Revised Study Plan

Susitna – Watana Hydroelectric Project

FERC No. 14241

[Insert photo]

Alaska Energy Authority

[Interim Draft: 10/26/12]

October 2012

TABLE OF CONTENTS

ATTACHMENTS

LIST OF TABLES

LIST OF FIGURES

8 INSTREAM FLOW STUDY: FISH, AQUATICS AND RIPARIAN

8.1 Introduction

Project construction and operation would have an effect on the flows downstream of the dam, the degree of which will ultimately depend on final Project design and operating characteristics. The Project would be operated in a load following mode. Project operations would cause seasonal, daily, and hourly changes in Susitna River flows compared to existing conditions. The potential alteration in flows would influence downstream resources/processes, including fish and aquatic biota and their habitats, channel form and function including sediment transport, water quality, groundwater/surface water interactions, ice dynamics and riparian and wildlife communities (AEA 2011).

The potential operational flow induced effects of the Project will need to be carefully evaluated as part of the licensing process. This Revised Study Plan (RSP) describes the Susitna-Watana Instream Flow Study (IFS) that will be conducted to characterize and evaluate these effects. The plan includes a statement of objectives, a description of the technical framework that is at the foundation of the IFS, the general methods that will be applied, and the study nexus to the Project. This plan will be subject to revision and refinements as part of the licensing participant review and comment process identified in the ILP. Pursuant to the standards, schedule, and process described below, these details will be developed in consultation with licensing participants as part of the continuing study planning process and during study implementation.

8.2 Nexus between Project Construction / Existence / Operations and Effects on Resources to be Studies

As described above, the operational strategy of the Project could result in a variety of flow responses to the river below Watana Dam. These may include seasonal, daily and hourly changes in river stage that would vary longitudinally along the river. Having a clear understanding of Project effects on instream flow and riparian habitats and biological resources present within the Susitna River corridor will be critical to environmental analysis of the Project.

8.3 Resource Management Goals and Objectives

Several natural resources agencies have jurisdiction over aquatic species and their habitats in the Project area. These agencies will be using in part, the results of the IFS and other fish and aquatic studies to satisfy their respective mandates. The following federal and state agencies and Alaska Native entities have identified their resource management goals, or provided comments in the context of FERC licensing, related to instream flow and riparian resource issues.

8.3.1 National Marine Fisheries Service

The following text is an excerpt of the May 31, 2012 NMFS letter and Instream Flow Study Request:

> *"NMFS has authority to request water quality and other natural resource studies related to the project pursuant to the: Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), National Environmental Policy Act (NEPA) of 1969 (83 Stat. 852; 42 U.S.C. §4321 et seq.), Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. §1531 et seq.), Bald and Golden Eagle Protection Act (BGEPA) (54 Stat. 250, as amended, 16 U.S.C. §668a-d), Migratory Bird Treaty Act (MBTA) (40 Stat. 755, as amended; 16 U.S.C. §703 et seq.), Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. §661 et seq.), and Federal Power Act (16 U.S.C. § 91 et seq.).*
>
> *Under Section 18 of the FPA, NMFS and the USFWS have authority to issue mandatory fishway prescriptions for safe, timely, and effective fish passage. Under Section 10(j) of the FPA, NMFS and USFWS are authorized to recommend license conditions necessary to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of hydropower projects. Section 10(a)(1) of the FPA requires FERC to condition hydropower licenses to best improve or develop a waterway or waterways for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat) based on NMFS and Service recommendations and plans for affected waterways. Therefore, one of the resource management goals of NMFS is to inform development of fishway prescriptions for this project pursuant to Section 18 of the FPA.*
>
> *A number of Federal regulations address the need to protect and preserve fish and wildlife resources and their habitats, including preventing the "take" of certain species (or groups of species). The following is a list of some of the most important of these regulations which are applicable or may be applicable to the proposed license applications:*
>
> - *Federal Power Act*
>   - *FERC is required to give equal consideration to "protection, mitigation of damage to, and enhancement of, fish and wildlife (including spawning grounds and habitat)."*
> - *Magnuson-Stevens Fishery Conservation Act*
>   - *Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267), established a new requirement to describe and identify EFH in each fishery management plan. The EFH provisions of the MSA (§305(b)) require federal agencies to consult with NMFS on all actions, or proposed actions, authorized, funded, or undertaken by the agency, that may adversely affect EFH*
> - *Fish and Wildlife Coordination Act*

- *Requires equal consideration and coordination of wildlife conservation with other water resources development programs.*
- *National Environmental Policy Act*
  - *Requires evaluation of project alternatives, cumulative effects.*
- *Endangered Species Act*
  - *Section 7(a)(2) requires Federal agencies to ensure that their activities are not likely to jeopardize the continued existence of listed species or adversely modify designated critical habitat.*
- *Anadromous Fish Conservation Act"*

8.3.2 U.S. Fish and Wildlife Service

The following text is an excerpt of the May 31, 2012 USFWS Instream Flow Study Request:

> *"The U.S. Fish and Wildlife Service (USFWS), U.S. Department of Interior, has authority to request fish and wildlife resources studies related to this project pursuant to:*
>
> *The National Environmental Policy Act (NEPA) of 1969 (83 Stat. 852; 42 U.S.C. 4321 et seq.), the Endangered Species Act (ESA) of 1973 (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.), the Bald and Golden Eagle Protection Act (BGEPA) (54 Stat. 250, as amended, 16 U.S.C. 668a-d), the Migratory Bird Treaty Act (MBTA) (40 Stat. 755, as amended; 16 U.S.C. 703 et seq.), the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.), and the Federal Power Act (16 U.S.C. § 791 et seq.).*
>
> *Under Section 18 of the Federal Power Act (FPA), the National Marine Fisheries Service (NMFS), U.S. Department of Commerce and the USFWS have authority to issue mandatory fishway prescriptions for safe, timely, and effective fish passage. Under Section 10(j) of the FPA, NMFS and USFWS are authorized to recommend license conditions necessary to adequately and equitably protect, mitigate damages to, and enhance, fish and wildlife (including related spawning grounds and habitat) affected by the development, operation, and management of hydropower projects. Section 10(a)(1) of the FPA requires FERC to condition hydropower licenses to best improve or develop a waterway or waterways for the adequate protection, mitigation, and enhancement of fish and wildlife (including related spawning grounds and habitat) based on NMFS and USFWS recommendations and plans for affected waterways.*
>
> *Consistent with our mission and with the legal authorities described above, our resource goal in this matter is to conserve existing fish and wildlife resources and their habitats in the Susitna River basin. With regard to fish passage, we will recommend scientifically-based and coordinated studies, collaborate with others, and ensure development of the best information possible to inform potential development of fishway prescriptions for this project pursuant to Section 18 of the Federal Power Act."*

8.3.3 Alaska Department of Fish and Game

The following text is an excerpt of the May 30, 2012 ADF&G letter and Instream Flow Study Request:

> *"The Fish and Game Act requires the Alaska Department of Fish and Game to, among other responsibilities, "…manage, protect, maintain, improve, and extend the fish, game and aquatic plant resources of the state in the interest of the economy and general well-being of the state" (AS 16.05.020)."*

8.3.4 Alaska Native Entities

8.3.4.1 Chickaloon Village Traditional Council

The Chickaloon Native Village provided comments on Project licensing activities in a May 31, 2012 letter to the FERC. Chickaloon Native Village is a federally recognized Alaska Native tribe. Chickaloon Village is an Ahtna Athabascan Indian Tribe governed by the nine-member Chickaloon Village Traditional Council. The Chickaloon Village Traditional Council strives to increase traditional Ahtna Dene' practices for the betterment of all residents in the area. Preserving and restoring the regions natural resources is one way of supporting Ahtna culture and the regional ecosystem.

8.4 Summary of Consultation with Agencies, Alaska Native Entities, and Other Stakeholders

Input regarding the issues to be addressed in the IFS has been provided by licensing participants during workgroup meetings commencing in late 2011. During 2012, workgroup meetings were held in January, February, April, June, August, September and October during which resource issues were identified and discussed and objectives of the instream flow studies were defined. Various agencies (USFWS, NMFS, ADF&G, etc.) provided written comments specific to this study which have been considered and will be addressed as part of this plan. A summary of comments and AEA responses relevant to the Instream Flow study plans is provided in Table 8.4-1. *[Given the size of the consultation table, it has been posted as a separate document for purposes of this October draft RSP].*

Table 8.4-1 Summary of consultation on Instream Flow Study plans.

[Given the size of the consultation table, it has been posted as a separate document for purposes of this October draft RSP].

8.5 Fish and Aquatics Instream Flow Study

8.5.1 General Description of the Study

8.5.1.1 Focus of IFS

The 2013-2014 IFS plan is specifically directed toward establishing an understanding of important biological communities and associated habitats, and the hydrologic, physical, and chemical processes in the Susitna River that directly influence those resources. The focus of much of this work will be on establishing a set of analytical tools/models based on the best available information and data that can be used for defining both existing or base conditions; i.e., without Project, and how these resources and processes will respond to alternate Project operations.

8.5.1.2 Study Objectives

The goal of the IFS and its component study efforts is to provide quantitative indices of existing aquatic habitats that enable a determination of the effects of alternate Project operational scenarios. Achievement of this goal will require close coordination with a number of interrelated studies (e.g., fish distribution (RSP Section 9.6), habitat characterization (RSP Section 9.9), geomorphology (RSP Section 6.0), water quality (RSP Section 5.0, etc.) that will provide important inputs into an overall project effects analysis (see Figure 8.5-1). Specific objectives of this and associated companion studies include the following:

1. Map the current aquatic habitat in main channel and lateral habitats of the Susitna River affected by Project operations. This objective will be completed as part of the habitat characterization study (RSP Section 9.9) (see Figure 8.5-1).
2. Select study sites and sampling procedures to collect data and information that can be used to measure and model mainstem and lateral Susitna River habitat types. This objective will be completed via a collaborative process involving this study, riparian instream flow (RSP Section 8.6), groundwater – aquatic habitats (RSP Section 7.5), geomorphology (RSP Section 6.0), water quality (RSP Section 5.0), and fisheries studies (RSP Section 9.0)).
3. Develop a hydraulic routing model that estimates water surface elevations and average water velocity along modeled transects on an hourly basis under alternate operational scenarios.
4. Develop site-specific Habitat Suitability Curves (HSC) and Habitat Suitability Indices (HSI) for various species and lifestages of fish for biologically relevant time periods selected in consultation with licensing participants. 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, etc.). 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 licensing participants.

5. Develop integrated aquatic habitat models that produce a time series of data for a variety of biological metrics under existing conditions and alternate operational scenarios. These metrics may include (but are not limited to):
   - water surface elevation at selected river locations;
   - water velocity within study site subdivisions (cells or transects) over a range of flows during seasonal conditions;
   - length of edge habitats in main channel and lateral habitats;
   - habitat area associated with lateral habitats;
   - clearwater area zones;
   - effective spawning and incubation habitats
   - varial zone area;
   - frequency and duration of exposure/inundation of the varial zone at selected river locations; and
   - habitat suitability indices.
6. Evaluate existing conditions and alternate 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 cold Pacific Decadal Oscillation (PDO) phases.
7. Coordinate instream flow modeling and evaluation procedures with complementary study efforts including riparian (RSP Section 8.6), geomorphology (RSP Sections 6.5 and 6.5), groundwater (RSP Section 7.5), water quality (RSP Section 5.5), fish passage (RSP Section 9.12), and ice processes (RSP Section 7.6) (see Figure 8.5-1). If channel conditions are expected to change over the license period, instream flow habitat modeling efforts will incorporate changes identified and quantified by riverine process studies.
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):
   - seasonal juvenile and adult fish rearing;
   - habitat connectivity;
   - spawning and egg incubation;
   - juvenile fish stranding and trapping;
   - ramping rates; and
   - distribution and abundance of benthic macroinvertebrates.

8.5.2 Existing Information and Need for Additional Information

8.5.2.1 Summary of Existing Susitna River Information

Substantial physical, hydrologic and biological information is available for the Susitna River as a result of previous hydropower licensing efforts conducted during the 1980s. The extent and details of many of those studies were provided in the Draft Environmental Impact Statement (DEIS 1984) for the previous proposed project (FERC No. 7114) along with companion appendices and attachments in the way of ADF&G reports. A gap analysis report conducted by HDR (2011) summarized some of the data. The gap analysis provided an initial listing of salient reports and data that warrant more detailed evaluations.

The 1980s project was envisioned as a two-dam project, with an upper dam, reservoir and powerhouse near RM 184 (Watana Dam). The upper development would be operated in load-following mode to meet power demands. A lower dam, reservoir and powerhouse (Devils Canyon Dam) would provide additional power generation, but would also reregulate flow releases from the upper development. Downstream flow releases from the Devils Canyon Dam would not have the daily flow fluctuations associated with load-following operations of the upper development. In addition, since the Devils Canyon Dam would create a reservoir that would inundate much of the river between the two dams, the instream flow and riparian study efforts in the 1980s focused on the effects of flow releases to the Susitna River downstream of the Devils Canyon Dam site and the reach between the Devils Canyon Dam and Watana Dam sites were not modeled as part of the Instream Flow Study. Instream flow related issues that were the focus of studies completed in the 1980s were thus more concerned with determining the effects of changes in the timing and magnitude of flows on the quantity and quality of fish habitats that would occur with the two dams as configured, rather than flow fluctuations. These are important differences between the current proposal and that of the 1980s. The Project, as currently proposed, without the re-regulation of flows that a second dam would allow, will require the evaluation of downstream effects of load-following operations on fish and wildlife resources downstream of the Watana Dam site, in addition to an assessment of overall effects due to shifts and changes in flow timing and magnitude.

Inspection of the 1980s reports confirms that the majority of efforts were focused on the Middle and Lower River segments of the Susitna River. As part of the review effort, over sixty reports from the 1980s and earlier were identified as useful for compilation or synthesis of existing information. The identified documents included 83 separate volumes containing descriptions of field studies and reports with tabular data, figures, and maps. A listing of the studies for which reports have been reviewed includes:

- Water quality investigations
- Adult salmon passage in sloughs and side channels
- Adult salmon spawn timing and distribution
- Channel geometry investigations
- Groundwater upwelling detection
- Hydrological investigations and modeling of anadromous and resident fish habitat
- Juvenile salmon abundance and distribution
- Resident fish abundance, distribution and life history
- Salmon habitat suitability criteria

- Salmon spawning habitat evaluation

8.5.2.1.1 Habitat Distribution

The spatial distribution and characterization of existing habitat conditions in the Susitna River will directly influence the potential flow induced effects of the Project. A description of existing information related to fish habitat in the Susitna River is provided in Section 9.9 of this RSP (Characterization and Mapping of Aquatic habitats in the Susitna River with Potential to be Affected by the Susitna-Watana Project), which is summarized here. Habitat characterization and mapping were conducted during the 1980s in the mainstem of the Middle Susitna River. Habitat types were identified based on distinct functional hydrology and channel morphology, and classified as mainstem channel, side channel, side slough, upland slough, tributary mouth, tributary, or lake (Trihey 1982, ADF&G 1983a). These habitat types were mapped using aerial photography (ADF&G 1983a). Klinger-Kingsley et al. (1985) identified the location and described the areal extent of the various habitat types in the Middle Susitna River. Based on aerial photographs at different intervals, they quantified the relative amount of different habitat types under a range of flow conditions (Figure 8.5-2).

8.5.2.1.2 Fish Distribution and Abundance

The distribution and abundance of fish species in the Susitna River will play an important role in evaluating the potential flow induced effects of the Project, particularly in the Middle and Lower Susitna River. Extensive studies were conducted during the 1980s related to fish distribution and abundance. Existing information related to fish distribution and abundance in the Middle and Lower Susitna River is summarized in Section 9.6 of this RSP (Study of Fish Distribution and Abundance in the Middle and Lower Susitna River). ADF&G (1981 and 1984), Barrett et al. (1983 and 1985), and Thomson et al. (1986) provide information related to adult anadromous fish investigations, including estimates of escapement and spawner distribution. Primary sources with information related to the distribution and abundance of resident and juvenile anadromous fish include Delaney et al. (1981), Schmidt et al. (1983, 1984, and 1985).

8.5.2.1.3 Salmonid Spawning and Incubation

Salmonid spawning and egg incubation in the Lower and Middle Segments of the Susitna River habitats are important considerations for development of instream flow studies. Salmonid spawning is sensitive to hydrologic conditions (e.g., water depth and velocity); as such it is important to identify the timing and distribution of spawning for salmonid species for instream flow purposes. Salmonid spawning behavior, such as colonization rates of new spawning areas and redd residence time, is an important aspect of this life history stage and may guide instream flow studies in the Susitna River. For salmonid eggs during the period of incubation and fry during the period of emergence, surface and intragravel flow conditions are critical for the development and survival. Descriptions of existing information on salmonid spawning and egg incubation in the Susitna River are provided in Section 9 of this RSP (Fish and Aquatic Resources).

Pacific salmon species use a range of habitats in the Lower and Middle Susitna River. During the 1980s, primary and secondary habitats used by spawning adult salmon were identified during adult salmon investigations (Table 8.5-1). Main channel habitats were used by all salmon species as a migratory route to spawning areas; however, minimal active spawning was recorded in main channel areas (Barrett et al. 1985, Jennings et al. 1985, Thompson et al. 1986). Tributaries to the Susitna River represented primary spawning habitats for Chinook, chum, coho and pink salmon and side slough habitats were particularly important spawning habitats for sockeye and chum salmon during the 1980s (Barrett et al. 1985, Jennings et al. 1985, Thompson et al. 1986). Among habitats utilized for spawning by salmon species, side channel and side slough habitats were observed to be most vulnerable to dewatering and/or freezing as a result of fluctuations in Susitna River discharge (Vining et al. 1985).

8.5.2.1.4 Study Site Selection

In general, the Susitna River was divided in the 1980s studies into segments, sub-reaches, and study sites based on hydrology, channel morphology, tributary input, macro- and mesohabitat features, and fish use. At the broadest scale, the Susitna River was divided into three reaches following the historic river mile (HRM) convention used at the time:

1. Upper River – Representing that portion of the watershed above the proposed Devils Canyon Dam site at HRM 152;
2. Middle River – Extending approximately 53.5 miles from HRM 152 downstream through Devils Canyon to the Three Rivers Confluence at HRM 98.5; and
3. Lower River – Extending 98.5 miles downstream from the Three Rivers Confluence to Cook Inlet [HRM 0].

These three breaks formed the first order level of stratification in the 1980s studies.

A second level of stratification was designated based on classifying riverine related habitats of the Susitna River into six macro-habitat categories consisting of mainstem, side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). The distribution and frequency of these habitats varied longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. The habitat types were described with respect to mainstem flow influence by ADF&G in the Susitna Hydroelectric Aquatic Studies Procedures Manual (1984) as follows, with additional clarification added here where considered appropriate:

- **Mainstem Habitat** consists of those portions of the Susitna River that normally convey streamflow throughout the year. Both single and multiple channel reaches are included in this habitat category. Groundwater and tributary inflow appear to be inconsequential contributors to the overall characteristics of mainstem habitat. Mainstem habitat is typically characterized by high water velocities and well armored streambeds. Substrates generally consist of boulder and cobble size materials with interstitial spaces filled with a grout-like mixture of small gravels and glacial sands. Suspended sediment concentrations and turbidity are high during summer due to the influence of glacial melt-water. Streamflows recede in early fall and the mainstem clears appreciably in October. An ice cover forms on the river in late November or December.

- **Side Channel Habitat** consists of those portions of the Susitna River that normally convey streamflow during the open water season but become appreciably dewatered during periods of low flow. Side channel habitat may exist either in well-defined overflow channels, or in poorly defined water courses flowing through partially submerged gravel bars and islands along the margins of the mainstem river. Side channel streambed elevations are typically lower than the mean monthly water surface elevations of the mainstem Susitna River observed during June, July and August. Side channel habitats are characterized by shallower depths, lower velocities and smaller streambed materials than the adjacent habitat of the mainstem river.
- **"Side" Slough Habitat** is located in spring- or tributary-fed overflow channels between the edge of the floodplain and the mainstem and side channels of the Susitna River and is usually separated from the mainstem and side channels by well vegetated bars. An exposed alluvial berm often separates the head of the slough from mainstem or side channel flows. The controlling streambed/streambank elevations at the upstream end of the side sloughs are slightly less than the water surface elevations of the mean monthly flows of the mainstem Susitna River observed for June, July, and August. At intermediate and low-flow periods, the side sloughs convey clear water from small tributaries and/or upwelling groundwater (ADF&G 1981c, 1982b). These clear water inflows are essential contributors to the existence of this habitat type. The water surface elevation of the Susitna River generally causes a backwater to extend well up into the slough from its lower end (ADF&G 1981c, 1982b). Even though this substantial backwater exists, the sloughs function hydraulically very much like small stream systems and several hundred feet of the slough channel often conveys water independent of mainstem backwater effects. At high flows the water surface elevation of the mainstem river is sufficient to overtop the upper end of the slough (ADF&G 1981c, 1982b). Surface water temperatures in the side sloughs during summer months are principally a function of air temperature, solar radiation, and the temperature of the local runoff.
- **"Upland" Slough Habitat** differs from the side slough habitat in that the upstream end of the slough is not interconnected with the surface waters of the mainstem Susitna River or its side channels at less than bankfull flows. The upstream end can be vegetated with mature trees, although a morphologic signature of a converging inlet and gravel levee closure can still be discerned. These sloughs are characterized by the presence of beaver dams and an accumulation of silt covering the substrate resulting from the absence of mainstem scouring flows. They are not truly "upland" in the geomorphic sense, but the use of this nomenclature in the 1980s studies reflects the observation that the understanding of floodplain and channel forming processes was in the early stage in fisheries, where some variation in interpretation existed over what constituted a floodplain versus an upland terrace (e.g., see Williams 1978). Essentially, the main distinguishing characteristic between a "side" slough and an "upland" slough was the level of high flow at which each was engaged.
- **Tributary Habitat** consists of the full complement of hydraulic and morphologic conditions that occur in the tributaries. Their seasonal streamflow, sediment, and

thermal regimes reflect the integration of the hydrology, geology, and climate of the tributary drainage. The physical attributes of tributary habitat are not dependent on mainstem conditions.

- **Tributary Mouth Habitat** extends from the uppermost point in the tributary influenced by mainstem Susitna River or slough backwater effects to the downstream extent of the tributary plume which extends into the mainstem Susitna River or slough (ADF&G 1981c, 1982b).

A schematic of these types of habitats as applied in the 1980s studies is depicted in Figure 8.5-3). These categories were also used by Trihey and Associates in their instream flow modeling studies (Aaserude et al. 1985). Beginning in the 1983 open water studies, however, a fundamental change was made in how side sloughs and side channels were identified during field studies (Dugan et al. 1984). During 1981 and 1982, side sloughs and side channels were distinguished primarily on their morphology. Side sloughs included an unvegetated berm at the head of the slough and were rarely overtopped. In contrast, a side channel conveyed mainstream flow during most of the year. During 1983 and following years, if a berm was overtopped and a channel conveyed mainstem flows it was characterized as a side channel. If the berm was not overtopped it was characterized as a side slough. Consequently, during the latter years of the 1980s Fish and Aquatic Program an area may have been characterized as a side channel during periods of high flows and a side slough during periods of lower flows.

Specific sites chosen for the completion of the various studies by ADF&G between 1981 and 1985 varied from year to year and study to study. In general, sampling was relatively broad during 1981 and 1982, and more focused during 1983 to 1985. The 1981 Aquatic Habitat Studies were focused on 'Fishery Habitat' evaluations and 'Selected Habitat' evaluations (Estes et al. 1981). The Fishery Habitat evaluations collected point information on observed fish habitat use and general habitat evaluations (water quality, hydrology, and mapping). The Selected Habitat evaluations collected water quality, discharge, and mapping information at selected sloughs between Talkeetna and Devils Canyon.

