/HSI studies conducted during 2013. Data collection efforts represent those completed through late September 2013, while the. analysis of the information presented continued into mid-December 2013. Much of the data analysis required for this study has not progressed beyond the development and refinement of analytical methods that will be performed in 2014. Additionally, draft periodicity tables (ISR Study 8.5, Appendix H) and results of the Biological Cues Study (ISR Study 8.5, Appendix B) have been developed.

Major activities completed in 2013 included: 1) selection of target species and life stages; 2) development of draft HSC/HSI curves using existing information; 3) selection of HSC/HSI sampling locations; 4) collection of microhabitat use data for the target fish species; 5) collection of habitat availability data; 6) development of HSC/HSI histograms displaying frequency of use for different microhabitat variables; 7) preliminary development of microhabitat preference curves; 8) completion of pilot winter use studies; 9) collection of microhabitat data as part of River Productivity studies; 10) development of draft periodicity tables; and 11) completion of the biological cues analysis. The following sections present results of each of these activities.

5.5.1. Selection of Target Species and Life Stages

In collaboration with the TWG, AEA identified 19 fish species for potential development of site-specific HSC curves (Table 4.5-2). The list of species was further refined by ranking or prioritizing the list into high, moderate, or low categories of potential curve development. High-ranked species included the five Pacific salmon species, Arctic grayling, and rainbow trout. The list of moderate-priority species included burbot, Dolly Varden, eulachon, humpback whitefish, and longnose sucker. The high and moderately ranked species are generally considered the most sensitive to habitat loss through manipulation of flows in the Susitna River. For low-priority species, it is anticipated that insufficient observations will be collected to develop site-specific HSC curves and therefore they will be grouped or guilded with other species for which curves can be developed.

5.5.2. Development of Draft HSC Curves Using Existing Information

A summary description of the data sources and HSC curve developed for each individual species as part of the 1980s Su-Hydro instream flow studies is presented below. Additionally, a brief description of other relevant HSC curve sets reviewed as part of this effort is provided. Additional details and plots of each of the curve sets discussed below are presented in the 2012 Compendium of Technical Memoranda (R2 2013e) and are not repeated here.

5.5.2.1. 1980s Susitna River HSC Curves

An extensive set of HSC curves was developed as part of the 1980s Su-Hydro instream flow studies. These criteria were developed using a combination of site-specific data collected through fish sampling and literature sources, and through refinement based on professional judgment of project biologists. Microhabitat data were collected for various species and life stages of fish, and are reflective of a suite of different parameters influenced by, or potentially influenced by, flow. These included water depth, water velocity, substrate, upwelling occurrence, turbidity, and cover.

Spawning HSC for chum and sockeye salmon were developed from redd observations in sloughs and side channels of the Middle Segment of the Susitna River (Vincent-Lang et al. 1984a). Data collection sites were concentrated in areas used for hydraulic simulation modeling to maximize the concomitant collection of utilization and availability data necessary for the evaluation of preference. HSC for chum salmon were modified using limited preference data; however, preference could not be incorporated for sockeye salmon. HSC for depth, velocity, and substrate were developed from this effort. Additionally, modified HSC were developed for substrate that reflected the presence or absence of upwelling. Spawning habitat utilization for Chinook, coho, and pink salmon was evaluated in tributaries of the Middle Segment of the Susitna River (Vincent-Lang et al. 1984b). Sufficient data were collected to develop depth, velocity, and substrate HSC curves for Chinook salmon. However, observations for spawning coho and pink salmon were insufficient to develop HSC. Instead, spawning HSC for these two species were based solely on literature data and modified using qualitative field observations.

HSC for rearing juvenile salmon were developed for the habitat parameters of depth, velocity, and cover used by juvenile Chinook, coho, sockeye, and chum salmon (Suchanek et al. 1984a). These HSC were developed based on field data collected at representative tributary, slough, and side channel sites between Three Rivers and Devils Canyon (Middle Susitna River) and were considered to be specific to this reach. In addition, if differences in habitat utilization were apparent at varying turbidity levels, separate HSC were developed for turbid vs. clear water conditions for those species with sufficient sample sizes (e.g., juvenile Chinook). A subsequent effort used similar methods to verify the applicability of these juvenile salmon-rearing HSC curves for the Lower River downstream of the Three Rivers confluence (Suchanek et al. 1985). Findings from this effort resulted in some modifications to HSC for use in the Lower River.

HSC for resident fish species were developed based on data collected through electrofishing, beach seining, and hook-and-line sampling in tributary mouths, tributaries, and sloughs of the Middle Susitna River (Suchanek et al. 1984b). Cover and velocity HSC were developed for adult rainbow trout, Arctic grayling, round whitefish, and longnose sucker. HSC for cover were developed separately for turbid vs. clear water conditions. A single depth HSC was developed for all of these species combined. Only round whitefish were collected in sufficient numbers to develop separate HSC for juveniles.

5.5.2.2. *Other Relevant HSC Curve Sets*

Baldrige (1981) developed HSC curve sets for the Terror and Kizhuyak rivers, located on the northern end of Kodiak Island, Alaska. These curves were also reviewed by researchers for the Su-Hydro instream flow study of the 1980s, using an alternate reference citation (Wilson et al. 1981). HSC curves for depth, velocity, and substrate were produced for spawning pink, chum, and coho salmon and Dolly Varden. Insufficient field data were collected for development of site-specific curves for coho and Dolly Varden spawning. A total of 815 observations were made for pink spawning, 121 for chum spawning, 752 for coho fry, 199 for coho juvenile, 460 for Dolly Varden fry, and 344 for Dolly Varden juvenile.

Lyons and Nadeau (1985) developed HSC curve sets for the Wilson River and Tunnel Creek, which are located in the south-central part of the Misty Fjords National Monument, about 50 miles east of Ketchikan, Alaska. Depth and velocity data were collected for pink and chum salmon spawning and HSC curves developed HSC curves for Chinook and coho spawning, incubation, fry, and juveniles were based solely on pre-existing depth and velocity curves.

Estes and Kuntz (1986) collected habitat utilization data for rearing juvenile Chinook salmon in selected bank-type habitats of the Kenai River from the mouth to the outlet of Skilak Lake. Data indicated that depth, velocity, and cover could be used to assess the usability of habitat for juvenile Chinook. Velocity and cover appeared to be the most important in determining habitat usability, though a set of "weighting factors" was developed all three habitat parameters.

More recently, PLP (2011) developed HSC curves for several species inhabiting the North and South Fork Koktuli rivers (Nushugak River tributaries) and Upper Talarik Creek (a Lake Iliamna/Kvichak River tributary). HSC curves were developed using a combination of literature information and curve sets from other studies, as well as through collecting and analyzing site-specific data for various target species and life stages. HSC curves developed included the following species (and life stages): sockeye salmon (spawning and juvenile), Chinook salmon (spawning and juvenile), coho salmon (spawning and juvenile), and Arctic grayling (adult).

5.5.3. HSC/HSI Study Area Selection

The selection of 2013 HSC/HSI sampling sites relied on a stratified random sampling approach based on macrohabitat composition within each Focus Area, as well as known fish use. The selection process also considered access restrictions. This resulted in selection of 68 individual habitat segments representing 10 different habitat types within the 7 Focus Areas: (FA-104 (Whiskers Slough), FA-113 (Oxbow 10, FA-115 (Slough 6A), FA-128 (Slough 8A), FA-138 (Gold Creek), FA-141 (Indian River) and FA-144 (Slough 21) (Table 4.5-4). Of the 10 habitat types selected for sampling, side channel habitat had the most (17) segments selected. The distribution of sampling sites between Focus Areas was generally equal with an average of 10 sampling reaches selected within each. Additional sampling sites were added from areas outside of the Focus Areas to ensure that highly utilized fish habitats (known spawning locations or areas identified by other study teams) were included in the sampling. Each of the selected habitat segments was sampled a minimum of two times and in some cases three times, resulting in a total of 210 unique sampling events (including both 50- and 100-meter sampling sites). The location of each sampling event within each of the 7 Focus Areas is presented in Figure 5.5-1 through Figure 5.5-7.

5.5.4. Collect Site-Specific Habitat Suitability Information

The following sections summarize the results of HSC data collection efforts and the resulting development of HSC histograms from the 2013 data collection effort. Results are organized and reported by species.

Habitat suitability sampling occurred over a variety of river flows during the summer of 2013 ranging from approximately 10,500 cfs to just over 45,000 cfs as measured at the Gold Creek gage (Figure 5.5-8). Habitat measurements were collected for four different life history stages (spawning, juvenile, fry, and adult) and twelve different fish species: Chinook, sockeye, chum, coho, and pink salmon; rainbow trout; Arctic grayling; Arctic lamprey; Dolly Varden char; whitefish; longnose sucker; and burbot. A total of 1,433 observations of site-specific habitat use was recorded during the 2013 HSC/HSI surveys of the Middle River Segment of the Susitna River (Table 5.5-1). As previously described, microhabitat observations were concentrated in randomly selected habitat types within 7 of the 10 Focus Areas. Data collection was completed during seven sampling sessions (June 18-22, July 10-17, July 23-30, August 6-13, August 20-26, September 10-17, and September 24-29) from mid-June through late-September 2013. The numbers of sampling events by sample session, Focus Area, and habitat type are presented in Table 5.5-2.

Spawning activities were first observed during HSC/HSI surveys in early August and extended until late September. Spawning activity in the seven Focus Areas was only observed for pink, chum, sockeye, and coho salmon. Approximately half (49 percent) of the 591 spawning HSC measurements were completed during the September 9-18 sampling session. Just over 70 percent of all spawning observations were recorded in side channel and side slough habitats. HSC/HSI surveys for the adult, juvenile, and fry life stages were completed within each of the seven sampled Focus Areas with a total of 851 habitat use measurements. Similar to the spawning life stage, just over 70 percent of all HSC observations for adult, juvenile, and fry life stages were collected from side channel, side slough, and upland slough habitat types. A summary of results for the 2013 HSC data collection is presented below for each of the twelve species mentioned above. Histogram plots are presented in ISR 8.5, Appendix G and describe the relative frequency in which individual species and life stages utilized depth, velocity, and substrate microhabitats.

5.5.4.1. Chinook Salmon

During the 2013 HSC surveys, no Chinook salmon were observed spawning in the mainstem Susitna River (Table 5.5-1). Although radio telemetry surveys conducted by LGL in 2012 and 2013 routinely found adult Chinook holding in the mainstem Susitna River, only one location at the mouth of Indian River was identified as a potential spawning location in the Middle River Segment of the Susitna River (ISR Study 9.7). A total of 33 Chinook juvenile and 57 Chinook fry microhabitat measurements were recorded, with nearly half (42%) of the total observations occurring in side slough macrohabitat areas (Table 5.5-1). Side channel and tributary delta macrohabitats had nearly equal numbers of observations with 16 and 12, respectively (Table 5.5-1). Just over 60 percent of the Chinook salmon rearing observations occurred during the late July (23-30) and early August (6-13) sampling effort (Table 5.5-3).

Microhabitat depth measurements of Chinook fry utilization ranged from 0.5-3.5 feet with the highest frequency occurring at a depth of 0.9-1.1 feet (ISR Study 8.5, Appendix G). For velocity, fry utilization ranged from 0.1-1.3 feet per second (fps) with the highest frequency occurring at a velocity of 0.1 fps. Chinook juveniles were most frequently observed in slightly deeper water with depths ranging from 0.3-4.1 feet with peak utilization occurring at a depth of 0.9 feet (ISR Study 8.5, Appendix G). The range of observed velocity utilized by Chinook juveniles was also higher at 0.1-2.3 fps with the highest frequency occurring at velocities of 0.1 fps. Although substrate utilization for juvenile Chinook was greatest for the “fines” particle size (Table 4.5-5), substrate utilization for Chinook fry was highest for small cobble. There were a few observations at nearly every substrate size for both the fry and juvenile life stages.

5.5.4.2. Chum Salmon

Observations of chum salmon spawning (n=346) were widely distributed throughout the Middle River Segment of the Susitna River, with observations in 5 of the 7 Focus Areas and extensive spawning (57 percent) also observed in areas outside of the Focus Areas (Table 5.5-1). Nearly 80 percent of the chum spawning observations occurred in side channel and side slough macrohabitat types. Upland slough areas had the next highest number of chum spawning observations at 51. Only 14 chum salmon fry and 2 juvenile chum were observed during the 2013 HSC/HSI surveys (Table 5.5-1).

Depth utilization by spawning chum salmon ranged from 0.3-3.3 feet with the highest frequency occurring at 0.9 feet (ISR Study 8.5, Appendix G). For velocity, spawning utilization ranged from 0.1-1.9 fps with the highest frequency occurring at the lowest measured velocity of 0.1 fps. Like spawning sockeye salmon, spawning chum were generally observed in side channel and side slough macrohabitat areas, which generally have low mean column velocities. Substrate utilization ranged from fines to large cobble with the highest frequency occurring in areas with large gravel substrates. For chum fry, water depth utilization ranged from 0.3-3.7 feet (ISR Study 8.5, Appendix G). Water velocity utilization ranged from 0.1-0.7 fps with the highest frequency occurring at 0.1 fps. Substrate utilization for chum fry ranged from fines to boulder sized substrate with the highest frequency of use found in areas with fine sediment.

5.5.4.3. Coho Salmon

There were only three coho salmon spawning observations in the Middle River Segment of the Susitna River during the 2013 HSC/HSI surveys (Table 5.5-1). All three observations were made in Focus Area -128 (Slough 8A) in an area that had previously been used by chum salmon for spawning. The observations were completed during the final HSC sampling session for the season in late September and so it is unknown if additional coho spawning occurred after that time (Table 5.5-3). Due to the small sample size (n=3) no effort was made to analyze the data. A total of 57 juvenile and 98 coho fry microhabitat measurements were recorded (Table 5.5-1). Coho fry observations were collected in nearly every habitat type with the exception of clear water plume areas. The largest numbers of measurements were made in upland slough, side slough, and tributary mouth/delta habitat areas (Table 5.5-1). For juvenile coho, approximately 59 percent of the observations were made in upland sloughs with lesser numbers of observations in side slough and tributary habitat areas (Table 5.5-1). Coho rearing observations were made in all seven of the surveyed Focus Areas with the highest number of HSC/HSI measurements collected in FA-104 (Whiskers Slough) and FA-141 (Indian River). Coho salmon rearing observations occurred during the entire summer sampling period with the largest number of observations occurring from mid-July through mid-September (Table 5.5-3).

Microhabitat depth measurements for coho fry utilization ranged from 0.3-3.3 feet with the highest frequency occurring at a depth of 0.9 feet (ISR Study 8.5, Appendix G). For velocity, fry utilization ranged from 0.1-1.7 fps with the highest frequency occurring at a velocity of 0.1 fps. Coho juvenile were most frequently observed in slightly deeper water with depths ranging from 0.3-4.5 feet with peak utilization occurring at depths from 1.5-1.7 feet (ISR Study 8.5, Appendix G). The range of observed velocity utilized by coho juvenile was slightly lower than for fry at 0.1-1.5 fps with the highest frequency occurring at velocities of 0.1 fps. Although substrate utilization for both the fry and juvenile life stages of coho occurred over a wide range of particle sizes, the frequency of use by both life stages was the highest for the fines substrate size.

5.5.4.4. Pink Salmon

Pink salmon spawning in tributary and tributary mouth habitat types accounted for nearly 90 percent of the total number (n=59) of spawning measurements (Table 5.5-1). No fry or juvenile pink salmon life stages were observed during the 2013 HSC/HSI surveys. The absence of observations of rearing pink salmon is probably due to the early outmigration of young fish prior to the start of the 2013 surveys (ISR Study 8.5, Appendix H). Pink salmon spawning HSC measurements were collected from only one of the seven Focus Areas (FA-144 [Slough 21]) with over 70 percent of the measurements made in areas outside of the Focus Areas (Table 5.5-1). Approximately 90 percent of the pink spawning observations were made during the August 6-17 sampling session (Table 5.5-3).

Pink salmon spawning depth utilization ranged from 0.3-3.3 feet with the highest frequency of observations occurring at a depth 0.7 feet (ISR Study 8.5, Appendix G). For velocity, spawning utilization ranged from 0.1-3.5 fps with the highest frequency occurring at a velocity of 1.3 fps. The relatively large range of velocities utilized by spawning pink salmon is not surprising since most (53 of 59) of the observations were made in tributary and tributary mouth/delta habitat areas, which generally have higher mean column velocities than other off-channel areas. Substrate utilization ranged from small gravel to small cobble with the highest frequency occurring in areas with large gravel substrates (ISR Study 8.5, Appendix G).

5.5.4.5. Sockeye Salmon

A total of 182 sockeye spawning utilization measurements was collected during the 2013 surveys with 80 percent of the observations in side channel and side slough macrohabitats (Table 5.5-1). Sockeye spawning observations were concentrated in three of the Focus Areas (FA-128 [Slough 8A], FA-138 [Gold Creek], and FA-144 [Slough 21]) accounting for just over 85 percent of the total number of measurements. Nearly 60 percent of the sockeye spawning redd measurements were completed during the September 10-17 sampling session (Table 5.5-3). Side channel and side slough macrohabitat types had the highest number of microhabitat observations (147) for spawning sockeye. Large gravel substrate was the highest frequency substrate type utilization for sockeye spawning. Microhabitat use observations were collected for 96 rearing sockeye salmon with measurements made in all seven Focus Areas except FA-144 (Slough 21). Rearing sockeye observations were made during each of the seven sampling sessions except for late September (Table 5.5-3). Over 70 percent of rearing sockeye observations were concentrated in side channel and side slough macrohabitat types (Table 5.5-1).

Sockeye spawning depth utilization ranged from 0.3-3.3 feet with the highest frequency occurring at 1.5 feet (ISR 8.5, Appendix G). For velocity, spawning utilization ranged from 0.1-2.5 fps with the highest frequency occurring at a velocity of 0.1 fps. Microhabitat depth measurements for sockeye fry utilization ranged from 0.1-3.3 feet with the highest frequency occurring at a depth of 0.7 feet. For velocity, fry utilization ranged from 0.1-1.7 fps with the highest frequency occurring at a velocity of 0.1 fps (ISR Study 8.5, Appendix G). Sockeye juveniles were most frequently observed in slightly deeper water with depths ranging from 0.7-3.5 feet with peak utilization occurring at depths of 1.3 feet (ISR Study 8.5, Appendix G). The range of observed velocities utilized by sockeye juveniles was slightly lower than for fry at 0.1-0.5 fps with the highest frequency occurring at velocities of 0.1 fps. Although substrate utilization for both the fry and juvenile life stages occurred over a wide range of particle sizes, the frequency of use by both life stages was the highest for the fines substrate size (ISR Study 8.5, Appendix G).

5.5.4.6. Arctic Grayling

Observations of Arctic grayling were limited to the adult, juvenile, and fry life stages as no spawning was observed. Arctic grayling was observed in all seven of the surveyed Focus Areas and in each of the eight macrohabitat types (Table 5.5-1). Of the 193 Arctic grayling observations, 114 were for the fry life stage, 41 for juvenile, and 4 adult (Table 5.5-1). Arctic grayling microhabitat use measurements were completed in all sampling sessions except late September (Table 5.5-3).

Depth utilization by juvenile grayling ranged from 0.5-3.5 feet with the highest frequency occurring at 0.5 feet (ISR Study 8.5, Appendix G). For velocity, juvenile utilization ranged from 0.1-2.9 fps with the highest frequency occurring at the lowest measured velocity of 0.1 fps. Substrate utilization ranged from fines to boulder with the highest frequency found in areas with fine substrate. For grayling fry, water depth utilization ranged from 0.5-3.7 feet with the highest utilization at 0.9 feet (ISR Study 8.5, Appendix G). Water velocity utilization ranged from 0.1-2.3 fps with the highest frequency occurring at 0.1 fps. Substrate utilization for grayling fry was similar to the juvenile life stage ranging from fines to boulder with the highest frequency of use found in areas with fine sediment.

5.5.4.7. Longnose Sucker

Observations of longnose sucker were limited to the adult, juvenile, and fry life stages as no spawning fish were observed. Longnose sucker was observed in all seven of the surveyed Focus Areas and in six of the eight macrohabitat types (Table 5.5-1). Of the 164 longnose sucker observations, 71 were for the adult life stage, 52 for juvenile, and 41 fry (Table 5.5-1). Longnose sucker microhabitat use measurements were completed in all sampling sessions except late September (Table 5.5-3).

Depth utilization by adult longnose sucker ranged from 0.5-3.1 feet with the highest frequency occurring at 0.9 feet (ISR Study 8.5, Appendix G). For velocity, adult utilization ranged from 0.1-2.9 fps with the highest frequency occurring at 0.1 fps. Substrate utilization ranged from fines to bedrock with the highest frequency found in areas with fine substrate. Juvenile longnose sucker depth utilization ranged from 0.3-3.5 feet with the highest frequency occurring at 1.1 feet (ISR Study 8.5, Appendix G). For velocity, juvenile utilization ranged from 0.1-1.9 fps with the highest frequency occurring at 0.1 fps. For longnose sucker fry, water depth utilization ranged from 0.5-2.5 feet with the highest frequency occurring at 0.9 feet (ISR Study 8.5, Appendix G). Water velocity utilization ranged from 0.1-0.5 fps with the highest frequency occurring at 0.1 fps. Substrate utilization for longnose sucker fry and juvenile was very similar ranging from fines to large cobble with the highest frequency of use found in areas with fine sediment.

5.5.4.8. Whitefish

Due to the difficulty in distinguishing between early life stages (fry and juvenile) of round and humpback whitefish, all microhabitat use observations for the two species have been lumped into a generic grouping of "whitefish." Observations of whitefish were limited to the adult, juvenile, and fry life stages as no spawning was observed. Whitefish were found in all seven of the surveyed Focus Areas and in each of the eight macrohabitat types (Table 5.5-1). Of the 106 whitefish observations, 28 were for the adult life stage, 38 juvenile, and 40 fry (Table 5.5-1).

Depth utilization by adult whitefish ranged from 0.5-2.9 feet with the highest frequency occurring at 0.9 feet (ISR Study 8.5, Appendix G). For velocity, adult utilization ranged from 0.1-2.5 fps with the highest frequency occurring at the lowest measured velocity of 0.1 fps. Substrate utilization ranged from fines to boulder with the highest frequency found in areas with fine substrate. Whitefish juvenile depth utilization ranged from 0.5-2.7 feet with the highest frequency occurring at 1.1 feet (ISR Study 8.5, Appendix G). For velocity, juvenile utilization ranged from 0.1-2.9 fps with the highest frequency occurring at the lowest measured velocity of 0.1 fps. For whitefish fry, water depth utilization ranged from 0.5-3.3 feet with the highest frequency occurring at 1.1 feet (ISR Study 8.5, Appendix G). Water velocity utilization ranged from 0.1-2.9 fps with the highest frequency occurring at 0.1 fps. Substrate utilization for both the fry and juvenile life stages of whitefish occurred over a wide range of particle sizes with the highest frequency of use by both life stages in the fines substrate size.