A total of five river reaches were delineated and eight to thirteen representative study sites were selected in each, without consideration of proportional sampling or optimal allocation (e.g., see Cochran 1977). These included:

- Yentna Reach (Cook Inlet to Little Willow Creek; HRM 0.0-50.5): 13 sites
- Sunshine Reach (Rustic Wilderness to Parks Highway Bridge; HRM 58.1-83.5): 10 sites
- Talkeetna Reach (Parks Highway Bridge to Curry; HRM 83.5-120.7): 11 sites
- Gold Creek Reach (Curry to Portage Creek; HRM 120.7-148.8): 12 sites
- Impoundment Reach (Devils Canyon to Denali Highway; HRM 151-281): 8 tributaries

With few exceptions, the sites sampled for Aquatic Habitat studies were the same as those sampled under resident and juvenile anadromous fish studies in 1981 and 1982. Selection of specific sampling sites was apparently not based upon a statistical sampling design. Instead, sites were considered representative of each reach, and were based effectively on where fish were found. This basis was carried forward in subsequent years. For example, in 1982, habitat information was collected where spawning fish were located within the mainstem Susitna River downstream of Devils Canyon (tributary/mainstem confluence areas and sloughs were not sampled). Only spawning sites for chum salmon were observed in the mainstem, which led to the identification of eight mainstem spawning locations between Lane Creek (HRM 113.6) to Devils Canyon.

In addition, seventeen Designated Fish Habitat (DFH) Sites were chosen in 1982 based upon four criteria (Estes and Schmidt 1983; ADF&G 1983[Cit ADF&G 1983; BibID 5504]):

1. Areas that will be affected by changes in discharge of the mainstem Susitna.
2. Sites identified from previous studies to have significant populations of resident and juvenile anadromous species.
3. Access to areas will not create severe logistic problems and limit the overall scope of the studies.
4. Sites selected represent a cross section of critical habitat available to resident and juvenile anadromous fish of the Susitna River.

Five of the DFH sites were located downstream of Talkeetna from HRM 73.1 to 88.4 and twelve were located in the reach from Whiskers Creek (HRM 101.2) to Portage Creek (HRM 148.8).

During 1983 and 1984 studies became focused on collecting specific data needed to develop three types of instream flow models: Resident and Juvenile Habitat (RJHAB) models, Instream Flow Group (IFG) models, and Direct Input Habitat (DIHAB) models developed by Trihey and Associates (Hilliard et al. 1985). As before, sites were selected based on where fish were found. During 1983, 32 sites (11 tributaries, 3 upland sloughs, 8 side slough/channel, 6 side channel, 4 side slough) were sampled in the reach from Talkeetna to Devils Canyon for fish distribution and 13 sites were modeled by ADF&G with either the RJHAB (2 upland sloughs, 2 side channel/ sloughs, 1 side slough, 1 side channel) approach or IFG approach (3 side slough/channels, 1 side slough, 3 side channels). The 13 modeled sites were chosen based upon observations of large numbers of spawning salmon or concentrations of juvenile salmon during 1981 and 1982 studies (Dugan et al. 1984). They were also selected as being representative of the habitat types present between the Chulitna River and Devils Canyon likely to be affected by changes in mainstem flow from the proposed project (Dugan et al. 1984, Marshall et al. 1984).

Sampling in 1984 focused on secondary side channels and sloughs in the reach downstream of Talkeetna between HRM 36.2 and 91.6. Crews sampled three types of study sites:

- RJHAB sites (16 sites)
- IFG sites (6 sites)
- Opportunistic sites (31 sites)

Opportunistic sites were only sampled once to expand the understanding of juvenile and resident fish distribution (Suchanek et al. 1985).

Instream flow modeling of spawning habitat was conducted for chum and sockeye salmon at mainstem margin, side channel, upland slough, and side slough habitat types. Modeled sites were considered to represent the range of spawning conditions for sloughs and side channels present in the mainstem between the Chulitna River and Devils Canyon. In addition, instream flow studies were performed to describe juvenile Chinook habitat-flow responses within mainstem margins, side channels, side sloughs, and upland sloughs of the middle Susitna River reach. The modeling studies relied effectively on the habitat classification, and manipulations thereof, for stratifying and extrapolating model results from sampled sites to larger study reaches (Steward et al. 1985, Ashton and Klinger-Kingsley 1985, and Klinger-Kingsley et al. 1985). The overall approach proposed for the extrapolation process was described in Aaserude et al. (1985) and consisted of methods for both single thread and multiple thread portions of the river. However, project funding was curtailed in 1985 and the approach was never implemented.

8.5.2.1.5 HSC/HSI

An important element of these studies was the collection of microhabitat data of various species and life stages of fish reflective of a suite of different parameters influenced by, or potentially influenced by, flow. These included water depth, water velocity, substrate, upwelling occurrence, turbidity.

A more detailed synthesis of pertinent information will be completed as part of the IFS and supplemented by analysis of aquatic-related information conducted as part of the Fish and Aquatic Program (Section x). As part of this synthesis, information will be compiled and reviewed related to instream flow regimes implemented at other large hydropower projects, with a special emphasis on projects developed in arctic and sub-arctic environments.

An extensive set of habitat suitability criteria were developed as part of the 1980s instream flow studies. These criteria were developed using a combination of site-specific data collected through fish sampling, literature sources, and through refinement based on the professional judgment of project biologists. Table 8.5-2 summarizes the species and life stages for which habitat suitability criteria (HSC) were developed during the 1980s efforts. Also described are the various habitat parameters for which curves describing habitat suitability criteria were developed (e.g., depth).

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. 1984b). These HSC were developed based on field data collected at representative tributary, slough, and side channel sites between the Chulitna River confluence and Devils Canyon (Middle Susitna River) and were considered to be specific to this reach. Fish observations were obtained by beach seining (turbid water) or electrofishing (clear water) systematically established 300-ft^2 cells with relatively uniform physical habitat (within cells) that captured the overall variability of site habitat conditions (across cells). Fish observations were then related to depth, velocity, and cover conditions characterized by each cell and collectively used to develop HSC for these parameters. 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 (i.e., juvenile Chinook). An example of HSC developed through this effort is shown in Figure 8.5-4. A subsequent effort used similar methods to verify the applicability of these juvenile salmon rearing HSC curves for the Lower River downstream of the Chulitna River confluence (Suchanek et al. 1985). Findings from this effort resulted in some modifications to HSC for use in the Lower River, particularly for water depth.

Spawning HSC for chum and sockeye salmon were developed from redd observations in sloughs and side channels of the Middle Susitna River (Vincent-Lang et al. 1984b). 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. A related study also examined chum salmon spawning habitat utilization in select tributary mouths of the Middle Susitna River and found that the range of utilized depths, velocities, and substrates were generally comparable to redds in sloughs in side channels (Sandone et al. 1984). Spawning habitat utilization for Chinook, coho, and pink salmon was evaluated in tributaries of the Middle Susitna River (Vincent-Lang et al. 1984a). 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 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. 1984a). 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.

8.5.2.1.6 Winter Studies

Winter instream flow conditions are a critical component of fish habitat, particularly with respect to egg incubation and juvenile rearing. The depth, velocity and temperature of surface flow are important habitat characteristics for juvenile fish, while intragravel flow or upwelling can be critical for salmonid egg and emergent fry survival. Intragravel flow provides oxygen to salmonid eggs during incubation and offers protection from temperature extremes and freezing, particularly in areas supplemented by groundwater upwelling (Burgner 1991). In aquatic habitats with minimal groundwater upwelling, intragravel temperatures during winter may approach the point of freezing, whereas in areas with extensive upwelling, intragravel temperatures remain above freezing and are typically very stable throughout winter. The rate of salmonid eggs incubation is a function of water temperature, with egg development occurring more quickly in warmer winter temperatures. Alterations to Susitna River streamflow caused by Project operations may affect the extent and degree of intragravel flow or lateral exchange between mainstem and off-channel habitats and consequently alter subsurface water temperatures critical for salmonid egg incubation and fry survival. Efforts conducted during the 1980s identified these as important considerations and focused several studies on evaluating habitat effects on early life stages for fish in the Susitna River.

Vining et al. (1985) reviewed the rationale and importance of studying redd stranding in the Susitna River. Declines in mainstem flow levels following spawning can cause areas that were suitable for spawning to become dewatered or have an increased risk of freezing. Chum in the Susitna River frequently select areas of groundwater upwelling for spawning. Because chum and sockeye salmon are the principle salmon species using side channels and side sloughs for spawning in the Susitna River (Sautner et al. 1984), egg development and incubation studies were conducted for these two species, though with a focus on chum salmon. Studies included monitoring of surface and intragravel water temperatures, egg development, spawning substrate composition, and trapping of emergent fry. Vining et al. (1985) selected study sites within slough, side channel, tributary, and mainstem habitats that included a range of spawning densities and upwelling, thermal, and substrate conditions. Sites were sampled for water quality, substrate composition, continuous water temperature, embryo survival, and embryo development. Standpipes were used to collect intragravel water samples and measurements including dissolved oxygen, pH, conductivity, and turbidity. Sediment samples were also collected and depths and velocities were measured periodically at each site.

Chum salmon survival and development were studied by artificially spawning chum and placing 50 fertilized eggs in Whitlock-Vibert Boxes (WVBs) containing appropriately sized gravel. To evaluate egg survival, WVBs were subsequently placed into artificial redds dug at randomly selected locations from a grid pattern. To evaluate egg development WVBs at two sites were placed in a single artificial redd. During the 1984-1985 winter study, chum egg survival in artificial redds ranged from 0.0 percent to 43.0 percent (Vining et al. 1985). It was concluded that freezing was the major factor affecting egg survival in the artificial redds and that upwelling was the main moderating factor. Upwelling contributed two important functions. First, upwelling can provide water to spawning habitat if mainstem flows decline. Second, upwelling water was generally warmer than surface water flows, which reduced the potential for ice cover and deep freezing of substrate down to the level where redds are created.

Seagren and Wilkey (1985) provided a data summary on intragravel and surface water temperature monitoring and substrate sampling at chum salmon spawning and upwelling sites from July 1 to October 15, 1984 and November 1, 1984 to April 25, 1985 in the Middle Susitna River, but no discussion of the biological relevance of the results. The objective of the study was to provide additional information for the planning of mitigation measures. Sampling occurred at 62 side channel and 27 mainstem sites. Three categories of sites were selected: those with open leads and previously observed spawning; open leads without any known spawning; and no open leads, but spawning previously observed.

Vining et al. (1985) concluded that sediment composition was also a factor contributing to egg survival. They observed that slough habitats had the highest level of fines, followed by side channel, tributary, and mainstem habitats. However, sediment composition sampled directly from redds were much lower. They suggested that egg survival approaches zero when fines (< 0.08 inches in diameter) in redds exceed 16 percent.

Water temperature is an important determinant of egg development and the timing of emergence. Related to this, intragravel water temperature studies began in February 1982 and led to the development of the following three hypotheses (Trihey 1982):

1. Mid-winter water temperatures in the sloughs are independent of mainstem water temperatures.
2. River stage appears to be influencing groundwater upwelling in the sloughs.
3. Spawning success at upwelling areas in side channels appears to be limited by availability of suitable substrate (streambed materials).

In addition to the importance to incubating salmon eggs, groundwater inflows to sloughs were also considered potentially important to overwintering habitat. During 1982, intragravel temperature monitoring occurred at thirteen sites between historic RM 125 and 143 that were identified from previous spawning surveys and were believed to have groundwater upwelling. Measurements of surface and intragravel water temperature revealed that intragravel temperatures were higher and more stable than surface water temperatures (e.g., Figure 8.5-5).

More intensive winter studies were implemented in March 1983 (Hoffman et al. (1983) and 1984-1985 (Vining et al. 1985; described above). Hoffman et al. (1983) reported on surface and intragravel water temperature monitoring at seven sites during the winter of 1982 to 1983 and also conducted incubation and emergences studies. In addition to water temperature, Hoffman et al. (1983) also monitored dissolved oxygen, pH, and specific conductance levels and noted the importance of dissolved oxygen exchange as a factor affecting egg incubation. Incubation and emergence studies were conducted in multiple sloughs and side channels (Hoffman et al. 1983).

The 1982-1983 winter study (Hoffman et al. 1983) and 1984-1985 winter study (Vining et al. 1985) confirmed patterns of surface- and ground-water temperature observed by Trihey (1982). Intragravel water temperatures in slough habitats tend to be relatively stable (Hoffman et al. 1983). Vining et al. (1985) observed similar patterns for sloughs, and also side channels where upwelling was present. At tributary and mainstem sites, Vining et al. (1985) observed that intragravel temperatures were variable and approach 0°C in October, which indicated intragravel waters were originating from surface waters. Continuous monitoring stations demonstrated intragravel water temperatures in areas with upwelling were warmer than surface waters during the ice covered period. As the spring thaw begins (about mid-April in 1983), intragravel temperatures then become cooler than surface water temperatures.

Both Hoffman et al. (1983) and Vining et al. (1985) found that dissolved oxygen concentrations were consistently lower in intragravel water compared to surface water. Vining et al. (1985) also found that the difference between intragravel and surface water dissolved oxygen levels was greatest for slough habitat and least for tributary and mainstem habitats, while differences were intermediate in side channel habitats. Vining et al. (1985) concluded that, with the possible exception of sloughs, the DO levels in most of the incubation habitat evaluated appear to be above recommended levels.

The sensitivity of incubating eggs to environmental conditions changes over the course of egg development. Understanding when incubating eggs are more sensitive to perturbations can be important to assessing potential effects of modified flow or temperature regimes. Sampling chum and sockeye redds for developing eggs by Hoffman et al. (1983) indicated that chum eggs deposited during late August and early September of 1982 were eyed by mid-December, hatched in late February and March and emergence occurred between early April through May. The development of sockeye eggs collected from field sites was not substantially different than chum salmon. Vining et al. (1985) also monitored egg development and attributed differences in development rates to temperature and the effects of upwelling. Vining et al. (1985) concluded that the presence of upwelling is an important factor contributing to emergence timing and that the beneficial effects of upwelling are more prominent in sloughs compared to mainstem, side channel, and tributary habitats because higher surface flows in the latter habitats dilute upwelling.

Wangaard and Burger (1983) incubated chum and sockeye eggs fertilized on three different dates and under four different temperature regimes that either simulated natural temperature regimes measured in the mainstem Susitna River and slough habitat sites, or was held at a constant 4°C. Chum eggs incubated under the mainstem temperature regime required substantially longer and fewer accumulated temperature units (ATUs) to reach the 50% hatch and yolk absorption stages compared to the Slough site and constant temperature regimes. A similar pattern was observed for incubating sockeye eggs. Following hatch, alevins required different amounts of ATUs to complete yolk absorption. Using data collected during the study and from the literature, Wangaard and Burger developed predictive regression equations for 50% hatch and complete yolk absorption for chum and sockeye salmon eggs based upon average incubation temperature.

Bigler and Levesque (1985) monitored surface and intragravel water temperature, egg development, outmigration, and substrate composition at three side channels in the Lower Susitna River with relatively high levels of chum salmon spawning that had not been anticipated. Results indicated that most of these chum spawning areas had upwelling and intragravel temperatures that were higher than surface water temperatures. In general, eggs developed through the alevin and emergence stage at all sites. In one of the side channels without groundwater upwelling, eggs laid in this portion of the study site froze.

Little information is available about over winter habitat use by juvenile salmon in the Susitna River. Surveys during the winter of 1980 to 1981 by Delaney et al. (1981) found that the majority of juvenile Chinook salmon captured between Cook Inlet and Devils Canyon occurred at slough and mainstem Susitna River sites. The majority of juvenile coho salmon captured between Cook Inlet and Talkeetna during winter occurred at tributary mouth sites whereas between Talkeetna and Devils Canyon, winter occurrence was greater at slough sites. Stratton (1986) studied overwinter habitat use by Chinook and coho salmon at four locations (Indian River, Slough 9A, Slough 10, and Slough 22) from October 1985 to April 1986. Findings suggested that coho salmon preferred areas with greater depth and cover consisting of debris, vegetation, and undercut banks, and beaver dams and ponds in particular. Chinook salmon preferred shallower, slightly higher velocity and cover consisting of rocks and boulders. Bigler and Levesque (1985) captured Chinook salmon juveniles using fyke nets at several side channels in the Lower Susitna River Trapper Side Channel in April and May, suggesting these side channels were being utilized as overwintering habitat.

8.5.2.1.7 Periodicity

Periodicity of fish habitat use in the middle and lower segments of the Susitna River during the 1980s was developed based on data collected during fish distribution and abundance studies. Salmon species in particular were studied intensively during the 1980s to identify the distribution, abundance of each life stage and species that used available aquatic habitats in the Susitna River. Other anadromous and freshwater resident fish species were studied, primarily to identify spawn locations and timing and seasonal movement patterns.

Periods of peak and off-peak habitat use by salmon in the Susitna River during the 1980s were developed by species and life stage based on juvenile and adult salmon distribution and abundance investigations conducted primarily during 1981-1985 (Table 8.5-3) (see Fish and Aquatic Resources, Section 9). More recent study efforts describing adult salmon abundance and spawning were completed between 2006 – 2010 (Merizon et al. 2010, Yanusz et al. 2011). Timing and location of adult salmon species migration and spawning during the 1980s was derived primarily from fish capture data at fishwheels located in the Susitna River main channel and surveys of spawning areas (Barrett et al. 1985, Jennings 1985, Thompson et al. 1986). The start of egg incubation was discerned from adult salmon spawn timing in fall and egg development during winter was monitored using fertilized eggs deposited in artificial redds in Susitna River habitats and in laboratory settings (Schmidt and Estes 1983, Wangaard and Burger 1983, Vining et al. 1985). Emergence timing of juvenile salmon fry was monitored during the 1980s using various capture methods at spawning sites, though sampling efforts in late winter were impeded by river ice conditions (Jennings 1985, Roth and Stratton 1985, Roth et al. 1986). The periods of juvenile salmon species rearing and migration timing were determined based on fish capture and sampling efforts in lower and middle Susitna River habitats throughout summer and using stationary downstream migrant traps in the Susitna River main channel (Jennings 1985, Roth and Stratton 1985, Suchanek et al. 1985, Roth et al. 1986).

For resident and non-salmonid fish, the timing and distribution of juvenile and adult fish, location and periodicity of adult spawning and descriptions of seasonal movements patterns were described in association with fish distribution and abundance studies during 1981-1985 (see Fish and Aquatic Resources, Section 9). Studies during the 1980s were conducted in the Lower, Middle and Upper Segments of the Susitna River and targeted the following species: rainbow trout, Arctic grayling, burbot, round whitefish, humpback whitefish, longnose suckers, Bering cisco, Dolly Varden, northern pike, lake trout, threespine and ninespine sticklebacks, and cottid species.

8.5.2.1.8 Instream Flow Methods and Models

Instream flow studies conducted during the 1980s focused on the middle and lower segments of the Susitna River downstream of Devils Canyon. Instream flow studies during the 1980s evaluated changes in adult and juvenile fish habitat relative to changes in mainstem Susitna River streamflow using hydraulic modeling and habitat mapping techniques. The availability and quality of instream fish habitat was measured during 1983 and 1984 at 20 sites in the lower Susitna River between RM 35 – RM 92 and at 36 sites in the middle Susitna River between RM 101 – RM 148 (Table 8.5-4). Fish habitat availability was modeled over a range of Susitna River discharges using Instream Flow Group (IFG), Direct Input Habitat (DIHAB), and Resident Juvenile Habitat (RJHAB) models. Two-dimensional mapping was also used to quantify available habitat at tributary mouths in the middle segment of the Susitna River over a range of streamflows. Instream flow sites during the 1980s were primarily located in side channel, side slough and upland slough habitats with relatively few sites in tributary mouths and mainstem channel margins. Hydraulic models were selected for each site based on site-specific channel and hydrologic characteristics, the desired resolution of microhabitat simulation, and the field logistics associated with each method.

IFG models were used at sites where streamflow was assumed to be the primary determinant of fish habitat quality (Trihey 1979, Hilliard et al. 1985). IFG models are based upon Instream Flow Incremental Methodology (IFIM) and are applied at locations with steady or uniform flow conditions and rigid stream channels (Trihey 1979, Hilliard et al. 1985). Use of IFG models were well-suited for use in the middle and lower Susitna River as these conditions were applicable to various juvenile and adult habitats. During the 1980s studies, IFG models were used to model changes in juvenile and adult fish habitats in side channel and side slough habitats and were applied at 6 sites in the lower segment of the Susitna River in 1983 and at 15 sites in the middle segment during 1983 and 1984 (Vincent-Lang 1984b, Hilliard et al. 1985) (Table 8.5-4). At each IFG site, water depth and velocity data were measured at multiple cross sections at a range of Susitna River streamflows. These data were used in conjunction with channel geometry and substrate data from the site to simulate changes in usable fish habitat area over the range of measured flows. Examples of IFG site locations in various side channel habitats in the middle Susitna River are depicted in Figure 8.5-6 and Figure 8.5-7.

In contrast to IFG models, DIHAB models were used during the 1980s at sites where flow conditions were spatially variable or where water velocities were near zero (Hilliard et al. 1985). DIHAB models were used to evaluate changes in adult chum spawning habitat at 14 sites located on mainstem margins and side channel habitats in the middle segment of the Susitna River in 1984 (Table 8.5-4). In addition to water depth and velocity and substrate data, the presence of upwelling was incorporated into DIHAB models as a binary variable (i.e., present, not present). Similar to IFG models, DIHAB models use hydraulic and channel geometry data to estimate changes to habitat area over the range of measured streamflows. An example DIHAB site location in side channel habitat is shown in Figure 8.5-7.

RJHAB models were used during the 1980s as a simplified means of estimating changes in fish habitat without hydraulic models. RJHAB modeling was applied at six sites in 1983 in the middle segment of the Susitna River and at 16 sites in 1984 in the lower segment to evaluate juvenile fish habitat (Table 8.5-4) (Marshall et al. 1984, Quane et al. 1985, Suchanek et al. 1985). Modeling sites were located in side channel, side slough and upland slough habitats. At each RJHAB site, multiple cross sections were established and divided into shoreline and mid-channel cells (Figure 8.5-9). Depth, velocity, and instream and overhead cover data measured in shoreline and mid-channel cells at a range of Susitna River streamflows were assumed to be representative of the usable fish habitat at each cross section and for the site (Marshall et al. 1984). An example of an RJHAB site location in Whiskers Creek side slough is shown in Figure 8.5-7.

Habitat mapping was conducted at tributary mouths in the middle segment of the Susitna River in 1983 to characterize changes in spawning habitat over a range of Susitna discharge conditions. The two tributary mouth sites measured in 1983 were considered to be representative of the 14 major tributary confluences in the middle segment (Table 8.5-4) (Sandone et al. 1984). At habitat mapping sites, depth, velocity and substrate habitat parameters were measured across multiple transects at four separate Susitna River streamflows. These data were used to create two-dimensional parameter-specific maps delineating the area of suitable chum spawning habitat. The three separate parameter-specific maps were overlaid to identify the composite area of habitat suitability that was available at each measured flow level (Sandone et al. 1984).