5.5.4.9. Rainbow Trout, Burbot, Arctic Lamprey, and Dolly Varden Char

A combined total of 56 HSC/HSI measurements was made for rainbow trout, burbot, Arctic lamprey, and Dolly Varden during the surveys; (Table 5.5-1). The lowest number of microhabitat measurements was for Arctic lamprey with only one measurement followed by rainbow trout with only 13 observations. No spawning observations were made for any of these species. Over 70 percent of the observations for these four species occurred in side channel, upland slough, and tributary macrohabitats (Table 5.5-1). Rainbow trout were the most widely distributed of the four species with observation in all seven of the sampled Focus Areas. As for habitat use, rainbow trout had the most diverse use and were observed in six of the eight macrohabitat types. Due to the limited number of observations, no attempt was made to develop frequency histograms for these four species.

5.5.5. Habitat Availability Data Collection

Both microhabitat utilization and availability data were collected during each sampling event. Microhabitat availability data will be combined with habitat utilization data for developing species and life stage habitat preference curves. 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 groundwater upwelling) using measurements at locations where fish were not observed, and utilization measurements as locations where fish were observed (Manly et al 1993).

Habitat availability data were collected during each of the 210 sampling events completed during the 2013 HSC field studies. A total of 3,297 measurements of habitat availability was collected from within each of the seven Focus Areas and from additional areas located outside of the Focus Areas. The distribution of availability sample sites is identical to the distribution of habitat utilization measurements as they were both collected from within each of the 50- and 100-meter sampling sites. The number of habitat availability measurements varied by habitat type with the highest number of measurements collected from side channel (n=926) and main channel (n=784) macrohabitat units (Table 5.5-4). The fewest numbers of measurements were collected in clearwater plume (n=93) and backwater (n=24) macrohabitat units. For availability measurements within Focus Areas, the highest numbers were collected from FA-104 (Whiskers Slough) and FA-128 (Slough 8A) and the fewest from within FA-115 (Slough 6A). Additionally, there were 375 habitat availability measurements collected in areas outside of the Focus Areas (Table 5.5-4).

Surface water temperature measurements collected during the sampling period (mid-June to late September) ranged from a low of 3.2°C (side channel habitat) to a high of 26.7°C in an isolated upland slough area during the height of a mid-July 2013 heat wave (Table 5.5-5). In general, the lowest water temperatures (<5°C) were associated with side channel, upland slough, and side slough macrohabitat types (Table 5.5-6). The warmest surface water temperatures (>20°C) were found in upland slough macrohabitat areas. Most (83 percent) of the surface water temperatures recorded during the data collection period ranged from 5-15°C (Table 5.5-6). Dissolved oxygen concentration (mg/L) ranged from a high of 13.0 mg/L to a low of 3.4 mg/L (Table 5.5-5). Dissolved oxygen levels were generally the highest in main channel and side channel macrohabitat areas and lowest in upland sloughs (Table 5.5-6). While a few upland slough areas had dissolved oxygen levels lower than 5 mg/L, most (88 percent) of the measured dissolved oxygen values in the Middle River Segment of the Susitna River ranged from 5-12 mg/L.

To detect the presence of groundwater upwelling, vertical hydraulic gradient (VHG) measurements were collected from within each of the 207 sample sites. Positive (>5mm) VHG values were considered an indication of groundwater upwelling, while negative VHG (<-5mm) was considered an area of groundwater downwelling. Measurements falling between +5 and -5 mm were considered neutral or an indication of no upwelling or downwelling at the site. Side slough and upland slough habitats had the highest maximum (+200 and +190) and mean VHG values of all habitat types. Tributary mouth habitats had the lowest mean VHG values at -120 mm indicating a strong signature for groundwater downwelling (Table 5.5-5). Forty-nine percent of all habitat availability measurements indicated the presence of groundwater upwelling with side channel, side slough, and upland slough macrohabitat areas having the largest number of positive measurements (Table 5.5-6). Main channel habitats had the highest number of neutral and negative VHG values.

The conductivity (or specific conductance) of water is a measure of its ability to conduct electricity and is generally linked to the quantity of total dissolved solids in water. Conductivity values in the Middle River Segment ranged from a high of 381 µs/cm to a low of 19 µs/cm (Table 5.5-5). The majority (60 percent) of conductivity values ranged from 87-173 µs/cm with a mean of 146 µs/cm (Table 5.5-6). Tributary and clearwater plume habitats had the lowest mean conductivity values at 44 and 69 µs/cm, respectively.

5.5.6. Habitat Utilization Frequency Histograms/HSC/HSI Curve Development

As noted in ISR 8.5, Section 5.5, histogram plots were developed for all species for which sufficient observations were made to adequately demonstrate a range of microhabitat use (ISR Study 8.5, Appendix G). Each histogram plot displays the normalized frequency (highest count set to equal 1.0) of microhabitat use over the range of measured values. For those species and life stages where data are available, results of the 2012 HSC/HSI sampling and curves developed from the 1980s surveys are presented on the same plot as the 2013 frequency analysis.

5.5.7. Methods for HSC/HSI Curve Development

Development of final habitat preference curves is scheduled for next year of study. Several different models are currently being tested for use in preference curve development, including univariate, multivariate, and polynomial regressions. Each of these models has the ability to predict fish presence/absence as a function of several different variables, including water depth, velocity, substrate, cover, upwelling, and water quality. A simplified example of the use of univariate-logistic modeling to predict the preference of depth, velocity, and substrate habitat use by spawning chum sampling is presented in Figure 5.5-9 and Figure 5.5-10. For depth suitability (upper plot), the impact of using preference instead of utilization is to increase the suitability for greater depths (Figure 5.5-9). This occurred because there were fewer overall habitats sampled in deeper water. Only a small number of locations with deep water were utilized by spawning chum, but they were a relatively large proportion of the overall deep water habitats that were available. The best-fit logistic model for depth was:

$$\log\left(\frac{p}{1-p}\right) = -3.6 + 7.4 * depth - 6.9 * depth^2 + 2.5 * depth^3 - 0.33 * depth^4,$$

where

log = natural logarithm,

p = probability of observing a redd, and

depth = depth in feet.

The second best model for depth, a third-order polynomial model, is also displayed for comparison (Figure 5.5-9).

For velocity (lower plot) the impact of using preference instead of utilization was to shift the peak suitability to the right (Figure 5.5-9). This occurred because there were fewer overall habitats sampled in faster water. Again, although only a small number of locations in faster water were utilized, a relatively large proportion of the overall fast water habitats were sampled. The best-fit model for velocity was:

$$\log\left(\frac{p}{1-p}\right) = -1.8 + 5.4 * vel - 8.4 * vel^2 + 4.9 * vel^3 - 1.0 * vel^4,$$

where *vel* = velocity in ft/sec.

The second best model for velocity, a quadratic model, is also plotted for comparison (Figure 5.5-9).

The utilization and preference results for substrate are plotted side-by-side in Figure 5.5-10. The largest difference between the two methods (utilization vs. preference) is seen for substrate code = 3, small gravel. There were relatively few utilization sites with small gravel, so this would give a smaller suitability value. However, the availability measurements found relatively few sites that had small gravel, which greatly increased the significance of the spawning taking place at those sites.

This type of analysis will be completed for all other species and life stages for which sufficient habitat utilization data are available. Additionally, the modeling will be used to predict habitat preference for the other variables listed above. Draft habitat preference curves will be presented to the TWG as part of the Proof of Concept scheduled for 2014.

5.5.8. Winter Habitat Use Sampling

Results of the 2012-2013 winter pilot studies are summarized below; more details are presented in Technical Memorandum (R2 2014).

5.5.8.1. Water Surface Elevations

Water surface elevations of the Susitna River main channel in FA-104 (Whiskers Slough) exhibited a long-term downward trend during the period February through April 2013, although short-term oscillations occurred throughout the measurement period (Figure 5.5-11). Water levels recorded at side channel site WSC-30 were similar to the main channel (MC-50) in terms of the long-term downward trend and short-term fluctuations based on comparison of normalized water levels (Figure 5.5-11). At monitoring sites in side slough and upland slough habitats, the long- and short-term stage patterns were generally more stable compared to the main channel (Figure 5.5-11). At most off-channel sites, water elevation changes through the period of measurement were minimal, and short-term stage fluctuations evident at off-channel monitoring sites in late March 2013 differed from the main channel in terms of magnitude and duration (Figure 5.5-11). While short-term stage fluctuations are evident at each site in late March, the events were typically not as large in magnitude or duration at side slough (WSC-20, WSC-40), upland slough (SL3A-70), or at side channel (SL3B-50) sites as in the main channel (MC-50) (Figure 5.5-11). The stage record in Whiskers Creek was substantially different from the patterns exhibited at all other continuous monitoring sites (Figure 5.5-11). The inlets to side channel and off-channel macrohabitats in FA-104 (Whiskers Slough) (e.g., Whiskers Slough, Slough 3A) were not visible due to snow and ice cover during the February through April 2013 effort, so it was not confirmed whether channels were breached by Susitna River main channel streamflow.

Comparison of water surface levels within FA-128 (Slough 8A) indicated similar stage responses between upland slough (US2-10) and side slough (SL8A-15) macrohabitats in terms of the magnitude and timing of seasonal and daily trends Figure 5.5-12. In addition, stage fluctuations at FA-128 (Slough 8A) off-channel sites were generally similar to the main channel Susitna River stage response during late May to early August 2013 based on comparison of normalized water levels among FA-128 (Slough 8A) sites and the recorded stage at the USGS gage at Gold Creek (No. 15292000) (Figure 5.5-12). Large-scale episodic stage fluctuations in the main channel measured at the USGS gage at Gold Creek (No. 15292000) during ice break-up in May and June 2013 were reflected at both off-channel monitoring sites, although the magnitude of such events was lower at the FA-128 (Slough 8A) sites compared to the main channel (Figure 5.5-12). The inlet of Slough 8A was not breached by Susitna River main channel flow during the March and April 2013 data collection trips and the upstream extent of surface water flow in Slough 8A extended approximately to site SL8A-50 (Figure 4.5-3). The timing and duration that the Slough 8A inlet was breached during spring flood events in May and June 2013 has not been established.

5.5.8.2. Water Temperature, Conductivity and Dissolved Oxygen

Surface and intergravel water temperatures differed among macrohabitat types in FA-104 (Whiskers Slough) during the 2012-2013 winter pilot study based on data collected at the nine continuous monitoring sites. Surface water temperatures recorded during February through April 2013 were near 0°C at main channel site MC-50, generally below 2°C at sites influenced by Whiskers Creek (WC-10 and WSL-20), and ranged between approximately 1-4°C at off-channel sites (Figure 5.5-13, Figure 5.5-14, and Figure 5.5-15). Intergravel water temperatures were warmer than surface water at all sites, although the difference at the main channel site was negligible. The largest observed differential between surface and intergravel water temperature was more than 3°C at site WSC-30 (Figure 5.5-13). Continuous intergravel temperature data were not collected at FA-128 (Slough 8A) due to ice formation within the intergravel insertion equipment during the March 2013 effort, which precluded deployment of temperature loggers into the channel substrate.

Diurnal fluctuations of water temperature were common among FA-104 (Whiskers Slough) monitoring sites, but were generally more prevalent among off-channel and tributary monitoring sites relative to mainstem locations (Figure 5.5-13, Figure 5.5-14, and Figure 5.5-15). Diurnal temperature changes were apparent throughout the vertical gradient at nearly all off-channel and tributary sites and the magnitude of daily fluctuation exceeded 1°C in Whiskers Creek, Whiskers Slough, and at sites upstream of Whiskers Slough (SL3B-10, SL3A-70) (Figure 5.5-13, Figure 5.5-14, and Figure 5.5-15). At side channel site WSC-30 and side slough site CFSL-10, a fluctuating daily temperature pattern was evident near the substrate surface (-5 cm), but was negligible at intergravel depths of 20 cm and 35 cm (Figure 5.5-13). Diurnal temperature variations were not apparent at main channel site MC-50 (Figure 5.5-13).

There was no clear effect of Susitna River main channel water level fluctuations on intergravel temperatures at the three FA-104 (Whiskers Slough) sites that were known to support salmon spawning in fall 2012 (WSC-30, WSL-20, WC-10). Although water levels at the side channel site WSC-30 were variable throughout the measurement period, and reflected the main channel (MC-50) stage response, intergravel water temperatures at WSC-30 were not visibly affected by such changes in water level (Figure 5.5-16). At side slough site WSL-20, stage was stable relative to the main channel and surface and intergravel water temperatures at WSL-20 did not appear to change in relation to main channel stage fluctuations (Figure 5.5-16). At Whiskers Creek site WC-10, main channel stage fluctuation did not visibly affect stage or water temperature (surface or intergravel) (Figure 5.5-16).

Instantaneous measurements of surface water temperature recorded in April 2013 at FA-104 (Whiskers Slough) were consistent with data recorded at continuous sites in that surface water was generally warmer in side slough and upland slough macrohabitats relative to Susitna River main channel and side channel sites (Figure 5.5-17). Conversely, specific conductance at mainstem instantaneous measurement sites was typically higher than in off-channel and tributary areas (Figure 5.5-17). Exceptions to this general trend were at side channel site SL3B-10, which exhibited lower specific conductance and higher water temperature than other side channel sites, and side slough site CFSL-10, at which the recorded specific conductance was more similar to mainstem habitat than other side slough habitats (Figure 5.5-17).

At FA-128 (Slough 8A), instantaneous water quality measurements measured during April 2013 suggested that side slough and upland slough macrohabitats were generally warmer relative to main channel and side channel areas, but specific conductance was not substantially different among habitats (Figure 5.5-17). Specific conductance was lower within Slough 8A (side slough) relative to main channel, side channel, and upland slough macrohabitats (Figure 5.5-18). Bank seepage flow at side channel sites was characterized by warmer temperature and slightly lower conductance than adjacent surface waters, whereas in upper Slough 8A (SL8A-50) bank seepage was similar to the main water body in terms of temperature and specific conductance (Figure 5.5-18).

Intergravel dissolved oxygen recorded at approximately 20 cm below the substrate surface at a known 2012 salmon-spawning site in FA-128 (Slough 8A) (SL8A-15) was generally stable (approximately 5.2 mg/L) through late March and April 2013 (Figure 5.5-19). Water temperature recorded by the dissolved oxygen logger was similarly stable through the period of measurement with minimal daily fluctuation (Figure 5.5-19). Continuous dissolved oxygen data recorded at FA-104 (Whiskers Slough) site SL3B-10 appeared to be erroneous (measurements fluctuated widely) and are not shown here. Intergravel temperature recorded by the dissolved oxygen logger at FA-104 (Whiskers Slough) site SL3B-10 closely reflected temperature values measured at a similar depth by an intergravel temperature logger at the site.

5.5.8.3. Fish Observations and Habitat Utilization

Underwater fish behavior observations and fish capture efforts during the February through April 2013 study period indicated that juvenile fish were active during both day and night periods in FA-104 (Whiskers Slough) and FA-128 (Slough 8A). Fish activity was observed during daytime and nighttime opportunistic underwater surveys of ice-covered side channel, side slough, and upland slough macrohabitats in which optical video cameras were used to actively scan the channel from one or more fixed positions in the ice (see ISR Study 9.6). No distinct difference in fish activity was apparent during day and night surveys during optical video camera surveys; however, DIDSON sonar surveys in FA-104 (Whiskers Slough) near site WS-70 identified directional movements of fish at dusk and at dawn that were not apparent at other times (see ISR Study 9.6). Based on daytime and nighttime electrofishing surveys of open-water areas, total fish capture at night was typically higher than daytime capture at sites sampled during both diurnal periods in FA-104 (Whiskers Slough) (SL3A-71) and FA-128 (Slough 8A) (SSC-20, SC8A-28, SL8A-10, US2-10) (Table 5.5-7).

A total of 29 HSC/HSI observations of juvenile Chinook and coho habitat utilization was recorded during electrofishing sampling efforts in open-water areas of FA-104 (Whiskers Slough) and FA-128 (Slough 8A) in March and April 2013 (Table 5.5-8). Of this total, 26 observations were recorded for juvenile Chinook and three for juvenile coho salmon (Table 5.5-8). No HSC data were recorded in ice-covered areas in association with underwater optical video surveys.

5.5.9. River Productivity

In 2013, data were collected in support of HSC/HSI models as described in ISR Study 8.5, Section 4.5 (River Productivity). These data were collected to assist in generating HSC/HSI criteria for Susitna River benthic macroinvertebrate and algae habitats for use in predicting potential changes in these habitats downstream of the proposed dam site. Approximately 300 Hess samples were collected with depth, velocity, and substrate composition measurements (Table 5.5-9). In addition, 150 samples of large woody debris ("snags") were collected with depth, velocity, and surrounding substrate composition estimates; 1,745 rock locations taken for composite algae samples recorded depth and velocity (Table 5.5-9). A detailed description of the location and timing of sampling is provided in the River Productivity Study (ISR Study 9.8).

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.

5.5.10. Draft Periodicity Tables

During 2013, AEA developed draft periodicity tables to describe the temporal periods which each target species and life stage are expected to occur in the Project area (ISR Study 8.5, Appendix H). These tables were based largely on information from the 1980s studies as presented in Technical Memorandum 5 [7]of R2 2013e, supplemented with contemporary information provided in ADF&G reports prepared in the 2000s (e.g., Merizon et al. 2010). To the extent possible, the timing of use by macrohabitat type (main channel, side channel, side slough, upland slough, tributary mouth, and tributary; see ISR Study 9.9 for detailed description of habitat types) was provided by species and life stage for each segment (Upper, Middle, Lower) based on reviews of these studies. However, habitat utilization data for some species and/or life stages in the Susitna River are sparse; in these cases, the available information was consolidated among Susitna River segments and/or was supplemented by data not specific to the Susitna Basin (e.g., Morrow 1980). The draft periodicities will be reviewed and modified based on results of fish distribution sampling and input from agency participants. A detailed description of the data sources and rationale for each individual species periodicity table is presented in the Technical Memorandum 5 of R2 (2013e).

5.5.11. Biological Cues Study

The objective of this exploratory analysis completed by AEA was to look for general relationships between hydrologic variables and biological responses of salmon species, in this case Chinook salmon, which may be relevant to the Susitna River. The analysis centered on two glacially fed river systems, the Taku and Stikine rivers. These systems were deemed the most suited for drawing inferences related to hydrologic variables and attributes of salmon escapement that might pertain to the Susitna River system, due to their glacial origin and the length of both

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[7] Technical Memorandum 5 – Selection of target species and development of species periodicity information for the Susitna River . In R2 (2013e).

their hydrologic and escapement records. Full results of the biological cues study are presented in ISR Study 8.5, Appendix B.

Overall, there were a number of weak to moderate correlations found between productivity or run-timing metrics and hydrologic indices for the Taku and Stikine rivers. For the Taku River, observed relationships are as follows:

- There were more returns per spawner when a wider range of flows occurred during adult migration.
- There were more returns per spawner when there were high winter flows combined with no large summer-flow decreases that could result in trapping events.
- There were more smolts per spawner when the summer low flow was moderate or relatively high.
- The duration of the Chinook salmon run was longer when flows were more variable.

For the Stikine River, observed relationships are as follows:

- Total returns tended to be higher when the winter minimum flow was higher.
- Total returns tended to be lower when PDO was higher during early ocean rearing.
- There tended to be fewer smolts per spawner when there were large flow decreases during the spawning period.
- The duration of the Chinook salmon run was longer when flows were more variable.
- The median date of the run was earlier when there were late high flows.

In general, significant correlations were inconsistent for similar indices analyzed from the Taku River and Stikine River datasets. Thus, applying the results from the Taku or Stikine rivers to other Chinook salmon populations, such as in the Susitna River, could be erroneous and should be done with caution. However, there was one consistent result for the two rivers: variable flows during the spring and summer were correlated with broader upstream migration periods. Upon further investigation, it was found that run duration was negatively correlated with total counts at the fishwheels or test fishery locations for both rivers; i.e., a more prolonged migration period was associated with smaller total counts. From these two relationships, i.e., 1) more variable flows in spring/summer were associated with broader/longer upstream migration periods; and 2) broader/longer migration periods were associated with smaller runs), it could be concluded that more consistent flows during the migration period may lead to larger runs. However, comparing flow range to total returns or returns per spawner does not result in significant correlations for either river. Therefore, the applicability of this relationship between flow variability and length of migration period to the Susitna River is unclear.

5.5.12. Relationship between Microhabitat Use and Fish Abundance

As noted in ISR Study 8.5, Section 4.5, all data (and samples from water quality sampling) necessary for this evaluation were collected during the 2013 field season as part of sampling efforts associated with Fish Distribution and Abundance (ISR Study 9.5), Water Quality (ISR Study 5.5), River Productivity (ISR Study 9.5), and Groundwater (ISR Study 7.5) studies. AEA has requested data from each of these studies, but is still waiting to receive some data and results, primarily from the studies that included a laboratory analysis component (e.g., Water quality sampling, River Productivity). The status of obtaining all data necessary to complete this analysis is summarized in Table 5.5-10. Once all data are obtained, site-specific data will be spatially located onto Focus Area maps to identify if overlaps are evident between specific microhabitat variables and fish abundance. AEA will complete a statistical analysis of the data to detect possible relationships between the variables and fish distribution and abundance information. The analysis proposed for completing this evaluation is described in ISR Study 8.5, Section 7.5.

5.5.13. Stranding and Trapping

No formal stranding and trapping surveys were completed in 2013. Informal, opportunistic surveys of stranded or trapped fish were completed in the Middle River Segment during completion of HSC/HSI surveys and Focus Area substrate characterization surveys (ISR Study 8.5, Section 4.6). No stranded or trapped fish were noted during any of these surveys. Opportunistic observations were also made in the Lower River Segment near PRM 95 during a June 13-14, 2013 site reconnaissance during which 3-4 unidentified salmonids were observed trapped in a pool disconnected from the main channel of the river. No stranded fish were observed during that survey. For the next year of study, only opportunistic stranding and trapping field surveys are scheduled (ISR Study 8.5, Section 7.5). AEA will discuss the need for more formalized stranding and trapping surveys with the resource agencies. If stranding and trapping surveys are not needed, 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.

5.6. Habitat-Specific Model Development

5.6.1. Habitat Model Selection

AEA selected and has proceeded with development of 2-D hydraulic models for seven of the ten Focus Areas in the Middle River Segment; the upper three Focus Areas were not measured due to access restrictions. Once developed, the 2-D model will provide the platform and analytical engine for conducting a variety of habitat analyses, including basic PHABSIM analysis to compute habitat flow relationships for different species and life stages of fish and macroinvertebrates using HSC/HSI criteria (ISR Study 8.5, Section 5.5), effective spawning/incubation analysis, stranding and trapping analysis, varial zone modeling, and habitat connectivity/breaching flow analysis. Due to the complexity of the channel network in the Lower River Segment, AEA selected the 1-D hydraulic model HEC-RAS Version 4.1 to simulate water surface elevations coupled with PHABSIM for determining habitat – flow relationships for different species and life stages at discrete locations, and has proceeded with data collection for those models (R2 2013b).

5.6.2. Field Coordination and Collection of Physical and Hydraulic Data

Field surveys occurred in 2013 and were closely coordinated between and among the different resource leads to ensure that data necessary for developing the respective hydraulic and habitat models was being collected. A description of the types of data and methods used in collecting the data are described in ISR Study 8.5, Section 4.6.

5.6.2.1. Boundary Condition Transects

Data were collected at each of the boundary condition transects as part of the hydrologic data collection field activities described in ISR Study 8.5, Section 4.3. The primary field data collected included; cross-sectional surveys to define channel topography and hydraulic controls; velocity and discharge measurements collected using an ADCP system; water surface elevation measurements taken during discharge measurements; and documentation of substrate types and roughness characteristics (ISR Study 8.5, Section 4.6).

Data collected at each of the boundary condition transects will be used to compute the energy slope, velocity, depth, and other hydraulic variables at each cross-section for use in development of the 2-D hydraulic models. Additional data that will be used for defining boundary conditions will be provided by the Open-water Flow Routing Model (ISR Study 8.5, Section 5.3) and the River 1D Ice Processes Model (ISR Study 7.6).

5.6.2.2. 2-D Modeling

In 2013, AEA collected bathymetry and hydraulic data for 2-D models at the seven Focus Areas between PRM 104 and PRM 145 in 2013 (ISR Study 6.6 and ISR Study 8.5, Section 4.3). Maps of the seven measured 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]), showing fine and coarse mesh overlays, channel inlet and outlet measurement locations, and calibration transects are shown in Figure 5.6-1 through Figure 5.6-7. The bathymetry data were collected using boat-mounted equipment in the main channel and side channels with sufficient depth to maneuver. Bathymetry and topography data were collected via wading in areas too shallow for boat mounted equipment and on areas above the water surface. The survey data were distributed to the Geomorphology Study (ISR Study 6.6) for development of the 2-D hydraulic models.

AEA also collected substrate and cover data at the seven Focus Areas in September, 2013. The field crews consisted of a boat crew for main channel/deep water habitats and a ground crew for shallow habitats and off-channel habitats. As noted in ISR Study 8.5, Section 4.6, the substrate and cover data collection followed the same protocols as the HSC development (ISR Study 8.5, Section 4.5). At each Focus Area, the field crew used laminated aerial photographs of the study area as the base map to record substrate and cover characteristics. Polygons of homogeneous substrate and cover type were drawn on the photographs and the dominant and subdominant substrate in the polygon recorded.

Photographs of data sheets were taken after each field day as a backup copy of the field data. The field data and polygons for each Focus Area were subsequently digitized and incorporated into GIS and will be used in developing substrate maps for the 2-D habitat analysis. The substrate maps will include geo-referenced polygons of substrate for the 2-D model domain in each of the Focus Areas. The GIS analysts completed the preliminary data entry for FA-104 (Whiskers Slough) and FA-128 (Slough 8A) in 2013, and will complete the geo-referenced substrate maps for the other five measured Focus Areas during next year. The preliminary data entry will undergo standard QA/QC procedures prior to use in the 2-D habitat model. The substrate maps developed for each Focus Area will be cross-checked/referenced with the results of the substrate characterization being conducted by the Geomorphology study (ISR Study 6.6).

5.6.2.3. 1-D Single Transect Modeling

The methods applied in 2013 for the collection of single transect data to support both the refinement of the Open-water Flow Routing Model and development of 1-D hydraulic models to support PHABSIM analysis are described in ISR Study 8.5, Section 4.6. Application of single transect modeling represents the primary method for deriving habitat-flow relationships in the Lower River Segment. In that segment, single transects were located across a range of macrohabitat types at five sites established between PRM 92.9 and PRM 97 to support development of 1-D hydraulic models and completion of a 1-D PHABSIM analysis (ISR Study 8.5, Section 4.6).

5.6.3. Model Development

5.6.3.1. 2-D Modeling

As noted in ISR Study 8.5, Section 4.6, there are currently two 2-D hydraulic models being considered for application in the Focus Areas, SRH-2D, a model from the US Bureau of Reclamation and River2D a model from the University of Alberta. These models were selected as candidates and are being evaluated for their potential applicability for the Geomorphology studies (ISR Study 8.5, Section 6.6). Only one of these models will ultimately be used for both the geomorphology and habitat modeling, but both are mentioned in this ISR.

Development of preliminary 2-D hydraulic models began in Q2 2013. Both of the models have the capability to vary the mesh size allowing the size of the model element to be varied. Selection of the appropriate mesh size for the 2-D Bed Evolution Model is dictated by several factors including the size and complexity of the site feature(s), the desired resolution of output information such as water surface elevation, velocity, depth, and bed material gradation, and limitations on the maximum number of elements that the model can simulate. Mesh size in near shore areas, side channels, and side sloughs that are relatively complex and contain a variety of habitat structures require a smaller mesh to provide greater resolution of discrete habitat features; a preliminary mesh size for these areas is 6.56 feet (2 meters). In contrast, the mesh size in the larger main channel areas that are morphologically uniform can be larger; a preliminary mesh size for these areas is 32.8 feet (10 meters).

At some Focus Areas, two separate model meshes may need to be developed. One mesh would be used for executing the 2-D Bed Evolution Model (ISR Study 6.6) and 2-D River Water Quality Model with Enhanced Resolution (ISR Study 5.6), which require significantly more time to execute than the 2-D model without the moveable bed options running. The other mesh would be associated with a fixed bed representation of the site that would be used to output the hydraulic conditions at a finer resolution for development of aquatic habitat indices. Calibration of the 2-D hydraulic models for the Middle River Segment Focus Areas was initiated in 2013.

Preliminary 2-D hydraulic model results from FA-104 (Whiskers Slough) were developed to support presentations at the November 13-15, 2013 IFS-Technical Team Riverine Modelers

Meeting (Tetra Tech 2013f). Calibrated hydraulic models for FA-128 (Slough 8A) will be developed and used in the Proof of Concept analysis in 2014.

The SRH-2D or River2D models will provide outputs of depth, velocity, and water surface elevations for a given flow, over an entire Focus Area. These outputs will be combined with the HSC/HSI curves and input to the 2D – PHABSIM based habitat models to calculate habitat quantities by species and life stage under different flows (ISR Study 8.5, Section 5.6).

5.6.3.2. 1-D Single Transect Modeling

Habitat modeling in the study sites located in Lower River Segment (ISR Study 8.5, Section 4.2) of the Susitna River is being completed using a single transect 1-D modeling approach. For this, the one-dimensional HEC-RAS (Version 4.1) model was selected to conduct initial hydraulic calibrations and to provide simulated water surface elevations for habitat modeling at each fish habitat transect (ISR Study 8.5, Section 4.6). HEC-RAS was selected since it can readily handle multiple inflow points within the model domain, which is needed for the Lower River fish habitat sites, and it can be integrated with the Open-water Flow Routing Model. This model will provide output that will be combined with HSC/HSI data for completing a PHABSIM based analysis for determining habitat – flow relationships and evaluating other habitat metrics. Detailed methods applied in the calibration and development of the HEC-RAS models are described in ISR Study 8.5, Section 4.6.

Calibration of the 1-D hydraulic models was initiated in 2013 and was based on data available as of December 1, 2013. Two of the five sites were selected for initial model calibration, the Birch Creek Site to represent a tributary confluence site and the PRM 97 Site to represent a main channel site. The details of the model calibration are provided in ISR Study 8.5, Appendix I. These calibrations relied on provisional tributary gaging results and results from Version 1 of the Open-water Flow Routing Model, and will be updated when new data and model results become available.

5.6.4. Habitat Evaluation Metrics

5.6.4.1. Weighted Usable Area Habitat Metrics

The 2-D and 1-D hydraulic models will provide input to the PHABSIM based models that incorporate HSC/HSI criteria allowing for the generation of a variety of different habitat-flow relationships for different species and lifestages of fish as well as macroinvertebrates. The metric generated from these types of studies is often expressed as WUA, which represents an index of habitat area provided at a given flow.

In a traditional PHABSIM analysis the computation of WUA generally only captures three variables, depth, velocity and substrate (or cover). While this type of PHABSIM analysis will be applied with both the 1-D and 2-D hydraulic models, other HSC/HSI type metrics will be integrated into the 2-D hydraulic analysis completed within Focus Areas. This will include HSC/HSI models pertaining to groundwater upwelling/downwelling, turbidity, and water temperature, and potentially others identified from the analysis of microhabitat use and fish abundance (ISR Study 8.5, Section 4.5).

Because the 2-D hydraulic models do not include a spatial component for habitat analysis at the macrohabitat or mesohabitat scales, a stand-alone VB model programmed specifically for this type of analysis, coupled with GIS tools is under development. The VB model combines the HSC/HSI criteria (including criteria for upwelling/downwelling, temperature, etc.) with the output for each point/node in the hydraulic model (e.g., depth and velocity) to compute its' habitat suitability value. The habitat suitability values for each node are then multiplied by the area of the mesh element to calculate the habitat area for each mesh element over the entire model domain. A GIS tool is then used to evaluate habitat characteristics in the smaller habitat areas as subsets of the model domain. The VB model output will include a geo-referenced text file that includes all the data from the 2-D hydraulic model and the calculated habitat use value for each element in the model domain. A text file will be generated for each simulated flow.

The model execution sequence will generally occur as follows:

1) Construction and calibration of the 2-D hydraulic models and simulation of a range of flows as provided in ISR Study 8.5, Section 6.6;
2) Transfer of hydraulic model results to the 2-D habitat modeling using text files (Figure 5.6-8);
3) Construction of habitat suitability functions into the VB model and selection of functions during model execution. The VB model is opened and the species/life stage is selected (Figure 5.6-9);
4) Selection of the input hydraulic simulation file; and
5) Model calculation of habitat use values for each element and production of graphic and tabular results (Figure 5.6-10 and Figure 5.6-11).

These steps are repeated for each species/life stage and each simulation flow. The result is habitat area for the model domain for the range of simulated flows. This analysis is analogous to a habitat versus flow analysis generated in a typical PHABSIM study. These habitat use data will also be used in the GIS tool developed for analysis of the smaller spatial areas in each Focus Area.

This general process was demonstrated for FA-104 (Whiskers Slough) using the uncalibrated preliminary output from the SHR-2D hydraulic model provided by the Geomorphology program, during the November 13-15, 2013 IFS-TT Riverine Modelers Meeting (Miller and R2 2013). Importantly, the 2-D habitat model is dependent on outputs from several other studies including Open-water Flow Routing Model, River 1D Ice Processes Model, 2-D hydraulic models, HSC/HSI criteria, results from Ground water studies regarding upwelling/downwelling, and 2-D River Water Quality Model with Enhanced Resolution (Figure 5.6-12). The general flow of data and data dependencies moves from the physical process models to the 2-D habitat models (Figure 5.6-13).

5.6.4.2. Effective Spawning/Incubation Habitat Analyses

AEA completed the initial model development for the Effective Spawning/Incubation Habitat Analyses of the Middle River Segment Focus Areas in 2013 (ISR Study 8.5, Section 4.6). The Effective Spawning/Incubation Habitat Analyses habitat analysis requires either model output or data from the 2-D hydraulic models for open-water conditions in the Focus Areas (ISR Study 6.6), 2-D hydraulic modeling of ice processes (ISR Study 7.6), ground water data or processes (ISR Study 7.5), water quality data or model results (ISR Study 5.6), and HSC/HSI data from the habitat suitability study (ISR Study 8.5, Section 5.5) (Figure 5.6-14). The temporal analysis of habitat over time uses the hydrology data from the Open-water Flow Routing Model (ISR Study 8.5, Section 5.4) and the 1-D Ice Processes Model (ISR Study 7.6).

The Effective Spawning/Incubation Model will include the use of the VB habitat model and GIS tool for the complete analysis. The VB model can be executed prior to the GIS tool to calculate habitat use at each model element for a specified range of flows. These data sets then are part of the input to the spatial analysis tool to determine suitability of the habitat in smaller spatial areas than the entire model domain. The potential or known fish spawning locations can be selected from within the Focus Area for analysis (Figure 5.6-15).

The 2-D habitat analysis sequence is being implemented in accordance with the steps illustrated in the Study Plan (Figure 5.6-16). The first steps in the 2-D habitat analysis for effective spawning/incubation include characterization of ground water and groundwater upwelling. Groundwater can have a profound influence on the suitability of spawning and incubation habitats over the winter and the ground water process analysis (ISR Study 7.5) will provide ground water data for the 2-D habitat analysis. These data will be used for both spatial (selected areas of certain Focus Areas) and temporal (trends over seasons) analysis (Figure 5.6-17). These general trends are then applied in the spatial domain of the smaller areas to determine which areas remain suitable over the entire temporal extent from spawning through incubation (Figure 5.6-18). Spatial areas that remain suitable over the entire temporal extent are then evaluated for other physical processes (Figure 5.6-19). These physical processes include freezing, dewatering, scour, and water quality. Open-water 2-D hydraulic modeling (SRH2-D or River 2-D) provides the data for scour. 2-D ice process modeling provides the data for freezing and dewatering for ice covered conditions. Water quality modeling provides the data for suitable water quality for the temporal extent from spawning through incubation (Figure 5.6-20).

The results of the effective spawning/incubation analysis will be presented in both tabular and spatial formats. The GIS tool converts the tabular, geo-referenced data into shape files for display and additional analyses. The spatial display can include both habitat use values (Figure 5.6-21) and physical parameters such as depth, velocity, and water surface elevations (Figure 5.6-22). The use of GIS provides an analysis framework that can be used for evaluation and comparison of spatial changes with and without the project on a scale that is smaller than the entire model domain.

5.6.4.3. Varial Zone Modeling

Varial zone modeling of the Focus Areas will begin when calibrated 2-D hydraulic models are completed. Varial zone modeling will use the 2-D hydraulic model output to determine water surface elevation at each simulation flow throughout each Focus Area. The change in spatial area will be calculated using a GIS tool to develop a wetted area versus discharge function. A flow time series from the Open-water Flow Routing Model will provide the data for the temporal analysis of changes in the varial zone. The process that AEA will utilize for varial zone modeling is described in ISR Study 8.5, Section 7.6.

5.6.4.4. Breaching Flows and Habitat Connectivity

Topographic and bathymetry data were collected in the seven Focus Areas of the Middle River Segment of the Susitna River in 2013 and will be used in development of 2-D hydraulic models (ISR Study 6.6) and in the analysis of breaching and habitat connectivity within these areas. The 2-D models are based on bed topography and produce water surface elevations over the entire Focus Area model domain. These water surface elevations can be used to establish the flow magnitudes in the Susitna River that result in the breaching of off-channel habitat control points and the inflow of water into the off-channel macrohabitats. In addition, single transect data can be extracted from the 2-D data to conduct an analysis of water depths at specific locations to evaluate fish habitat connectivity within a Focus Area. If needed, a single transect analysis can be completed using a 1-D model developed from data collected within Focus Areas. The approach and methods AEA will utilize for this analysis are described in ISR Study 8.5, Section 7.6.

As noted in ISR Study 8.5, Section 5.6, the assessment of breaching flows, fish barriers and connectivity in habitats within the Lower River Segment will be completed based on depths and velocities at the fish 1-D habitat transects and will focus on the areas around tributary confluences and the connectivity within braided island complexes and side channels with the main channel cross-sections. No additional data collection specific to breaching flows, fish barriers or connectivity was collected at the LR-1 fish habitat sites. Some drying of bar island complex channels was observed at surveyed transects between high flow conditions and low flow conditions. No barriers or loss of connectivity for fish movements between the main channel and side channels or tributary mouths was observed at the 2013 lower river fish habitat sites at any of the three flow conditions directly observed during field surveys. Additional transect surveys were completed in 2013 on the Deshka River and at the Deshka River confluence as a component of the geomorphology study (ISR Study 6.6). The results from that modeling effort will be used to assess breaching flow and connectivity to the Deshka River through an assessment of flow depth and velocity at the Deshka River confluence. Temporal and Spatial Habitat Analyses

5.7. Temporal and Spatial Analysis

Completion of the temporal and spatial analyses is contingent on the acquisition and analysis of data and subsequent development of models that will be used to assess both temporal and spatial effects of Project operations. IFS-related data acquisition was initiated in Q2 2013 and will continue through the next year of study; model development activities are ongoing and will likewise continue through the next year of study. However, planning activities associated with development of potential methods and approaches for conducting the temporal and spatial analyses were completed in 2013. These were initially provided in the Study Plan, discussed briefly during the IFS-TT riverine Modelers Meeting on November 13-15, 2013, and presented in ISR Study 8.5, Section 7.6. Further discussion with the TWG will occur in 2014 and will be presented as part of the Proof of Concept discussions.

5.8. Instream Flow Study Integration

Study integration efforts are scheduled to contine in the next study season. There were planning and organizational activities in 2013, that are discussed below. Progress on these topics was also discussed during the November 13-15, 2013 IFS Technical Team (TT) Riverine Modelers meeting (AEA 2013). During that meeting, several options for developing a Susitna River DSS were presented and discussed.

6. DISCUSSION

6.1. IFS Analytical Framework

The IFS analytical framework developed in 2012 was successfully applied in principle throughout 2013 as studies were implemented to collect data from a range of macrohabitat types within the Middle River Segment and to a lesser extent in the Lower River Segment. This has included data associated with discrete transects and monitoring sites, as well as information from within seven of ten Focus Areas in the Middle River Segment that will be used for evaluating Project effects across multiple resources. Much of the data collected in 2013 will be used in developing flow-sensitive models that can be linked with Project operations to evaluate effects on fish habitat, water quality (ISR Study 5.6), sediment transport (ISR Study 6.6), ice processes (ISR Study 7.6), groundwater (ISR Study 7.5), and riparian vegetation (ISR Study 8.6).

6.2. River Stratification and Study Area Selection

The Fish and Aquatics IFS stratification and selection of study areas was successfully completed in 2013 and resulted in the selection of ten Focus Areas in the Middle River Segment and two study sites in the Lower River Segment. During 2013, data were collected and subsequently analyzed from seven of the ten Focus Areas in the Middle River Segment and within Geomorphic Reach LR-1 of the Lower River Segment. The three Focus Areas that were not sampled in 2013 (due to access restrictions) in the Middle River Segment, and the IFS study sites in Geomorphic Reach LR-2 in the Lower River Segment, will be sampled during the next year of study. Likewise, consideration will be given to adding supplemental sites pending completion of the habitat mapping (ISR Study 9.9).

6.3. Hydrologic Data Analysis

6.3.1. Mainstem Susitna River

During 2013, 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 will be used in development of Version 2 of the Open-water Flow Routing Model. 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, Appendix C). In some cases data collection efforts were streamlined and only a water surface elevation was collected at a given cross-section. However, in these cases, the discharge for these transects can be interpolated from a nearby discharge measurement.

Analysis of the channel cross-sectional profiles before and after the September 21, 2012 flood revealed little change in channel structure (Figure 5.3-2 and Figure 5.3-3) suggesting little bedload transport occurred during the flood. Even when the post-June flood 2013 cross-sections are included in the comparisons (Figure 5.3-4), the differences in channel profiles are comparatively small given the overall width of the channels and are unlikely to result in detectable differences in water surface elevations for a given discharge. Moreover, some changes were expected between the 2012 and 2013 profiles due to the variability in the 2013 profiles obtained via ADCP measurements that were proximal to but not directly aligned with the 2012 cross-sections. This is exemplified in Figure 6.3-1 and Figure 6.3-2 that display locations of 2012 profiles at PRM 124.1 and PRM 137.6 respectively, relative to ADCP paths measured in 2013. The corresponding cross-sectional profiles for the two sites are provided in the results section in Figure 5.3-4 and do show some topographic differences along the profiles between the different ADCP paths. The differences in channel elevations that are evident between the 2012 and 2013 cross-sectional profiles (Figure 5.3-4) may be due to the June 2013 flood and/or ice scour that occurred as part of spring-breakup. Again, such differences are comparatively small relative to overall channel widths and not expected to result in substantial changes in stage-discharge relationships.

As noted in ISR Study 8.5, Section 5.3, 2-D flow measurements were performed in 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); and FA-144 (Slough 21). The 2-D model flow measurements consisted of closely spaced transects to quantify flow splits between various channels and sloughs. Results from individual transects were added to obtain streamwise flow summations throughout each Focus Area. Measurements at the remaining three Focus Areas will occur during the next year of study.

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 Open-water Flow Routing Model and other riverine-related studies, such as ISR Study 5.6, Water Quality; ISR Study 6.6, Geomorphology; and ISR Study 7.5, Groundwater. Some data gaps remain after the 2013 data collection effort. For three sites (the Oshetna River, Deshka River, and Kosina Creek) only two discharge-staff gage data pairs were collected. At least three pairs are needed to develop a rating curve. Additional pairs for these locations will be collected in the next year of study. Companion stage-only gages were installed along the mainstem at the confluence of Trapper Creek, Birch Creek, and the Deshka River. The local benchmarks at these three sites were not surveyed, prohibiting stage comparisons between the confluence and the upstream tributary. These benchmarks will be surveyed during the next year of study to allow this comparison.

Preliminary rating curves have been developed for those stations with at least three discharge-staff gage pairs. However, the hourly data are provisional and not included in this ISR. Additional data will be collected during the next year of study, which will revise the rating curves and change the hourly flow estimates. The complete set of rating curves will be provided in the USR. The current tributary gage data, in addition to the data that will be collected in the next year of study, will allow development of synthesized tributary records.

6.3.3. Realtime Hydrologic Data and Network

The objectives of the Realtime Hydrologic Data Network were met in 2013 with the continuation of collection of data at the 13 mainstem recording stations. However, during development of the Open-water Flow Routing Model it became apparent that all 13 mainstem water-level recording stations were not needed for calibration purposes. In 2013, the 13 hydrology stations were prioritized based on whether data from the stations were needed for calibration of the flow routing model, as well as their utility in other studies (ISR Study 8.5, Section 4.3). The priority levels of the 13 stations are provided in Table 4.4-2. Several of these sites were not actively supported in 2013 due to land access conflicts. As a result, some data gaps of water stage and water temperature exist for the original 13 hydrology stations. Three stations (ESS80, ESS30, and ESS20) have complete or near-complete datasets. Six stations (ESS65, ESS55, ESS50, ESS45, ESS40, and ESS35) have partial datasets. Stations ESS70 and ESS60 were removed in 2013, but station ESS60 has data for part of 2013. Stations ESS15 and ESS10 are downstream of the lower extent of the Open-water Flow Routing Model and were installed to provide basic hydrology data for LR studies. The ESS data, along with available data from USGS at four additional sites along the mainstem of the Susitna River, will be used in calibration of Version 2 of the Open-water Flow Routing Model, as well as for modeling in other studies. Given the availability of complete datasets at seven mainstem locations (three ESS stations and four USGS stations) it is not anticipated that data gaps at the other ESS stations will hinder study objectives.