The output provided by IFG, DIHAB and RJHAB models were generally similar to that supplied by the habitat mapping method used at tributary mouths. Each method characterized changes in fish habitat by relating the amounts of wetted surface area and area usable for juvenile and adult fish to Susitna River discharge. The amount of wetted surface area at modeling sites invariably increased with rising streamflows, however, the relationship between the amount of habitat area suitable for juvenile and adult fish use was often not directly correlated with Susitna River discharge. Suitable depth, velocity, substrate and/or cover habitat was defined for each life stage of anadromous and resident fish species in the form of Habitat Suitability Criteria (HSC). Species and life stage-specific HSC provided a basis for evaluating the amount of usable habitat at observed and simulated streamflow levels for each habitat model.

8.5.2.2 Need for Additional Information

The gap analysis presented in HDR (2011) outlines the major elements required in an instream flow study. Although substantial data and information were collected in the 1980s, those data are approximately 30 years old and therefore additional information needs to be collected to provide a contemporary understanding of the baseline conditions existing in the Susitna River. In addition, the configuration and proposed operations of the Project are different from the previously proposed project and must be evaluated within the context of the existing environmental setting. This includes consideration of potential load following effects on important aquatic and riparian habitats downstream of the proposed Watana Dam site (including both the Middle River and Lower River, as appropriate). Potential effects of proposed Project operations on aquatic habitats and biota and potential benefits and impacts of alternative operational scenarios have not been quantitatively analyzed. The aquatic habitat specific models will provide an integrated assessment of the effects of Project operations on biological resources and riverine processes. These models will provide an analytical framework for assessing alternative operational scenarios and quantitative metrics that will provide the basis for the environmental assessment and aid in comparing alternatives that may lead to refinements in proposed Project operations.

[In progress; additional detail describing how the results of the 1980s studies will be integrated into instream study will be provided in the December draft RSP].

8.5.3 Study Area

During the 1980s studies, the Susitna River was characterized into three segments extending above and below the two proposed dam sites. After researching potential Project configurations, AEA is proposing a single dam configuration at the Watana Dam site at RM 184. The proposed study characterizes the Susitna River as three segments (Figure 8.5-8). The Upper River segment represents that portion of the watershed above the Watana Dam site at RM 184; the Middle River segment (extending from RM 184 downstream to the Three River Confluence at RM 98.5) and the Lower River segment (extending from the confluence of Chulitna and Talkeetna rivers (three rivers) to Cook Inlet (RM 0). Potential Project effects to the Upper River segment above the Watana Dam site are addressed in Section 9: Fish and Aquatics, Section 10: Wildlife, Section 11: Botanical, and other studies. Potential Project effects to the Upper River segment will not be addressed in the Instream Flow Study. The Study Area of the Instream Flow Study is focused on the two lower segments of the river, the Middle River segment and the Lower River segment.

The Middle River segment encompasses approximately 85 miles between the proposed Watana Dam site (at RM 184) and the Three Rivers Confluence, located at RM 98.5. The river flows from Watana Canyon into Devils Canyon, the narrowest and steepest gradient reach on the Susitna River. In Devils Canyon, constriction creates extreme hydraulic conditions including deep plunge pools, drops, and high velocities. The Devils Canyon rapids appear to present a partial barrier hindering upstream passage at some flow conditions to the migration of anadromous fish; only a few adult Chinook salmon have been observed upstream of Devils Canyon. Downstream of Devils Canyon, the middle Susitna River widens but remains essentially a single channel with stable islands, occasional side channels, and sloughs. The Lower River segment consists of an approximate 98-mile section between the Chulitna River confluence and Cook Inlet (RM 0). An abrupt change in channel form occurs where the Chulitna River joins the Susitna River near the town of Talkeetna. The Chulitna River drains a smaller area than the Middle River segment at the confluence, but drains higher elevations (including Denali and Mount Foraker) and many more glaciers. 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. For several miles downstream of the confluence, the Susitna River becomes braided, characterized by unstable, shifting gravel bars and shallow subchannels. For the remainder of its course to Cook Inlet, the Susitna River alternates between single channel, braided, and meandering planforms with multiple side channels and sloughs. Major tributaries drain the western Talkeetna Mountains (the Talkeetna River, Montana Creek, Willow Creek, Kashwitna River), the Susitna lowlands (Deshka River), and the Alaska Range (Yentna River). The Yentna River is the largest tributary in the Lower River segment, supplying about 40 percent of the mean annual flow at the mouth.

Further refinements to the classification system being applied to the Susitna River have been made since the PSP but the major divisions associated with the middle and lower segments have been retained. However, these are now incorporated into a more refined hierarchical classification system which scales from relatively broad to more narrowly defined categories as follows:

Segment → Geomorphic Reach → Mainstem Habitat Type → Mesohabitat Types (Main channel only) → Off-channel Habitat Types.

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 eight categories *(MR-1 through MR-8)* for the Middle Segment and four categories *(LR-1 through LR-4)* for the Lower Segment. 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 is followed by **Mainstem Habitat Types** which include the same categories applied during the 1980s studies – *Main Channel, Side Channel, Side Slough, Upland Slough, Tributary Mouth, and Tributary*. The next level in the hierarchy is **Mesohabitat Type** which at this time is reserved for classifying main channel habitats into categories of *Riffle, Pool, Run, and Glide*. The last level in the hierarchy is referred to as **Lateral Habitats** consisting of a number of descriptive categories and quantitative indices including *Turbid/Clear*, *Beaver*

Presence (Y/N), Gross Area (Off-channel Habitats), Shoreline Length (includes both Main Channel and Off-Channel Habitats). These are more fully described in Table 8.5-xxx (table not created – placeholder) and illustrated in Figure 8.5-10, with further information provided in both the Geomorphic Study Plan (cite to it) and the Habitat Characterization Study Plan (Cite to it).

8.5.4 Study Methods

Evaluation of potential Project effects to Middle River and Lower River habitats will consist of the following components (these components will be refined based on licensing participant review and TWG input):

- IFS Analytical Framework (Section 8.5.4.1);
- River Stratification and Study Area Selection (Section 8.5.4.2);
- Hydraulic Routing (Section 8.5.4.3)
- Hydrologic Data Analysis (Section 8.5.4.4);
- Habitat Suitability Criteria Development (Section 8.5.4.5);
- Habitat-Specific Model Development (Section 8.5.4.6); Temporal and Spatial Habitat Analyses (Section 8.5.4.8); and
- Instream Flow Study Integration (Section 8.5.4.8).

Details concerning each of these components including Proposed Methodologies and resulting Work Products are provided below.

8.5.4.1 IFS Analytical Framework

Figure 8.5-11 depicts the analytical framework of the IFS commencing with the Reservoir Operations Model (ROM) that will be used to generate alternate operational scenarios under different hydrological conditions. The overall framework includes analytical steps that are consistent with those described in the Instream Flow Incremental Methodology (IFIM) (Stalnaker et al. 1996), which will be used as a guide for completing the instream flow evaluation for the Project. The ROM will provide the input data to the mainstem flow routing model that will be used to predict hourly flow and water surface elevation data at multiple points downstream, taking into account accretion and flow attenuation. Coincident with the development of the flow routing model, a series of biological and riverine process studies will be completed (other studies) to supplement the information collected in the 1980s as necessary to define reliable relationships between mainstem flow and riverine processes and biological resources. This will result in development of a series of flow sensitive models (e.g., models of selected anadromous and resident fish habitats by species and life stage, models to assess connectivity and passage conditions provided into side channel and slough habitats, models to describe invertebrate habitats, temperature model, ice model, sediment transport model, turbidity model, large woody debris (LWD) recruitment model) that will be able to translate effects of alternative Project operations on the respective processes and biological resources.

As part of the Analytical Framework, an Instream Flow Study-Technical Work Group (IFS-TWG) has been formed consisting of technical representatives from agency and licensing participant groups. The IFS-TWG will provide input into specific study design elements pertaining to the IFS including selection of study sites, 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. The initial TWG meeting occurred on September 14 and focused on study site selection process.

Resource and process effects will be location and habitat specific (e.g., responses are expected to be different in side sloughs versus mainstem versus side channel versus tributary delta versus riparian habitats) but there will also be a cumulative effect that translates throughout the entire length of the Susitna River. Alternate Project operational scenarios will likely affect different habitats and processes differently, both spatially and temporally. The habitat and process models will therefore be spatially discrete (e.g., by site, segment, and reach) and yet able to be integrated to allow for a holistic evaluation of each alternative operational scenario. This will allow for an Integrated Resource Analysis (IRA) of separate operational scenarios that includes each resource element, the results of which can serve in a feedback capacity leading to new or modifications of existing operations scenarios. Figure 8.5-11 represents the types of IRA that can be made for the Susitna-Watana project.

The IFS plan is focused on development of macro-habitat specific models that can reliably estimate flow-habitat response patterns for different species and life stages of fish and other aquatic biota. These models represent the core tools that will be used for assessing changes in aquatic habitats under alternative Project operational scenarios. The conceptual framework for these tools and how they will interface with other resource specific models is depicted in Figure 8.5-11. A study focused on groundwater related aquatic habitat will be also be developed that may incorporate one or more of these models to assess linkages between surface flows and groundwater flows that comprise important fish habitats. Additionally, a fish passage analysis (RSP Section 9.12) will also be used to develop the relationship between main channel flow and connectivity with side channel and off-channel areas. Data collection and modeling for the fish passage study will be coordinated with the instream flow, fisheries (RSP Section 9), and geomorphology (RSP Section 6) studies to ensure identification of potential fish passage barriers and hydraulic control points (see Figure 8.5-1).

8.5.4.2 River Stratification and Study Area Selection

8.5.4.2.1 Proposed Methodology

8.5.4.2.1.1 River Stratification

The fundamental question in stratifying the river system for the 2012-14 studies is: How many levels of stratification are necessary for each study focus before study sites or areas should be selected? Effects to physical processes and aquatic resources will be resource type, location and habitat specific. For example, at the site scale level, responses of fish habitat to changes in flow are expected to be different in side sloughs versus mainstem versus side channel versus tributary delta versus riparian habitats. At a broader scale, e.g., segment, it is plausible that effects to the same mainstem habitat types will differ depending on location in the river network, not only at the project footprint scale listed above, but also between geomorphic reaches. In addition, there will be a cumulative effect running down the length of the Susitna River below the dam. Different Project operations will likely affect different habitats and processes differently, both spatially and temporally. The habitat and process models will therefore need to be spatially discrete, at potentially the site/area level, mainstem habitat type level, and segment levels, and yet able to be integrated to allow for a holistic evaluation of each alternative operational scenario.

As noted in Section 8.5.3, the Instream Flow Study area consists of two segments of the river:

- Middle River – Susitna River from Watana Dam site to confluence of Chulitna and Talkeetna rivers (three rivers) (RM 184 to RM 98.5); and
- Lower River — Susitna River extending below Talkeetna River to mouth (RM 98.5 to RM 0)

The Middle River segment represents the section of river below the Project dam that was projected 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 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 that supplies about 40 percent of the mean annual flow at the mouth.

Geomorphic analysis of both the Middle River and Lower River segments confirmed the distinct variations in geomorphic attributes (e.g., channel gradient, confinement, channel planform types, and others) (RSP Section 6.5). That analysis resulted in a further refinement of the classification into eight geomorphic reaches in the Middle River segment (Figure 8.5-12) and six geomorphic reaches in the Lower River segment (Figure 8.5-13).

The overall goal of stratification is 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 is 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 be drawn.

8.5.4.2.1.2 Selection of Study Areas/Study Sites

The selection of study areas or study sites represents an important aspect of instream flow study development inasmuch as the sites or areas studied are those that will ultimately be used for evaluating project effects. It is therefore fundamentally important that the logic and rationale for the selection of such areas be clearly articulated, understood, and agreed to by the TWG.

In general, (as noted by Bovee 1982; xxxx) there are three characteristic approaches in instream flow studies that pertain to site selection that have been considered for application in the Susitna – Watana Project. These include:

<u>Representative Sites</u> – 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 will be to identify river segments that are relatively homogenous in terms of mesohabitat mixes, and the methods used for stratification tend to be classification-based using logical or heuristic rules. 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 number of replicate sites can be identified via power analysis, although this ideally requires a priori knowledge of the statistical variance associated with a measurable quantity. In the absence of such knowledge, a distribution may be assumed (e.g., standard normal, Student's t statistic, other).

> - *Applicability to the Susitna-Watana Project: Yes, but will require results of more detailed habitat mapping to determine representativeness of study areas.*

<u>Critical Habitat Sites</u> – 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) where 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 sites. For example, in the case of the Susitna River, historical fish studies repeatedly showed the importance of side slough, upland slough and side channel areas for spawning and juvenile rearing. Critical sites are typically selected assuming that project effects to other sites 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 were 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.

> - *Applicability to the Susitna-Watana Project: Yes, especially with respect to selection of side channel/side slough/upland slough complexes that have been shown to be influenced by main channel flows and that are biologically important.*

<u>Randomly Located Sites</u> – Where sites, areas or measurement locations are 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. In this case, initial groundwork is necessary to identify relevant variables suitable for grouping, and then the data need to be collected or derived to describe those variables spatially. The approach is the least subject to potential for bias, because it relies on distinct rules and algorithms. However, this 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 data set: the greater the number of clusters, the greater the potential number of sites. Strict random sampling is therefore not likely applicable for evaluating off-channel habitats and sloughs where the morphology of multiple channels varies substantially and in complex ways within and across sites.

> *- Applicability to the Susitna – Watana Project: Yes, but more appropriate with respect to main channel mesohabitat sampling (i.e., riffle, run, glide, pool) or selection of mainstem habitat types for HSC sampling (see Section xxxxx)*

These approaches were reviewed at a recent TWG meeting (September 11, 2012) and the process and criteria used for the selection of study areas/sites presented.

Focus Areas

During the TWG meeting, the concept of "intensive study areas" was introduced and discussed. Such areas represent specific sections of the river that will be investigated across resource disciplines that will provide for an overall understanding of interrelationships of river flow dynamics on the physical, chemical and biological factors that influence fish habitat.

The concept represents a combination of all three of the methods described above. A total of ten intensive study areas, (hereafter referred to as Focus Areas (FA)) were presented and discussed with the TWG and are proposed for detailed study within the Middle Segment of the river. Locations of the FAs are depicted in Figure 8.5-12. The FAs are intended to serve as specific geographic areas of the river that will be the subject of intensive investigation by multiple resource disciplines including Instream Flow – Fish (this RSP), Instream Flow – Riparian (this RSP), Groundwater – Aquatic Habitat (Section 7.5), Geomorphology (Section 6), Ice Water Quality (Section 7.6) and water quality (Section 5)). The FAs were selected during an inter-disciplinary resource meeting that involved a systematic review of aerial imagery within each of the Geomorphic Reaches (MR1 through MR8) for the entire Middle Segment of the river. Focus Areas were selected within MR1 (one FA), MR2 (two FAs), MR5 (one FA), MR6 (four FAs), MR7 (one FA), and MR8 (one FA). Focus Areas were not selected for MR3 or MR4 due to safety considerations related to Devils Canyon.

The areas selected were those deemed representative of the major features in the 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 areas included representative side channels, side sloughs, upland sloughs, and tributary mouths.

Three of the FAs in Geomorphic Reach M6 and one in M8 contain specific habitat types that were found, during the 1980s studies to be consistently used by salmon for spawning and/or rearing. These areas included Slough 21, Slough 11, and Slough 8A in MR6 and Whiskers Slough in M8. Overall, 92% of the sockeye, 70% of the chum and 44% of the slough spawning pink salmon were found in just these four sloughs). By definition, these areas represent "critical areas" and were included in the FAs to allow some comparisons with the 1980s data. Other portions of these same FAs were not studied during the 1980s but will be as part of the RSP. The upper three FAs (one in Geomorphic Reach MR1 and two in MR2 Gwere selected based on their representativeness of the respective geomorphic reaches and the inclusion of a mix of side channel and slough habitat types. However, there is no existing fish information on these areas, since they were not sampled in the 1980s. Nominally, the FA's range in length from xxx to xxx ft. Details of each of the FAs are presented in Table 8.5-xxx (placeholder); schematic photos of each of the areas are depicted in Figure 8.5-14 through Figure 8.5-23. A similar process will be applied to the Lower Segment of the river in December but will focus on the upper portions of that segment that will be most susceptible to flow modification.

These ten areas have been selected for planning purposes but will be evaluated further for their representativeness of other areas based on results of habitat mapping that will be completed at the end of 2012. The goal is to obtain TWG concurrence on the initial set of study areas by February/March of 2013 to enable detailed field studies to occur. The data and information collected in 2013 from this study and other related investigations (e.g., fish distribution – Section 9.5; radiotagging – Section 9.7; Habitat Characterization – Section 9,9, and others) will be reviewed, and necessary refinements to existing sites made or new sites added to the studies completed in 2014. This adaptive management approach to site selection will allow for shifts in study focus to other areas should results of 2013 studies reveal their biological importance and sensitivity to flow modifications.

The criteria applied in the selection of the FAs and study sites within incorporated (or will incorporate) elements from all three of the above mentioned selection methods and considered the following:

- All major habitat types (main channel, side channel, side slough, upland slough, tributary delta) will be sampled within each geomorphic reach
- At least one (and up to three) Focus Area(s) per geomorphic reach (excepting geomorphic reaches associated with Devils Canyon – MR3 and MR4) will be included that is/are r**epresentative** of other areas
- A replicate sampling strategy will be used for measuring habitat types within each Focus Area which may include a **random selection** process
- Areas that are known (based on existing and contemporary data) to be biologically important for salmon spawning/rearing in mainstem and lateral habitats will be sampled (i.e., **critical habitats**) and
- Areas for which little or no fish use has been documented or for which information on fish use is lacking, will also be sampled

Sites Outside of the Focus Areas- In addition to the identified FAs, a total of xxx cross-channel transects in the Middle Segment and xxx transects in the Lower Segment have been established to support development of the flow routing model (see Section 8.5.4.3). These transects were primarily located across single thread sections of the river, however, some do extend across more complex sections. In most cases, two to three sets of flow measurements have been made at each transect. The resulting data sets can be used for at a minimum, 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 PHABSIM type analysis. Importantly, once the main channel habitat mapping is completed (see Section XXXXX Habitat Characterization), the transect locations will be assigned to a specific mesohabitat type (e.g., riffle, run, glide, pool) and may be useful for extrapolating results/relationships from measured to unmeasured sites.

8.5.4.2.2 Work Products

[In progress; additional detail will be provided in the December RSP].

8.5.4.3 Hydraulic Routing

Project operations will likely store water during the snowmelt season (May through August), and release it during the winter (October through April) (AEA 2011). This would alter the seasonal hydrology in the Susitna River downstream from the dam (lower flows from May through August and higher flows from October through April). In addition to these seasonal changes, the Project may be operated in a load-following mode. Daily load-following operations will typically release higher volumes of water during peak-load hours, and lower volumes of water during off-peak hours. Flow fluctuations that originate at the powerhouse will travel downstream and attenuate, or dampen, as they travel downstream. The waves created by load-following operations impact the aquatic habitat of the Susitna River downstream from the powerhouse, especially along the margins of the river that are alternately wetted and dewatered (the varial zone).

8.5.4.3.1 Proposed Methodology

To analyze the impacts of alternate Project operational scenarios on habitats downstream of the Watana Dam site, a hydraulic routing model will be used to translate the effects of changes in flow associated with Project operations to downstream Susitna River locations; the hydraulic routing model will be extended downstream until the flow fluctuations are within the range of without-Project conditions.

Steady-state flow models assume that velocity or flow at a given location remain constant. Unsteady flow models are used when flows change rapidly and 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. Examples of public-domain computer models used to perform these types of processes include FEQ (USGS 1997), FLDWAV (U.S. National Weather Service 1998), UNET (U.S. Army Corps of Engineers 2001), and HEC-RAS (U.S. Army Corps of Engineers 2010a, 2010b, and 2010c). The HEC-RAS model has proven to be very robust under mixed flow conditions (subcritical and supercritical), as will be expected in the Susitna River. The HEC-RAS model also has the capability of automatically varying Manning's "n" with stage through the use of the equivalent roughness option. Another feature of HEC-RAS is the capability of varying Manning's "n" on a seasonal basis. The robust performance and flexibility of HEC-RAS make this model an appropriate choice for routing stage fluctuations downstream from the proposed Project dam under summer ice-free conditions. Under winter ice-covered conditions, the CRISSP1D (Comprehensive River Ice Simulation System Project) model (or equivalent) can be used to route unsteady flows downstream through the Susitna River. CRISSP1D is a one-dimensional unsteady flow model that can be used to analyze water temperature, thermal ice transport processes, and ice cover breakup (Chen et al. 2006). The seasonal timing of the transition from the HEC-RAS model to the CRISSP1D model and vice versa will vary from year-to-year and will depend on meteorological conditions.

The foundation of the IFS analyses rests with the development of the Susitna River Mainstem Flow Routing Models (HEC-RAS, CRISSP1D and/or other routing models) (MFRM) that will provide hourly flow and water surface elevation data at numerous locations longitudinally distributed throughout the length of the river extending from RM 184 downstream to RM 75 (about 23 miles downstream from the confluence with the Chulitna River). Two different flow routing models will be developed: a summer ice-free model (HEC-RAS); and a winter model to route flows under ice-covered conditions (CRISSP1D or equivalent).

The routing models will initially be developed based on river cross-sections and on gaging stations at on the Susitna River that were established and measured in 2012 as part of the IFS program. A partial list of the river cross-sections that were surveyed is provided in Table 8.5-5. Prior to late September, 2012, a total of 87 cross-sections had been surveyed (16 between the proposed dam site and Devils Canyon, 58 between Devils Canyon and the Three Rivers Confluence, and 13 downstream from the Three Rivers Confluence). Additional river cross-sections were established in late September/October. Those cross-sections were not included in Table 8.5-5 because those measurements had not been processed at the time this study plan was prepared.

At each river cross-section, ground surface and water surface elevations were surveyed using 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.

Examples of some of the river cross-sections that were surveyed in 2012 are shown in Figure 8.5-24. At River Mile 170 (between the proposed dam site and Devils Canyon), the channel had a single thread with a width of about 600 ft. At River Mile 75, (downstream from the Three Rivers Confluence) the channel was multi-threaded with a total width of about 1 mile.

At each river cross-sections, a minimum of four passes across the channel width were used to measure the flow, in accordance with USGS standards. An example of the output from one of the passes is shown in Figure 8.5-25 for River Mile 170 on June 21, 2012. While maximum velocities in the 10 to 15 fps range were recorded, the cross-sectional average velocity was 8.0 fps.

A total of 13 gaging stations were established on the Susitna River in 2012 at the locations listed in Table 8.5-6. These stations were set up to measure stage in real time every 15 minutes. They will be maintained in 2013/2014. Data recorded at these stations will be used to calibrate flow pulse arrival time in the flow routing model, based on measured diurnal glacial melt pulses, and rainstorm-generated flood peaks.

The hourly flow records from USGS gaging stations on the Susitna River will also be utilized to help develop the routing models. Depending on the initial results of the flow routing models, it may be necessary to add additional transects to improve the performance of the models between RM 75 and RM 184, and to possibly extend the models further downstream past RM 75.

During the development and calibration of the HEC-RAS model, the drainage areas of ungaged tributaries will be 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 measured in those tributaries in 2013 and 2014.

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. The gaging stations will be used to monitor stage and flow under summer ice-free conditions and to monitor water pressure under winter ice-covered conditions. Continuous measurement of water pressures during the 2012/2013 and the 2013/14 winter periods under ice-covered conditions will produce information different from open-water conditions. During partial ice cover, the pressure levels measured by the pressure transducers is affected by flow velocities, ice-cover roughness characteristics and other factors such as entrained ice in the water column. The pressure-head data are important for understanding groundwater/surface-water interactions.