6.3.4. Representative Years

Study objectives for Representative Years are being met through the selection of three candidate representative years for wet, average, and dry conditions during periods of warm or cool PDO phases. These were selected based on input from multiple resource teams, including sediment transport, instream flow, and ice processes. These representative years will be presented to and discussed with the TWG and presented in the Proof of Concept in 2014.

6.3.5. Indicators of Hydrologic Alteration and Environmental Flow Components

The objectives of the IHA analysis will be completed during the next of study once a final set of hydrologic metrics are selected. As noted in ISR Study 8.5, Section 5.5, these metrics will include those specific to IHA as well as others that will be developed that will be sensitive to load-following operations. The selection of metrics will be discussed with the TWG and finalized as part of the Proof of Concept. Results of the IHA analysis will be included in 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 working groups. 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 Open-water Flow Routing Model. Additional detail and discussion will be provided in the USR.

6.4.2. Open-water Flow Routing Model

The Open-water Flow Routing Model developed in 2012 and 2013 (Version 1) met Project objectives by providing information to support decisions on the downstream extent of Project effects, helping schedule field studies targeting specific flow and stage conditions, and identifying 2013 data needs to improve model accuracy. This model will be refined and improved based on field data collected in 2013 and 2014. A refined version (Version 2) of the Open-water Flow Routing Model is currently being developed incorporating additional data collected in 2013; Version 2 will be available in 2014. Hydrologic data include additional transect cross-sectional profiles, additional discharge/water level data pairs, and hourly stage data from the main channel and tributary location. Hydrologic data will continue to be collected in 2014 and a final Open-water Flow Routing Model will be developed and distributed for review during the last year of study. Major changes in the mainstem Open-water Flow Routing Model findings are not anticipated as a result of the additional data collected. However, the additional data and model refinements will improve the accuracy of hourly flow and stage simulations at complex channel features and within instream flow sampling and modeling areas.

Version 2 of this model, which is under development, will incorporate the following additional information:

- Tributary drainage areas will be delineated, and tributary flow measurements will be made. These will be used to help estimate lateral accretion flows.
- Cross-sections will be extended up to higher elevations using LiDAR data and ground-based RTK-GPS surveys.
- Additional pairs of flow/water surface elevations will be incorporated, especially in the Lower Susitna River. These data will be used to help improve the steady-state calibration.
- Additional cross-sections from the geomorphology study will be incorporated in the model.
- Diurnal glacial melt fluctuations will be incorporated into the summer hydrographs.

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, Section 4.4), Ice Processes (River1D) (ISR Study 7.6), Water Quality (EFDC) (ISR Study 5.6), and Fluvial Geomorphology (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 Open-water Flow Routing Model to link with an under ice model (River1D). The sediment transport modeling uses input from the Open-water Flow Routing Model 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 Open-water Flow Routing Model 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, Section 5.6 and 6.6). At this time, data collection efforts are on schedule to provide sufficient microhabitat use and availability data to develop site-specific HSC/HSI preference curves for each of the high and moderate priority species. In addition, HSC/HSI data have been and will continue to be collected that will in combination with other studies, be used for evaluating Project effects on other ecologically important factors such as groundwater upwelling, intergravel temperature and dissolved oxygen.

The following section provides an overview of the key activities completed during the 2013 HSC/HSI curve development.

6.5.1. Selection of Priority Species and Life Stage

A priority ranking of the 19 fish species to be considered for site-specific HSC curve development was developed in collaboration with the TWG in Q2 2013. The high and moderate ranked species are generally considered the most sensitive to habitat loss through manipulation of flows in the Susitna River. Although no direct effort was made to collect site-specific microhabitat use information for low-priority ranked species during the 2013 effort, incidental observations of these species were noted. Microhabitat use observations were collected for all seven of the high priority species and three of the five moderate priority species (Table 5.5-1). For the two moderate priority species (Dolly Varden and eulachon) for which no HSC measurements were collected in 2013, the next year sampling effort will target areas of known use (upstream of Devils Canyon and downstream of Three Rivers Confluence) to improve the chance of detection.

6.5.2. HSC/HSI Study Site Selection

A substantial effort was made in 2013 directed toward collection of HSC/HSI data. However, issues related to access and flow caused delays in habitat mapping that precluded sampling in the Lower River Segment and upper portion of the Middle River Segment of the Susitna River. Site access restrictions for the upstream-most Focus Areas (FA-151 [Portage Creek], FA-173 [Stephan Lake Complex], and FA-184 [Watana Dam]) in the Middle River Segment prevented these areas from being sampled in 2013. For the seven Focus Areas that were sampled in 2013, 68 sampling segments were selected within which data were collected in accordance with the Study Plan (ISR Study 8.5, Section 5.5).

6.5.3. Collection of Site-Specific Microhabitat Utilization and Availability Data

Field data collection in 2013 was completed during 210 unique sampling events and included 1,443 measurements of microhabitat use and 3,297 habitat availability measurements in mainstem and off-channel habitats in the Middle River Segment of the Susitna River. Collection of both microhabitat use and availability data will allow for development of site-specific HSC/HSI curves for most if not all of the moderate and high priority species. Of the eleven species (round and humpback whitefish observations combined) for which microhabitat use measurements were collected, seven species had more than 100 unique observations.

6.5.4. Habitat Utilization Frequency Histograms

Frequency distributions (i.e., histograms) were generated for mean velocity, depth, and substrate use 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. For a subset of HSC frequency distribution plots, data from both the 2013 and 2012 HSC surveys were plotted together to see if patterns of microhabitat use were similar.

6.5.5. Winter Studies

The 2012-2013 winter pilot study was conducted at two Focus Areas, FA-104 (Whiskers Slough) and FA-128 (Slough 8A), that supported salmon spawning in 2012 and contained a diversity of main channel and off-channel habitats. The close proximity of FA-104 (Whiskers Slough) to Talkeetna allowed greater time allotment on field data collection relative to logistic support demands (e.g., remote camp construction and travel). Winter studies data collection during the next winter season will be conducted at additional sites as described in ISR Study 8.5, Section 7.5.

6.5.6. Stranding and Trapping

There were no formal stranding and trapping surveys completed in 2013. AEA will discuss the need for stranding and trapping surveys with the resource agencies. If stranding and trapping surveys are not needed, ramping criteria developed in Washington State (Hunter 1992) will be proposed as fallback criteria during effects analyses.

6.5.7. River Productivity

AEA implemented data collection methods for developing HSC/HSI models for invertebrates as described in the River Productivity Study Plan with no variances. However, laboratory results from a majority of the samples collected in 2013 were not available for inclusion in the ISR. These results are scheduled to be available in 2014, at which time HSC/HSI model development will begin. Initial models will be presented as part of the Proof of Concept discussions in 2014.

6.5.8. Interim Periodicity Tables

Detailed interim periodicity tables were developed for all twelve of the high and moderate priority ranked species. In many cases, distinctions were made between differences in timing of habitat use within a river segment and between river segments. There were no variances from the Study Plan. The interim periodicity tables will be reviewed for possible revisions as data from other fisheries studies become available. Final species and life stage periodicity will be used as part of the Project effects analysis.

6.5.9. Biological Cues

The Biological Cues analysis identified several weak to moderate correlations between productivity or run timing metrics and hydrologic indices for the Taku and Stikine rivers. For the Taku River, observed relationships were as follows:

- There are more returns per spawner when there are high winter flows combined with no large summer flow decreases that could result in trapping events.
- There are more smolts per spawner when the summer low flow is moderate or relatively high.
- The duration of the Chinook run is longer when flows are more variable.

For the Stikine River, observed relationships were as follows:

- Total returns tend to be higher when the winter minimum flow is higher.
- Total returns tend to be lower when PDO is higher during early ocean rearing.
- There tend to be fewer smolts per spawner when there are large flow decreases during the spawning period.
- The duration of the Chinook run is longer when flows are more variable.
- The median date of the run is earlier when there are late high flows.

In general, significant correlations were inconsistent for similar indices analyzed from the Taku River and Stikine River datasets. Thus, applying the results from the Taku or Stikine rivers to other Chinook salmon populations, such as in the Susitna River, could be erroneous and should be done with caution.

6.5.10. Relationship Between Microhabitat Use and Fish Abundance

In the Study Plan Determination (FERC 2013b), 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. At this time, most of the data necessary to complete this analysis are not available. It is anticipated that most if not all of the data will be available from the various studies in 2014 and that preliminary results of the analysis will be available for presentation as part of the Proof of Concept. This will provide sufficient time to adjust the HSC/HSI data collection efforts to add any variables found to exhibit relationships with fish.

6.6. Habitat-Specific Model Development

During 2013, the objectives of developing Habitat-Specific Models were met via the selection of hydraulic and habitat models and collection of data to support those models. Data analysis and model calibrations were likewise initiated in 2013 and preliminary model results presented to the TWG during the IFS-TT Riverine Modelers Meeting on November 13-15, 2013. Model development is on schedule and a more complete presentation of preliminary results will be provided during Proof of Concept discussions in 2014.

6.6.1. Habitat Model Selection

The selection of habitat models for both the Middle River Segment and Lower River Segment of the Susitna River was successfully completed in 2013. For the Middle River Segment, 2-D hydraulic models were selected for application within each Focus Area, to be coupled with appropriate HSC/HSI Supplemental analysis within the Middle River Segment may also be provided via 1-D hydraulic and PHABSIM analysis of data collected at selected cross-sections. For the Lower River Segment, a 1-D hydraulic model based PHABSIM analysis was selected.

6.6.2. Field Coordination and Collection of Physical and Hydraulic Data

6.6.2.1. Boundary Conditions

As noted in ISR Study 8.5, Section 5.6., AEA identified the upstream and downstream boundaries as well as the lateral extents of the Focus Areas within the Middle River Segment for the hydraulic and bed evolution modeling. Considerations included encompassing potential inflow and outflow points to preserve the mass balance and minimize difficulties and assumptions associated with inflow points.

6.6.2.2. 2-D Modeling

Data collection for 2-D habitat modeling was completed in seven Focus Areas in 2013. Data collection for the remaining three Middle River Segment Focus Areas is planned for the next year of study prior to the USR. Data for the seven Focus Areas between PRM 104 and PRM 145 in 2013 (ISR Study 6.6 and ISR Study 8.5, Section 4.4) were primarily collected by survey crews for the 2-D hydraulic models. Field crews collected substrate and cover data at these same seven Focus Areas in 2013. The survey data included topography, bathymetry, stage-discharge measurements and velocity profiles. Evaluation of the adequacy of the 2013 field data to support modeling efforts will be conducted during model calibration. If data gaps or additional data needs are identified, the information can be collected prior to the USR. Data collection for the remaining three Focus Areas is planned for the next year of study prior to the USR.

6.6.2.3. 1-D Single Transect Modeling

The collection of field data for the development of hydraulic models for the Lower River Segment sites in 2013 was based on an approach to collect channel geometry, water surface elevation and velocity profile data at a single discharge with water surface elevations surveyed at two additional flow conditions. The 2013 study effort concentrated on sites located in and near Trapper Creek and within Birch Creek Slough, as well as the main channel Susitna River near PRM 97. During the next year of study, sites will be established and measured within Sheep Creek Slough, Caswell Creek, and within main channel and side channel areas of the Susitna River near PRM 66 through 68. The single discharge approach requires an assumption of a stable bed profile amongst all of the field surveys, which may be difficult to uphold for the main channel and bar island complex habitats areas where within year channel changes were observed at several locations during the 2013 field surveys. Evaluation of the adequacy of the 2013 field data to support modeling efforts will be conducted during model calibration. If data gaps or additional data needs are identified, the information can be collected during the next year of study.

6.6.3. Model Development

6.6.3.1. 2-D Modeling

Calibration of the 2-D hydraulic models for the Middle River Segment Focus Areas was initiated but not completed in 2013. This schedule is consistent with the Study Plan that identified hydraulic model calibration would occur after the ISR but before the USR. AEA completed and presented preliminary 2-D modeling results of one Focus Area (FA-104 [Whiskers Slough]) at the November 13-15, 2013 IFS-TT Riverine Modelers Meeting. That analysis was based on the SRH – 2D model, which is one of two models (the second model is River2D) being evaluated for use in the geomorphology studies (ISR Study 6.6).

AEA also developed the conceptual framework for the 2-D habitat analysis in 2013 that includes a tabular and spatial analysis framework. That framework was presented and discussed at the November 13-15, 2013 IFS-TT Riverine Modelers meeting. The framework uses both a VB model and GIS tool; the VB model automates some of the analysis sequence and can be applied to all species/life stages over the extent of the 2-D model domain; the GIS tool can be applied to either the entire model domain or selected smaller spatial areas within the model domain. The VB model and GIS are necessary since the SRH-2D model does not include a direct simulation of habitat and both SRH-2D and River2D do not include a means to analyze areas smaller than the entire model domain. River2D contains a habitat simulation component but only for the use of HSC data with physical parameters of depth, velocity or channel index paired with a suitability index. River2D cannot directly compute habitat area from an HSC equation. The VB model and GIS tool can calculate habitat use from an HSC equation which can then be applied within the 2D-hydraulic model(s).

6.6.3.2. 1-D Single Transect Modeling

Results of the initial calibration runs of the HEC-RAS model indicate it is the appropriate model for meeting the study objectives of providing water level predictions over the range of simulated discharges required to assess project impacts. Final calibrations will be made in 2014, with results presented during the Proof of Concept discussions. Those calibrations will rely on the next version (Version 2) of the Open-water Flow Routing Model (ISR Study 8.5, Section 5.3) Version 2 of the Open-water Flow Routing Model update will include additional transects in the vicinity of the fish habitat sites that can be used for set-up and calibration.

6.6.4. Fish Habitat Evaluation Metrics

The development of fish habitat evaluation metrics was initiated in 2013 and is on schedule for completion. These metrics are dependent on inputs from a variety of other studies and models including the 2-D and 1-D hydraulic models; HSC/HSI studies (ISR Study 8.5, Section 5.5 and 6.5); Geomorphology models (ISR Study 6.6); Ice processes studies and models (ISR Study 7.6), Groundwater analysis (ISR Study 7.5) and Water quality models (ISR Study 5.6).

6.6.4.1. Weighted Useable Area

Weighted useable area metrics and flow relationships will be generated using select priority species and life stages of fish and macroinvertebrates identified for the Middle and Lower River segments and in a basic time series analysis for assessing differences among existing and Project flow scenarios. Final HSC/HSI data are not yet available. Weighted useable area curves may also be generated for certain species and life stages at selected transects within the Middle River Segment (ISR Study 8.5, Section 5.6).

6.6.4.2. Effective Spawning / Incubation Habitat Analyses

An overview of the general approach for and a specific example of the Effective Spawning/Incubation Habitat Analyses was presented and discussed during the November 13-15, 2013 IFS TT Riverine Modelers Meeting on November 13-15, 2013. This approach will be further refined in 2014 and presented in detail in the Proof of Concept.

6.6.4.3. Varial Zone Modeling

Varial zone modeling of the Focus Areas will begin when calibrated 2-D hydraulic models are completed. Varial zone modeling will use the 2-D hydraulic model output to determine water surface elevation at each simulation flow throughout each Focus Area.

6.6.4.4. Breaching Flows and Habitat Connectivity

Breaching flow analysis will be conducted during the next year of study in conjunction with Focus Area hydraulic modeling. The breaching flow analysis will require iterative hydraulic model runs to determine the breaching flows in each Focus Area. This will be accomplished by closely coordinating with the 2-D hydraulic modelers on the simulation flows needed to determine breaching.

An assessment of breaching flows, fish barriers and connectivity within Lower River Segment study sites was not conducted in 2013 and will be completed during the next year of study. The approach being proposed is to apply simulated cross-sectional averaged depth and velocity conditions at each of the lower river fish habitat transects as an indicator of changes to breaching, fish passage and connectivity in terms of frequency, timing and duration based on specific depth and velocity criteria to be developed as part of ISR Study 9.12.

6.7. Temporal and Spatial Habitat Analyses

Several general approaches for completing the Fish and Aquatics IFS temporal and spatial habitat analyses were discussed at the November 13-15, 2013 IFS-TT Riverine Modelers Meeting on. These approaches will be further discussed with the TWG in 2014 and finalized and presented during the Proof of Concept.

6.8. Instream Flow Study Integration

Although most work on study integration will not take place until the next year of study, AEA initiated the process of building a DSS framework in 2013. 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 decision-making, with the possible consideration of addressing uncertainties in a decision analysis framework. AEA does not intend to produce stand-alone software for the DSS. Work on the DSS will continue in 2014.

7. COMPLETING THE STUDY

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

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9. TABLES

Table 4.2-1. Geomorphic reach designations for the Upper River (UR) Segment, Middle River (MR) Segment, and Lower River (LR) Segment of the Susitna River.

Reach Designation	Reach Breaks (PRM) Upstream	Reach Breaks (PRM) Down-stream	Reach Classification	Slope (ft/mi)	Lateral Constraints
Upper Susitna River Segment (UR)					
UR-1	261.3	248.6	SC2	NA	Quaternary Basin Fill
UR-2	248.6	234.5	SC1	NA	Quaternary Basin Fill
UR-3	234.5	224.9	SC1	NA	Quaternary Basin Fill
UR-4	224.9	208.1	SC2	NA	Granodiorite
UR-5	208.1	203.4	SC1	NA	Quaternary Basin Fill
UR-6	203.4	187.1	SC2	NA	Quaternary Basin Fill
Middle Susitna River Segment (MR)					
MR-1	187.1	184.6	SC2	9	Tertiary-Cretaceous Gneiss
MR2	184.6	169.6	SC2	10	Cretaceous Kahiltna Flysch Tertiary-Cretaceous Gneiss
MR-3	169.6	166.1	SC2	17	Paleocene Granites
MR-4	166.1	153.9	SC1	30	Paleocene Granites
MR-5	153.9	148.4	SC2	12	Cretaceous Kahiltna Flysch
MR-6	148.4	122.7	SC3	10	Cretaceous Kahiltna Flysch with undifferentiated Upper Pleistocene moraines, kames, lacustrine deposits
MR-7	122.7	107.8	SC2	8	Cretaceous Kahiltna Flysch with undifferentiated Upper Pleistocene moraines, kames, lacustrine deposits
MR-8	107.8	102.4	MC1/SC3 (Reach is a transition from SC3 to MC1 as the Three Rivers Confluence is approached)	8	Upper Pleistocene moraines, outwash and Holocene Alluvial Terrace deposits
Lower Susitna River Segment (LR)					
LR-1	102.4	87.9	MC1	5	Upper Pleistocene Outwash, Moraine and Lacustrine deposits
LR-2	87.9	65.6	MC2/MC3	5	Upper Pleistocene Outwash, Moraine and Lacustrine deposits
LR-3	65.6	44.6	MC3	4	Upper Pleistocene Glaciolacustrine deposits
LR-4	44.6	32.3	MC2	2	Upper Pleistocene Glaciolacustrine deposits
LR-5	32.3	23.5	SC2	2	Upper Pleistocene Glaciolacustrine and Moraine deposits and Late Cretaceous granodiorite
LR-6	23.5	3.3	MC4	1.4	Upper Pleistocene Glaciolacustrine and Holocene Estuarine deposits

Table 4.2-2. Nested and tiered habitat mapping units, categories, and definitions.

Level	Unit	Grouping	Category	Definitions
1	Major Hydrologic Segment	Segments	Upper, Middle, Lower River	*Upper River* – PRM –187.1 – 261.3 (habitat mapping extended up to mainstem PRM 235.1 and included the Oshetna River. *Middle River* – PRM –102.4 – 187.1 *Lower River* – PRM 0 – 102.4
2	Geomorphic Reach	Upper River Segment	6 reaches	Geomorphic reaches that uniquely divide the Major Hydrologic Segments based on geomorphic characteristics.
		Middle River Segment	8 reaches	
		Lower River Segment[1]	6 reaches	
3	Macrohabitat	Mainstem Habitat	Main Channel	Single dominant main channel.
			Split Main Channel	Two dominant channels.
			Multiple Split Main Channel	Three or more distributed dominant channels.
			Side Channel	Channel that is turbid and connected to the active main channel but represents non-dominant proportion of flow[1]
			Tributary Mouth	Clear water areas that exist where tributaries flow into Susitna River main channel or side channel habitats (upstream Tributary habitat will be mapped as a separate effort).
		Off-Channel Habitat[2]	Side Slough	Overflow channel contained in the floodplain, but disconnected from the main channel. Surveyed when flows < 18,000 cfs or at higher flows if there was no evidence of breaching. Had clear water.[3,4]
			Upland Slough	Similar to a side slough, but contains a vegetated bar at the head that is rarely overtopped by mainstem flow. Has clear water.[1].
		Tributary Habitat	Single Channel	Single dominant channel
			Split Channel	Two dominant channels
			Channel complex	Three or more distributed dominant channels

Level	Unit	Grouping	Category	Definitions
4	Mesohabitat	Fast water	Rapid	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0 percent slope.[2]
			Riffle	A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section. Low gradient; usually 0.5-2.0 percent slope.[2]
			Run	A habitat area with minimal surface turbulence over or around protruding boulders with generally uniform depth that is generally greater than the maximum substrate size.[2] Velocities are on border of fast and slow water. Gradients are approximately 0.5 percent to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[2]
			Glide	An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 percent slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[2]
		Slow Water	Pool	Slow water habitat with minimal turbulence and deeper due to a strong hydraulic control.
		Special Habitat Feature	Clearwater Plume	Discharge from a tributary that forms a pronounced area of clearwater, in contrast to the turbid water of the main channel, along the main channel shoreline. The length, breadth, and depth of the clearwater plume depend on the relative discharge between the tributary and the main channel, relative turbidity, and on mixing conditions along the shoreline. A clear water plume will be mapped as if it were a separate mesohabitat type.
			Backwater	Found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear. A backwater will be mapped as if it were a separate mesohabitat type.
			Beaver Complex	Complex ponded water body created by beaver dams. A beaver dam will be mapped as if it were a separate mesohabitat type.
		Tributary Mesohabitat		Tributary mesohabitats were typed using the classification system described in Table 1.1-2

Notes:

1 For the purposes of this ISR, classification of the Lower River segment stopped at Level 2. A classification system for the Lower River segment is still in development pending determination of Project effects in the Lower River.

2 All habitat within this designation received an additional designation of whether water was clear or turbid within the database.

3 The terms Side Channel, Slough, and Upland Slough are similar but not necessarily synonymous with the terms for macrohabitat type as applied by Trihey (1982) and ADF&G (1983a).