Periodic winter discharge measurements will be completed at selected gaging stations in the winter, in coordination with USGS winter measurement programs, and will provide valuable information for understanding hydraulic conditions in the river during a season when groundwater plays a more prominent role in aquatic habitat functions. Winter flow measurements will also be used to help develop the CRISSP1D model (or equivalent).

Output from the flow routing models will provide the fundamental input data to a suite of habitat specific and riverine process specific models that will be used to describe how the existing flow regime relates to and has influenced various resource elements (e.g., salmonid spawning and rearing habitats and the accessibility to these habitats in the mainstem, side channels, sloughs, and tributary deltas, invertebrate habitat, sediment transport processes, ice dynamics, large woody debris (LWD), the health and composition of the riparian zone). These same models will likewise be used to evaluate resource responses to alternative Project operational scenarios, again via output from the routing models, including various baseload and load following alternatives, as appropriate. As an unsteady flow model, the routing models will be capable of providing flow and water surface elevation information at each location on an hourly basis and therefore Project effects on flow can be evaluated on multiple time steps (hourly, daily, and monthly) as necessary to evaluate different resource elements.

The study objective for the flow routing data collection effort is to provide input, calibration, and verification data for a river flow routing model extending from the proposed dam site to RM 75. Specific objectives are as follows:

- Survey cross sections to define channel topography and hydraulic controls between RM 75 and RM 184, excluding Devils Canyon (for safety reasons);
- Measure stage and discharge at each cross section during high and low flows, with the potential addition of an intermediate flow measurement;
- Measure the water surface slope during discharge measurements, and document the substrate type, groundcover, habitat type, and woody debris in the flood-prone area for the purposes of developing roughness estimates; and
- Install and operate 13 water-level recording stations within the mainstem Susitna River.

The routing model will rely upon existing Susitna River hydrology as well as output from the ROM.

8.5.4.3.2 Work Products

[In progress; additional detail will be provided in the December RSP].

8.5.4.4 Hydrologic Data Analysis

The assessment of hydrology data will include a summary of 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.

8.5.4.4.1 Proposed Methodology

8.5.4.4.1.1 Hydrologic Data Collection

As part of the 2013-2014 IFS, hydrologic data collection will include stage and discharge measurements, cross-sectional and areal bathymetric surveys, velocity mapping, and roughness determinations. The IFS will also incorporate hydrologic data collected by other studies, including water quality (RSP Section 5), water temperature, and ice process data (RSP Section 7.6).

Stage and discharge measurements were performed in 2012 at 88 cross sections between RM 76 and RM 184. Twelve of these cross sections are located at or near gaging stations operated by USGS or AEA. Stage and discharge measurements were also performed at inactive USGS gaging stations in the Lower River (Susitna River at Susitna Station (ESS20), RM 20) and in the upper basin (Susitna River near Cantwell (ESS80), RM 224). Gaging equipment was re-installed at these locations, as well as two tidal monitoring stations in the Susitna delta. Water level, water temperature, camera images, and meteorological data from these stations are shared online via an internal project website.

Depending on results of the 2012 flow routing model and analysis from other studies, additional cross sections may be surveyed in 2013 and 2014. Sections of the river that have stable cross sections will likely not require additional cross-section measurements. Sections of the river that demonstrate changes in cross-section profiles seasonally of event based (floods) may require additional cross-section measurements. Stage and discharge measurements will be used to calibrate the flow routing models, and to develop or confirm ratings for new and existing gaging stations.

Instantaneous stage measurements will be performed using either optical level or RTK GPS methods, using benchmarks and geodetic control points installed during the 2012 field program. This survey-control network will be evaluated each spring to have vertical datums verified and any missing benchmarks due to bank erosion or other issues replaced if needed. Together with water temperature and meteorological data, continuous stage measurements will be recorded at AEA gaging stations with a minimum of 15-minute intervals and made available to studies via the online gaging network. Continuous stage measurements are made using vented pressure transducers accurate to within about 0.02 feet. The data collection stations will be operated throughout the year to support both summer (open water) and winter (ice covered) study needs for IFS and other studies. Table 8.5-7 shows a listing of the current stations in the near-real-time reporting network. Additional stations may be added to the near-time-reporting network as warranted by study activities and analysis needs and deadlines.

During open-water conditions, mainstem discharge measurements will be performed using acoustic Doppler current profilers (ADCPs) following current USGS guidance (Mueller and Wagner 2009). Due to their shallow depths, tributary inflows will usually be measured using conventional current meter methods (Rantz and others 1982). Winter mainstem flows will be measured using a combination of current meter and ADCP methods. The winter gaging program will be coordinated with USGS so that the measurements from both programs occur at the same general time period. This will help assess gaining and losing river reaches during winter conditions. This effort will be coordinated with Ice Processes (RSP Section 7.6) so that measurements also have direct applications to the ice processes analysis and model development efforts.

In accordance with current USGS guidance (Mueller 2012), all discharge measurements will include sufficient quality assurance data to rate the measurements as either Excellent, Good, Fair, or Poor, corresponding to categories of uncertainty ranging from zero to over 8 percent.

During 2012, 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 MHz vertical-beam depth sounder and RTK GPS positioning. A minimum of four transects were completed at each cross section, and results were used to prepare a digital elevation model of the streambed. Together with shore-based RTK GPS surveys, the digital elevation model was used to develop cross sections for use in the river flow routing model.

Additional cross sections may be needed for flow routing or other IFS models. Depending on the need for concurrent flow data, the cross sections will be surveyed using either ADCPs or single-beam depth sounders. In either case, bathymetric data will be referenced to the project geodetic control network using RTK GPS positioning.

Within the Focus Areas, bathymetric surveys will be required for 2-D hydraulic and other IFS models. Although multi-beam sonar provides better coverage, it provides little advantage in shallow water, which comprises most of the Focus Areas. As a result, single-beam sonar surveys will be conducted along pre-planned survey lines throughout each Focus Area. The planned survey lines will be developed using recent imagery and hydrographic data acquisition software (e.g., HyPack). The density of survey lines will be commensurate with the minimum model grid spacing needed for 2-D hydraulic or other IFS models.

In several of the Focus Areas, water depths and velocities will preclude boat surveys throughout the entire wetted area. Areas of shallow, fast water may require land-based surveying during low water conditions using RTK GPS methods.

Velocity and discharge measurements will also be needed in the Focus Areas for calibration of 2-D hydraulic and other IFS models. ADCP measurements will be used to generate the necessary discharge and velocity distribution data. Equipment selection will be based on instrument depth limitations and compatible velocity mapping software (e.g., VMS).

Roughness determinations will be made by solving Manning's equation using field measurements of discharge and water surface slope. These results will be compared against visual estimates based on handbook values.

8.5.4.4.1.1.1 Hydrologic Data Real-time Reporting Network Operations

Project hydrologic studies include river-flow routing models (RSP Section 7.6, Section 8.5.4.3) ice and water quality (RSP Section 5.6) models and several studies to look at the potential effects of the Project and how to minimize them. In order to accurately simulate unsteady flows, the studies require a series of gaging (water level and discharge), water level, and meteorological stations. These stations are connected through a radio-telemetry system using spread-spectrum radio communication and a network of base stations. The purpose of the radio telemetry system is to improve a number of key Project objectives;

Safety

- Real-time access to data can reduce field hours associated with data retrieval; in some cases this reduces trips per year, or time on site for each trip.
- Providing real-time access to field weather conditions for travel logistics such as helicopter or small aircraft.

Data Quality

- Real time access to data can allow easier and more cost effective data monitoring, thus field related problems (e.g., ice jam floods, bears, lightning strikes) can be detected quickly, and site conditions better understood before going in the field, and reduced data loss.
- Real time data access minimizes data loss by enabling timely response to problems caught when they occur, rather than their discovery during a site visit. By providing information on a specific problem, proper equipment replacements and tools can be brought along for the site visit, ensuring the problem will be corrected without necessitating an additional trip.
- Real-time retrieval of data also allows off-site data storage, so if a site is severely damaged, there is no data loss even if there is a complete failure of data acquisition equipment. Data is preserved both on the data servers and the data loggers.
- Study team staff has access to data for on-going data QAQC before going into the field, so can better address potential sensor or programming issues and proactively plan for field repairs. Programming issues can be caught early and corrected without a site visit.

Deadlines

- Real-time access allows field staff to access to data 24/7, so data QAQC, reduction, and analysis applications can be accomplished between field trips. This also benefits the effectiveness of field trips by allowing a better understanding of field conditions before going in the field. QA checks and graphs can be set up, tested, and adjusted early in the project in an unhurried manner. QA can be up-to-date when it is time to create reports.

Data network management will include maintaining network Metadata standards, increase sharing and common data-acquisition equipment and allow savings for backup equipment to help support the various stations in the network. This includes the coordination of network activities, bulk procurement of network station supplies, setup of water level, gaging, repeater, and base stations, and coordinated reporting for the stations in the network linked together with the radio-telemetry system. This includes the data retrieval and online reporting setup for water-level and gaging stations, repeater stations, base stations, meteorological stations and associated co-located meteorological. The internal reporting will be on a password-protected website/wiki and include network status and diagnostics information (Figure 8.5-26), current conditions pages for each station (Figure 8.5-27), basic station information pages, near-real-time graphs for selected sensors (such as air temperature, relative humidity, water level over sensor, water temperature, and station diagnostics information). Data plots will be setup display in 7 and 14 day periods, as well as 1-month, 6-month and 1-year graphs. Short-period graphs will be updated hourly, while long period graphs (1 month or longer) will update every three hours. Cameras will be maintained at gaging stations and selected repeater stations. Cameras image will be captured and reported hourly, and displayed online internally in 24-hour sequences. All camera images collected will be accessible through the online image interface.

8.5.4.4.1.2 Hydrologic Data Analyses

The hydrologic period of record for the Susitna Project has been established for the 61-year period extending from Water Years 1950 through 2011 (October 1, 1949 to September 30, 2011). Historically flows have been measured by the USGS in the Susitna Basin at various locations and over different time periods. USGS gaging stations on the Susitna River are listed in Table 8.5-8, and USGS gaging stations on tributaries of the Susitna River are listed in Table 8.5-9.

The periods of record of measured flows at each of the sites listed in Table 8.5-8 and Table 8.5-9 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. This work was performed by the USGS and details of the analysis will be provided in a report that has not been released yet. The 61-year period of record at the sites listed in Table 8.5-8 and Table 8.5-9 will establish a baseline hydrologic condition from which to assess Project effects.

Potential alterations to this baseline condition will be assessed as part of the Glacial and Runoff Changes Study (RSP Section 7.7). These evaluations will be performed with the WaSiM-ETH model (Water Balance Simulation Model). The WaSiM-ETH model accounts for evapotranspiration, snow accumulation, snow and glacier melt, interception, infiltration, soil water storage, and runoff, such as surface, interflow, and baseflow. The model will be calibrated to match conditions observed from 1960 through 2010, and used to forecast conditions out to the year 2100. The proposed extent of the WaSiM-ETH model is the Susitna River Basin upstream from the proposed dam site.

Hydrologic data analyses will include post-processing of discharge data, correction of pressure transducer records, rating curve development, streamflow computations, and cross section and bathymetric data post-processing.

Discharge data post-processing will include the elements described in Mueller (2012) for ADCP measurements. A similar procedure will be used for current meter data, resulting in data qualification as either Excellent, Good, Fair, or Poor.

Pressure transducer records will be corrected using instantaneous stage measurements and hydrologic data correction software such as Aquarius Workstation. The software maintains a record of all corrections used in the computation of hourly and daily streamflow data. Other data from the gaging, water level and repeater stations will have monthly quality assurance evaluations performed as well as shorter timer check made to identify problems with station or sensor operations.

Rating curves for new gaging stations will be developed using rating development software such as the Aquarius Rating Development Toolbox. Streamflow computations will be performed using hydrologic data management software such as Aquarius Workstation.

Bathymetric data will be post-processed using hydrographic data processing software (e.g., HyPack) to obtain a digital terrain model. The digital terrain model can be used to develop cross sections or as input for 2-D hydraulic and other ISF models. ADCP files will be post-processed using velocity mapping software (e.g., VMS) to develop cross-sectional or plan-view velocity maps for calibration of hydraulic models.

8.5.4.4.1.3 Indicators of Hydrologic Alteration and Environmental Flow Components

The Index of Hydrologic Alteration (IHA)/Range of Variability analysis is a tool designed to assess the impacts of a project on unregulated hydrologic conditions (The Nature Conservancy 2009). These analyses are based on 33 IHA hydrologic statistics defined in Table 8.5-10, and 34 Environmental Flow Components (EFC) defined in Table 8.5-11.

The 33 hydrologic parameters listed in Table 8.5-10 are divided into five parameter groups: 1) magnitude of monthly water conditions; 2) magnitude and duration of annual extreme water conditions; 3) timing of annual extreme water conditions; 4) frequency and duration of high and low flow pulses; and 5) rate and frequency of water condition changes. The 34 hydrologic parameters listed in Table 8.5-11 are divided into five parameter groups: 1) monthly low flows; 2) extreme low flows; 3) high flow pulses; 4) small floods; and 5) large floods.

Pre- and post-Project hydrologic conditions will be assessed by performing IHA/RVA evaluations in the Susitna River just downstream from the proposed project site. The period of assessment will be based on the 61-year duration from Water Years 1950 through 2010 (October 1, 1949 to September 30, 2010). Daily flows will be used to perform these assessments in accordance with the IHA/RVA software input requirements.

8.5.4.4.2 Work Products

The Hydrologic Data Analysis study component will include the following work products:

- GPS Survey Control Network Summary Report
- Cross-section profiles at new cross sections and water level and slope table for cross-sections
- Rating curve analysis for AEA gaging stations
- Data tables and quality assurance reports for gaging, water level and repeater stations
- Summary of Internet data reporting operations each year
- Tabular summaries of selected IHA-type statistics.
- Summary charts to provide visual comparisons of selected hydrologic statistics to facilitate discussion of the effect of modeled future operational scenarios on the without-Project hydrologic regime.

These work products and other results of the hydrologic data analyses will be compiled and presented in a study report.

8.5.4.5 Habitat Suitability Criteria Development

Habitat suitability criteria and index curves have been utilized by natural resources scientists for over two decades to assess the effects of habitat changes on biota. The abbreviation HSI is used in this document to refer to either Habitat Suitability Index (HSI) models or Habitat Suitability Criteria (HSC) curves, depending on the context. HSI models provide a quantitative relationship between numerous environmental variables and habitat suitability. An HSI model describes how well each habitat variable individually and collectively meets the habitat requirements of the target species and life stage, under the structure of Habitat Evaluation Procedures (USFWS 1980). Alternatively, HSC are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC describes the instream suitability of habitat variables related only to stream hydraulics and channel structure. 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. For the Susitna-Watana Hydroelectric Project aquatic habitat studies, both HSC (i.e., depth, velocity and substrate/cover) and HSI (e.g., turbidity, colonization rate, dewatering mortality) models will be used to analyze the effects of alternate operational scenarios.

For the mainstem aquatic habitat model, HSC/HSI curves for some species (e.g., benthic macroinvertebrates, benthic algae, fry) will also need to be developed to describe the response of aquatic organisms to relatively short-term flow fluctuations (i.e., ramping). Methods for development of HSC/HSI for benthic macroinvertebrate and algal habitats are described in the River Productivity study (Section 9.8), but in general include the collection of velocity, depth, and substrate composition data during benthic macroinvertebrate and algae sampling. Development of HSC/HSI curves for fish is described in the following section.

8.5.4.5.1 HSC/HSI Proposed Methodology

The fish community in the Susitna River is dominated by anadromous and non-anadromous salmonids, although numerous non-salmonid species are also present (Table 8.5-12). Development of HSC will involve the following steps: 1) selection of target species and life stages, 2) develop draft HSC curves using existing information, 3) collect site specific HSC data, 4) develop habitat utilization frequency histograms/preference curves from the collected data, 5) determine variability/uncertainty around the HSC curves, and 6) finalize the HSC curves in collaboration with TWG and licensing participant representatives. Each of these steps will be described in the following sections.

8.5.4.5.1.1 Habitat Suitability Curves (HSC)

HSC curves represent an assumed functional relationship between an independent variable, such as depth, velocity, substrate, groundwater upwelling, turbidity, etc., and the response of a species life stage to a gradient of the independent variable (suitability). In traditional instream flow studies, HSC curves for depth, velocity, substrate and/or cover are combined in a multiplicative fashion to rate the suitability of discrete areas of a stream for use by a species and life stage of interest. HSC curves translate hydraulic and channel characteristics into measures of overall habitat suitability in the form of weighted usable area (WUA). Depending on the extent of data available, HSC curves can be developed from the literature, or from physical and hydraulic measurements made in the field in areas used by the species and life stages of interest (Bovee 1986). HSC curves for the Susitna-Watana Hydroelectric Project will be based on information consisting of (in order of preference): 1) new site specific data collected for selected target species and life stages (seasonally if possible (e.g., winter)); 2) existing site specific data collected from the Susitna River during the 1980s studies; 3) site specific data collected from other similar Alaska river systems; and 4) professional opinion (roundtable or Delphi) of local resource specialists that are familiar with habitat use by the species and life stages of interest for this study.

8.5.4.5.1.1.1 Select Target Species and Life Stages

For planning purposes, target species are assumed to include Chinook, coho, chum and sockeye salmon, rainbow trout, arctic grayling, Dolly Varden trout, burbot, longnose sucker, humpback whitefish, and round whitefish. The target species are generally considered the most sensitive to habitat loss through manipulation of flows in the Susitna River. Other species and life stages will be considered in collaboration with the TWG (Table 8.5-12). A daft list of target species and life stages will be presented to the TWG during a meeting to be held the Q1 2013. The final list of species and life stages to be included in the HSC/HSI development process will be developed during a subsequent TWG meeting to be held just prior to field activities in the Q2 2013.

8.5.4.5.1.1.2 Develop Draft HSC Curves

The initial determination of mainstem, microhabitats used by the target fish species in the Susitna River will rely heavily on information obtained as part of the 1980s assessments, in particular, the Instream Flow Relationships Report (Trihey & Associates and Entrix 1985 a and b) and a four volume series on the aquatic habitat and instream flow assessment produced by ADF&G (1984). This information will be synthesized and compared to findings of other studies and data gaps will be identified. Comparisons will be made to an available set of library based HSC curve sets including a data set of over 1,300 recently obtained field microhabitat observations for most of the same species found in the Susitna. Study gaps will be identified and plans to fill the gaps integrated into the 2013-2014 HSC sampling plan. The existing HSC curve sets developed during the 1980s will be compared with more contemporary curve sets developed for similar river systems. In addition, the HSC data collected in 2012 will be compared with existing curve sets to see if patterns of use are similar. Several different methods will be evaluated for updating the 1980s HSC curve sets including, Enveloping, Habitat Guilds, bootstrapping, roundtable/expert opinion, and statistical approaches as noted by Abmadi-Nedushan et al. (2006). To the extent available, habitat suitability information will address fish responses to changes in depth, velocity, substrate, cover, groundwater upwelling, and turbidity. A summary of the 1980s data sets available and reviewed to date are presented in Table 8.5-2. The draft HSC curve will be presented in the HSC/Periodicity TM scheduled for completion Q4 2012 and will be reviewed during a Q1 2013 TWG meeting (Table 8.5-13).

8.5.4.5.1.1.3 HSC Study Site Selection

The distribution and number of HSC study sites for the 2013 and 2014 data collection will be based on a stratified random sampling approach which will include several levels based on channel attributes including river segment, geomorphic reach (RSP 6.0), mainstem habitat composition (RSP 6.8.4.1), relative fish use, number of instream flow Focus Areas, mesohabitat composition (RSP 9.09), and site specific attributes including the presence of groundwater upwelling, water clarity (turbid vs. clear water areas), and safety concerns.

The stratified random sampling scheme will be used to select study sites to cover the range of habitat types. The mainstem Susitna River and its tributaries downstream of the proposed dam will be subjected to Project operations that will affect flow levels on an hourly, daily, seasonal, and annual timeframe. It is assumed, that the effects of Project operations on mainstem and tributary habitats will diminish below the Three Rivers Confluence. The mainstem Susitna River and its tributaries upstream of the proposed dam will be within the proposed impoundment zone and therefore are not included as part of the instream flow sampling effort. Hence, sample sites will be stratified and randomly selected from within the Lower River (HRM 77¬HRM98) and Middle River (HRM 98–HRM 184) segments of the Susitna River.

A second level of stratification will be based on geomorphic reaches. The Geomorphic Study Team has delineate the Lower and Middle River segments into large-scale geomorphic river reaches with relatively homogeneous landform characteristics, including at generally decreasing scales: geology, hydrology (inflow from major tributaries), slope, channel form, braiding or sinuosity index (where relevant), entrenchment ratio, channel width, and substrate size (Figure 8.5-12 and Figure 8.5-13). Stratification of the river into relatively homogeneous reaches facilitates a relatively unbiased extrapolation of sampled site data within the individual reaches because sources of variability associated with large scale features will be reduced.

The third level of stratification is designated based on a modified 1980s classification of river types into two mainstem categories of main-channel and off-channel types (RSP Section 6.0). Main-channel areas are further divided into single, divided, and asymmetric channel types. Off-channel areas are further divided into areas of backwater, slough, beaver complex, tributary mouth, and percolation channel habitats type. Each of these main-channel and off-channel habitat types will be identified and mapped based on the use of aerial imagery, LiDAR, and aerial videography (RSP 6.8.4.1). The distribution and frequency of these habitats vary longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient.

The Geomorphic Study Team will complete the delineation of mainstem habitat units for the Middle River segment before the end of the Q4 2012. Once the mainstem habitat areas are mapped, a minimum of three replicates will be randomly selected from each of the mainstem habitat types (or bins) that are represented within each of the geomorphic reaches.

Applying the stratification system discussed above, the proposed HSC sampling effort for the Lower River segment (HRM 77- HRM 97) would include three replicates of each mainstem channel type for a maximum of 24 sample sites. Similarly, in the Middle River, three sites of each channel type will be randomly selected from within each of the 7 geomorphic reach (excludes reach MR-4 due to safety issues) for a maximum of 168 potential sampling locations. This total will include the Focus Areas proposed for sampling in instream flow program. For each of the Middle River sampling sites, a special effort will be made to ensure that HSC sampling occurs within each of the main-channel mesohabitat types present. The proposed number and distribution of 2013 HSC sampling sites will be presented to the TWG during the Q2 2013 meeting (Table 8.5-13).

Site selection includes completing the geomorphic reach delineation and habitat mapping tasks first. In addition to technical considerations, access and safety will be key non-technical attributes for site selection for all studies. This, too, influenced site selection in the 1980s studies, and will certainly influence site selection in the present studies.

Finally, winter sites will be selected based on information gathered from winter 2012–2013 pilot studies at Whisker's Slough and Slough 8A (Figure 8.5-28). At a minimum, attempts will be made to complete winter sample at all Focus Areas located downstream of Devils Canyon. Winter sampling upstream of Devils Canyon will be dependent on access/safety issues. The farthest upstream sites will need to be accessed by air travel; sites closer to Talkeetna may be accessed by snow machine. Safety and access are important considerations for the selection of these sites. Sampling methodologies including, but not limited to, under ice use of DIDSON and video cameras will be tested in 2012–2013.

8.5.4.5.1.1.4 Collect Site-Specific Habitat Suitability Information.

For the target species, site-specific habitat suitability information will be collected using HSC-focused field surveys to locate and measure microhabitat use by spawning and rearing (adult and juvenile) life stages. Proposed sampling methods include biotelemetry, pedestrian, snorkel, and seining. Two other possible methods, DIDSON sonar and electrofishing are being explored for use in detecting habitat use in turbid water conditions. Selected methods will vary based on habitat characteristics, season, and species/ life history of interest. Selected methods are subject to ADF&G Fishery Resource Collection Permit requirements. Additionally, wintertime surveys will utilize underwater video, during clear water periods, to identify under ice and open water habitat use by rearing life stages. Depending on safety concerns, it has been proposed to conduct both daytime and nighttime surveys during wintertime sampling to determine any differences in habitat use.