4 All slough habitat will have an associated area created during the mapping process to better classify size.

5 Adapted from Moore et al. 2006.

Table 4.2-3. Locations, descriptions and selection rationale of 10 Final Focus Areas identified for detailed study in the Middle River Segment of the Susitna River. Focus Area identification numbers (e.g., Focus Area 184) represent the truncated Project River Mile (PRM) at the downstream end of each Focus Area.

Focus Area ID	Common Name	Description	Geomorphic Reach	Location (PRM)		Area Length (mi)	Habitat Types Present							Fish Use in 1980s		Instream Flow Studies in 1980s			Rationale for Selection
				Upstream	Downstream		Main Channel, Single	Main Channel, Split	Main Channel, Multiple Split	Side Channel	Side Slough	Upland Slough	Tributary	Spawning	Rearing	IFG	DIHAB	RJHAB	
FA-184	Watana Dam	Area approximately 1.4 miles downstream of dam site	MR-1	185.7	184.7	1.0	X			X				N/A	N/A	N/A	N/A	N/A	FA-184 length comprises 40% of MR-1 reach length (2.5 miles long) and contains split main channel and side channel habitat present in this reach.
FA-173	Stephan Lake Complex	Wide channel near Stephan Lake with complex of side channels	MR-2	175.4	173.6	1.8	X			X	X	X	X	N/A	N/A	N/A	N/A	N/A	FA-173 contains a complex of main channel and off-channel habitats within wide floodplain. Represents greatest channel complexity within MR-2. Reach MR-2 is 15 miles long and channel is generally straight with few side channels and moderate floodplain width (2-3 main channel widths).
FA-151	Portage Creek	Single channel area at Portage Creek confluence	MR-5	152.3	151.8	0.5	X						X	X	X				FA-151 is a single main channel and thus representative of the confined Reach MR-5. Portage Creek is a primary tributary of the Middle Segment and the confluence supports high fish use.
FA-144	Slough 21	Side channel and side slough complex approximately 2.3 miles upstream Indian River	MR-6	145.7	144.4	1.3	X			X	X	X	X	X	X	X			FA-144 contains a wide range of main channel and off-channel habitats, which are common features of Reach MR-6. Side Channel 21 is a primary salmon spawning area. Reach MR-6 is 26 miles long (30% of Middle Segment length) and is characterized by a wide floodplain and complex channel morphology with frequent channel splits and side channels.
FA-141	Indian River	Area covering Indian River and upstream channel complex	MR-6	143.4	141.8	1.6	X		X	X		X	X	X	X		X		FA-141 includes the Indian River confluence and a range of main channel and off-channel habitats. High fish use of the Indian River mouth has been documented and DIHAB modeling was performed in main channel areas in the 1980s. Studies in the 1980s did not document high fish use of lateral habitats on the right bank upstream of the Indian River confluence.
FA-138	Gold Creek	Channel complex including Side Channel 11 and Slough 11	MR-6	140	138.5	1.5	X		X	X	X	X		X	X	X			The FA-138 primary feature is a complex of side channel, side slough and upland slough habitats, each of which support high adult and juvenile fish use. Complex channel structure of FA-138 is characteristic of Reach MR-6. IFG modeling was performed in side channel habitats in the 1980s.
FA-128	Slough 8A	Channel complex including Slough 8A and Skull Creek side channel	MR-6	129.7	128.1	1.6	X			X	X	X	X	X	X	X	X		FA-128 consists of side channel, side slough and tributary confluence habitat features that are characteristic of the braided MR-6 reach. Side channel and side slough habitats support high juvenile and adult fish use and habitat modeling was completed in side channel and side slough habitats.
FA-115	Slough 6A	Area 0.6 miles downstream of Lane Creek, including Upland Slough 6A	MR-7	116.5	115.3	1.2	X	X		X		X	X		X	X		X	FA-115 contains side channel and upland slough habitats that are representative of MR-7. Reach MR-7 is a narrow reach with few braided channel habitats. Upland Slough 6A is a primary habitat for juvenile fish and habitat modeling was done in side channel and upland slough areas.
FA-113	Oxbow 1	Oxbow 1 Complex and Upstream Area	MR-7	115.3	113.6	1.7	X	X		X		X	X	X	X				FA-113 was added in response to Agency comments that important fish habitat area was underrepresented in MR-7. Oxbow I is an important chum salmon rearing area.
FA-104	Whiskers Slough	Whiskers Slough Complex	MR-8	106	104.8	1.2	X			X	X	X	X	X	X	X	X	X	FA-104 contains diverse range of habitat, which is characteristic of the braided, unconfined Reach MR-8. FA-104 habitats support juvenile and adult fish use and a range of habitat modeling methods were used in side channel and side slough areas.

Table 4.2-4. Summary of Potential Effects of With-Project Flows on Tributaries of the Lower Susitna River from 1980s studies, and tributary mouths proposed for modeling in 2013 (indicated by highlighting) (1980s summary adapted from Ashton and Trihey (1985)).

Tributary	Project River Mile (approx.)	Geomorphic Reach	Location of Tributary Mouth in		Effects of With-Project Flows on			
					Fish Access into Tributaries at 21,000 cfs (USGS Sunshine Gage 15292780)		Reduction in Backwater Area during June/July	
			Side Channel	Main Channel	Potential Passage Problem	No Passage Problem	Moderate Change	Slight Change
Trapper Cr.	95.4	LR-1	X		X		X	
Birch Cr.	93.3	LR-1		X		X	X	
Sunshine Cr.	88	LR-1	X			X	X	
Rabideaux Cr.	87.2	LR-2	---	---		X	X	
Montana Cr.	81	LR-2		X	X			X
Goose Cr.	76.8	LR-2	X		X			X
Sheep Cr.	71.7	LR-2	X			X	X	
Caswell Cr.	67.3	LR-2	X		X		X	
Kashwitna R.	64.7	LR-3	X			X		X
Little Willow Cr.	54.5	LR-3	X			X	X	
Willow Cr.	52.1	LR-3	X			X		X
Deshka R.	44.9	LR-3		X		X	X	
Alexander Cr.	13.7	LR-6	X			X	X	

Table 4.3-1. Susitna Real-Time Reporting Network Stations.

Site Name	Short Name	Parameters
Upper Segment AEA Gaging Stations		
15291500 Susitna River Near Cantwell	ESS80	discharge, water level, water and air temperature, camera
Middle Segment AEA Gaging Stations		
Susitna River Below Deadman Creek	ESS70	discharge, water level, water and air temperature, camera
Susitna River Below Fog Creek	ESS65	discharge, water level, water and air temperature, camera
Susitna River Above Devil Creek	ESS60	discharge, water level, water and air temperature, camera
Susitna River Below Portage Creek	ESS55	discharge, water level, water and air temperature, camera
Susitna River at Curry	ESS50	discharge, water level, water and air temperature, camera
Susitna River Below Lane Creek	ESS45	discharge, water level, water and air temperature, camera
Susitna River Above Whiskers Creek	ESS40	discharge, water level, water and air temperature, camera
Lower Segment AEA Gaging Stations		
Susitna River at Chulitna River	ESS35	discharge, water level, water and air temperature, camera
Susitna River Below Twister Creek	ESS30	discharge, water level, water and air temperature, camera
15294350 Susitna River at Susitna Station	ESS20	discharge, water level, water and air temperature, camera
Susitna River Near Dinglishna Hill	ESS15	water level, water and air temperature, camera
Susitna River Below Flat Horn Lake	ESS10	water level, water and air temperature, camera
Repeater Stations		
Mount Susitna Near Granite Creek	ESR1	air temperature
Repeater, East of ESM1, First Potential Site	ESR2	air temperature
Repeater, Dam Site to Glacial Repeater	ESR3	air temperature
Curry Ridge near McKenzie Creek Repeater	ESR4	air temperature
Curry Pt. To State Park Repeater	ESR5	air temperature, camera
State Park over Devils Canyon Repeater	ESR6	air temperature, camera
Portage Creek Repeater	ESR7	air temperature
ESR2 to ESS80, ESM2 link	ESR8	air temperature
Base Stations		
Talkeetna Base Station	ESB2	N/A

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. Summary of gaging stations established on Susitna River in 2012.

Gaging Station	Project River Mile	Segment
Susitna River near Cantwell (ESS80)	225.0	Upper Susitna River
Susitna River below Deadman Creek (ESS70)	187.1	Middle Susitna River (above Devils Canyon)
Susitna River below Fog Creek (ESS65)	176.5	
Susitna River above Devil Creek (ESS60)	168.1	
Susitna River above Portage Creek (ESS55)	152.2	Middle Susitna River (below Devils Canyon)
Susitna River at Curry (ESS50)	124.1	
Susitna River below Lane Creek (ESS45)	116.6	
Susitna River above Whiskers Creek (ESS40)	107.2	
Susitna River at Chulitna River (ESS35)	102.1	
Susitna River below Twister Creek (ESS30)	98.4	Lower Susitna River
Susitna River at Susitna Station (ESS20)	29.9	
Susitna River near Dinglishna Hill (ESS15)	24.7	
Susitna River below Flat Horn Lake (ESS10)	17.4	

Notes:

1 ESS = AEA Susitna River Surface-Water Station.

Table 4.3-3. Tributary gaging site information.

Tributary Name	Susitna PRM	Gage Site Type	Elevation (ft)	Latitude	Longitude
Oshetna River	235.1	Continuous	2173	62.628520	-147.369830
Kosina Creek	209.1	Continuous with barologger	1911	62.755970	-147.955150
Unnamed Tributary 144.6	144.6	Spot	750	62.803980	-149.591350
Indian River	142.1	Continuous	775	62.800826	-149.664417
Skull Creek	128.1	Continuous with barologger	599	62.657530	-149.932540
Gash Creek	115	Continuous	460	62.504288	-150.104018
Slash Creek	114.9	Spot	452	62.503202	-150.103737
Unnamed Tributary 113.7	113.7	Continuous	455	62.486316	-150.093785
Whiskers Creek	105.1	Continuous with barologger	370	62.378096	-150.170806
Trapper Creek	95.4	Continuous	310	62.257540	-150.172762
Susitna River at Trapper Creek	95.4	Continuous stage only	306	62.253622	-150.168375
Birch Creek	93.3	Continuous	307	62.250468	-150.089622
Susitna River at Birch Creek Slough	92.6	Continuous stage only	291	62.223373	-150.116821
Deshka River	44.9	Continuous with barologger	83	61.754230	-150.328540
Susitna River at Deshka River	44.9	Continuous stage only	78	61.696491	-150.313659

Table 4.3-4. Period of record of flows measured by the USGS on the Susitna River.

Gage Number	Site	Project River Mile	Drainage Area (mi^2)	Latitude	Longitude	Elevation (ft, NGVD 29)	Period of Record of Measured Flows
15291000	Susitna River near Denali	291.8	950	63.10389	147.51583	2,440	27 years: 1957-1976; 1978-1986
15291500	Susitna River near Cantwell	225.0	4,140	62.69861	147.54500	1,900	17 years: 1961-1972; 1980-1986
15292000	Susitna River at Gold Creek	140.0	6,160	62.76778	149.69111	677	57 years: 1949-1996; 2001-2011
15292780	Susitna River at Sunshine	87.9	11,100	62.17833	150.17500	270	5 years: 1981-1986
15294350	Susitna River at Susitna Station	29.9	19,400	61.54472	150.51250	40	19 years: 1974-1993

Table 4.3-5. Period of record of flows measured by the USGS on tributaries of the Susitna River.

Gage Number	Site	Susitna River PRM at Confluence	Drainage Area (mi^2)	Latitude	Longitude	Elevation (ft, NGVD 29)	Period of Record of Measured Flows
15291200	Maclaren River near Paxson	261.1	280	63.11944	146.52917	2,866	28 years: 1958-1986
15292400	Chulitna River near Talkeetna	102.4	2,570	62.55861	150.23389	520	20 years: 1958-1972; 1980-1986
15292700	Talkeetna River near Talkeetna	100.3	1,996	62.34694	150.01694	400	47 years: 1964-2011
15294005	Willow Creek Near Willow	52.1	166	61.78083	149.88444	350	25 years: 1978-1993; 2001-2011
15294345	Yentna River near Susitna Station	31.4	6,180	61.69861	150.65056	80	6 years: 1980-1986

Table 4.4-1. Comparison of the content contained in the three versions of the hydraulic routing model.

Model Component	**Version 1**	**Version 2**	**Version 3**
Extent	PRM 80-187.2	PRM 29.9-187.2	PRM 29.9-187.2
Number of Cross-sections	88	167	212
WSE/Q Measurements	120	419	486
Accretion	Hourly	Hourly	Hourly
Diurnal Fluctuations	None	Partial	Complete
Floodplain coverage	None	None	Extended using LiDAR
Calibration/Validation Data	5 gages 15291700 15292000 15292780 15292400 15292700	7 gages 15291700 15292000 15292780 15294350 15292400 15292700 15294345	7 gages 15291700 15292000 15292780 15294350 15292400 15292700 15294345

Table 4.4-2. Summary of 2012-2013 surface water data collected at selected ESS stations in the Susitna River. ESS = AEASusitnaSurface water measurements.

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	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, Jan – May 2013	Oct 2012, 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 – Oct 2012, Aug – Dec 2013	Aug – Oct 2012, Aug – Dec 2013	Complete	Yes	Yes	IFS, Ice Processes, Geomorphology, Water Quality, Groundwater
ESS45	116.6	Aug 2012 – May 2013, Aug – Dec 2013	Aug 2012 – May 2013, Aug – Dec 2013	Complete	Yes	Yes	IFS, Ice Processes, Geomorphology, Water Quality, Groundwater
ESS40	107.2	Aug 2012 – May 2013, Aug – Dec 2013	Aug 2012 – May 2013, 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	Complete	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 – Oct 2012; Oct – Dec 2013	Aug – Oct 2012; Oct – Dec 2013	Complete	Yes	Yes	Ice Processes, Beluga

Table 4.5-1. Common names, scientific names, life history strategies, and habitat use of fish species within the Lower, Middle, and Upper Susitna River, based on sampling during the 1980s (from HDR 2011).

Common Name	Scientific Name	Life History	Susitna Usage
Chinook salmon	*Oncorhynchus tshawytscha*	A	M2, R
Chum salmon	*Oncorhynchus keta*	A	M2, S
Coho salmon	*Oncorhynchus kisutch*	A	M2, S, R
Pink salmon	*Oncorhynchus gorbuscha*	A	M2
Sockeye salmon	*Oncorhynchus nerka*	A	M2, S
Arctic grayling	*Thymallus arcticus*	F	O, R, P
Alaska blackfish	*Dallia pectoralis*	F	U
Arctic lamprey	*Lethenteron japonicum*	A,F	O, M2, R, P
Bering cisco	*Coregonus laurettae*	A	M2, S
Burbot	*Lota lota*	F	O, R, P
Dolly Varden	*Salvelinus malma*	A,F	O, P
Eulachon	*Thaleichthys pacificus*	A	M2, S
Humpback whitefish	*Coregonus pidschian*	A,F	O, R, P
Lake trout	*Salvelinus namaycush*	F	U
Longnose sucker	*Catostomus catostomus*	F	R, P
Northern pike	*Esox lucius*	F	P
Pacific lamprey	*Lampetra tridentata*	A,F	U
Rainbow trout	*Oncorhynchus mykiss*	F	O, M2, P
Round whitefish	*Prosopium cylindraceum*	F	O, M2, P
Sculpin	*Cottid spp.*	M1, F	P
Threespine stickleback	*Gasterosteus aculeatus*	A,F	M2, S, R, P

Notes:

A = anadromous

M1 = marine

F = freshwater

O=overwintering

R=rearing

P=present

M2 = migration

S=spawning

U=unknown

Table 4.5-2. Priority ranking of fish species for development of site-specific Habitat Suitability Curves for the Susitna River, Alaska.

Common Name	Low	Moderate	High
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 4.5-3. Summary of HSC curves developed during 1980s Susitna Studies.

Species	Life Stage	Depth	Velocity	Substrate	Upwelling	Cover	Turbidity[4]
Coho	Juvenile	✓[1]	✓			✓	
Chinook	Spawning	✓	✓	✓			
	Juvenile	✓[1]	✓			✓	✓
Sockeye	Spawning	✓	✓	✓			
	Juvenile	✓[1]	✓			✓	
Chum	Spawning	✓	✓	✓	✓[3]		
	Juvenile	✓[1]	✓			✓	
Pink	Spawning	✓	✓	✓	✓[3]		
Rainbow Trout	Spawning	✓	✓	✓			
Dolly Varden	Adult	✓[2]	✓			✓	✓
Arctic Grayling	Adult	✓[2]	✓			✓	✓
Humpback Whitefish	Juvenile	✓	✓			✓	✓
Round Whitefish	Adult	✓[2]	✓			✓	✓
Longnose Sucker	Adult	✓[2]	✓			✓	✓
Burbot	Adult	✓	✓			✓	✓

Notes:

1,2 Depth curves for multiple species combined

3 Integrated with substrate suitability

4 Separate curves developed for clear vs. turbid water for one or

Table 4.5-4. Summary of habitat units selected from within each Focus Area for HSC sampling in 2013.

Macrohabitat	Known Fish Use	FA-104	FA-113	FA-115	FA-128	FA-138	FA-141	FA-144	Total
Main Channel	No	2	1	1	2	2	1	2	11
	Yes						1		1
Side Channel	No	2	1	1	2	2	1	2	11
	Yes		1		2	1		2	6
Side Slough	No	2				2			4
	Yes	2				2		2	6
Side Slough Beaver Complex	Yes				2				2
Upland Slough	No	2	1	1	2	2		2	10
	Yes	2					1		3
Upland Slough Beaver Complex	No			1			1		2
Tributary	No	2	1						3
	Yes		1				1		2
Tributary Mouth	No		1						1
	Yes				2		1		3
Plume	Yes						1		1
Backwater	No						1		1
	Yes			1					1
Total		14	7	5	12	11	9	10	68

Notes:

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)

Table 4.5-5. Substrate classification system used in development of HSC/HSI curves for the Susitna-Watana Project (adapted from Wentworth 1922).

Substrate Code	Substrate Type	Size (Decimal Inches)	Size (mm)
1	Silt, Clay, or Organic	<0.01	<1
2	Sand	0.05-0.1	1-2
3	Small Gravel	0.1-0.6	2-16
4	Large Gravel	0.6-2.5	16-64
5	Small Cobble	2.5-5.0	64-128
6	Large Cobble	5.0-10.0	128-256
7	Boulder	>10.0	>256
8	Bedrock		

Table 4.5-6. Summary of velocity meter and water quality probe specifications.

Parameter	Instrument(s)	Units	Range	Accuracy	Precision
Temperature	YSI ProPlus and Hach HQ40d	˚C	0-70	±0.3	0.1
Dissolved oxygen		mg/L	0-20	±0.2	0.01
Specific conductance		µS/cm	0.1-400	±0.5	0.01
Water velocity	USGS Type AA (Price)	m/s	0.05 – 20	±1-6%	--
Turbidity	Hach 2100P	NTU	0-1000	±0.2%	0.01

Table 4.6-1. Assessment of physical and biological processes and potential habitat modeling techniques.

Physical and Biological Processes	Habitat Types			
	Mainstem	**Side Channel**	**Slough**	**Tributary Mouths**
Spawning	PHAB/VZM	PHAB	PHAB/HabMap	PHAB/RFR
Incubation	RFR/VZM	PHAB	PHAB/HabMap	PHAB/RFR
Juvenile Rearing	PHAB/RFR	PHAB	PHAB/HabMap	PHAB/RFR
Adult Holding	RFR	RFR	PHAB/HabMap	PHAB/RFR
Macroinvertebrates	VZM/WP	VZM/WP	PHAB/HabMap/WP	N/A
Standing/Trapping	VZM	VZM	VZM/WP	VZM/WP
Upwelling/Downwelling	FLIR	HabMap/FLIR	HabMap/FLIR	HabMap/FLIR
Temperature	WQ	WQ	WQ	WQ
Ice Formation	IceProcesses/WQ/RFR	IceProcesses/WQ/RFR	HabMap/Open leads	N/A

Notes:

1 PHAB-Physical Habitat Simulation Modeling (1-D, 2-D, and empirical); VZM-Effective Spawning and Incubation/Varial Zone Modeling; RFR-River Flow Routing Modeling; FLIR – Forward-looking Infrared Imaging; HabMap-Surface Area Mapping; WQ-Water Quality Modeling; WP-Wetted Perimeter Modeling.

Table 5.2-1. Metrics used to compare the representation and proportionality of habitat types between Focus Areas and non-Focus Areas within each geomorphic reach.

Level[1]	Habitat Type	Comparison Metric	Numerator	Denominator
Macro-Habitat	Main Channel	Percent of main channel that is single unsplit main channel	Length of main channel habitat (HDR)	Total length of main channel (thalweg, R2)
	Split Main Channel	Percent of main channel that is in split main channel	Length of main channel that is in split main channel (R2 calculated)	Total length of main channel (thalweg, R2)
	Braided Main Channel	Percent of main channel that is in braided main channel	Length of main channel that is in braided main channel (R2 calculated)	Total length of main channel (thalweg, R2)
	Side Channel	Side channel length per river mile	Total length of side channels (HDR)	Total length of main channel (thalweg, R2)
	Upland Slough	Upland slough length per river mile	Total length of upland slough habitat (HDR)	Total length of main channel (thalweg, R2)
	Side Slough	Side slough length per river mile	Total length of side channel habitat (HDR)	Total length of main channel (thalweg, R2)
	Backwater	density of backwaters (#/mile)	# backwaters (HDR)	Total length of main channel (thalweg, R2)
	Tributary	density of tributaries (#/mile)	# tributaries (HDR)	Total length of main channel (thalweg, R2)
	Tributary Mouth	density of tributary mouths (#/mile)	# Tributary Mouths (HDR)	Total length of main channel (thalweg, R2)
	Clear Water Plume	density of plumes (#/mile)	# plumes (HDR)	Total length of main channel (thalweg, R2)
Mesohabitat	Glide or Run	Percent of main/side channel habitat in glide/run	Total length of Glide or Run (HDR)	Total Length of Main + Side Channel Habitat (HDR)
	Riffle	Percent of main/side channel habitat in riffle	Total length of Riffle (HDR)	Total Length of Main + Side Channel Habitat (HDR)
	Beaver Complex	Percent of slough habitat that is beaver complex	Total length of Beaver Complex Habitat (HDR)	Total length of slough habitat (HDR)

Notes:

1 The habitat classifications in this table are those reflected in the RSP

Table 5.2-2. Estimated bias for each proportionality metric (total for reach – Focus Area) where estimates could be made. Statistical comparison was made using a t-test or nonparametric alternative when the sample size (number of geomorphic reaches with bias estimate) was greater than three.