For development of site specific HSC curves, habitat use information (water depth, velocity, substrate type, upwelling, turbidity, and cover) will be collected at the location of each identified target fish and life stage. If possible, a minimum of 100 habitat use observations will be collected for each target species life stage. However, the actual number of measurements targeted for each species and life stage will be based on a statistical analysis that considers variability and uncertainty (Bootstrapping). While information will be collected on all species and life stages encountered, the locations, timing and methods of sampling efforts may target key species and life stages identified in consultation with the TWG. A description of each of the proposed sampling methods in presented below.

8.5.4.5.1.1.5 Spawning/Redd Surveys

The timing and location of spawning/redd surveys will be based in part on the periodicity data developed in a previous step (Section 8.5.4.5.1.2) as well as from information obtained during radio telemetry surveys conducted as part of fisheries studies. This information will be used to help identify sampling timing and areas with the highest concentration of spawning activity for the four main salmon species (sockeye, coho, Chinook, pink, and chum salmon). A proposed schedule for 2013 and 2014 spawning/ redd surveys is presented in Table 8.5-13.

Although several different methods may be used to identify the presence of spawning fish (biotelemetry, pedestrian survey, or DIDSON sonar), once an actively spawning fish or newly constructed redd is identified each of the following measurements will be made:

- Location of sample area on high resolution aerial photographs and/or GPS location for individual or groups of measurements
- Species of fish occupying the redd or responsible for construction
- Redd dimensions (length and width in feet to nearest 0.1 ft)
- Water depth at upstream end of the redd (nearest 0.1 ft) using a top setting rod
- Mean water column velocity (feet per second to nearest 0.05 ft/sec) measured using a Price AA current meter[1]

[1] Water velocities will be measured using Price AA current meters. Calibration of the Price AA meters will employ a spin test whenever the meter is assembled in the field. Once assembled, Price AA meter operation will be tested by performing a spin test. The cups should spin freely for a minimum of 3.5 minutes for the AA meter. The results will be recorded on a calibration data sheet kept in the meter housing.

- Substrate size (dominant, sub-dominant, and percent dominant) characterized in accordance with a Wentworth gain size scale modified to reflect English units (Table 8.5-14).
- Water temperature in degrees Celsius
- Note any indication of the presence of groundwater upwelling (changes in water clarity, temperature, or visible upwelling)
- For each group of redds or in mainstem habitat areas with relatively large concentrations of spawning fish, a measure of turbidity will be made using a portable turbidity meter. This information will be used for comparison to measurements made during the 1980s survey.
- All data will be recorded on waterproof data sheets to ensure consistent data collection between surveys.

8.5.4.5.1.1.6 Juvenile and Resident Rearing

To ensure the identification of habitat use by adult (resident species) and juvenile rearing species, a combination of survey methods will be employed including snorkel surveys, beach/stick seining, underwater video, and if permitted, electrofishing. Seining and electrofishing techniques will predominately be used in turbid water areas (main channel, side channels, side sloughs) where underwater visibility is limited (generally greater than 4 NTU). The surveys will be conducted by a team of two or three fish biologists with extensive experience in salmonid species identification. A proposed schedule for 2013 and 2014 adult and juvenile rearing surveys is presented in Table 8.5-13. A general description of each of the proposed sampling methods is presented below:

8.5.4.5.1.1.6.1 Snorkel Survey/Fish Observations

Prior to each survey, a Secchi disk reading will be taken to determine the visibility corridor for sampling. For this, a Secchi disk will be held underwater by the data recorder, and a tape measure extended by the snorkeler from the Secchi disk outward to a point where the disk is no longer clearly visible. As a general rule, when visibility conditions are less than four feet, no underwater sampling will occurred. Water temperature will also be recorded at the beginning of each survey.

To ensure accurate estimation of fish size underwater, the snorkelers calibrated their sight to a ruler prior to beginning each survey. Rulers and objects of known length (e.g., fingers, marks on diving gloves) will be used during the survey to maintain accuracy in the estimation of fish length. Starting at the lower/downstream point within a study site, the snorkelers will proceed in an upstream direction making observations of all microhabitat types within their line of sight. When two divers are working together, both sides of the clear water slough or side channel will be covered, with the midpoint of the water body serving as the delineation point of coverage for each diver. When only a single diver is conducting the survey, the diver surveys one or both sides of the channel, depending on the range of microhabitats present. When a fish is observed the snorkeler verbally transmits the following information to the data recorder:

- Location of sample site or area on high resolution aerial photographs and/or GPS location for individual or groups of measurements
- Fish species
- Assumed life stage (adult, juvenile, or fry)
- Total fish length (mm)
- Number of fish observed
- Mesohabitat type
- Water depth (nearest 0.1 ft) using a top setting rod
- Location in water column (distance from the bottom)
- Focal point and mean column velocity (feet per second to nearest 0.05 ft/sec) measured using a Price AA current meter
- Substrate size (dominant, sub-dominant, and percent dominant) characterized in accordance with a Wentworth gain size scale modified to reflect English units (Table 8.5-14)
- Proximity/affinity to habitat structure/cover features (e.g., boulder, wood debris, aquatic vegetation, undercut bank, and overhanging vegetation)
- Relevant comments pertaining to cover associations and/or behavioral characteristics of the fish observed
- All data will be recorded on waterproof data sheets to ensure consistent data collection between surveys.

Only fish holding over a fixed position will be included in the microhabitat survey. Moving fish will not be enumerated in order to minimize inaccurate habitat measurements, and to prevent double-counting of fish.

8.5.4.5.1.1.6.2 Pole/Beach Seining

Pole seining will be used in turbid water areas of all mainstem habitat types that cannot be sampled with underwater techniques due to visibility limitations. Since water depth and velocity are generally the limiting factors for fish sampling in river systems where stream wading is required, the pole seines used for this effort will be 4 feet in depth and 40 feet in length, 3/16-inch mesh (net body) with a 1/8-inch net bag. The pole seine is operated with one person on each pole and the net is worked through the sample area in an upstream direction. A bag is kept in the middle of the net to collect fish as they are directed into the net by the wings. The operators must work carefully to ensure that the lead line is kept on the bottom to prevent the fish from escaping from under the net and to keep the bag expanded as they work the net upstream.

An attempt should be made to sample fish from relatively small areas of approximately 5 meters x 5 meters with consistent depths, velocities, and substrates; however, exact size and dimensions will sometimes change to facilitate sampling larger areas of relatively uniform habitat when fish densities are low. The field crew should measure and record the area sampled by the seine in order to express the number of fish captured per unit area.

Once captured, fish will be identified to species, counted, and released in close proximity to the capture site. For each area sampled, data collection will be very similar to that collected during snorkel surveys with the exception of fish distance from the bottom and focal velocity. Since no direct observation of the position of the fish in the water column can be made in turbid water, this information is not recorded. Additionally, surveys will have to rely on feeling the channel bottom with their hands and feet to characterize substrate composition. Once again, all data will be recorded on waterproof data sheets. Digital photographs will be taken of representative habitat types where fish of different species and size classes are observed.

8.5.4.5.1.1.6.3 Electrofishing

If electrofishing is permitted in turbid water areas of the Middle and Lower River segments, barge or backpack electrofishing surveys maybe used to capture fish and determine microhabitat use. Barge-mounted electrofishing is effective in areas that are wadeable, but have relatively large areas to cover. Backpack electrofishing is effective in wadeable areas that are relatively narrow and shallow. The effectiveness of barge and backpack electrofishing systems can be enhanced through the use of block nets. In all cases the electrofishing unit will be operated and configured with settings consistent with guidelines established by ADF&G. The location of each electrofishing area will be mapped using handheld GPS units and marked on high-resolution aerial photographs.

Selection of the appropriate electrofishing system will be made as part of site selection. To the extent possible, the selected electrofishing system will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish habitat use. HSC measurements will be collected at each site using the methods described in Pole/Beach Seining section. Where safety concerns can be adequately addressed, electrofishing may also be conducted after sunset in clear water areas; otherwise electrofishing surveys will be conducted during daylight hours.

8.5.4.5.1.1.7 Habitat Utilization Frequency Histogram/ HSC Curve Development

Histograms (i.e., bar chart) will be developed for each of the habitat parameters (e.g., depth, velocity, substrate, cover, groundwater use, etc.) using the site-specific field observations. The histogram developed using field observations will be compared to the draft HSC curves and literature-based HSC curves. Prior to calculation of the HSC curves, the habitat data from each stream were organized by species and life stage, entered into commercially available spreadsheets, and subsequently checked for data entry accuracy. Frequency distributions will then generated for mean velocity, depth, and substrate type for each species and then normalized. Histogram plots of depth and mean column velocity utilization will be developed using bin sizes defined by using the Stuges (1926) formula:

$$R/(1+3.322\text{Log}(n))$$

Where R is the range of values and n is the total number of observations. The frequency of the field observations will then be converted into HSC curves by scaling the distribution between 0 and 1 (utilization values divided by the maximum value observed). The resulting curves will be inspected and visually adjusted, in part to smooth out sharp breakpoints, and in the case of depth, extend the range of the curve to reflect a non-limiting condition.

For comparative purposes, HSC curves for each species and life stage will first be developed using pooled data from all sampling areas and time periods, and then (depending on available data) separate curves will be developed based on stream-specific data (i.e., geomorphic reach, mainstem habitat type, clear vs. turbid water, and upwelling areas) and winter vs. summertime sampling efforts. Thus, for certain species and life stages four or five separate HSC curves may be generated.

8.5.4.5.1.1.8 Bootstrap Analysis for HSC Curve Development

For data sets with less than the target number of observations ($n \geq 100$), bootstrap analysis will be used to assess the variability and confidence intervals around each of the data sets used to develop the HSC 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). This method is especially useful when the sample size is insufficient for straightforward statistical inference. Bootstrapping provides a way to account for the distortions that may be caused by a specific sample that may not be fully representative of a population.

To complete the analysis a group of individual observations (e.g., depth, velocity measurement for a particular species and life stage) will be resampled with replacement up to the number of the original data set. Each sample involves the following steps:

1. A vector of length equal to the observed data set (N) is created;
2. The vector is filled with the N random samples (with replacement) from the observed data set;
3. The observations are then grouped into bins for velocity and depth – bin sizes will be driven by the desire to group a minimum of 25 observations within each velocity and depth bin;
4. The bin counts will be normalized so that the HSC value for the bin with the maximum count equals 1.0.

The resulting bootstrap samples represent 1,000 possible HSC curves that might be generated from empirical data assuming random chance in observing fish. Using the resulting curve sets, confidence intervals can then be derived from the resulting HSC curves.

8.5.4.5.1.2 Habitat Suitability Index (HSI)

Additionally, criteria will be developed related to juvenile fish stranding and trapping in the varial zone (e.g., the size, species, and periodicity of susceptible fish, recolonization rates, critical streambed gradient, cover factor, periodicity of cover factor, isolation elevations with/without cover, and minimum size of trapping areas). These criteria are described in more detail in subsequent sections.

8.5.4.5.1.2.1 Winter Habitat Use Sampling

To determine if there are temporal (seasonal and diurnal) difference in microhabitat use by rearing fish in the Susitna River daytime and nighttime sampling a pilot study is proposed at two selected sloughs and side channels areas (Whiskers Slough and Slough 8a) during the 2012/2013 wintertime period. The sloughs will be the same as those selected as Focus Areas in Section 8.5.4.4.1.4. Wintertime detection of microhabitat use will be conducted using a video camera or, if water turbidity >4 NTU, DIDSON sonar to observe rearing fish. The deployment techniques will follow those described by Mueller et al. (2006). Sampling will be conducted in both open water and areas under ice cover. For ice covered areas, the video camera of DIDSON unit will be lowered through auger holes drilled through the ice to make 360 degree surveys. Mueller et al. (2006) found that DIDSON cameras were useful for counting and measuring fish up to 52.5 feet (16 meters) from the camera and were effective in turbid waters. In contrast, they found that video cameras were only effective in clear water areas with turbidity less than 4 NTU. However, Mueller et al. (2006) noted that identifying species and observing habitat conditions were more effective with video cameras than DIDSON cameras. In addition to fish observations, video cameras will also be used to characterize winter habitats attributes such as the presence of anchor ice, hanging dams, and substrate type.

Data collection will be similar to that presented for snorkel surveys and will include collection of water depth (open water areas only), mean column velocity, nose velocity, substrate composition, and use of instream cover during both day and nighttime surveys. For fish observed by use of the DIDSON sonar in turbid water conditions (>4 NTU), an attempt will be made to estimate fish length/life stage and microhabitat use but no distinction of species will be made. For planning purposes, a range of 7-10 sampling sites will be established at each of the two sampling areas (Whiskers Slough and Slough 8a). Figure 8.5-29 and Figure 8.5-30 illustrate the anticipated number and distribution of sampling locations within the two off-channel areas proposed for sampling during this pilot study. The anticipated timing and frequency of wintertime sampling is presented in the ISF schedule.

Sampling to address winter day/night behavior will be integrated into sampling being conducted to achieve other objectives including fish presence, water temperature, and intragravel temperature and dissolved oxygen. A proposed schedule for completion of 2012 /2013 wintertime HSC data collection is presented in Table 8.5-13.

8.5.4.5.1.2.2 Stranding and Trapping

Fluctuations in river flow will cause portions of the channel along the margins to alternate between wet and dry conditions, an area referred to as the varial zone. Flow fluctuations can be the result of precipitation falling as rain, snowmelt, and glacial meltwater, but the frequency, timing, and magnitude of flow fluctuations will change under proposed Project operations. In addition to altering the availability of suitable habitat, flow fluctuations associated with Project operations have the potential to cause strand or trap of fish and other aquatic organisms on dewatered portions of the channel bed. While the physical and hydraulic processes associated with stranding and trapping are related, aquatic organisms have different responses to stranding and trapping. Stranding occurs where fish become beached on dewatered streambed areas as water levels recede and is generally associated with shoreline areas having low gradient and/or dewatered areas having sufficient cover to attract fish (Figure 8.5-31). Trapping occurs where fish in channel depressions become isolated from flowing water as water levels recede and are subjected to stress or mortality from predation, reduced dissolved oxygen, water temperature fluctuations, or subsequent stranding if trapping areas drain.

The incidence and severity of stranding and trapping effects will be influenced by a suite of biological and hydrological/geomorphological factors. Stranding susceptibility varies with fish size, time of day and season.

Based on a review of studies conducted in Washington State, Washington Department of Fish and Wildlife (Hunter 1992) concluded that salmonid fry smaller than 50 mm in length are most susceptible to stranding.

The following excerpts and synopses support Hunter's (1992) hypothesis that salmonid fry smaller than about 50 mm in length are more vulnerable to direct impacts from ramping events than larger fish.

Source	**River Location**	**Comment**
Bauersfeld 1977	Columbia River, Washington	Reporting on stranding of trout, Chinook, coho and chum salmon, Bauersfeld noted that 86 percent of all stranded fish were between 30 and 50 mm. The majority of fish stranded (78%) were Chinook salmon.
Bauersfeld 1978	Cowlitz River, Washington	"A size comparison of Chinook stranded (Figure 5) versus fish available (Figure 4, April 26 and May 6) show that stranding was size selective, impacting the small (35 to 45 mm) recently emerged fry, even though larger fish were present."
Olson 1990	Sultan River, Washington	"Susceptibility to stranding was particularly evident for salmon fry less than 50 mm long and for steelhead less than 40 mm long." All Chinook salmon fry observed (n=44) during downramping trials were 48 mm or less and all but one coho fry were less than 46 mm (n = 12). All steelhead fry stranded were less than 40 mm in length.

R.W. Beck 1989	Skagit River, Washington	"Once [steelhead] fry size increased above 4.0 cm, vulnerability decreased rapidly ... Above a fry size of 4.0 cm the percentage of the main-channel population is always found to be much greater than the associated stranded fry of corresponding size." R.W. Beck and Assoc. reported that the mean size of Chinook fry stranded was 4.3 cm. Ninety-nine percent of Chinook fry stranded were less than 50 mm.
Stober et al. 1982	Skagit River, Washington	"The 1992 observations indicate that while the fry may be present in the nearshore area, they appear to be less susceptible to stranding once they reach a length of about 40 mm."

Related to this, size (or life stage) periodicity will dictate the seasonal timing during which vulnerable size classes may be present in the varial zone. Stranding and trapping susceptibility may also vary by species based on differences in periodicity, as well as species-specific habitat preferences and behavior. Recolonization rates, or how quickly organisms return once a dewatered area is rewetted, will also influence cumulative susceptibility to stranding and trapping.

Hydrological/geomorphological factors also affect stranding and trapping rates. Streambed areas with low gradient represent the greatest risk to stranding. Bauersfeld (1978) reported that stranding occurred primarily on bars less than 4 percent gradient; other studies also reported high incidence of juvenile salmonids stranding on bars with low gradient slope (Hilgert and Madsen 1998, R.W. Beck 1989).

The density of juvenile salmonids may be higher in the vicinity of woody debris and emergent or submergent macrophytes which contributes to a higher incidence of stranding should those areas become dewatered. At existing hydroelectric projects, site-specific trapping and stranding criteria can be developed through experimental manipulation of flow conditions through project operations. The current pre-project conditions of the Susitna River preclude this approach. Thus, developing stranding and trapping criteria for the Susitna River will need to be determined based on a combination of observations under natural flow variations as well as literature-based information derived from other regulated systems where stranding and trapping studies have been conducted.

The general susceptibility of target species and life stages to stranding and trapping will initially be identified based on their life stage periodicity, length frequency, habitat utilization, distribution, and abundance in the Middle River and Lower River segments, as determined by fish distribution studies (RSP Section 9.6) and the downstream extent of Project effects. This information will then be used to identify areas for potential field investigations of stranding and trapping. Under existing, unregulated conditions, the frequency, magnitude and rate of water level fluctuations in the Susitna River will be less than the rate of change associated with load-following operations at existing hydroelectric Projects. However, flow reductions under unregulated flows in the Susitna River have the potential to cause stranding and trapping of aquatic organisms. Field surveys of potential stranding and trapping areas will be conducted immediately following flow reduction events. Immediately following such an event, a field crew will conduct survey potential stranding and trapping areas following field protocols to be developed in consultation with the TWG. Field surveys will follow a stratified random sampling strategy at potential stranding areas to estimate the number, size, and species of fish stranded or trapped. Field surveys will be conducted at potential stranding and trapping areas on an opportunistic basis following up to three flow reduction events during 2013 and up to three flow reduction events during 2014. The goal of these surveys will be to provide a relative indication of those species, life stages, and sizes susceptible to stranding and trapping to corroborate literature-derived criteria. In addition, the mechanisms through which each stranding or trapping occurs will be identified (e.g., streambed gradient, emergent vegetation, etc.) and reviewed to ensure that subsequent modeling efforts accurately reflect the relevant processes. The risks of fish stranding and trapping will be assessed through the development of models developed to evaluate each process separately. While stranding and trapping are both related to reductions in water surface elevations, the specific mechanisms through which they occur are different, requiring discrete models for each process. Time-step increments, used to calculate stage changes, will be identified during calibration of the mainstem open-water flow routing model in Q4 2012 (see Section 8.5.4.3). Depending on the initial calibration results, time steps as short as 3-minutes may be needed to match predicted to measured stage changes in the flow routing model. In 2014, the calibrated flow routing model will be used to evaluate the effects of Project operations on stranding and trapping using 1-hour time-steps unless the TWG determines that shorter time steps are needed to evaluate specific fisheries resources. Potential stranding and trapping of juvenile salmonids associated with twice-daily stage reductions from the Baker River Hydroelectric Project was evaluated using 1-hour time steps (Hilgert et al. 2008). Each model will incorporate relevant criteria, developed as described above, and provide indices to quantify the extent of stranding/trapping for individual events. The stranding index will reflect the area of potential stranding and is conceptually depicted as follows, where SI = stranding index, AS = stranding area in square feet, and CS = cover factor for stranding:

$$SI = AS * CS$$

The trapping index will reflect the area of potential trapping and is conceptually depicted as follows, where TI = trapping index, AT = trapping area (square feet), TT(D) = duration of trapping factor, and CT = cover factor:

$$TI = AT * TT(D) * CT$$

These indices will then be considered in relation to the monthly frequency of potential stranding/trapping events for a given Project operational scenario such as the example provided in Table 8.5-15.

8.5.4.5.1.3 Periodicity

A species and life stage periodicity table will be developed applicable to the different segments of the Susitna River. Information presented in the 1980s reports will be used to generate a draft periodicity table that will be included in the HSC/Periodicity TM scheduled for completion in December 2012. Specifically, the TM will summarize relevant literature from the 1980s studies identifying time periods when various life stages (e.g., migration, spawning, incubation, emergence, rearing) are present for Chinook, coho, chum, pink, and sockeye salmon in main channel, tributary, and slough habitat areas in middle and lower Susitna River sections. An example of the draft periodicity table is present in Table 8.5-3. The information presented in the periodicity table will assist in development of the aquatic habitat modeling effort for the lower and middle sections of the Susitna River. Periodicity information for resident fish species including Arctic Grayling, round whitefish, humpback whitefish, longnose sucker, and burbot will be obtained from other literature sources (e.g., Morrow 1980, etc.) and TWG members. Updates and/or revisions to the draft periodicity table will be completed in cooperation with the TWG during proposed meetings to be held in the Q1 2013 and Q4 of 2014 (Table 8.5-13). The final periodicity table will be developed following the 2014 field season and will incorporate the findings of the 2012, 2013, and 2014 fisheries studies (Table 8.5-13).

8.5.4.5.2 Work Products

The final work product of this study effort will consist of HSC curves for the target fish species and life stages, and/or habitat guilds. Separate draft reports will be prepared that describe survey methods, results of 2012 review of 1980s HSC data, results of 2013 and 2014 sampling efforts, and discussion of recommendations for final HSC selection. A final report describing survey methods and results and the final selection of HSC curves will be prepared at the end of 2014.

8.5.4.6 Habitat-Specific Model Development

This study component develops the core structures of the aquatic habitat specific models. Development of these models will require careful evaluation of existing data and information as well as focused discussions with technical representatives from the licensing participants. These models will rely in part on information and technical analyses performed in other study components as a basis for developing model structures (e.g., Habitat Mapping; other riverine process studies). Physical habitat models are often used to evaluate alternative instream flow regimes in rivers (e.g., the Physical Habitat Simulation [PHABSIM] modeling approach developed by the U.S. Geological Survey; Bovee 1998, Waddle 2001). Methods available for assessing instream flow needs vary greatly in the issues addressed, their intended use, their underlying assumptions, and the intensity (and cost) of the effort required for the application. Many techniques, ranging from those designed for localized site or specific applications to those with more general utility have been used. The summary review reports of Wesche and Rechard (1980), Stalnaker and Arnette (1976), EA Engineering, Science and Technology (1986), the proceedings of the Symposium on Instream Flow Needs (Orsborn and Allman eds. 1976), Electric Power Research Institute (2000), and more recently the Instream Flow Council (Annear et al. 2004) provide more detailed information on specific methods. The methods proposed in the IFS 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.).

8.5.4.6.1 Proposed Methodology

Development of the models will involve completion of a series of tasks as noted below.

- Transect/Study Segment Selection – In coordination with licensing participants and riverine process study leads, use the results of the Habitat Mapping study component to select transects/study segments within each of the selected habitat types identified in the Susitna River to describe habitat conditions based on channel morphology and major habitat features. Additional habitat transects/segments will be selected to describe distinct habitat features such as groundwater areas, spawning and rearing habitats, overwintering habitats, distinct tributary mouths/deltas, and potential areas vulnerable to fish trapping/stranding. The transects used for defining the flow routing model will also be integrated into this analysis.

- Agency/Licensing participant Site Reconnaissance – Conduct a site reconnaissance with personnel from agencies, Alaska Native entities and other licensing participants to review river reaches, select candidate study sites and potential transect/study segment locations, and discuss options for model development. This reconnaissance trip has been scheduled for early-mid September and will encompass a 3-4 day effort. The first day will be an office based meeting during which specific methods will be reviewed and their applicability to addressing specific questions will be discussed, and the field itinerary reviewed. This will be followed by a 1-2 day field reconnaissance of representative habitat types including but not limited to mainstem channel, side channels, side sloughs, and upland sloughs. Stops will be made at each of these habitat types and assessment methods will be discussed, with the goal of reaching consensus on which methods will be applied for evaluating flow-habitat relationships. Participants will reconvene in the office on the final day of the trip to discuss observations and reach agreement on assessment methods.
- Model Selection: Field Surveys and Data Collection – Once study sites and transects/study segments have been identified, detailed field surveys will begin. These will be tailored based on habitat types to be measured and the selected models to be used. It is likely this will involve a combination of 1-D and 2-D modeling approaches as well as application of empirically based methods such as the RJHAB model applied in the 1980s studies (ADF&G 1984L). The RJHAB model was used to assess/model the effects of flow alterations on juvenile fish habitat for off-channel areas. At this time, it is anticipated that two-dimensional modeling will be applied to one or more representative reaches in the Middle River. For this, a multi-stepped approach will be used so that after each field data collection effort, topographic data will be projected via computer analysis to identify locations requiring the collection of more data points. Table 8.5-16 provides a listing of potential models/methods that will be considered as part of the IFS. The most appropriate methods for selected study sites will be determined via careful review of site conditions and the underlying questions needing to be addressed. Methods selection will be done as a collaborative process within the IFS-TWG.

Regardless of specific method, field surveys will involve measurement of water velocities, water depths, water surface elevations, bottom profiles/topography, substrate characteristics, and other relevant data (e.g., upwelling, water temperature) under different flow conditions. One of the tasks for 2012 is to evaluate and determine specific flow targets for these field surveys.

8.5.4.6.1.1 Habitat Model Selection

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.2 Physical and Hydraulic Data Collection

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.3 Hydraulic Model Calibration

Susitna mainstem flow routing models (HEC-ResSim; HEC-RAS; CRISSP1D and/or other routing models) will provide hourly flow and water surface elevation data at numerous locations longitudinally distributed throughout the length of the river extending downstream from RM 184. Two different flow routing models will be developed: a summer ice-free model (HEC-RAS); and a winter model to route flows under ice-covered conditions (CRISSP1D). Output from the flow routing model will provide the fundamental input data to a suite of habitat specific and riverine process models that will be used to describe how the existing flow regime relates to and has influenced various resource elements (e.g., salmonid spawning and rearing habitats, invertebrate habitat, sediment transport processes, ice dynamics, large woody debris (LWD), the composition and structure of riparian floodplain vegetation). These same models will likewise be used to evaluate fish habitat responses to alternate Project operational scenarios. As an unsteady flow model, the routing model will be capable of providing flow and water surface elevations on an hourly basis and therefore Project effects on flow can be evaluated on multiple time steps (hourly, daily, monthly) as necessary to evaluate different resource elements.

Habitat-specific models represent the core analytical tools for assessing potential Project effects on fish and aquatic resources.

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.4 Weighted Usable Area Habitat Metrics

The methods proposed in the IFS will include a combination of approaches 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.). During the 1980s studies, methods were designed to focus on both mainstem and off-channel habitats, although mainstem analysis was generally limited to near-shore areas. PHABSIM-based 1-D models, juvenile salmon rearing habitat models, fish passage models, and others were employed and will be considered as part of the IFS plan. As part of the 2013-2014 study efforts, more rigorous approaches and intensive analyses will be applied to habitats determined as representing especially important habitats for salmonid production. This will include both 1-D and 2-D hydraulic modeling that can be linked to habitat based models.

As part of the Geomorphology Modeling Study (Section 5.9), several 2-D models are being considered including the Bureau of Reclamation's SRH2-D, USACE's Adaptive Hydraulics ADH, the U.S. Geological Survey's (USGS) MD_SWMS suite, DHIs MIKE 21, and the suite of River2D models (see Section 5.9 for a description of various 2-D model attributes and references). The River2D model is a two-dimensional, depth-averaged finite-element hydrodynamic model developed at the University of Alberta that is capable of simulating complex, transcritical flow conditions. River2D also has the capability to assess fish habitat using the PHABSIM weighted-usable area approach (Bovee, 1982). Habitat suitability indices are input to the model and integrated with the hydraulic output to compute a weighted useable area at each node in the model domain. While evaluation of habitat indices directly incorporated into the River2D suite of models, other 2-D models are also complementary to habitat evaluations. Selection of potential 2-D models for fish and aquatics evaluations will be coordinated with other pertinent studies and the Licensing participants in the Q1 2013 and revisited in the Q1 2014.

The models noted above will be used to translate changes in water surface elevation/flow at each of the measured transects/study segments into changes in depth, velocity, substrate, cover and other potential habitat (e.g., turbidity, upwelling). Linking this information with HSC/HSI curves will allow for translation of changes in hydraulic conditions resulting from Project operations into indices of habitat suitability. This will allow for the quantification of habitat areas containing suitable habitat indices for target species and life stages of interest for baseline conditions and alternate operational scenarios.

In response to the effect of potential load-following operations, habitat modeling using weighted usable area indices may need to be developed using both daily and hourly time steps. Evaluating the effects of changes in habitat conditions on an hourly basis may require additional habitat-specific models such as effective habitat and varial zone modeling.

8.5.4.6.1.5 Effective Spawning/Incubation Habitat Analyses

The risk of salmonid redd dewatering and scour will be assessed by developing an effective spawning/incubation model. Spawning/incubation analyses will be based on identifying potential use of a small, discrete channel area (cell) by spawning salmonids on an hourly basis and then tracking that cell through the subsequent egg and alevin incubation periods to determine whether that cell was subject to dewatering or scour. Within each cell, the maximum and minimum stage for spawning to occur will be identified based on the range of flow depths and velocities between those two stages. Use of that cell by spawning fish is assumed to occur if substrate conditions are suitable and habitat suitability indices for both depth and velocity are within an acceptable range. HSC/HSI information used to develop the effective spawning/incubation model will be developed in consultation with the licensing participants as part of the previously described section on HSC development.

A varial zone habitat model will be developed to quantify the magnitude, frequency and duration of the channel area that may be exposed to inundation and dewatering. The varial zone analysis will be conducted by discrete portions of each of the habitat types (e.g., mainstem, side channel, sloughs) using an hourly time step integrated over a specified period that considers fluctuations in water surface elevations that occurred during the period. The varial zone is defined as the area between the high water surface elevation and the low water surface elevation for a given project operating range using a span of time periods reflective of the aquatic species and life stage of interest. The selection of time periods to define the upper and lower extent of the varial zone for the Project will be coordinated with licensing participants. However, for planning purposes, three time scales are being considered: 12 hours, 7 days and 30 days. A 12-hour time series may provide an indication of the effects of water level changes on aquatic biota that rapidly colonize a previously dewatered area. Salmonid fry and some benthic macroinvertebrate may rapidly recolonize or occupy a previously dewatered area when they are moving downstream from upstream areas during outmigration or a result of displacement from upstream areas. A 7-day time series may be used as an indicator of the risk of dewatering due to hourly and daily changes in load-following operations, such as weekday versus weekend generation. Some aquatic organisms may require several days to colonize an area, or the density of organisms may increase rapidly over the first several days of access to a previously dewatered area. A 30-day time series can be used as an indicator of the risk of dewatering associated with weekly to monthly changes in flow patterns, such as changes in minimum flow requirements or seasonal runoff. A complex assemblage of benthic macroinvertebrates may require weeks to months to become established along channel margins. Information on the rate of colonization, dewatering mortalities and conditions supporting suitable habitats for organisms of interest will be developed as part of the HSC/HSI study component. Figure 8.5-32 and Figure 8.5-33 illustrate the concept of a varial zone and the framework for the varial zone model.

8.5.4.6.1.6 Varial Zone Modeling (Downramping, Stranding, Trapping)

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.6.1 Fish

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.6.2 Aquatic Productivity

[In progress; additional detail will be provided in the December RSP].

8.5.4.6.1.7 Fish Passage/Off-channel Connectivity

The extent to which mainstem flows dictate connectivity to off-channel habitats will be evaluated via development of models that consider the depth, velocity and substrate requirements of adult salmon upstream migrations as well as juvenile downstream movements. This analysis will be completed on a representative number of the different habitat types found in the Susitna River including side channels, side-sloughs, and upland sloughs. Proposed locations for this analysis will be identified during the 2012 Agency Field Reconnaissance trip scheduled for September. To the extent applicable, the analysis will utilize information and modeling results developed during the 1980s studies, but entirely new studies will be completed as a means to test the results of the earlier studies, as well as to apply new technologies in making this evaluation (e.g., possible application of 2-D modeling). This work will be closely coordinated with and linked to the Fish Barrier Analysis study described in Section 7.12 of this study plan.

8.5.4.6.2 Work Products

[In progress; additional detail will be provided in the December RSP].

8.5.4.7 Temporal and Spatial Habitat Analyses

The hydraulic-routing and habitat models will be used to process output from the ROM. This will be done for each scenario and hydrologic period and will allow for the quantification of Project operation effects on:

- Habitat areas (for each habitat type – mainstem, side channel, slough, etc.) by species and life stage;
- Varial zone area;
- Effective spawning areas for fish species of interest (i.e., spawning sites remain wetted through egg hatching);
- Other riverine processes that will be the focus of the Geomorphology (Section 5.8 and 5.9), Water Quality (Section 5.5), and Ice Processes (Section 5.10) studies including mobilization and transport of sediments, channel form and function, water temperature regime, and ice formation and decay timing. The IFS studies will be closely linked with these studies and will incorporate various model outputs in providing a comprehensive evaluation of instream flow related effects on fish and aquatic biota and habitats.

The various indices of Project effects on aquatic habitats will be summarized and tabulated to allow ready comparison of the effects of alternative operational scenarios. It is anticipated that the varial zone and effective habitat analysis will be used as a primary indicator of the effects of operational scenarios related to relatively short-term flow alterations. Analyses of habitat area will be developed for each species and life stage of interest (or as combinations of species via habitat guilds), and the results will be used in part for identifying the spatial distribution of potential habitats. Each indicator of environmental effect will be tallied separately, and the relative importance of the effects of Project operations on various aquatic resources can be determined independently by interested parties.

8.5.4.7.1 Proposed Methodology

[In progress; additional detail will be provided in the December RSP].

8.5.4.7.2 Work Products

At a minimum, reports will be prepared at the end of each year of study that will describe the methods and results of the IFS components completed during that year. There will be other technical information prepared throughout the duration of the IFS including \ describing flow routing, fish and aquatics study site selection, HSC field methods, HSC and periodicity development, habitat modeling, and habitat analyses.

8.5.4.8 Instream Flow Study Integration

8.5.4.8.1 Proposed Methodology

[In progress; additional detail will be provided in the December RSP].

8.5.4.8.2 Work Products

[In progress; additional detail will be provided in the December RSP].

8.5.5 Consistency with Generally Accepted Scientific Practice

The proposed IFS, including methodologies for data collection, analysis, modeling, field schedules, and study durations, is consistent with generally accepted practice in the scientific community. The study plans were collaboratively developed with technical experts representing the applicant, state and federal resource agencies, Alaska Native entities, non-government organizations and the public. Many of these technical experts have experience in multiple FERC licensing and relicensing proceedings. The IFS is consistent with common approaches used for other FERC proceedings and the IFS reference specific protocols and survey methodologies, as appropriate.

8.5.6 Schedule

The schedule for completing all components of the Mainstem Aquatic Habitat Model is provided in Table 8.5-13. Licensing participants will have opportunities for study coordination through regularly scheduled meetings, reports and, as needed, technical subcommittee meetings. Initial and Updated Study Reports will be issued in December 2013 and 2014, respectively. Reports are planned for preparation at the end of 2013 and 2014 for each of the study components. Workgroup meetings are planned to occur on at least a quarterly basis, and workgroup subcommittees will meet or have teleconferences as needed.

8.5.7 Level of Effort and Cost

Based on a review of study costs associated with similar efforts conducted at other hydropower projects, and in recognition of the size of the project and logistical challenges and costs associated with the remoteness of the site, study costs associated with the Instream Flow Study are expected to be approximately $5,000,000 to $6,000,000. Estimated study costs are subject to review and revision as additional details are developed.

Portions of this study will be conducted in conjunction with water resource, geomorphology, water quality, operational modeling, and fisheries and aquatic resource studies; however, specific costs of those studies will be reflected in those individual study plans.

8.5.8 Literature Cited

ADF&G Alaska Department of Fish and Game. 1981. Subtask 7.10 Phase 1 Draft Report. Adult Anadromous Fisheries Project ADF&G/SuHydro 1981. Prepared for Acres American Incorporated. 467 pp.

—. 1981a. Aquatic studies procedures manual: Phase I. Su-Hydro Aquatic Studies Program. Anchorage, Alaska. Susitna Hydro document no. 3506.

—. 1981b. Subtask 7.10 Phase 1 Final Draft Report Resident Fish Investigation on the Upper Susitna River. Alaska Department of Fish and Game, Anchorage, Alaska.

—. 1982. Upper Susitna River Impoundment Studies 1982. ADF&G. Anchorage, Alaska.

—. 1983a. Susitna Hydro aquatic studies phase II final report. Adult anadromous fish studies, 1982, volume 2. Susitna Hydro Document No. 588, Anchorage, Alaska.

—. 1983b. Aquatic Habitats and Instream Flow Studies Parts I and II. Susitna Hydro Aquatic Studies Phase II Basic Data Report volume 4, Susitna Hydro Document No. 585. Anchorage, Alaska.

—. 1984. Adult Anadromous Fish Investigations: May-October, 1983. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 430 pp.

—. 1984a. Susitna Hydro aquatic studies report no. 1. ADF&G, Susitna Hydro Aquatic Studies Report Series, Susitna Hydro Document No. 1450, Anchorage, Alaska.

—. 1984b. Population Dynamics of Arctic Grayling in the Upper Susitna Basin, Report 4, Part II. Schmidt, D.C., C. Estes, D. Crawford, and D. Vincent-Lang, editor. Access and Transmission Corridor Aquatic Investigations (July–October 1983). Susitna Hydro Document No. 2049. ADF&G, Anchorage.

—. 1984d. Aquatic Habitat and Instream Flow Investigations (May–October, 1983). Chapter 1. Stage and Discharge Investigations – 1984. Susitna Hydro Document No. 1930. ADF&G, Anchorage, Alaska.

—. 1984e. Aquatic Habitat and Instream Flow Investigations (May–October, 1983). Chapter 2. Channel Geometry Investigations. Susitna Hydro Document No. 1931. ADF&G, Anchorage, Alaska.

—. 1984f. Aquatic Habitat and Instream Flow Investigations (May–October, 1983). Chapter 3. Continuous Water Temperature Investigations. Susitna Hydro Document No. 1932. ADF&G, Anchorage, Alaska.

—. 1984g. Aquatic Habitat and Instream Flow Investigations (May–October, 1983). Chapter 5. Eulachon Spawning Habitat – 1984. Susitna Hydro Document No. 1934. ADF&G, Anchorage, Alaska.

—. 1984h. Aquatic Habitat and Instream Flow Investigations (May–October, 1983). Chapter 6. An evaluation of passage conditions for adult salmon in sloughs and side channels of the Middle Susitna River. Susitna Hydro Document No. 1935. ADF&G, Anchorage, Alaska.

—. 1984k. Aquatic Habitat and Instream Flow Investigations, (May–October, 1983). Chapter 9. Habitat suitability criteria for Chinook, coho and pink salmon spawning in tributaries of the Middle Susitna River. Susitna Hydro Document No. 1938. ADF&G, Anchorage, Alaska.

—. 1984k. Aquatic Habitat and Instream Flow Investigations, (May–October, 1983). Modeling of juvenile salmon and resident fish habitat. Susitna Hydro Development Part 7. ADF&G, Anchorage, Alaska.

Addley, C. 2006. Habitat modeling of river ecosystems: Multidimensional spatially explicit and dynamic habitat templates at scales relevant to fish. Ph.D. dissertation. Utah State University, Logan, Utah.

Annear, T., I. Chisholm, H. Beecher, A. Locke and 12 other authors. 2004. Instream flows for riverine resource stewardship, revised edition. Instream Flow Council, Cheyenne, WY. 268 pp.

Barrett, B.M. 1985. Adult Salmon Investigations, May-October 1984. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 528 pp.

Barrett, B.M., F.M. Thompson, S. Wick, and S. Krueger. 1983. Adult Anadromous Fish Studies, 1982. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 275 pp.

Barrett, B., M., F. M. Thompson and S. N. Wick. 1985. Adult salmon investigations. Susitna Hydro Aquatic Studies Report No. 6. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 528 pp. APA Document # 2748.

Bauersfeld, K. 1977. Effects of peaking (stranding) of Columbia River dams on juvenile anadromous fishes below the Dalles Dam, 1974 and 1975. Washington Department of Fisheries, Technical Report 31. 111 pp.

Bauersfeld, K. 1978. Stranding of juvenile salmon by flow reductions at Mayfield Dam on the Cowlitz River 1976. Washington Department of Fisheries Technical Report No. 36. Prepared for the City of Tacoma, Department of Public Utilities. 36 pp.

Bigler, J., and K. Levesque. 1985. Lower Susitna River Preliminary Chum Salmon Spawning Habitat Assessment. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies. 140 pp.

Bovee, K. D. 1982. A guide to stream habitat analysis using the Instream Flow Incremental Methodology. Instream Flow Paper No. 12. Washington, DC: U.S. Fish and Wildlife Service (FWS/OBS-82/26).

Bovee, K. D. 1986. Development and evaluation of habitat suitability criteria for use in the instream flow incremental methodology. Washington, DC: U.S. Fish and Wildlife Service (Biological Report 86[7]). 235pp.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981. Juvenile Anadromous Fish Study on the Lower Susitna River. Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska 200 pp.

Delaney, K., D. Crawford, L. Dugan, S. Hale, K Kuntz, B. Marshall, J. Mauney, J. Quinn, K. Roth, P Suchanek, R. Sundet, and M. Stratton. 1981. Resident Fish Investigation on the Lower Susitna River. Prepared by Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies. Prepared for Alaska Power Authority, Anchorage, AK. 311 pp.

DeVries, P., B. Kvam, S. Beck, D. Reiser, M. Ramey, C. Huang, and C. Eakin. 2001. Kerr Hydroelectric Project, Lower Flathead River ramping rate study. Prepared by R2 Resource Consultants, for Confederated Salish and Kootenai Tribes of the Flathead Nation, Montana.

Dugan, L.J., D. A. Sterritt, and M.E. Stratton. 1984. The distribution and relative abundance of juvenile salmon in the Susitna River drainage above the Chulitna River confluence. Alaska Department of Fish and Game. Completion Report. Susitna Hydroelectric Studies. Anchorage, Alaska.

EA Engineering, Science, and Technology, Inc. 1986. Instream flow methodologies. Electric Power Research Institute (EPRI). EPRI EA-4819, Project 2194-2, Final Report.

Electric Power Research Institute (EPRI). 2000. Instream flow assessment methods: guidance for evaluating instream flow needs in hydropower licensing. Electric Power Research Institute (EPRI). Report number 1000554.

Hardy Thomas B., and Tarbet Karl, 1996. *Evaluation of one-dimensional and two-dimensional hydraulic modeling in a natural river and implications in instream flow assessment methods*. Proceedings of Second International Symposium on Habitat Hydraulics Ecohydraulics 2000, Quebec, Canada, June 1996, Volume B, 395-406.

HDR Alaska. 2011. Susitna-Watana Hydroelectric Project; Railbelt Large Hydro; Aquatic Resources Data Gap Analysis. Prepared for Alaska Energy Authority, Anchorage, Alaska.

Hilliard, N. D., S. Williams, E. W. Trihey, R. C. Wilkinson, and C. R. Steward, III. 1985. Hydraulic relationships and model calibration procedures at 1984 study sites in the Talkeetna-to-Devil Canyon segment of the Susitna River, Alaska. Prepared for the Alaska Power Authority. 303 pp. APA Document # 2898.

Hilgert, P.J. and S.W. Madsen. 1998. Evaluation of potential stranding and trapping of juvenile salmonids as a result of flow fluctuations in the lower White River, Washington. White River Hydroelectric Project, FERC No. 2494, prepared for Puget Sound Energy, Bellevue, Washington.

Hilgert, P.J, S.M. Beck, and S.W. Madsen. 2008. Instream Flow Summary Report, A-09, Baker River Hydroelectric Project, FERC No. 2150, Aquatic Resource Working Group, prepared for Puget Sound Energy, Bellevue, Washington.

Hoffman, A., L. Vining, J. Quinn, R. Sundet, M. Wenger, and M Stratton. 1983. Winter Aquatic Studies (October, 1982-May, 1983). Alaska Department of Fish and Game Susitna Hydro Aquatic Studies, Anchorage, Alaska. 269 pp.

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

Jennings, T. R. 1985. Fish Resources and Habitats in the Middle Susitna River. Instream Flow Relationships Series, Technical Report No. 1. Prepared for the Alaska Power Authority. Woodward-Clyde Consultants and Entrix, Inc. APA Document # 2744.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1990. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. EPA/600/4-90/030, Environmental Monitoring Systems Laboratory, U.S. Environmental Protection Agency, Cincinnati, Ohio.

Leclerc, M., Boudreault A., Bechara, J. A., and Corfa, G., 1995. Two-dimensional hydrodynamic modeling-a neglected tool in the instream flow incremental methodology. Transactions of the American Fisheries Society 124(5), 645-662.

Locke, A., C. Stalnaker, S. Zellmer, K. Williams, H. Beecher, T. Richards, C. Robertson, A. Wald, A. Paul, and T. Annear. 2008. Integrated Approaches to Riverine Resource Management: Case Studies, Science, Law, People, and Policy. Instream Flow Council, Cheyenne, WY. 430 pp.

Marshall, R. P., P. M. Suchanek, and D.C. Schmidt. 1984. Juvenile salmon rearing habitat models. Report No. 2, Part 4. Susitna Hydro Aquatic Studies, Alaska Department of Fish and Game, Anchorage, Alaska.

Merizon, R.A.J., F. Alaska. Division of Sport, and F. Alaska. Division of Commercial. 2010. Distribution of spawning Susitna River chum Oncorhynchus keta and coho O. kisutch salmon, 2009. Alaska Dept. of Fish and Game, Division of Sport Fish, Research and Technical Services, Anchorage, Alaska.

Mueller, D.S. and Wagner, C.R. 2009. Measuring discharge with acoustic Doppler current profilers from a moving boat: U.S. Geological Survey Techniques and Methods 3A-22, 72 pp.

Mueller, D.S. 2012. Review and rating of moving-boat ADCP Q measurements. USGS HydroAcoustics Webinar available at http://hydroacoustics.usgs.gov/training/webinars.shtml

Murphy, B. R. and D. W. Willis. 1996. Fisheries Techniques, Second Edition. American Fisheries Society, Bethesda Maryland. 732 pp.