	MR-1	MR-2	MR-5	MR-6	MR-7	MR-8	Average Bias	p-value
Main Channel		-5%	-8.7%	-18%	40%	-33%	-5%	0.70
Split Main		5%	8.7%	22.4%	-40%	7%	0.6%	0.63
Braided Main				-4.0%		26%	11%	n/a
Side Channel	-0.33	-0.10		0.021	0.13	-1.02	-0.26	0.28
Side Slough		-0.46	0.155	-0.14	0.13	-0.42	-0.15	0.32
Upland Slough		0.04		-0.02	-0.43	-0.29	-0.1740	0.22
Backwaters		0.07		-0.018	-1.35	0.19	-0.28	1.00
Tributaries		0.18	-1.64	0.337	0.10	-0.66	-0.34	0.41
Tributary Mouth		0.36	-1.46	0.081	0.20		-0.20	0.88
Clear Water Plumes		0.33	-1.64	-0.018	0.07		-0.31	1.00
Beaver Complex				-9.8%	-25%		-18%	n/a
Glides/Runs		-3.3%		4.43%	14.0%	4.0%	4.8%	0.27
Riffles		3.3%		-4.43%	-14.0%	-4.0%	-4.8%	0.27

Table 5.2-3. Identification of existing Focus Area boundaries and counterpart locations of areas selected via a random systematic approach.

Geomorphic Reach	Geomorphic Reach			Focus Area[1]			Random Focus Area		
	Start	End	Length	Start	End	Length	Start	End	Length
MR-1	187.1	184.6	2.5	185.7	184.7	1	186.2	185.2	1
MR-2	184.6	169.6	15	175.4	173.6	1.8	181.4	179.8	1.6
				173	171.6	1.4	175.0	173.4	1.6
MR-5	153.9	148.4	5.5	152.3	151.8	0.5	152.8	152.3	0.5
MR-6	148.4	122.7	25.7	145.7	144.4	1.3	146.8	145.3	1.5
				143.4	141.8	1.6	140.8	139.3	1.5
				140	138.7	1.3	134.8	133.3	1.5
				129.7	128.1	1.6	128.8	127.3	1.5
MR-7	122.7	107.8	14.9	116.5	115.3	1.2	117.8	116.6	1.2
MR-8	107.8	102.4	5.4	106	104.8	1.2	104.9	103.7	1.2

Notes:

1 The Focus Areas used in this analysis were those presented in the RSP.

Table 5.2-4. Estimated bias for each proportionality metric (total for reach – Focus Area) where estimates could be made for random Focus Areas. Statistical comparison was made using a t-test or nonparametric alternative when the sample size (number of geomorphic reaches with bias estimate) was greater than three.

	MR-1	MR-2	MR-5	MR-6	MR-7	MR-8	Average Bias	p-value
Main Channel		17%	-9.5%	-14%	17%	60%	14%	0.34
Split Main		-17%	9.5%	7.5%	-17%	-31%	-9.6%	0.29
Braided Main				6.3%		-28%	-11%	n/a
Side Channel	-0.31	-0.20	0.073	0.018	-0.15	-0.41	-0.16	0.084
Side Slough		0.17		-0.19	0.63	0.58	0.30	0.22
Upland Slough		-0.17	0.17	0.13	-0.39	0.22	-0.0058	0.96
Backwaters		0.07		-0.011	0.20	0.19	0.11	0.12
Tributaries		1.2	0.20	-2.0	-1.1	0.57	-0.22	0.71
Tributary Mouth		0.045	0.40	-0.28	-1.4		-0.32	0.48
Clear Water Plumes		0.33	0.20	-0.011	-0.78		-0.07	0.81
Beaver Complex				7.9%	-68%		-30%	n/a
Glides/Runs		-3.3%	-2.0%	-0.54%	-8.4%	-1.9%	-3.2%	0.078
Riffles		3.3%	2.0%	0.54%	8.4%	1.9%	3.2%	0.078

Table 5.3-1. 2012 and provisional 2013 cross-sectional data (✓ indicate measured WSEs).

PRM	XS Profile Date 1	XS Profile Date 2	June/July 2012			August 2012			Sep/Oct 2012			June/July 2013[2]			August 2013[2]			Sep/Oct 2013[2]		
			Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]
UPPER RIVER (PRM 261.3 - 187.1)																				
225.0	NA		6/14	26,932	NA	8/9	11,260	NA	10/18		1906.26				8/8	11,912	NA	9/3	14,696	NA
187.2	6/17/12		6/17	27,698	1466.42	8/6	14,707	1464.09	9/15	7,838	1461.81									
MIDDLE RIVER (PRM 187.1 - 102.4)																				
186.2	6/18/12		6/18	24,493	1458.50	8/6	14,419	1457.07	9/15	7,630	1455.36									
185.5	6/18/12		6/18	25,389	1452.14	8/6		1450.52	9/15		1449.17									
185.2	6/19/12		6/19	26,676	1449.28	8/6		1447.37	9/15		1445.92									
184.9	6/19/12		6/19	27,619	1446.04	8/6	14,239	1443.72	9/15	7,714	1442.10									
184.4	6/19/12		6/19	27,886	1440.48	8/7	14,775	1437.43	9/15	8,353	1435.55									
183.3	6/20/12		6/20	29,426	1424.86	8/7	14,183	1422.91	9/15	8,310	1421.75									
182.9	6/20/12		6/20	29,128	1418.25	8/7		1416.49	9/15		1415.30									
181.6	6/20/12		6/20	29,645	1402.27	8/7	14,705	1400.11	9/15	8,689	***1398.98***									
179.5	6/21/12		6/21	30,866	1381.40	8/7	14,345	1377.74	9/14	8,361	1375.79									
178.5	6/16/12		6/16	29,756	1370.75	8/7	14,799	1367.82	9/14	8,738	1366.14									
176.5	6/21/12		6/21	31,240	1346.56	8/8	14,559	1344.03	9/16	10,768	1343.18									
174.9	6/21/12		6/21	31,163	1329.91	8/8		1327.53	9/16		1326.88									
173.1	6/21/12		6/21	30,571	1310.65	8/8		1307.89	9/16	11,082	1306.82									
170.1	6/22/12		6/22	31,121	1285.05	8/8	14,568	1282.38	9/16	11,137	1281.59									
168.1	6/22/12		6/22	32,265	1259.50	8/8	14,655	1256.43	9/17	14,619	1256.46									
153.7	6/25/12		6/25	32,162	862.57	8/10	14,588	858.93												
152.9	6/26/12		6/26	30,487	853.72	8/10		850.17												
152.1	6/26/12	9/29/12	6/26	30,036	843.65	8/10	15,351	840.96	9/29	18,488	841.61									
151.1	6/25/12		6/25	33,180	832.09	8/10		827.79	9/29		829.13									
148.3	6/26/12		6/26	32,114	796.39	8/10	14,941	793.54	9/29		794.00									
146.6	6/27/12		6/27	31,030	773.49	8/12		771.94	9/29		772.02									
146.1	8/4/13														8/3 8/4		✓ ✓	9/5		✓
145.7	6/27/12	9/29/12	6/27	31,396	761.96	8/12	17,354	759.65	9/29	18,131	759.86	6/20		✓				9/7		✓
145.5	6/27/12		6/27	31,868	760.04	8/12		757.93				6/20		✓	8/3		✓	9/5		✓
144.9	6/27/12		6/27	31,949	751.50	8/12		749.46	9/29		749.80	6/20		✓						
144.3	6/27/12		6/27	31,121	742.52	8/12		740.68							8/3 8/15		✓ ✓	9/5		✓
143.9	8/4/13											8/3		✓				9/5		✓
143.5	6/28/12		6/28	30,330	732.35	8/12	17,006	730.64	9/29		730.72	7/30		✓						
143.0	6/28/12		6/28	29,492	725.04	8/12		723.49				6/23		✓	8/4		✓	9/5		✓
142.2	6/28/12	9/29/12	6/28	29,753	716.41	8/12	16,798	714.51	9/29	18,301	714.78							9/8		✓
141.9	6/28/12		6/28	30,583	712.88	8/12	16,803	710.84				6/22		✓	8/4		✓	9/5		✓
141.7	6/28/12		6/28	30,555	711.43	8/12		709.09							8/4		✓	9/5		✓
141.2	8/4/13														8/4		✓	9/6		✓
140.8	8/4/13														8/4		✓	9/6		✓
140.5	8/5/13														8/5		✓	9/6		✓
140.0	6/29/12	9/30/12	6/29	30,378	693.77	8/13	16,350	691.69	9/30	17,619	691.94				8/5		✓	9/6		✓
139.8	6/29/12		6/29	29,071	691.34	8/13		689.07							8/5 8/10		✓ ✓	9/6		✓
139.0	6/30/12		6/30	28,039	679.92	8/13	16,449	678.26	9/30		678.50	6/7 6/25		✓ ✓	8/10	15,949	✓	9/6		✓

PRM	XS Profile Date 1	XS Profile Date 2	June/July 2012			August 2012			Sep/Oct 2012			June/July 2013[2]			August 2013[2]			Sep/Oct 2013[2]		
			Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]
												7/28		✓						
138.7	6/30/12		6/30	28,230	678.08	8/13	16,344	677.07							8/5 8/10		✓ ✓	9/6		✓
138.4	8/5/13														8/5		✓	9/6		✓
138.1	6/30/12		6/30	28,203	670.43	8/13		669.00	9/30		669.36				8/5 8/10		✓ ✓	9/6		✓
137.6	6/30/12	9/30/12	6/30	27,893	664.17	8/13	16,409	662.67	9/30	17,382	662.58				8/10	15,702	✓	9/6		✓
137.2	8/5/13														8/5		✓	9/6		✓
136.7	7/1/12		7/1	26,756	654.82	8/13		653.46							8/5		✓	9/6		✓
136.2	7/1/12		7/1	26,943	648.86	8/13		648.12							8/6		✓	9/6		✓
135.6	8/6/13														8/6		✓	9/6		✓
135.0	7/1/12		7/1	26,526	634.86	8/13	15,627	632.97							8/6		✓	9/6		✓
134.7	8/6/13														8/6		✓	9/6		✓
134.3	7/2/12	10/1/12	7/2	25,463	627.51	8/13		625.41	10/1	15,568	***625.68***				8/6		✓	9/6		✓
134.1	7/2/12		7/2	26,166	625.74	8/14	16,491	624.10							8/7		✓	9/12		✓
133.8	7/2/12		7/2	25,715	623.51	8/14	16,275	622.22							8/7		✓	9/12		✓
133.3	7/2/12		7/2	25,678	618.46	8/14		617.34							8/7		✓	9/12		✓
132.6	7/2/12		7/2	25,046	609.97	8/14	16,039	608.67							8/7		✓	9/12		✓
132.0	8/7/13														8/7		✓	9/12		✓
131.4	7/3/12		7/3	28,628	598.37	8/14		597.82							8/7		✓	9/10		✓
130.9	8/8/13														8/8		✓	9/10		✓
130.4	8/9/13														8/9		✓	9/10		✓
129.7	7/3/12	10/1/12	7/3	28,243	580.58	8/14	16,330	578.98	10/1	15,731	579.02	6/27		✓				9/10		✓
128.1	7/4/12		7/4	26,748	564.50	8/15	15,926	563.54							8/9		✓			
127.8	8/9/13														8/9		✓			
126.8	7/4/12	10/1/12	7/4	27,608	552.41	8/15	16,078	550.87	10/1	15,582	551.04	7/9	23,082	✓	8/11	16,185	✓	9/12	31,059	✓
126.4	8/10/13														8/10		✓			
126.1	7/5/12		7/5	27,248	546.88	8/15		545.26							8/11		✓			
125.8	8/11/13														8/11		✓			
125.4	7/5/12		7/5	26,427	541.32	8/15		540.09							8/10		✓			
124.9	8/11/13														8/11		✓			
124.5	8/11/13														8/11		✓			
124.1	7/5/12	10/1/12	7/5	26,132	530.43	8/15	16,161	529.24	10/1	15,582	529.40	7/9	22,514	✓	8/11	16,603	✓	9/10 9/12	30,632	✓ ✓
123.7	7/6/12		7/6	23,875	527.93	8/15		527.43							8/11		✓	9/10		✓
123.2	8/12/13														8/12		✓			
122.7	7/6/12		7/6	23,331	518.91	8/15		517.91							8/12		✓	9/9		✓
122.6	7/6/12		7/6	22,890	517.85	8/15	16,287	516.97							8/12		✓	9/9		✓
122.1	8/12/13														8/12		✓			
121.4	8/12/13														8/12		✓			
120.7	7/6/12		7/6	22,687	502.03	8/15		501.13							8/12		✓	9/9		✓
120.3	8/12/13														8/12		✓			
119.9	7/7/12	10/3/12	7/7	20,715	495.29	8/16	16,005	494.37	10/3	13,998	493.97	7/9	22,745	✓	8/14		✓	9/9		✓
118.9	8/14/13														8/14		✓			
118.4	7/7/12		7/7	20,656	485.32	8/16		484.18	10/3		484.62				8/14		✓	9/9		✓
117.9	8/14/13														8/14		✓			
117.4	7/7/12		7/7	20,747	477.82	8/16		477.21							8/14		✓	9/9		✓
117.0	8/14/13														8/14		✓			

PRM	XS Profile Date 1	XS Profile Date 2	June/July 2012			August 2012			Sep/Oct 2012			June/July 2013[2]			August 2013[2]			Sep/Oct 2013[2]		
			Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]
116.6	7/7/12		7/7	20,665	468.98	8/16	16,136	468.16	10/3	14,323	467.97	7/9	22,932	✓	8/14	18,085	✓	9/9 9/13	30,796	✓ ✓
116.3	7/8/12		7/8	23,766	467.39	8/16		466.24				7/23		✓	8/14		✓			
115.7	7/8/12		7/8	25,006	461.95	8/16		461.01							8/14		✓			
115.4	7/8/12		7/8	25,958	458.41	8/16		456.99				7/5 7/23		✓ ✓	8/14		✓			
114.4	7/8/12		7/8	25,860	450.21	8/16		448.97							8/13 8/14		✓ ✓			
113.6	7/9/12	10/3/12	7/9	28,329	444.75	8/16	16,311	443.10	10/3	13,476	442.90				8/14 8/14	18,135	✓ ✓			
113.1	8/15/13														8/14 8/15		✓ ✓			
112.5	8/15/13														8/15		✓			
111.9	7/9/12		7/9	28,296	429.73	8/17		427.98							8/15		✓			
110.5	7/9/12	10/3/12	7/9	28,825	417.55	8/17	15,254	415.70	10/3	14,172	415.49				8/15		✓			
109.0	8/15/13														8/15		✓			
108.3	8/18/12					8/17	16,394	396.50							8/15		✓	9/7		✓
107.8	8/15/13														8/15		✓			
107.1	7/9/12		7/9	28,409	387.63	8/18	15,508	385.44	10/4	14,558	385.12	7/11	19,719	✓	8/15	18,921	✓	9/7 9/15	21,713	✓ ✓
106.6	8/15/13														8/15		✓			
106.1	8/18/12					8/18	15,278	377.95	10/4		377.75				8/15		✓	9/7		✓
105.3	8/18/12					8/18	15,362	372.01							8/16		✓	9/7		✓
104.7	8/18/12					8/18	15,377	367.05	10/4		366.93				8/16		✓			
104.1	8/19/12					8/19	15,345	364.79							8/16		✓	9/6		✓
103.5	10/1/12								10/4	14,575	358.05				8/16		✓	9/6		✓
102.7	7/10/12		7/10	26,635	352.87	8/19		351.70							8/16		✓			
LOWER RIVER (PRM 102.4 - 3.3)																				
102.1	8/16/13														8/16		✓			
101.4	7/10/12	10/15/12	7/10		346.09	8/19		344.82	10/15		343.67									
100.7	6/10/13 - 6/11/13, 7/17/13											6/10 7/17		✓ ✓	8/1		✓			
99.9	6/11/13											6/10 6/11		✓ ✓	8/1		✓			
98.4	7/11/12	10/5/12	7/11	46,499	326.86	8/20	40,623	326.37	10/5	39,065	326.08				8/1		✓			
97.0	7/11/12		7/11	45,118	318.49	8/20	40,261	318.38	10/5		318.21				8/1		✓			
96.2	6/12/13											6/12		✓	8/1		✓			
94.8	6/12/13											6/12 7/18		✓ ✓	8/1 8/2	53,839	✓ ✓			
94.0	6/13/13											6/13 7/18		✓ ✓						
93.2	6/13/13											6/13		✓	8/2		✓			
92.3	6/13/13											6/13 7/18		✓ ✓	8/2		✓			
91.6	8/21/12					8/21	46,330	285.74							8/2		✓			

PRM	XS Profile Date 1	XS Profile Date 2	June/July 2012			August 2012			Sep/Oct 2012			June/July 2013[2]			August 2013[2]			Sep/Oct 2013[2]		
			Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]
91.0	7/12/12		7/12	43,922	282.34	8/21	46,197	282.34							8/2		✓			
90.2	6/14/13											6/14		✓	8/3	51,896	✓			
89.5	6/14/13											6/14 7/18		✓ ✓	8/2		✓			
88.4	8/22/12					8/22	41,697	268.25							8/3		✓			
88.0	6/15/13											6/15		✓	8/3		✓			
87.6	6/15/13											6/15		✓	8/3	52,697	✓			
87.1	7/12/12		7/12	42,550	263.24	8/22		262.89							8/3		✓			
86.3	7/13/12		7/13	41,895	258.59	8/22		258.39							8/3		✓			
85.4	8/22/12					8/22	40,468	255.18							8/3		✓			
84.4	8/23/12					8/23	36,933	251.19							8/3		✓			
83.0	7/13/12		7/13	41,975	245.29	8/23		244.93							8/4		✓			
82.3	8/23/12					8/23	37,947	241.19							8/4		✓			
81.4	6/16/13											6/16		✓	8/4		✓			
80.7	6/16/13											6/16		✓	8/4		✓			
80.0	8/24/12					8/24	36,503	229.51							8/4		✓			
79.0	6/17/13											6/17		✓	8/4		✓			
78.0	6/17/13											6/17		✓	8/4	52,133	✓	9/20		✓
77.0	6/18/13											6/18		✓						
75.9	6/18/13											6/18		✓	8/5 8/20		✓ ✓	9/20		✓
75.0	6/19/13											6/19		✓						
74.1	6/19/13											6/19		✓	8/5		✓			
73.1	6/20/13											6/20		✓	8/5	51,077	✓	9/20		✓
71.0	6/20/13											6/20 6/21		✓ ✓	8/5 8/26		✓ ✓	9/20		✓
69.2	6/23/13											6/23		✓	8/5		✓	9/20		✓
68.2	6/23/13											6/25		✓	8/5		✓			
67.2	6/23/13											6/25		✓	8/6	45,437	✓	9/20		✓
66.1	6/24/13											6/25		✓	8/6		✓			
64.6	6/26/13											6/27		✓	8/6		✓	9/20		✓
62.7	6/27/13											6/27		✓	8/6		✓	9/20		✓
60.3	6/26/13											6/27		✓	8/6		✓	9/18		✓
59.1	6/28/13											6/28		✓						
57.8	6/28/13											6/28		✓	8/6 8/27		✓ ✓	9/18		✓
55.4	6/29/13											6/29		✓	8/27		✓	9/18		✓
54.2	6/30/13											6/30		✓	8/27		✓	9/16 9/18	50,633	✓ ✓
52.1	7/2/13											7/2 7/3		✓ ✓	8/28		✓			
49.0	7/4/13											7/4		✓	8/28		✓	9/12 9/18	 44,070	✓ ✓
47.9	7/4/13											7/4		✓	8/28		✓			
47.1	7/5/13											7/5		✓	8/28		✓			
46.3	7/5/13											7/7		✓	8/28		✓	9/12 9/18		✓ ✓
45.6	7/7/13											7/7		✓	8/29		✓			

PRM	XS Profile Date 1	XS Profile Date 2	June/July 2012			August 2012			Sep/Oct 2012			June/July 2013[2]			August 2013[2]			Sep/Oct 2013[2]		
			Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs[1]	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]	Date	Q, cfs	WSE[3]
44.5	7/7/13											7/7		✓	8/29		✓	9/12 9/18		✓ ✓
41.3	7/8/13											7/8		✓	8/29		✓			
40.4	7/8/13 - 7/10/13											7/8		✓	8/29		✓	9/19	44,519	✓
39.5	7/10/13 - 7/11/13											7/10		✓	8/29		✓	9/12 9/19		✓ ✓
38.3	7/11/13 - 7/12/13											7/12 7/18		✓ ✓	8/29		✓			
36.4	7/11/13											7/13		✓				9/15 9/20	40,858	✓ ✓
34.8	7/13/13											7/14		✓				9/12 9/15 9/19 9/21	38,056	✓ ✓ ✓ ✓
33.7	7/14/13											7/14		✓	8/30		✓			
32.4	7/14/13											7/15		✓	8/30		✓			
31.6	7/15/13											7/13		✓						
29.9	7/15/13									9/11		40.16	7/15		✓	8/30		✓	9/9 9/19		✓ ✓

Notes:

Bold PRMs indicates a new cross-section collected in 2013.

1 Data approved by HDR, 5/1/13: "Quality Assurance / Quality Control Review of ADCP Discharge Data collected by Brailey Hydrologic - Draft."

2 Data collected in 2013 are provisional pending final review and approval.

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.

Table 5.3-2. Summary of Focus Area measurements.