Olson, F.W. 1990. Downramping regime for power operation to minimize stranding of salmonid fry in the Sultan River. Prepared by CH2M Hill for PUD No.1, Snohomish County. 48 pp.

Orsborn, J.F. and C.H. Allman (editors). 1976. Proceedings of the symposium and specialty conference on instream flow needs. American Fisheries Society, Bethesda, Maryland 20014. Volume I & II.

Perry, S.A. and W.B. Perry. 1986. Effects of experimental flow regulation on invertebrate drift and stranding in the Flathead and Kootenai rivers, Montana, USA. Hydrobiologia. 134: 171 182.

Quane, T., P. Morrow, and I. Queral. 1985. Hydrological investigations at selected lower Susitna River study sites. Task 14 Support Technical Report. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 533 pp. APA Document # 2736.

R2 Resource Consultants, Inc. 2003. Baker River Project Relicensing (FERC No. 2150), Large Woody Debris Budget, Aquatic Resource Study A-20. Prepared by R2 Resource Consultants, Redmond, WA, prepared for Puget Sound Energy, Inc., Bellevue, WA. 105 pp.

R2 Resource Consultants, Inc. 2004. Baker River Project Relicensing (FERC No. 2150), Lower Baker Physical Habitat Mapping, Aquatic Resource Study A-02. Prepared by R2 Resource Consultants, Redmond, WA, prepared for Puget Sound Energy, Inc., Bellevue, WA. 105 pp.

R.W. Beck and Associates. 1989. Skagit River salmon and steelhead fry stranding studies. Report prepared for Seattle CitY Light, Environmental Affairs Division by R W. Beck and Associates, Seattle, WA.

Rabeni, C. F. 1996. Invertebrates. Chapter 11 in Murphy, B. R. and D. W. Willis. (eds) Fisheries Techniques, Second Edition. American Fisheries Society, Bethesda Maryland.

Rantz, S.E. and others 1982. Measurement and computation of streamflow: Volume 1. Measurement of stage and discharge. U.G. Geological Survey Water Supply Paper 2175, 284 p.

Reice, S.R. and M. Wohlenberg. 1993. Monitoring freshwater benthic invertebrates and benthic processes: Measures for assessment of ecosystem health. Pages 287-305 in D.M. Rosenberg and V.H. Resh, editors. Freshwater biomonitoring and benthic macroinvertebrates. Routledge, Chapman and Hall, Inc., New York, New York.

Reiser, D.W, T. Nightengale, N. Hendrix, and S. Beck. 2005. Effects of pulse-type flows on benthic macroinvertebrates and fish: a review and synthesis of information. Report prepared by R2 Resource Consultants for Pacific Gas and Electric Company, San Ramon, California.

Roth, K. J. and M. E. Stratton. 1985. The migration and growth of juvenile salmon in Susitna River, 1985. Susitna Aquatic Studies Program Report No. 7, Part 1. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 202 pp. APA Document # 2836.

Roth, K. J., D. C. Gray, J. W. Anderson, A. C. Blaney, J. P. McDonell. 1986. The migration and growth of juvenile salmon in Susitna River, 1985. Susitna Aquatic Studies Program Report No. 14. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 130 pp. APA Document # 3413.

Sandone, G. D. Vincent-Lang, and A. Hoffman. 1984. Evaluations of chum salmon spawning habitat in selected tributary mouth habitats of the middle Susitna River. Aquatic Habitat and Instream Flow Investigations (May–October, 1983), Report 3 Chapter 8. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 83 pp. APA Document # 1937.

Sautner, J., and M. Stratton. 1983. Upper Susitna River Impoundment Studies 1982. Alaska Department of Fish and Game. Anchorage, Alaska. 220 pp.

Sautner, J.S., L.J. Vining, and L.A. Rundquist. 1984. An evaluation of passage conditions for adult salmon in sloughs and side channels of the middle Susitna River. Page 148 in: Estes, C.C., and D.S. Vincent-Lang. (eds.) Aquatic Habitat and Instream Flow Investigations (May-October 1983). Alaska Dept. Fish and Game. Susitna Hydro Aquatic Studies, Anchorage, Alaska.

Schmidt, D. and C. Estes. 1983. Winter aquatic studies (October 1982-May 1983). Susitna Hydro Aquatic Studies Phase II Data Report. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 269 pp. APA Document # 397.

Schmidt, D., S. Hale, D. Crawford, and P. Suchanek. 1983. Resident and Juvenile Anadromous Fish Studies on the Susitna River Below Devil Canyon, 1982. Prepared by Alaska Department of Fish and Game for the Alaska Power Authority. 303 pp. APA Documents # 486, 487.

Schmidt, D.C., S.S. Hale, D.L. Crawford, and P.M. Suchanek. 1984. Resident and juvenile anadromous fish investigations (May-October 1983). Prepared for the Alaska Power Authority. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Anchorage, Alaska. 458 pp. APA Document # 1784.

Schmidt, D.C., S.S. Hale, D.L. Crawford, and P.M. Suchanek. 1984. Resident and juvenile anadromous fish investigations (May-October 1983). Prepared for the Alaska Power Authority. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Anchorage, Alaska. 458 pp.

Schmidt, D.C., S.S. Hale, and D.L. Crawford. 1985. Resident and juvenile anadromous fish investigations (May-October 1984). Prepared for the Alaska Power Authority. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Anchorage, Alaska. 483 pp.

Seagren, D.R., and R.G. Wilkey. 1985. Summary of water temperature and substrate data from selected salmon spawning and groundwater upwelling sites in the middle Susitna River. ADF&G Susitna River Aquatic Studies Program Technical Data Report No 12. Prepared for Alaska Power Authority, Anchorage, Alaska. 90 pp.

Stalnaker, C. and J. Arnette (eds). 1976. Methodologies for the determination of stream resource maintenance flow requirements: an assessment. U.S. Fish and Wildlife Service, Western Water Allocation.

Stalnaker, C., B.L. Lamb, J. Henriksen, K. Bovee, and J. Bartholow. 1995. The instream flow incremental methodology, a primer for IFIM. National Biological Service, U.S. Department of the Interior. Biological Report 29.

Stober, Q.J., and six others. 1982. Effects of hydroelectric discharge fluctuations on salmon and steelhead in the Skagit River, Washington. Final report for period December 1979 to December 1982, prepared for Seattle City Light. University of Washington Fisheries Research Institute FRI-UW-8218. 302 pp.

Stratton, M.E. 1986. Summary of Juvenile Chinook and Coho Salmon Winter Studies in the Middle Susitna River, 1984-1985. Report to Alaska Power Authority by Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 148 pp.

Suchanek, P. M., R. L. Sundet and M. N. Wenger. 1984a. Resident fish habitat studies. 1984 Report 2, Part 6. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 40pp. APA Document # 1784.

Suchanek, P. M., R. P. Marshall, S. S. Hale, and D. C. Schmidt. 1984b. Juvenile salmon rearing suitability criteria. 1984 Report 2, Part 3. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 49pp. APA Document # 1784.

Suchanek, P. M., K. J. Kuntz, and J. P. McDonell. 1985. The relative abundance, distribution, and instream flow relationships of juvenile salmon in the lower Susitna River. Report 7, Part 2. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 243pp. APA Document # 2836.

Sundet, R.L. 1986. Winter Resident Fish Distribution and Habitat Studies Conducted in the Susitna River Below Devil Canyon, 1984-1985. Report to Alaska Power Authority by Alaska Department of Fish and Game, Susitna Hydro Aquatic Studies, Anchorage, Alaska. 80 pp. APA Document # 3062.

Sundet, R.L., and S.D. Pechek. 1985. Resident Fish Distribution and Life History in the Susitna River Below Devil Canyon. Pages 97 In: Schmidt, D.C., S.S. Hale, and D.L. Crawford. (eds.) Resident and Juvenile Anadromous Fish Investigations (May-October 1984). Prepared by Alaska Department of Fish and Game. Prepared for Alaska Power Authority, Anchorage, AK. APA Document # 2837.

Tarboton, K. C., Irizarry-Ortiz, M. M., Loucks, D. P., Davis, S. M., and Obeysekera, J. T. 2004. Habitat Suitability Indices for Evaluating Water Management Alternatives. Office of Modeling Technical Report. South Florida Water Management District, West Palm Beach, Florida. December, 2004.

The Nature Conservancy. 2009. Indicators of hydrologic alteration, Version 7.1, User's Manual, April.

Thompson, F. M., S. N. Wick, and B. L. Stratton. 1986. Adult salmon investigations, May – October 1985. Susitna Hydro Aquatic Studies Report No. 13, Volume 1. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 173 pp. APA Document # 3412.

Thorp, J.H. and A.P. Covich. 2001. An overview of freshwater habitats. Pages 19-41 *in* J.H. Thorp and A.P. Covich, editors. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego, California.

Trihey, LW. 1979. The IFG incremental methodology. Pages 24-44 in G.L. Smith, ed. Workshop in instream flow habitat criteria and modeling. Colorado Water Resources Research Institute, Colorado State University, Fort Collins, CO. Information Series No. 40.

Trihey, E.W. 1982. 1982 Winter Temperature Study. Prepared for Acres American, Inc. by E.W. Trihey, Anchorage, Alaska. 151 pp.

Troelstrup, N.H., Jr. and G.L. Hergenrader. 1990. Effect of hydropower peaking flow fluctuations on community structure and feeding guilds of invertebrates colonizing artificial substrates in a large impounded river. Hydrobiologia 199: 217 228.

U.S. Army Corps of Engineers. 2001. UNET One-dimensional unsteady flow through a full network of open channels, User's manual, CPD-66.

U.S. Army Corps of Engineers. 2002a. HEC-RAS River Analysis System User's Manual, CPD-68.

U.S. Army Corps of Engineers. 2002b. HEC-RAS River Analysis System Hydraulic Reference Manual, CPD-69.

U.S. Army Corps of Engineers. 2002c. HEC-RAS River Analysis System Applications Guide, CPD-70.

USFWS (U.S. Fish and Wildlife Service). 1980. Habitat evaluation procedures (HEP). ESM 102. U.S. Fish and Wildlife Service, Division of Ecological Services, Washington, D.C. March 31, 1980.

USFWS (U.S. Fish and Wildlife Service). 1981. Standards for the development of habitat suitability index models for use in the Habitat Evaluation Procedures, USDI Fish and Wildlife Service. Division of Ecological Services. ESM 103.

Vincent-Lang, D., A. Hoffman, A.E. Bigham, and C.C. Estes. 1984a. Habitat suitability criteria for Chinook, coho, and pink salmon spawning in tributaries of the middle Susitna River. Aquatic Habitat and Instream Flow Investigations (May-October, 1983) Report No. 3, Chapter 9. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Anchorage, Alaska. 79 pp. APA Document # 1938.

Vincent-Lang, D., A. Hoffman, A.E. Bigham, C.C. Estes, D. Hilliard, C. Stewart, E.W. Trihey, and S. Crumley. 1984b. An evaluation of chum and sockeye salmon spawning habitat in sloughs and side channels of the Middle Susitna River. Aquatic Habitat and Instream Flow Investigations (May-October, 1983) Report No. 3, Chapter 7. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game Susitna Hydro Aquatic Studies Anchorage, Alaska. 339 pp. APA Document # 1936.

Vining, L. J., J. S. Blakely, and G. M. Freeman. 1985. An evaluation of the incubation life-phase of chum salmon in the middle Susitna River, Alaska. Winter Aquatic Investigations, September 1983 – May 1984, Report No. 5, Volume 1. Prepared for the Alaska Power Authority. Alaska Department of Fish and Game. 232 pp. APA Document # 2658.

Wangaard, D. B. and C. V. Burger. 1983. The effects of various water temperature regimes on the egg and alevin incubation of Susitna River chum and sockeye salmon. United States Fish and Wildlife Service, National Fishery Research Center, Alaska Field Station, Anchorage, Alaska, USA.

Wesche, T. A., and P. A. Rechard. 1980. A summary of instream flow methods for fisheries and related research needs. Eisenhower Consortium Bulletin 9. Water Resources Research Institute, University of Wyoming, Laramie, Wyoming. 122 p.

Yanusz, R., R. Merizon, M. Willette, D. Evans, and T. Spencer. 2011. Inriver abundance and distribution of spawning Susitna River sockeye salmon Oncorhynchus nerka, 2008. Alaska Dept. of Fish and Game, Fishery Data Series No. 11-12. Anchorage, Alaska.

8.5.9 Tables

Table 8.5-1 Primary (dark gray) and secondary (light gray) utilization of habitats in the Middle Segment of the Susitna River by adult and juvenile Pacific salmon.

Species	Life Stage	Main Channel	Side Channel	Slough: Side	Slough: Upland	Tributary Mouth	Tributary
Chinook Salmon	Adult Migration	Primary				Primary	Primary
	Spawning					Secondary	Primary
	Incubation					Secondary	Primary
Chum Salmon	Adult Migration	Primary	Secondary	Primary		Primary	Primary
	Spawning	Secondary	Secondary	Primary		Secondary	Primary
	Incubation	Secondary	Secondary	Primary		Secondary	Primary
Coho Salmon	Adult Migration	Primary	Secondary	Secondary		Primary	Primary
	Spawning	Secondary	Secondary	Secondary			Primary
	Incubation	Secondary	Secondary	Secondary			Primary
Sockeye Salmon	Adult Migration	Primary		Primary			
	Spawning	Secondary		Primary	Secondary		Secondary
	Incubation	Secondary		Primary	Secondary		Secondary
Pink Salmon[2]	Adult Migration	Primary		Secondary	Secondary	Primary	Primary
	Spawning			Secondary	Secondary		Primary
	Incubation			Secondary	Secondary		Primary

Primary Use (dark gray) Secondary Use (light gray)

Table 8.5-2 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	✓	✓			✓	✓

<u>Notes:</u>

[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 more parameters

t and juvenile Pacific salmon presence in the middle Susitna River, between the Chulitna River confluence (RM 98.5) and Devils ry stage. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

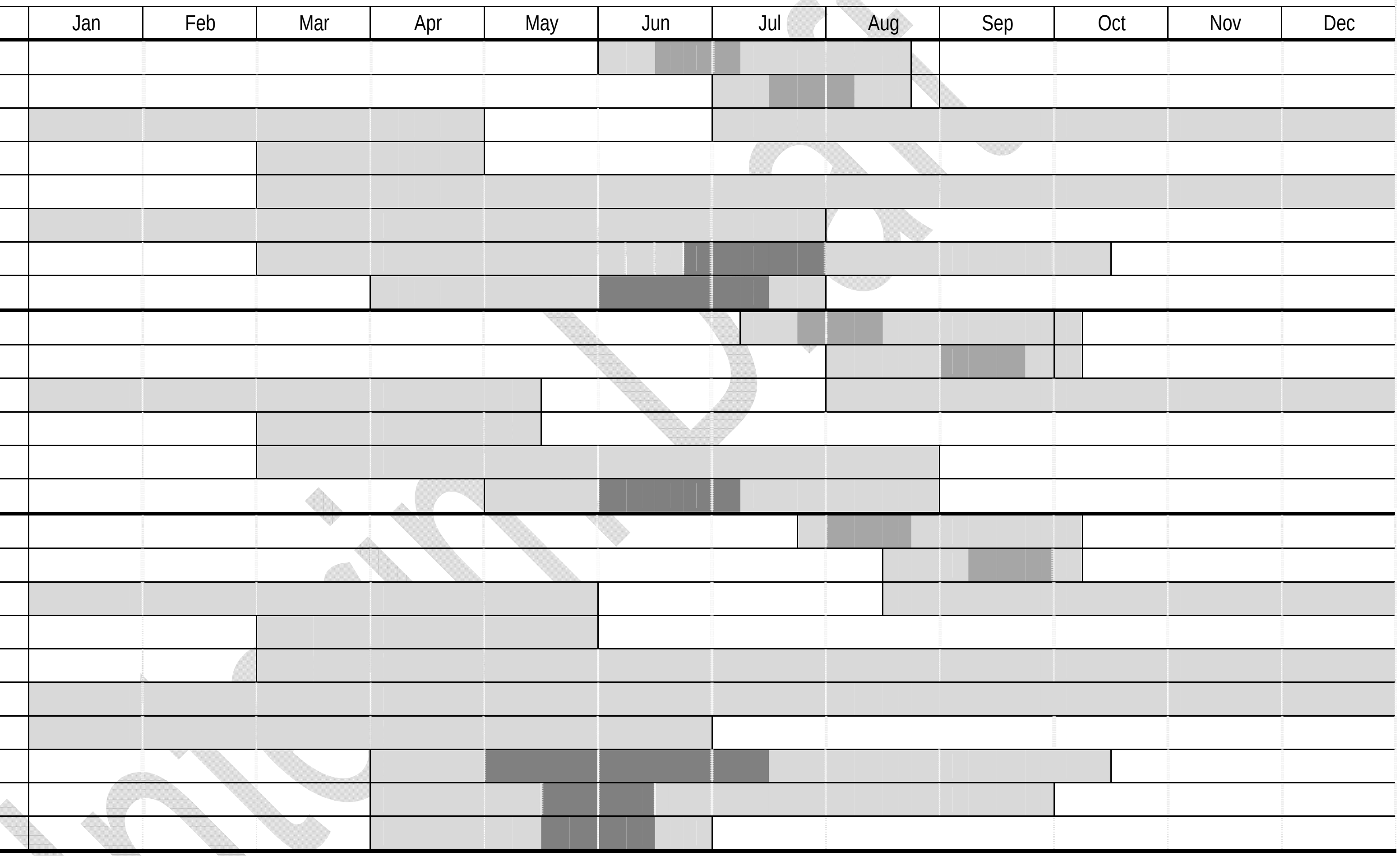


Table 8.5-3 Periodicity of adult and juvenile Pacific salmon presence in the middle Susitna River, between the Chulitna River confluence (RM 98.5) and Devils Canyon (RM 152), by life history stage. Light gray indicates total duration of residence in the middle Susitna River and dark gray represents periods of peak use.

Species	Life Stage (Age)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sockeye Salmon[1,2]	Adult Migration[1]												
	Spawning[1]												
	Incubation												
	Fry Emergence												
	Rearing (0+)												
	Rearing (1+)												
	Juvenile Migration (0+)												
	Juvenile Migration (1+)												
Pink Salmon[3]	Adult Migration												
	Spawning												
	Incubation												
	Fry Emergence												
	Juvenile Migration (0+)												

1 Early-run (A) and late-run (B) sockeye salmon exhibit distinct timing of adult migration and spawning, and utilize separate areas for spawning. Early-run sockeye do not spawn in the middle Susitna River, consequently incubation, emergence, rearing and outmigration periodicity represents that of late-run sockeye in the middle Susitna River.

2 The period of juvenile sockeye migration represents age 0+ movement from natal areas in the middle Susitna River to winter rearing areas in the lower Susitna River. While nearly all Susitna Basin sockeye emigrate as age 1+ smolts, sockeye native to the middle Susitna River typically emigrate downstream to the lower Susitna River as age 0+ fry.

3 No rearing period for age 0+ pink salmon is identified because this species migrates to the estuary soon after emergence.

Peak Use   Off-Peak Use

Table 8.5-4 Instream flow sites and habitat modeling methods used during the 1980s in the middle and lower Susitna River (Marshall et al. 1984, Sandone et al. 1984, Vincent-Lang et al. 1984, Hilliard et al. 1985, Suchanek et al. 1985).

River Mile	Site Name	Susitna Reach	Meso-Habitat Type	Site Type	No. of Transects	Year(s) Measured
35.2	Hooligan Side Channel	Lower	Side Channel	RJHAB	5	1984
36.2	Eagles Nest Side Channel	Lower	Side Channel	RJHAB	4	1984
36.3	Kroto Slough Head	Lower	Side Slough	RJHAB	5	1984
39.0	Rolly Creek mouth	Lower	Tributary Mouth	RJHAB	6	1984
42.9	Bear Bait Side Channel	Lower	Side Channel	RJHAB	5	1984
44.4	Last Chance Creek Side Channel	Lower	Side Channel	RJHAB	6	1984
59.5	Rustic Wilderness Side Channel	Lower	Side Channel	RJHAB	5	1984
63.0	Caswell Creek mouth	Lower	Tributary Mouth	RJHAB	8	1984
63.2	Island Side Channel	Lower	Side Channel	RJHAB, IFIM	9	1984
74.4	Mainstem West Bank	Lower	Side Slough	IFG-4	7	1984
74.8	Goose 2 Side Channel	Lower	Side Channel	RJHAB	6	1984
75.3	Circular Side Channel	Lower	Side Channel	IFG-4	6	1984
79.8	Sauna side channel	Lower	Side Channel	IFG-4	4	1984
84.5	Sucker side channel	Lower	Side Channel	RJHAB	6	1984
86.3	Beaver Dam side channel	Lower	Side Channel	RJHAB	5	1984
86.3	Beaver Dam Slough	Lower	Side Slough	RJHAB	5	1984
86.9	Sunset side channel	Lower	Side Channel	IFG-4	7	1984
87.0	Sunrise side channel	Lower	Side Channel	RJHAB	7	1984
88.4	Birch Slough	Lower	Side Slough	RJHAB	8	1984
91.6	Trapper Creek side channel	Lower	Side Channel	IFG-4, RJHAB	5	1984
101.2	101.2 R, Whiskers East side channel	Middle	Side Channel	IFG-4	9	1984
101.4	Whiskers Slough	Middle	Side Slough	RJHAB	8	1983
101.5	101.5 L, Whiskers West side channel	Middle	Side Channel	IFG-2	5	1984
101.7	101.7 L	Middle	Side Channel	DIHAB	4	1984
105.8	105.8 L	Middle	Mainstem	DIHAB	4	1984
107.6	Slough 5	Middle	Upland Slough	RJHAB	9	1983
112.5	Slough 6A	Middle	Upland Slough	RJHAB	8	1983
112.6	112.6 L, Side Channel 6A	Middle	Side Channel	IFG-2	9	1984
113.6	Lane Creek mouth	Middle	Tributary Mouth	Habitat Mapping	7	1983
113.7	Slough 8	Middle	Side Slough	RJHAB	5	1983
114.1	114.1 R	Middle	Side Channel	DIHAB	3	1984
115.0	115.0 R	Middle	Side Channel	DIHAB	4	1984
118.9	118.9 L	Middle	Mainstem	DIHAB	3	1984
119.1	119.1 L	Middle	Mainstem	DIHAB	3	1984
119.2	119.2 R, Little Rock side channel	Middle	Side Channel	IFG-2	5	1984
125.2	125.2 R	Middle	Side Channel	DIHAB	2	1984
125.3	Slough 8A	Middle	Side Slough	IFG-4	11	1983
128.8	Slough 9	Middle	Side Slough	IFG-4	10	1983
130.2	130.2 R	Middle	Side Channel	DIHAB	3	1984
131.1	4th of July Creek mouth	Middle	Tributary Mouth	Habitat Mapping	8	1983
131.3	131.3 L	Middle	Side Channel	DIHAB	4	1984
131.7	131.7 L	Middle	Side Channel	IFG-4	7	1984
132.6	132.6 L, Side channel 10A	Middle	Side Channel	IFG-4, RJHAB	9	1983-84
133.8	133.8 R	Middle	Mainstem	DIHAB	3	1984
133.8	Side channel 10	Middle	Side Channel	IFG-4	4	1983
134.9	Lower Side channel 11	Middle	Side Channel	IFG-2	6	1983
136.0	136.0 L, Slough 14	Middle	Side Channel	IFG-4	6	1984

Table 8.5-4 Instream flow sites and habitat modeling methods used during the 1980s in the middle and lower Susitna River (Marshall et al. 1984, Sandone et al. 1984, Vincent-Lang et al. 1984, Hilliard et al. 1985, Suchanek et al. 1985).