FA-144 (Slough 21)														
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total Flow, cfs	95% Uncertainty, percent
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right		
6/29/2013	16:02	T1		0.0809		R			2,104		R		26,020	10.4
9/7/2013	14:46	T1		0.0849		0.915			2,234		24,091		26,325	3.5
6/29/2013	14:43	T2		0.0183		0.982			475		25,545		26,020	7.1
9/7/2013	14:32	T2		0.0178		0.982			469		25,897		26,366	7.1
6/29/2013	14:26	T3		0.0105	0.273	0.716			274	7,114	18,632		26,020	10.4
9/7/2013	14:05	T3		0.0092	0.258	0.733			244	6,825	19,374		26,442	7.1
6/29/2013	13:26	T4		0.0023		0.998			59		25,961		26,020	10.4
9/7/2013	13:25	T4		0.0009		0.999			23		26,529		26,552	7.1
6/29/2013	13:05	T5			single channel					26,020			26,020	2.7
9/7/2013	13:14	T5			single channel					26,583			26,583	1.9

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-141 (Indian River)														
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total Flow, cfs	95% Uncertainty, percent
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right		
6/30/2013	13:53	T1			single channel					24,992			24,992	1.96
9/8/2013	15:10	T1			single channel					30,551			30,551	1.53
6/30/2013	13:18	T2			single channel					24,835			24,835	1.96
9/8/2013	15:04	T2			single channel					30,546			30,546	1.53
6/30/2013	13:05	T3		0.4870		0.513			12,112		12,757		24,869	7.1
9/8/2013	14:04	T3		0.4964		0.504			14,650		14,865		29,515	3.8
6/30/2013	11:51	T4		0.8335		0.167			20,893		4,175		25,068	23.6
9/8/2013	12:42	T4		0.8339		0.166			24,554		4,890		29,444	3.5
6/30/2013	11:29	T5			single channel					25,130			25,130	1.96
9/8/2013	12:30	T5			single channel					29,434			29,434	1.53
6/30/2013	14:27	T6		0.0583					1,437				24,650	3.8
9/8/2013	13:04	T6		0.0591					1,800				30,443	3.5
6/30/2013	14:36	T7		0.0992					2,443				24,625	3.8
9/8/2013	13:29	T7		0.0939					2,862				30,465	3.5
6/30/2013	15:30	T8		0.000051					1.24				24,481	>50
6/30/2013	15:45	T9		-0.000032					-0.78				24,441	>50
6/30/2013	15:59	T10		-0.000026					-0.63				24,402	>50
9/8/2013	14:35	T11		0.000123					3.76				30,521	>50

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-138 (Gold Creek)														
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total	95% Uncertainty,
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right	Flow, cfs	percent
7/1/2013	14:37	T1		see T6/T7	0.141	R			see T6/T7	3,520			25,001	3.8
9/9/2013	13:32	T1		0.1522	0.145	0.703			4,383	4,181	20,228		28,793	7.1
7/1/2013	13:51	T2			single channel					25,001			25,001	3.2
9/9/2013	13:10	T2			single channel					28,841			28,841	1.14
7/1/2013	12:44	T3			0.817	0.025				20,434	621		25,001	7.1
9/9/2013	11:59	T3		0.1544	0.815	0.031			4,478	23,629	887		28,994	7.1
7/1/2013	12:28	T4		0.0066		0.993			165		24,837		25,001	23.6
9/9/2013	11:48	T4		0.008		0.992			247		28,771		29,017	3.8
7/1/2013	11:57	T5			single channel					25,001			25,001	3.18
9/9/2013	11:24	T5			single channel					29,068			29,068	1.14
7/1/2013	14:52	T6			0.130					3,258			25,001	7.1
9/9/2013	14:08	T6			0.141					4,050			28,714	7.1
7/1/2013	15:03	T7			0.007					183			25,001	26.9
9/9/2013	14:19	T7			0.012					346			28,692	3.8
7/1/2013	15:18	T8			0.00038					10			25,001	>50
9/9/2013	14:01	T8			0.00021					6			28,729	>50

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-128 (Slough 8A)														
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total Flow, cfs	95% Uncertainty, percent
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right		
7/2/2013	13:14	T1		0.304		0.696			7,520		17,197		24,717	7.1
9/10/2013	14:03	T1		0.327		0.673			8,547		17,551		26,098	3.5
7/2/2013	12:46	T2	0.010	0.251	0.0311	0.718		236	6,204	766	17,710		24,916	7.1
9/10/2013	13:40	T2		0.267	0.0434	0.690			6,960	1,134	18,019		26,113	7.1
7/2/2013	12:12	T3		0.0154	0.237	0.747			379	5,843	18,413		24,635	3.5
9/10/2013	13:13	T3		0.0181	0.242	0.740			473	6,331	19,328		26,132	7.1
7/2/2013	11:26	T4	3.7E-04	0.0152	0.107	0.522	0.356	9.10	374	2,629	12,818	8,745	24,575	3.8
9/10/2013	12:20	T4		0.0181	0.111	0.522	0.349		473	2,907	13,659	9,127	26,167	7.1
7/2/2013	10:58	T5			single channel					24,538			24,538	3.2
9/10/2013	11:54	T5			single channel					26,184			26,184	1.1
7/2/2013	12:24	T6			0.0094					231			24,651	4.0
9/10/2013	13:26	T6			0.0096					250			26,123	13.7
7/2/2013	15:36	T7			1.2E-04					2.95			24,905	>20
9/10/2013	15:10	T7			1.4E-04					3.68			26,053	7.1

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-115 (Slough 6A)														
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total Flow, cfs	95% Uncertainty, percent
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right		
7/10/2013	14:09	T1		0.100		0.900			2,165		19,484		21,649	10.4
9/13/2013	13:21	T1		0.100		0.900			3,077		27,715		30,792	3.8
7/10/2013	12:53	T2		0.751		0.249			16,275		5,409		21,683	3.8
9/13/2013	12:53	T2		0.707		0.293			21,756		9,036		30,792	3.5
7/10/2013	11:23	T3		0.000	0.253	0.000			5	5,493	1		21,725	3.8
9/13/2013	14:07	T3		0.013	0.986	0.001			415	30,354	23		30,792	3.5
7/10/2013	12:43	T4		0.745		0.255			16,154		5,534		21,688	3.8
9/13/2013	12:43	T4		0.707		0.293			21,783		9,009		30,792	3.5
7/10/2013	12:08	T5			single channel					21,705			21,705	1.31
9/13/2013	12:26	T5			single channel					30,792			30,792	0.85

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-113 (Oxbow 1)													Focus	95%
Date	Time	Transect	Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Area Total	Uncertainty,
			Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right	Flow, cfs	percent
7/11/2013	15:26	T1			single channel					19,715			19,715	1.4
9/14/2013	15:41	T1			single channel					25,101			25,101	1.06
7/11/2013	15:05	T2		0.999		0.001			19,701		24		19,725	13.7
9/14/2013	15:08	T2		0.994		0.006			25,101		150		25,251	7.1
7/11/2013	14:49	T3		0.999		0.001			19,710		24		19,733	7.1
9/14/2013	14:56	T3		0.994		0.006			25,154		152		25,306	3.5
7/11/2013	13:26	T4		0.189		0.001			3747		24		19,775	3.5
9/14/2013	14:27	T4		0.218		0.782			5,537		19,899		25,436	3.5
7/11/2013	11:56	T5		0.166		0.834			3,288		16,532		19,820	3.8
9/14/2013	11:49	T5		0.196		0.804			5,127		21,026		26,153	3.8
7/11/2013	13:48	T6		0.075		0.925			1490		18,350		19,840	3.8
9/14/2013	11:40	T6		0.069		0.931			1815		24,380		26,195	3.8
7/10/2013	14:09	T7		0.071		0.929			1526		20,122		21,649	7.10
9/14/2013	11:22	T7		0.068		0.932			1800		24,474		26,274	3.8

Table 5.3-2. Summary of Focus Area measurements (continued).

FA-104 (Whiskers Slough)														
			Proportion of Total Flow					Flow (cfs), adjusted to match Focus Area Total					Focus Area Total Flow, cfs	95% Uncertainty, percent
Date	Time	Transect	Far left	Left	Middle	Right	Far right	Far left	Left	Middle	Right	Far right		
7/12/2013	13:44	T1	0.00008	0.006	0.843	0.150		1.48	113	14,756	2,629		17,498	7.1
9/15/2013	15:01	T1	0.00013	0.018	0.811	0.172		2.74	377	17,345	3,675		21,396	3.8
7/12/2013	11:55	T2		0.837		0.163			14,640		2,858		17,498	10.4
9/15/2013	13:11	T2		0.818		0.182			17,606		3,914		21,520	3.8
7/12/2013	11:44	T3		0.992		0.008			17353		145		17,498	3.8
9/15/2013	13:01	T3		0.976		0.024			21,020		511		21,531	3.8
7/12/2013	11:34	T4			single channel					17,498			17,498	2.3
9/15/2013	12:51	T4			single channel					21,546			21,546	1.06
7/12/2013	13:34	T5		0.005		0.001			91		14		17,498	3.8
9/15/2013	14:46	T5		0.011		0.003			236		63		21,413	3.8
7/12/2013	12:20	T6		0.147				2,576					17,498	3.50
9/15/2013	13:26	T6	0.161					3,471					21,503	3.5

Table 5.3-3. Tributary gaging streamflow and staff gage measurements collected in 2013.

Location	Field Visit 1 (Jun/Jul)			Field Visit 2 (Aug)			Unscheduled Field Visit			Field Visit 3 (Sep/Oct)		
	Date	Q (cfs)	SG (ft)	Date	Q (cfs)	SG (ft)	Date	Q (cfs)	SG (ft)	Date	Q (cfs)	SG (ft)
Oshetna River[1]	7/13/2013		1.55	8/9/2013	604.7	1.42	9/3/2013	1000	2.2	9/26/2013		1.44
Kosina Creek	7/13/2013	620	1.46	8/7/2013	610	1.38				9/26/2013		1.53
Unnamed Tributary 144.6	7/12/2013	0.33	NA	8/7/2013	0	NA	9/15/2013	17.9	NA	9/26/2013	12.2	NA
Indian River	7/11/2013	231.5	1.61	8/9/2013	136.8	1.28				9/28/2013	286.3	1.68
Skull Creek	7/12/2013	7.4	0.96	8/8/2013	2.5	0.75	9/13/2013	48.5	1.6	9/29/2013	13.7	1.15
Gash Creek	6/16/2013	2.4	1.12	8/8/2013	2.9	1.00				9/29/2103	5.3	1.13
Slash Creek	6/16/2013	0.17	NA	8/8/2013	0.031	NA				9/29/2013	0.28	NA
Unnamed Tributary 113.7	6/16/2013	2.3	1.26	8/8/2013	0.3	1.00				9/29/2013	4.9	1.42
Whiskers Creek	6/22/2013	17.6	1.99	8/6/2013	5.7	1.75	9/11/2013	147.7	3.59	9/30/2013	39.3	2.41
Trapper Creek	6/17/2103	31.7	1.26	8/6/2013	10.8	1.01				9/30/2013	89.7	1.7
Birch Creek	7/14/2013	35.1	1.85	8/9/2013	23.9	1.76				9/27/2013	82.3	2.33
Deshka River[2]	7/15/2013	317.4	95.45	8/10/2013	245	95.3				9/27/2013		98.41

Note:

1 Note that discharge measurements collected for the Oshetna River were measured on different dates than when surveying and data downloading occurred.

2 Note that no staff gage was installed at the Deshka River site so the staff gage reading is the measured water surface elevation.

Table 5.4-1. USGS Gage No. 15292000 – Susitna River at Gold Creek (cfs).

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1950	6,335	2,583	1,439	1,027	788	726	870	11,511	19,600	22,600	19,877	8,301	8,032
1951	3,848	1,300	1,100	960	820	740	1,617	14,089	20,787	22,568	19,674	21,243	9,106
1952	5,571	2,744	1,900	1,600	1,000	880	920	5,419	32,370	26,387	20,923	14,480	9,552
1953	8,202	3,497	1,700	1,100	820	820	1,615	19,271	27,323	20,197	20,610	15,273	10,091
1954	5,604	2,100	1,500	1,300	1,000	780	1,235	17,281	25,250	20,358	26,097	12,916	9,681
1955	5,370	2,760	2,045	1,794	1,400	1,100	1,200	9,319	29,860	27,558	25,752	14,288	10,256
1956	4,951	1,900	1,300	980	970	940	950	17,665	33,343	31,090	24,532	18,333	11,474
1957	5,806	3,050	2,142	1,700	1,500	1,200	1,200	13,755	30,163	23,306	20,539	19,800	10,384
1958	8,212	3,954	3,264	1,965	1,307	1,148	1,533	12,896	25,700	22,877	22,542	7,550	9,476
1959	4,811	2,150	1,513	1,448	1,307	980	1,250	15,987	23,323	25,000	31,181	16,924	10,560
1960	6,558	2,850	2,200	1,845	1,452	1,197	1,300	15,781	15,533	22,977	23,594	20,510	9,713
1961	7,794	3,000	2,694	2,452	1,754	1,810	2,650	17,361	29,453	24,574	22,103	13,373	10,810
1962	5,916	2,700	2,100	1,900	1,500	1,400	1,700	12,590	43,273	25,855	23,555	15,890	11,566
1963	6,723	2,800	2,000	1,600	1,500	1,000	830	19,026	26,000	34,400	23,674	12,318	11,073
1964	6,449	2,250	1,494	1,048	966	713	745	4,307	50,577	22,945	16,435	9,571	9,799
1965	6,291	2,799	1,211	960	860	900	1,360	12,987	25,720	27,842	21,116	19,351	10,168
1966	7,205	2,098	1,631	1,400	1,300	1,300	1,775	9,645	32,953	19,865	21,826	11,753	9,432
1967	4,163	1,600	1,500	1,500	1,400	1,200	1,167	15,481	29,513	26,800	32,623	16,867	11,219
1968	4,900	2,353	2,055	1,981	1,900	1,900	1,910	16,177	31,550	26,423	17,168	8,816	9,810
1969	3,822	1,630	882	724	723	816	1,510	11,045	15,503	16,103	8,879	5,093	5,597
1970	3,124	1,215	866	824	768	776	1,080	11,381	18,633	22,661	19,977	9,121	7,591
1971	5,288	3,407	2,290	1,442	1,036	950	1,082	3,745	32,933	23,948	31,906	14,442	10,251
1972	5,847	3,093	2,510	2,239	2,028	1,823	1,710	21,887	34,430	22,768	19,287	12,403	10,885
1973	4,826	2,253	1,465	1,200	1,200	1,000	1,027	8,235	27,803	18,252	20,290	9,074	8,087
1974	3,733	1,523	1,034	874	777	724	992	16,181	17,867	18,797	16,218	12,246	7,630
1975	3,739	1,700	1,603	1,516	1,471	1,400	1,593	15,355	32,310	27,716	18,094	16,307	10,276
1976	7,739	1,993	1,081	974	950	900	1,373	12,623	24,380	18,935	19,796	6,881	8,189
1977	3,874	2,650	2,403	1,829	1,618	1,500	1,680	12,677	37,967	22,868	19,235	12,636	10,108
1978	7,571	3,525	2,589	2,029	1,668	1,605	1,702	11,945	19,050	21,019	16,394	8,607	8,194
1979	4,907	2,535	1,681	1,397	1,286	1,200	1,450	13,868	24,690	28,881	20,461	10,774	9,490
1980	7,311	4,192	2,416	1,748	1,466	1,400	1,670	12,065	29,080	32,658	20,965	13,281	10,748
1981	7,725	3,569	1,915	2,013	1,975	1,585	2,040	16,550	19,300	33,935	37,871	13,786	11,960
1982	7,463	3,260	1,877	1,681	1,486	1,347	1,783	13,384	26,100	24,123	15,274	17,783	9,669
1983	6,892	2,633	2,358	2,265	1,996	1,690	1,900	14,945	24,510	21,145	24,500	13,585	9,924
1984	8,301	3,153	2,258	2,048	1,969	1,900	1,810	12,961	26,773	23,542	20,397	9,429	9,599
1985	5,670	3,093	2,394	1,939	1,643	1,726	1,977	11,171	26,333	26,510	19,919	15,637	9,881
1986	6,944	2,673	1,929	1,658	1,561	1,394	1,565	12,084	20,007	21,868	17,252	12,860	8,531
1987	12,675	3,450	1,955	1,615	1,518	1,500	2,048	12,990	22,997	29,890	21,752	13,339	10,551
1988	5,924	2,483	1,600	1,561	1,500	1,500	1,587	17,371	29,723	25,690	19,542	13,781	10,241
1989	7,674	3,013	2,000	2,000	1,800	1,800	2,137	13,742	26,770	23,652	22,390	15,433	10,252
1990	8,025	2,997	1,848	1,765	1,700	1,852	4,250	25,632	33,803	23,513	23,732	26,507	13,018
1991	6,895	2,447	2,200	1,897	1,800	1,619	1,613	6,048	25,627	21,219	18,281	12,347	8,532
1992	5,817	2,440	2,200	1,965	1,800	1,868	2,100	6,104	23,140	25,535	21,145	10,175	8,739
1993	4,379	2,733	2,039	1,865	1,754	1,639	2,537	20,881	23,483	19,345	18,745	21,287	10,099
1994	9,915	3,327	2,529	2,058	1,786	1,526	3,221	14,612	31,087	20,961	18,581	9,357	9,960
1995	4,530	2,780	2,097	1,855	1,718	1,700	2,846	17,712	24,710	25,497	18,381	19,137	10,294
1996	6,482	2,657	1,442	1,248	1,186	1,100	1,350	6,613	15,707	16,006	17,132	10,412	6,816
1997	3,505	1,955	1,748	1,626	1,515	1,405	1,642	9,660	19,100	24,435	24,748	13,592	8,800
1998	3,939	1,781	1,551	1,412	1,353	1,290	1,748	9,616	24,597	25,790	22,797	16,151	9,382
1999	7,739	3,040	2,110	1,698	1,417	1,224	1,412	9,380	23,073	22,923	25,448	11,354	9,294
2000	6,892	3,101	2,019	1,674	1,539	1,440	1,721	11,515	31,280	29,468	16,381	15,505	10,253
2001	8,110	3,067	2,101	1,770	1,593	1,482	1,619	9,016	31,000	22,048	21,790	10,355	9,539
2002	4,840	2,627	1,897	1,548	1,421	1,303	1,330	11,506	16,547	18,148	23,781	16,250	8,483
2003	10,953	5,394	2,590	1,655	2,243	1,509	2,173	8,019	24,330	29,200	21,119	13,513	10,278
2004	8,109	2,500	1,810	1,471	1,276	1,081	2,730	23,574	25,330	20,158	17,723	6,452	9,419
2005	3,300	1,733	1,610	1,439	1,239	1,045	2,611	26,942	34,323	26,761	21,974	22,857	12,207
2006	8,238	2,143	1,497	1,400	1,389	1,361	1,535	15,734	23,287	23,142	30,813	12,303	10,314
2007	10,388	3,140	2,319	2,024	1,905	1,744	2,273	17,190	19,707	21,584	19,265	13,504	9,649
2008	5,017	3,222	2,813	1,842	1,343	1,360	1,670	11,865	21,120	22,032	19,726	14,520	8,926
2009	5,529	1,548	1,300	1,385	1,300	1,340	4,547	22,932	23,113	19,368	18,474	12,481	9,499
2010	7,122	2,807	1,842	1,468	1,350	1,305	1,847	19,606	20,023	27,519	20,077	15,824	10,137
Average	6,319	2,672	1,893	1,593	1,420	1,303	1,743	13,785	26,292	23,988	21,382	13,737	9,729
Maximum	12,675	5,394	3,264	2,452	2,243	1,900	4,547	26,942	50,577	34,400	37,871	26,507	13,018
Minimum	3,124	1,215	866	724	723	713	745	3,745	15,503	16,006	8,879	5,093	5,597

Table 5.4-2. Inflows to Watana Reservoir (cfs).

Water Year	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Annual
1950	5,164	2,078	1,149	817	625	575	691	9,449	16,180	18,678	16,401	6,777	6,599
1951	3,113	1,037	876	763	651	587	1,295	11,586	17,169	18,646	16,234	17,550	7,495
1952	4,529	2,210	1,522	1,280	795	699	731	4,435	26,820	21,830	17,270	11,907	7,865
1953	6,697	2,825	1,360	876	651	651	1,295	15,900	22,627	16,668	17,014	12,566	8,306
1954	4,554	1,684	1,199	1,037	795	618	986	14,253	20,892	16,795	21,560	10,602	7,966
1955	4,359	2,222	1,641	1,436	1,118	876	956	7,637	24,756	22,821	21,212	11,746	8,442
1956	4,017	1,522	1,037	779	771	747	755	14,578	27,534	25,800	20,308	15,123	9,465
1957	4,720	2,458	1,719	1,360	1,199	956	956	11,328	24,990	19,270	16,950	16,339	8,551
1958	6,702	3,198	2,634	1,575	1,043	915	1,226	10,601	21,269	18,907	18,589	6,155	7,787
1959	3,900	1,725	1,209	1,157	1,043	779	997	13,194	19,282	20,688	25,674	13,943	8,691
1960	5,342	2,295	1,768	1,477	1,160	954	1,038	12,995	12,773	18,997	19,511	16,930	7,989
1961	6,362	2,418	2,169	1,971	1,404	1,449	2,133	13,638	22,784	19,841	19,479	10,148	8,701
1962	4,638	2,263	1,760	1,609	1,257	1,177	1,457	11,333	36,020	23,446	19,890	12,746	9,834
1963	5,560	2,509	1,709	1,309	1,185	884	777	15,297	20,663	28,767	21,012	10,799	9,277
1964	5,187	1,789	1,195	852	782	575	609	3,579	42,839	20,081	14,044	7,524	8,262
1965	4,759	2,368	1,070	863	773	807	1,232	10,964	21,214	23,236	17,392	16,226	8,451
1966	5,221	1,565	1,204	1,060	985	985	1,338	7,094	25,941	16,154	17,387	9,216	7,374
1967	3,270	1,202	1,122	1,102	1,031	890	850	12,556	24,715	21,989	26,106	13,670	9,096
1968	4,019	1,934	1,704	1,618	1,560	1,560	1,577	12,825	25,704	22,086	14,144	7,164	8,032
1969	3,135	1,355	754	619	608	686	1,262	9,311	13,962	14,844	7,772	4,260	4,912
1970	2,403	1,021	709	636	602	624	986	9,537	14,401	18,411	16,264	7,224	6,115
1971	3,768	2,496	1,687	1,097	777	717	814	2,857	27,613	21,125	27,445	12,190	8,588
1972	4,979	2,587	1,957	1,671	1,491	1,366	1,305	15,972	27,428	19,818	17,509	10,957	8,963
1973	3,913	1,810	1,171	956	956	795	817	6,741	22,974	15,046	16,755	7,418	6,641
1974	3,019	1,217	822	694	616	574	789	13,361	14,726	15,498	13,353	10,050	6,268
1975	3,025	1,360	1,282	1,212	1,176	1,118	1,274	12,661	26,784	22,963	14,915	13,424	8,468
1976	6,314	1,599	860	775	755	715	1,098	10,361	20,170	15,619	16,343	5,603	6,728
1977	3,132	2,133	1,932	1,464	1,294	1,199	1,344	10,439	31,366	18,902	15,870	10,367	8,311
1978	6,174	2,847	2,083	1,627	1,335	1,284	1,362	9,803	15,712	17,360	13,502	7,030	6,720
1979	3,980	2,039	1,345	1,116	1,025	956	1,158	11,429	20,429	23,937	16,892	8,823	7,812
1980	5,959	3,393	1,942	1,399	1,171	1,118	1,337	9,846	23,400	26,741	18,006	10,995	8,827
1981	6,632	3,044	1,790	1,858	1,592	1,262	1,641	14,415	16,737	27,598	30,542	11,666	9,984
1982	5,700	2,468	1,596	1,380	1,104	971	1,196	10,878	21,441	20,442	13,203	13,979	7,898
1983	5,154	2,132	1,893	1,797	1,610	1,427	1,565	11,671	20,603	18,768	20,863	11,194	8,270
1984	6,882	2,657	1,939	1,782	1,741	1,697	1,613	10,831	22,911	20,708	17,420	7,347	8,174
1985	4,257	2,384	1,799	1,479	1,273	1,298	1,517	8,440	21,226	23,295	16,433	11,700	7,966
1986	5,073	2,039	1,425	1,207	1,131	1,038	1,162	9,736	17,817	20,425	14,207	10,558	7,193
1987	10,415	2,786	1,567	1,292	1,213	1,199	1,644	10,671	19,016	24,765	17,964	10,962	8,686
1988	4,814	1,997	1,280	1,248	1,199	1,199	1,269	14,335	24,637	21,261	16,119	11,326	8,434
1989	6,262	2,429	1,602	1,602	1,441	1,441	1,715	11,292	22,163	19,554	18,497	12,695	8,433
1990	6,552	2,416	1,480	1,413	1,360	1,483	3,446	21,223	28,001	19,439	19,627	21,863	10,733
1991	5,622	1,968	1,768	1,519	1,441	1,295	1,290	4,934	21,210	17,526	15,071	10,130	7,008
1992	4,730	1,962	1,768	1,574	1,441	1,496	1,685	4,985	19,122	21,130	17,459	8,331	7,180
1993	3,546	2,200	1,634	1,493	1,404	1,311	2,042	17,252	19,421	15,957	15,458	17,589	8,310
1994	8,116	2,685	2,034	1,650	1,429	1,220	2,603	12,014	25,724	17,312	15,321	7,654	8,185
1995	3,670	2,239	1,682	1,485	1,375	1,360	2,293	14,604	20,451	21,099	15,152	15,779	8,471
1996	5,278	2,139	1,152	995	945	876	1,078	5,403	12,922	13,169	14,113	8,524	5,581
1997	2,815	1,561	1,389	1,277	1,176	1,078	1,282	7,885	15,738	20,166	20,415	11,132	7,206
1998	3,171	1,418	1,210	1,084	1,031	977	1,370	7,856	20,300	21,280	18,812	13,257	7,686
1999	6,285	2,434	1,684	1,344	1,089	917	1,087	7,662	19,026	18,902	20,946	9,273	7,603
2000	5,588	2,483	1,612	1,321	1,199	1,110	1,354	9,415	25,738	24,263	13,455	12,724	8,390
2001	6,592	2,456	1,676	1,411	1,249	1,147	1,271	7,376	25,715	18,217	18,001	8,479	7,835
2002	3,925	2,114	1,520	1,238	1,135	1,040	1,061	9,473	13,624	14,959	19,678	13,376	6,969
2003	8,973	4,380	2,084	1,324	1,802	1,207	1,750	6,553	20,125	24,139	17,450	11,110	8,452
2004	6,627	2,010	1,449	1,176	1,018	860	2,203	19,489	20,957	16,635	14,600	5,252	7,745
2005	2,663	1,387	1,288	1,149	988	832	2,112	22,327	28,455	22,160	18,157	18,893	10,079
2006	6,732	1,720	1,196	1,118	1,109	1,086	1,227	12,996	19,261	19,131	25,426	10,093	8,489
2007	8,517	2,532	1,864	1,622	1,526	1,396	1,827	14,166	16,260	17,828	15,887	11,095	7,928
2008	4,071	2,599	2,265	1,476	1,072	1,086	1,336	9,736	17,438	18,204	16,280	11,934	7,331
2009	4,494	1,238	1,037	1,106	1,037	1,070	3,701	18,949	19,105	15,977	15,233	10,242	7,812
2010	5,804	2,261	1,475	1,173	1,078	1,041	1,481	16,183	16,524	22,802	16,573	13,031	8,344
Average	5,096	2,152	1,521	1,275	1,129	1,037	1,398	11,284	21,718	20,034	17,757	11,257	8,015
Maximum	10,415	4,380	2,634	1,971	1,802	1,697	3,701	22,327	42,839	28,767	30,542	21,863	10,733
Minimum	2,403	1,021	709	619	602	574	609	2,857	12,773	13,169	7,772	4,260	4,912

Table 5.5-1. Number of microhabitat use measurements by Focus Area and habitat type for all species and life stages observed during the 2013 HSC surveys of the Middle River Segment of the Susitna River, Alaska.

		Focus Area[1]									Habitat Type								
Species	**Life Stage**	**FA-104**	**FA-113**	**FA-115**	**FA-128**	**FA-138**	**FA-141**	**FA-144**	**NFA**	**Total**	**BW**	**CWP**	**MC**	**SC**	**SS**	**TM**	**TRIB**	**US**	**Total**
Chinook	FRY	10	0	0	14	14	15	2	2	**57**	0	0	3	4	28	12	5	5	**57**
	JUV	8	0	2	6	10	5	0	3	**34**	1	1	4	12	10	0	1	5	**34**
Chum	FRY	4	2	0	5	2	1	0	0	**14**	0	0	1	7	4	0	1	1	**14**
	JUV	0	0	0	1	0	0	0	1	**2**	0	0	0	1	1	0	0	0	**2**
	Spawning	1	0	0	36	54	13	45	197	**346**	0	21	0	135	132	7	0	51	**346**
Coho	FRY	31	10	2	6	4	36	2	7	**98**	8	0	1	12	23	17	9	28	**98**
	JUV	21	10	15	3	2	1	0	5	**57**	1	0	0	5	9	1	7	34	**57**
	Spawning	0	0	0	3	0	0	0	0	**3**	0	0	0	3	0	0	0	0	**3**
Pink	Spawning	0	0	0	0	0	17	0	42	**59**	0	0	0	0	6	36	17	0	**59**
Sockeye	FRY	12	9	10	19	21	6	0	2	**79**	0	0	1	18	36	0	3	21	**79**
	JUV	5	2	0	3	4	2	0	1	**17**	0	0	0	6	9	0	0	2	**17**
	Spawning	0	0	0	44	40	9	72	17	**182**	0	0	0	73	74	12	7	16	**182**
Arctic Grayling	FRY	10	6	11	22	11	35	11	8	**114**	6	5	7	35	23	17	1	20	**114**
	JUV	4	3	0	9	3	14	4	4	**41**	2	6	5	19	6	1	0	2	**41**
	ADULT	0	0	0	0	0	4	0	0	**4**	0	4	0	0	0	0	0	0	**4**
Lamprey	JUV	1	0	0	0	0	0	0	0	**1**	0	0	0	0	1	0	0	0	**1**
Burbot	JUV	1	0	0	0	0	1	0	0	**2**	0	0	2	0	0	0	0	0	**2**
	ADULT	6	1	5	2	2	0	1	0	**17**	0	0	3	9	0	0	0	5	**17**
Dolly Varden	FRY	1	7	0	0	0	10	0	1	**19**	2	0	0	0	0	4	10	3	**19**
	JUV	1	0	0	0	1	0	0	0	**2**	0	0	0	0	0	0	0	2	**2**
	ADULT	0	0	0	0	1	0	0	0	**1**	0	0	0	0	1	0	0	0	**1**
Longnose Sucker	FRY	7	17	4	1	0	9	1	2	**41**	3	0	1	14	3	0	8	12	**41**
	JUV	15	7	5	3	9	7	1	5	**52**	1	0	6	29	7	0	0	9	**52**
	ADULT	17	8	4	7	13	6	4	12	**71**	2	0	19	36	9	0	0	5	**71**
Rainbow Trout	FRY	0	2	0	0	0	0	0	0	**2**	0	0	0	0	0	0	2	0	**2**
	JUV	2	2	0	0	0	1	0	0	**5**	0	1	0	1	0	0	2	1	**5**
	ADULT	3	0	0	1	0	0	1	1	**6**	0	0	1	2	1	0	0	2	**6**
Whitefish	FRY	4	5	2	3	12	9	1	4	**40**	5	0	1	13	12	1	1	7	**40**
	JUV	6	3	2	9	5	8	2	3	**38**	1	2	3	14	7	0	1	10	**38**
	ADULT	2	3	1	5	6	6	1	4	**28**	0	5	7	12	0	0	0	4	**28**
		174	**97**	**63**	**119**	**120**	**176**	**31**	**65**	**1433**	**32**	**24**	**65**	**249**	**193**	**53**	**51**	**178**	**1433**

Notes:

1 NFA indicates Non-Focus Area. 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)

Table 5.5-2. Number of individual sampling events by Focus Area, habitat type, and sampling session during 2013 HSC sampling in the Middle Susitna River, Alaska.

Focus Area	Number of Sampling Events	Habitat Type[1]	Number of Sampling Events	Sample Session	Number of Sampling Events
FA-104 (Whiskers Slough)	47	Backwater	2	June 18-22	12
FA-113 (Oxbow 1)	14	Clearwater Plume	4	July 10-17	44
FA-115 (Slough 6A)	11	Main Channel	30	July 23-30	26
FA-128 (Slough 8A)	36	Side Channel	66	August 6-13	58
FA-138 (Gold Creek)	32	Side Slough	44	August 20-23	18
FA-141 (Indian River)	22	Upland Slough	40	September 10-17	39
FA-144 (Slough 21)	23	Tributary Mouth	9	September 24-29	10
Outside Focus Area	25	Tributary	12		

Notes:

1 Habitat types defined in ISR Study 9.9.

Table 5.5-3. Number of HSC microhabitat use observations by sampling session for each species and life stage collected during the summer 2013 sampling of the Middle Segment of the Susitna River, Alaska.

Species	Life Stage	Jun 18-22	Jul 10-17	Jul 23-30	Aug 6-13	Aug 20-27	Sep 10-16	Sep 24-30	Total
Chinook	FRY	0	12	18	23	0	4	0	**57**
	JUV	9	3	2	12	4	4	0	**34**
Chum	FRY	6	5	3	0	0	0	0	**14**
	JUV	0	0	0	2	0	0	0	**2**
	Spawning	0	0	0	9	52	185	101	**346**
Coho	FRY	1	5	26	23	19	24	0	**98**
	JUV	4	3	12	13	16	9	0	**57**
	Spawning	0	0	0	0	0	0	3	**3**
Pink	Spawning	0	0	0	53	6	0	0	**59**
Sockeye	FRY	17	24	9	12	9	8	0	**79**
	JUV	2	0	0	0	5	10	0	**17**
	Spawning	0	0	0	6	6	106	64	**182**
Arctic Grayling	FRY	0	23	46	34	6	5	0	**114**
	JUV	0	3	4	20	6	8	0	**41**
	ADULT	0	2	0	2	0	0	0	**4**
Lamprey	JUV	0	0	0	0	0	1	0	**1**
Burbot	JUV	1	0	0	0	1	0	0	**2**
	ADULT	3	4	1	8	0	1	0	**17**
Dolly Varden	FRY	0	0	17	0	1	1	0	**19**
	JUV	0	0	0	1	0	1	0	**2**
	ADULT	0	1	0	0	0	0	0	**1**
Longnose Sucker	FRY	0	1	5	4	23	8	0	**41**
	JUV	5	11	5	14	12	5	0	**52**
	ADULT	7	14	3	31	9	7	0	**71**
Rainbow Trout	FRY	0	0	2	0	0	0	0	**2**
	JUV	0	0	2	2	0	1	0	**5**
	ADULT	1	1	0	4	0	0	0	**6**
Whitefish	FRY	0	10	8	11	10	1	0	**40**
	JUV	2	8	2	14	7	5	0	**38**
	ADULT	0	10	1	15	0	2	0	**28**
Total		**58**	**140**	**166**	**313**	**192**	**396**	**168**	**1433**

Table 5.5-4. Number of microhabitat availability measurements by Focus Area and habitat type collected during the 2013 field season for the Middle Segment of the Susitna River, Alaska.

	Habitat Type								
Focus Area	**BW**	**CWP**	**MC**	**SC**	**SS**	**TM**	**TRIB**	**US**	**Total**
FA-104 (Whiskers Slough)			220	105	206		90	126	**747**
FA-113 (Oxbow 1)			60	104			31	25	**220**
FA-115 (Slough 6A)			20	25				100	**145**
FA-128 (Slough 8A)			140	219	135	35		57	**586**
FA-138 (Gold Creek)			75	124	241			62	**502**
FA-141 (Indian River)	24	75	100	30		32	30	65	**356**
FA-144 (Slough 21)			110	184	42			30	**366**
Outside Focus Areas		18	59	135	39	34	15	75	**375**
Total	**24**	**93**	**784**	**926**	**663**	**101**	**166**	**540**	**3297**

Notes:

BW-backwater, CWP-clearwater plume, MC-main channel, SC-side channel, SS-side slough, TM-tributary mouth, Trib-tributary

Table 5.5-5. Summary statistics for water quality variables collected during summer 2013 in habitat units within the Middle Segment of the Susitna River, Alaska.

Statistic	Main Channel	Side Channel	Backwater	Clearwater Plume	Side Slough	Upland Slough	Tributary	Tributary Mouth	Total
	Temperature (°C)								
Max	17.3	16.7	13.2	14.9	17.9	26.7	17.1	16.4	**26.7**
Mean	12.5	10.4	10.3	11.2	9.4	10.4	13.1	10.4	**10.9**
Min	7.7	3.2	7.5	7.1	4.6	3.6	7.8	5.4	**3.2**
Count	784	926	24	93	663	540	166	101	**3297**
	Conductivity (uS)								
Max	173	258	126	95	328	381	78	253	**381**
Mean	143	159	96	69	179	136	44	128	**146**
Min	100	43	28	19	28	23	24	66	**19**
Count	784	926	24	93	663	540	166	101	**3297**
	Dissolved Oxygen (mg/L)								
Max	12.5	13.0	10.5	11.8	12.4	12.8	11.8	12.7	**13.0**
Mean	11.0	10.7	9.5	10.8	10.0	8.1	10.3	10.8	**10.3**
Min	10.1	6.7	8.6	8.8	5.3	3.4	8.2	7.9	**3.4**
Count	685	861	24	93	654	536	166	110	**3129**
	Turbidity (NTU)								
Max	962	528	89	21	95	312	3	10	**962**
Mean	209	73	49	8	7	28	1	3	**77**
Min	1	1	10	2	1	1	0	1	**0**
Count	784	926	24	93	663	540	166	101	**3297**
	VHG (mm)								
Max	40	80	70	10	200	190	62	75	**200**
Mean	-8	14	24	4	20	31	6	-20	**11**
Min	-95	-60	0	-5	-75	-32	-35	-120	**-120**
Count	784	926	24	93	663	540	166	101	**3297**

Table 5.5-6. Number of water quality observations by metric bin and habitat type collected during summer 2013 HSC surveys in the Middle Segment of the Susitna River, Alaska.

Metric Bin	Main Channel	Side Channel	Backwater	Clearwater Plume	Side Slough	Upland Slough	Tributary	Tributary Mouth	Total
	Temperature (°C)								
0-4.9	0	54	0	0	30	27	0	0	**111**
5.0-9.9	195	364	12	15	365	198	18	27	**1194**
10.0-14.9	396	410	12	78	230	269	103	64	**1562**
15.0-19.9	193	98	0	0	38	37	45	10	**421**
20.0-24.9	0	0	0	0	0	9	0	0	**9**
Total	**784**	**926**	**24**	**93**	**663**	**540**	**166**	**101**	**3297**
	Conductivity (uS)								
0-86	0	41	3	70	123	126	166	56	**585**
87-173	769	632	21	23	246	262	0	20	**1973**
173-258	15	253	0	0	75	89	0	25	**457**
259-344	0	0	0	0	219	46	0	0	**265**
>344	0	0	0	0	0	17	0	0	**17**
Total	**784**	**926**	**24**	**93**	**663**	**540**	**166**	**101**	**3297**
	Dissolved Oxygen (mg/L)								
0-4.9	0	0	0	0	0	35	0	0	**35**
5.0-9.9	0	146	18	14	241	373	42	20	**854**
10.0-14.9	693	652	6	79	339	76	124	71	**2040**
≥15	0	0	0	0	3	0	0	0	**3**
NA	91	128	0	0	80	56	0	10	**365**
Total	**784**	**926**	**24**	**93**	**663**	**540**	**166**	**101**	**3297**
	Turbidity (NTU)								
≤30	220	490	12	93	630	445	166	101	**2157**
>30	564	436	12	0	33	95	0	0	**1140**
Total	**784**	**926**	**24**	**93**	**663**	**540**	**166**	**101**	**3297**
	VHG (mm)								
<(-5)	305	73	0	0	22	21	29	55	**505**
(-5) – (+5)	399	275	9	48	222	108	87	34	**1182**
>5	80	578	15	27	419	411	50	12	**1592**
NA	0	0	0	18	0	0	0	0	**18**
	784	**926**	**24**	**93**	**663**	**540**	**166**	**101**	**3297**

Table 5.5-7. Total number of fish captured by species and life stage during daytime and nighttime electrofishing surveys conducted in FA-104 (Whiskers Slough) and FA-128 (Slough 8A) in March and April 2013.

Site	Survey Date	Habitat Type[1]	Area Surveyed (ft^2)	Capture totals, by species			Total Count
				Chinook, Juvenile	Coho, Juvenile	Sculpin sp., Juvenile, adult	
FA-104-WSL-20	24-Mar	SS	12502	0	0	8	*8*
FA-104-WSC-10	24-Mar	SC	4256	0	0	0	*0*
FA-104-SL3B-10	24-Mar	SC	3432	1	0	4	*5*
FA-104-SL3A-71	24-Mar	US	4455	1	0	35	*36*
	25-Mar[2]		4455	12	3	35	*50*
FA-128-SL8A-10	22-Mar	SS	14850	0	0	1	*1*
	22-Mar[2]		14850	3	0	0	*3*
	9-Apr		18150	2	0	8	*10*
FA-128-SC8A-28	9-Apr	SC	4356	0	0	0	*0*
	9-Apr[2]		4356	7	0	6	*13*
FA-128-SSC-20	10-Apr	SC	5610	0	0	0	*0*
	10-Apr[2]		5610	0	0	0	*0*
FA-128-US2-10	22-Mar	US	240	0	0	0	*0*
	22-Mar[2]		240	1	0	0	*1*

Notes:

1 SS = Side slough, SC = Side Channel, US = Upland Slough; habitat designations are based on 2012 Middle Susitna River remote line habitat mapping (HDR 2013).

2 Survey was conducted at night.

Table 5.5-8. Total number of HSC observations recorded during electrofish sampling in March and April 2013 by species and life stage.

Species	Life stage	FA-104 (Whiskers Slough)	FA-128 (Slough 8A)	*Total*
Chinook salmon	Juvenile	14	12	*26*
Coho salmon	Juvenile	3	0	*3*

Table 5.5-9. Number of Hess, algae, and snag samples collected with associated depth (D), velocity (V), and substrate composition (Sub) measurements for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

		Hess Samples (D, V, Sub)					Algae Samples (D, V)					Snag Samples (D, V, Sub)				
Site	**Macro-habitat Type**	**Spr**	**Sum**	**Fall**	**Post-Storm**	**Total**	**Spr**	**Sum**	**Fall**	**Post-Storm**	**Total**	**Spr**	**Sum**	**Fall**	**Post-Storm**	**Total**
RP-184-1	Tributary Mouth	5	4	5		14	25	20	25		70	5	2	3		10
RP-184-2	Side Channel	5	5	5		15	25	25	25		75		1			1
RP-184-3	Main Channel	5	5	5		15	25	25	25		75					
RP-173-1	Tributary Mouth	5	5	5		15	25	25	25		75	2	3	1		6
RP-173-2	Main Channel	5	5	5		15	25	25	25		75					
RP-173-3	Side Channel	5	5	5		15	25	25	25		75		3			3
RP-173-4	Side Slough	5	5	2	5	17	25	25	25	25	100	1	2	5		8
RP-141-1	Tributary Mouth	5	5	5		15	25	25	25		75	3	5	5		13
RP-141-2	Side Channel	5	5			10	25	25	25		75		5	1		6
RP-141-3	Mult Split Main Channel	5	5	5		15	25	25	25		75					
RP-141-4	Upland Slough	5	4	3		12	25	25	25		75	3	4	5		12
RP-104-1	Side Slough	5	5	5		15	25	25	25		75	2	5	5		12
RP-104-2	Side Slough	5	5	2	5	17	25	25	25	25	100	3	5	5	5	18
RP-104-3	Main Channel	5	5	5		15	25	25	25		75					
RP-104-4	Upland Slough						25		25		50	5	5	3		13
RP-104-5	Side Channel	5	5	5		15	25	25	25		75	2		5		7
RP-81-1	Upland Slough			5		5	25	25	25		75	5	2	5		12
RP-81-2	Tributary Mouth	5	5	5		15	25	25	25		75	5	5	5		15
RP-81-3	Split Main Channel	5	5	5		15	25	25	25		75		2	2		4
RP-81-4	Side Channel	5	5	5		15	25	25	25		75	0	5	5		10
RP-TKA-1	Side Channel	5	5	5		15	25	25	25		75					
RP-TKA-2	Upland Slough						25	25	25		75					
RP-TKA-3	Side Slough	5	5	5		15	25	25	25		75					
	Totals	100	98	92	10	**300**	575	545	575	50	**1745**	36	54	55	5	**150**

Table 5.5-10. Source and projected availability of water quality and fish abundance data needed for completion of an evaluation of relationships between fish abundance and water quality within Middle River Segment Focus Areas.

Variable	Source/Study	Availability (QA/QC'd data)
Water Temperature	Water Quality, River Productivity, Groundwater, FDA, HSC	Q4 2013
Dissolved Oxygen	Water Quality, River Productivity, FDA, HSC	Q4 2013
Conductivity	Water Quality, River Productivity, FDA, HSC	Q4 2013
pH	Water Quality	Q4 2013
Surface flow and groundwater exchange flux	Groundwater	Q1 2014
Intergravel water temp.	Groundwater	Q1 2014
Macronutrients	Water Quality	Q1 2014
Dissolved Organic Carbon	Water Quality	Q1 2014
Alkalinity	Water Quality	Q1 2014
Chlorophyll-a	Water Quality	Q1 2014
Fish Distribution/Abundance	FDA	Q1 2014

10. FIGURES

[See separate file for Figures.]

APPENDIX A: HYDROLOGIC METHODS

[See separate file for Appendix.]

APPENDIX B: BIOLOGICAL CUES STUDY

[See separate file for Appendix.]

APPENDIX C: MOVING BOAT ADCP MEASUREMENTS

[See separate file for Appendix.]

APPENDIX D: GINA INITIAL STUDY REPORT 8.5 DATA FILES

[See separate file for Appendix.]

APPENDIX E: TRIBUTARY GAGING SITE SCHEMATICS

[See separate file for Appendix.]

APPENDIX F: TRIBUTARY GAGING REPRESENTATIVE SITE PHOTOS

[See separate file for Appendix.]

APPENDIX G: HSC HISTOGRAM PLOTS

[See separate file for Appendix.]

APPENDIX H: PERIODICITY TABLES

[See separate file for Appendix.]

APPENDIX I: LOWER RIVER HYDRAULIC MODEL CALIBRATION

[See separate file for Appendix.]