136.3	Upper Side channel 11	Middle	Side Channel	IFG-4	4	1983
137.5	137.5 R	Middle	Side Channel	DIHAB	3	1984
138.7	138.7 L	Middle	Mainstem	DIHAB	3	1984
139.0	139.0 L	Middle	Mainstem	DIHAB	4	1984
139.4	139.4 L	Middle	Side Channel	DIHAB	3	1984
141.2	Side channel 21	Middle	Side Channel	IFG-4	5	1983
141.8	Slough 21	Middle	Side Slough	IFG-4	5	1983
144.4	Slough 22	Middle	Side Slough	RJHAB	8	1983
147.1	147.1 L, Fat Canoe SC	Middle	Side Channel	IFG-2	6	1984

Table 8.5-5 Partial list of river cross-sections, and flow and water surface elevations measured in 2012 on the Susitna River between River Miles 75 and 184. The list does not include additional measurements in late September/October. Those measurements had not been processed at the time this study plan was prepared.

Approx-imate River Mile[1]	Flow and Water Surface Elevation Measurements									
	June		July		August		September		October	
	Date	Flow at Gold Creek (cfs)	Date	Flow at Gold Creek (cfs)	Date	Flow at Gold Creek (cfs)	Date	Flow at Gold Creek (cfs)	Date	Flow at Gold Creek (cfs)
184.1	6/17/2012	33,400			8/6/2012	19,700	9/15/2012	11,900		
183.4	6/18/2012	32,200			8/6/2012	19,700	9/15/2012	11,900		
182.8	6/18/2012	32,200			*8/6/2012*[2]	19,700	*9/15/2012*[2]	11,900		
182.6	6/19/2012	33,900			*8/6/2012*[2]	19,700	*9/15/2012*[2]	11,900		
182.2	6/19/2012	33,900			8/6/2012	19,700	9/15/2012	11,900		
181.7	6/19/2012	33,900			8/7/2012	18,200	9/15/2012	11,900		
180.3	6/20/2012	35,500			8/7/2012	18,200	9/15/2012	11,900		
179.8	6/20/2012	35,500			*8/7/2012*[2]	18,200	*9/15/2012*[2]	11,900		
178.9	6/20/2012	35,500			8/7/2012	18,200	9/15/2012	11,900		
176.8	6/21/2012	36,700			8/7/2012	18,200	9/14/2012	10,900		
176.1	6/16/2012	36,700			8/7/2012	18,200	9/14/2012	10,900		
173.9	6/21/2012	36,700			8/8/2012	17,300	9/16/2012	17,100		
172.0	6/21/2012	36,700			*8/8/2012*[2]	17,300	*9/16/2012*[2]	17,100		
170.0	6/21/2012	36,700			8/8/2012	17,300	9/16/2012	17,100		
167.0	6/22/2012	36,000			8/8/2012	17,300	9/16/2012	17,100		
164.5	6/22/2012	36,000			8/8/2012	17,300	9/17/2012	21,600		
162.0	Devils Canyon – No Measurements in This Reach for Safety Reasons									
161.0										
160.0										
159.0										
158.0										
157.0										
156.0										
155.0										
154.0										
153.0										
152.0										
151.0										
150.2	6/25/2012	36,000			8/10/2012	16,700				
149.5	6/26/2012	35,100			*8/10/2012*[2]	16,700				
148.7	6/26/2012	35,100			8/10/2012	16,700	*Planned*[3]			
147.6	6/25/2012	36,000			*8/10/2012*[2]	16,700				
144.8	6/26/2012	35,100			8/10/2012	16,700				
143.2	6/27/2012	34,700			*8/10/2012*[2]	16,700				
142.3	6/27/2012	34,700			8/12/2012	17,600	*Planned*[3]			
142.1	6/27/2012	34,700			*8/12/2012*[2]	17,600				
141.5	6/27/2012	34,700			*8/12/2012*[2]	17,600				

Table 8.5-5 Partial list of river cross-sections, and flow and water surface elevations measured in 2012 on the Susitna River between River Miles 75 and 184. The list does not include additional measurements in late September/October. Those measurements had not been processed at the time this study plan was prepared.

140.8	6/27/2012	34,700			*8/12/2012*[2]	17,600				
140.2	6/28/2012	33,300			8/12/2012	17,600				
139.4	6/28/2012	33,300			*8/12/2012*[2]	17,600				
138.9	6/28/2012	33,300			8/12/2012	17,600	*Planned*[3]			
138.5	6/28/2012	33,300			8/12/2012	17,600				
138.2	6/28/2012	33,300			*8/12/2012*[2]	17,600				
136.7	6/29/2012	32,700			8/13/2012	17,500	*Planned*[3]			
136.4	6/29/2012	32,700			*8/13/2012*[2]	17,500				
135.7	6/30/2012	31,100			8/13/2012	17,500				
135.4	6/30/2012	31,100			8/13/2012	17,500				
134.7	6/30/2012	31,100			*8/13/2012*[2]	17,500				
134.3	6/30/2012	31,100			8/13/2012	17,500	*Planned*[3]			
133.3			7/1/2012	29,800	*8/13/2012*[2]	17,500				
132.9			7/1/2012	29,800	*8/13/2012*[2]	17,500				
131.8			7/1/2012	29,800	8/13/2012	17,500				
131.2			7/2/2012	28,100	*8/13/2012*[2]	17,500	*Planned*[3]			
130.9			7/2/2012	28,100	8/14/2012	17,100				
130.5			7/2/2012	28,100	8/14/2012	17,100				
130.0			7/3/2012	29,900	*8/14/2012*[2]	17,100				
129.4			7/2/2012	28,100	8/14/2012	17,100	*Planned*[3]			
128.1			7/3/2012	29,900	*8/14/2012*[2]	17,100				
126.6			7/3/2012	29,900	8/14/2012	17,100			*Planned*[3]	
124.4			7/4/2012	29,800	8/15/2012	17,100				
123.3			7/4/2012	29,800	8/15/2012	17,100			*Planned*[3]	
122.6			7/5/2012	28,700	*8/15/2012*[2]	17,100				
121.8			7/5/2012	28,700	*8/15/2012*[2]	17,100				
120.7			7/5/2012	28,700	8/15/2012	17,100			*Planned*[3]	
120.3			7/6/2012	24,400	*8/15/2012*[2]	17,100				
119.3			7/6/2012	24,400	*8/15/2012*[2]	17,100				
119.2			7/6/2012	24,400	8/15/2012	17,100				
117.2			7/6/2012	24,400	*8/15/2012*[2]	17,100				
116.4			7/7/2012	21,400	8/16/2012	17,200			*Planned*[3]	
115.0			7/7/2012	21,400	*8/16/2012*[2]	17,200				
114.0			7/7/2012	21,400	*8/16/2012*[2]	17,200				
113.0			7/7/2012	21,400	8/16/2012	17,200			*Planned*[3]	
112.7			7/8/2012	26,700	*8/16/2012*[2]	17,200				
112.2			7/8/2012	26,700	*8/16/2012*[2]	17,200				
111.8			7/8/2012	26,700	*8/16/2012*[2]	17,200				
110.9			7/8/2012	26,700	*8/16/2012*[2]	17,200				
110.0			7/9/2012	31,200	8/16/2012	17,200			*Planned*[3]	
108.4			7/9/2012	31,200	*8/16/2012*[2]	17,200				
106.7			7/9/2012	31,200	8/17/2012	17,200			*Planned*[3]	
104.8					8/17/2012	17,200				

Table 8.5-5 Partial list of river cross-sections, and flow and water surface elevations measured in 2012 on the Susitna River between River Miles 75 and 184. The list does not include additional measurements in late September/October. Those measurements had not been processed at the time this study plan was prepared.

103.0			7/9/2012	31,200	8/18/2012	16,600			*Planned*[3]	
102.4					8/18/2012	16,600				
101.5					8/18/2012	16,600				
101.0					8/18/2012	16,600				
100.4					8/19/2012	16,600				
99.6									*Planned*[3]	
98.8			7/10/2012	27,200	*8/19/2012*[2]	16,600				
98.2					8/19/2012	16,600			*Planned*[3]	
98.0			7/10/2012	27,200	*8/19/2012*[2]	16,600				
97.1									*Planned*[3]	
95.9									*Planned*[3]	
95.0			7/11/2012	22,600	8/20/2012	17,100				
94.0			7/11/2012	22,600	8/20/2012	17,100				
93.1									*Planned*[3]	
91.8									*Planned*[3]	
90.6									*Planned*[3]	
89.0									*Planned*[3]	
87.7					8/21/2012	18,700				
86.9			7/12/2012	20,100	8/21/2012	18,700				
84.6					8/22/2012	18,600				
83.0			7/12/2012	20,100	*8/22/2012*[2]	18,600				
82.0			7/13/2012	18,800	*8/22/2012*[2]	18,600				
81.0					8/22/2012	18,600				
80.0					8/23/2012	16,300				
79.0			7/13/2012	18,800	*8/23/2012*[2]	16,300				
78.0					8/23/2012	16,300				
77.0									*Planned*[3]	
76.0					8/24/2012	15,900				
75.0									*Planned*[3]	

[1] Approximate river miles to be superseded by new river mile system derived from current orthophotographs.

[2] Only stage was measured at these cross-sections. Flows were measured on the same day at nearby cross-sections.

[3] Low flow field measurements planned for late September/October were only partially completed. Flow conditions were unusually high in September/October and freeze up began in mid-October.

Table 8.5-6 Summary of gaging stations established on Susitna River in 2012.

Gaging Station	Approximate River Mile	Reach
Susitna River near Cantwell (ESS80)	223.2	Upper Susitna River
Susitna River below Deadman Creek (ESS70)	184.0	Middle Susitna River above Devils Canyon
Susitna River below Fog Creek (ESS65)	173.9	
Susitna River above Devil Creek (ESS60)	164.3	
Susitna River above Portage Creek (ESS55)	148.6	Middle Susitna River below Devils Canyon
Susitna River at Curry (ESS50)	120.7	
Susitna River below Lane Creek (ESS45)	113.0	
Susitna River above Whiskers Creek (ESS40)	103.3	
Susitna River at Chulitna River (ESS35)	98.1	
Susitna River below Twister Creek (ESS30)	95.9	Lower Susitna River
Susitna River at Susitna Station (ESS20)	25.7	
Susitna River near Dinglishna Hill (ESS15)	19.9	
Susitna River below Flat Horn Lake (ESS10)	13.7	

Table 8.5-7 Susitna Real-Time Reporting Network Stations.

Site Name	Short Name	River Mile (Brailey)	Latitude	Longitude	Parameters
Upper Watershed AEA Gaging Stations					
15291500 Susitna River Near Cantwell	ESS80				discharge, water level, water and air temperature, camera
Middle Watershed 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
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
Lower Watershed AEA Gaging Stations					
15294350 Susitna River at Susitna Station	ESS20	*[In progress; additional detail will be provided in the December RSP]*			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

Table 8.5-8 Period of record of flows measured by the USGS on the Susitna River.

Gage Number	Site	Approximate River Mile	Drainage Area (mi^2)	Latitude	Longitude	Elevation (ft, NGVD 29)	Period of Record of Measured Flows
15291000	Susitna River near Denali	290.6	950	63.10389	147.51583	2,440	27 years: 1957 - 1976; 1978 - 1986
15291500	Susitna River near Cantwell	223.2	4,140	62.69861	147.54500	1,900	17 years: 1961 - 1972; 1980 - 1986
15292000	Susitna River at Gold Creek	136.6	6,160	62.76778	149.69111	677	57 years: 1949 - 1996; 2001 - 2011
15292780	Susitna River at Sunshine	83.9	11,100	62.17833	150.17500	270	5 years: 1981 - 1986
15294350	Susitna River at Susitna Station	25.8	19,400	61.54472	150.51250	40	19 years: 1974 - 1993

Table 8.5-9 Period of record of flows measured by the USGS on tributaries of the Susitna River.

Gage Number	Site	Approximate River Mile in Susitna River at Confluence	Drainage Area (mi^2)	Latitude	Longitude	Elevation (ft, NGVD 29)	Period of Record of Measured Flows
15291200	Maclaren River near Paxson	259.7	280	63.11944	146.52917	2,866	28 years: 1958 - 1986
15292400	Chulitna River near Talkeetna	98.0	2,570	62.55861	150.23389	520	20 years: 1958 - 1972; 1980 - 1986
15292700	Talkeetna River near Talkeetna	97.0	1,996	62.34694	150.01694	400	47 years: 1964 - 2011
15294005	Willow Creek Near Willow	48.4	166	61.78083	149.88444	350	25 years: 1978 - 1993; 2001 - 2011
15294345	Yentna River near Susitna Station	27.6	6,180	61.69861	150.65056	80	6 years: 1980 - 1986

Table 8.5-10 List of 33 Index of Hydrologic Alteration (IHA) parameters (The Nature Conservancy 2009).

IHA Parameter Group	Hydrologic Parameters	Ecosystem Influences
1. Magnitude of monthly water conditions	Mean or median value for each calendar month *Subtotal 12 parameters*	• Habitat availability for aquatic organisms • Soil moisture availability for plants • Availability of water for terrestrial animals • Availability of food/cover for forbearing mammals • Reliability of water supplies for terrestrial animals • Access by predators to nesting sites • Influences water temperature, oxygen levels, photosynthesis in water column
2. Magnitude and duration of annual extreme water conditions	Annual minima, 1-day mean Annual minima, 3-day means Annual minima, 7-day means Annual minima, 30-day means Annual minima, 90-day Means Annual maxima, 1-day mean Annual maxima, 3-day means Annual maxima, 7-day means Annual maxima, 30-day means Annual maxima, 90-day means Number of zero-flow days Base flow: 7-day minimum flow/mean flow for year *Subtotal 12 parameters*	• Balance of competitive, ruderal, and stress-tolerant organisms • Creation of sites for plant colonization • Structuring of aquatic ecosystems by abiotic vs. biotic factors • Structuring of river channel morphology and physical habitat conditions • Soil moisture stress in plants • Dehydration in animals • Anaerobic stress in plants • Volume of nutrient exchanges between rivers and floodplains • Duration of stressful conditions such as low oxygen and concentrated chemicals in aquatic environments • Distribution of plant communities in lakes, ponds, floodplains • Duration of high flows for waste disposal, aeration of spawning beds in channel sediments
3. Timing of annual extreme water conditions	Julian date of each annual 1-day maximum Julian date of each annual 1-day minimum *Subtotal 2 parameters*	• Compatibility with life cycles of organisms • Predictability/avoidability of stress for organisms • Access to special habitats during reproduction or to avoid predation • Spawning cues for migratory fish • Evolution of life history strategies, behavioral mechanisms
4. Frequency and duration of high and low pulses	Number of low pulses within each water year Mean or median duration of low pulses (days) Number of high pulses within each water year Mean or median duration of high pulses (days) *Subtotal 4 parameters*	• Frequency and magnitude of soil moisture stress for plants • Frequency and duration of anaerobic stress for plants • Availability of floodplain habitats for aquatic organisms • Nutrient and organic matter exchanges between river and floodplain • Soil mineral availability • Access for waterbirds to feeding, resting, reproduction sites • Influences bedload transport, channel sediment textures, and duration of substrate disturbance (high pulses)
5. Rate and frequency of water condition changes	Rise rates: Mean or median of all positive differences between consecutive daily values Fall rates: Mean or median of all negative differences between consecutive daily values Number of hydrologic reversals *Subtotal 3 parameters* *Grand total 33parameters*	• Drought stress on plants (falling levels) • Entrapment of organisms on islands, floodplains (rising levels) • Desiccation stress on low-mobility streamedge (varial zone) organisms

Table 8.5-11 List of 34 Environmental Flow Component (EFC) parameters (The Nature Conservancy 2009).

EFC Type	Hydrologic Parameters	Ecosystem Influences
1. Monthly low flows	Mean or median values of low flows during each calendar month ______________________ *Subtotal 12 parameters*	• Provide adequate habitat for aquatic organisms • Maintain suitable water temperatures, dissolved oxygen, and water chemistry • Maintain water table levels in floodplain, soil moisture for plants • Provide drinking water for terrestrial animals • Keep fish and amphibian eggs suspended • Enable fish to move to feeding and spawning areas • Support hyporheic organisms (living in saturated sediments)
2. Extreme low flows	Frequency of extreme low flows during each water year or season Mean or median values of extreme low flow event: • Duration (days) • Peak flow (minimum flow during event) • Timing (Julian date of peak flow) ______________________ *Subtotal 4 parameters*	• Enable recruitment of certain floodplain plant species • Purge invasive, introduced species from aquatic and riparian communities • Concentrate prey into limited areas to benefit predators
3. High flow pulses	Frequency of high flow pulses during each water year or season Mean or median values of high flow pulse event: • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates ______________________ *Subtotal 6 parameters*	• Shape physical character of river channel, including pools, riffles • Determine size of streambed substrates (sand, gravel, cobble) • Prevent riparian vegetation from encroaching into channel • Restore normal water quality conditions after prolonged low flows, flushing away waste products and pollutants • Aerate eggs in spawning gravels, prevent siltation
4. Small floods	Frequency of small floods during each water year or season Mean or median values of small flood event: • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates ______________________ *Subtotal 6 parameters*	Applies to small and large floods: • Provide migration and spawning cues for fish • Trigger new phase in life cycle (i.e., insects) • Enable fish to spawn in floodplain, provide nursery area for juvenile fish • Provide new feeding opportunities for fish, waterfowl • Recharge floodplain water table • Maintain diversity in floodplain forest types through prolonged inundation (i.e., different plant species have different tolerances) • Control distribution and abundance of plants on floodplain • Deposit nutrients on floodplain
5. Large floods	Frequency of large floods during each water year or season Mean or median values of large flood event: • Duration (days) • Peak flow (maximum flow during event) • Timing (Julian date of peak flow) • Rise and fall rates ______________________ *Subtotal 6 parameters* ______________________ *Grand total 34 parameters*	Applies to small and large floods: • Maintain balance of species in aquatic and riparian communities • Create sites for recruitment of colonizing plants • Shape physical habitats of floodplain • Deposit gravel and cobbles in spawning areas • Flush organic materials (food) and woody debris (habitat structures) into channel • Purge invasive, introduced species from aquatic and riparian communities • Disburse seeds and fruits of riparian plants • Drive lateral movement of river channel, forming new habitats (secondary channels, oxbow lakes) • Provide plant seedlings with prolonged access to soil moisture

Table 8.5-12 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
Arctic grayling	*Thymallus arcticus*	F	O, R, P
Dolly Varden	*Salvelinus malma*	A,F	O, P
Humpback whitefish	*Coregonus pidschian*	A,F	O, R, P
Round whitefish	*Prosopium cylindraceum*	F	O, M2, P
Burbot	*Lota lota*	F	O, R, P
Longnose sucker	*Catostomus catostomus*	F	R, P
Sculpin	*Cottid spp.*	M1, F	P
Eulachon	*Thaleichthys pacificus*	A	M2, S
Bering cisco	*Coregonus laurettae*	A	M2, S
Threespine stickleback	*Gasterosteus aculeatus*	A,F	M2, S, R, P
Arctic lamprey	*Lethenteron japonicum*	A,F	O, M2, R, P
Chinook salmon	*Oncorhynchus tshawytscha*	A	M2, R
Coho salmon	*Oncorhynchus kisutch*	A	M2, S, R
Chum salmon	*Oncorhynchus keta*	A	M2, S
Pink salmon	*Oncorhynchus gorbuscha*	A	M2
Sockeye salmon	*Oncorhynchus nerka*	A	M2, S
Rainbow trout	*Oncorhynchus mykiss*	F	O, M2, P
Northern pike	*Esox lucius*	F	P
Lake trout	*Salvelinus namaycush*	F	U
Pacific lamprey	*Lampetra tridentata*	A,F	U
Alaska blackfish	*Dallia pectoralis*	F	U

Notes:

A = anadromous
M1 = marine
F = freshwater
O=overwintering
R=rearing
P=present
M2 = migration
S=spawning
U=unknown

Table 8.5-13 Schedule for implementation of the Fish and Aquatics Instream Flow Study.

Activity	2012				2013				2014				2015	
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q
Study Area Selection (Focus Areas and supplementary areas)														
Compile aquatic habitat (RSP Sec 9.09) and geomorphology (Sec 6.8.4) characterization study results														
Identify proposed Focus Areas														
Refine Focus Areas and identify supplementary areas if needed for any underrepresented habitats														
TWG confirmation of study areas														
Review available data and modify or add Focus Areas and supplementary sampling areas									Δ					
TWG review of proposed area weighting factors to extrapolate modeled to non-modeled areas														
TWG meeting on area weighting													▲	
Review of 1980s Data and Information									Δ				▲	
Model Selection by habitat type (2-D, 1-D, etc.)														
Propose habitat models for Focus Areas and supplemental area														
TWG review and meeting on habitat model selection									Δ					
Hydraulic Routing														
Review 2012 transect data RM 184 to 75														
Develop executable mainstem open water flow routing model														
Model verification using stage recorder data														
Identify need for additional data									Δ					
Distribute draft Mainstem Open Water Flow Routing Model to TWG for review														
Use draft model to support IFS, water quality, geomorphology, and fisheries 2013-14 study efforts														
Refine open water routing model using 2013 and 2014 data														
Distribute final Mainstem Open Water Routing Model to TWG for review													▲	

Activity	2012				2013				2014				2015	
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q
Use final Mainstem Open Water Routing Model for scenario evaluations													—	→
Hydrology		—	—	—	—	—	—	—	—	—	—	—		
Obtain existing daily flow records from USGS		—	—	—										
Obtain analysis of climate change effects on flow from USGS			—	—										
Obtain basin area calculations from GINA-UAF				—										
Calculate estimated trib accretion flows				—	—	—								
TWG review of hydrologic record of daily flow							—							
TWG review of representative years for modeling							—		Δ					
Collect 15-min stage records from mainstem, tribs and Focus Areas		—	—	—	—	—	—	—	—	—	—			
Develop hourly flow record for Focus Areas / other mainstem locations							—	—	—					
Develop hourly inflow for select tributaries							—	—	—					
Develop list of potential and recommended IHA-type parameters								—	—					
TWG review of selected IHA-type parameters									—					
Examine 2014 stage data and refine hydrologic record to support scenario evaluations											—	—		
TWG meeting to review complete hydrologic record												—	▲	
Use hydrologic record for scenario evaluations													—	→
Periodicity		—	—	—	—	—	—	—	—	—	—	—		
Review draft species and lifestage periodicity data developed under Fish Distribution and Abundance (Sec 9.06)			—	—			---				---			
Identify specific HSC/HSI periodicity data needs				—				---			---	---		
Distribute HSC/HSI periodicity to TWG				—				---	Δ			---		
TWG meeting on HSC/HSI periodicity used to model scenarios												—	▲	
HSC/HSI Fish: Field data collection (summer, fall, winter)		—	—	—	—	—	—	—	—	—	—	—	—	
Use 1980s Susitna data and other existing HSC curves to develop draft species / lifestage HSC curves for the lower and middle Susitna River			—	—	—	—								
Propose target HSC species, lifestages, substrate and cover				—	—									

Activity	2012				2013				2014				2015	
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q
TWG meeting on HSC/HSI and data collection study details					—	—			---	---				
Conduct HSC/HSI summer surveys (snorkel, seining, electrofishing)		—	—			—	—			—	—	—		
Conduct fish HSC/HSI winter surveys (underwater camera, electrofishing)					—			—	—	—		---	---	
Conduct aquatic biota stranding and trapping surveys						—	—			---	---			
Coordinate and review adult/spawning HSC data collected by Fish and Aquatic biotelemetry (Sec 9.06)			—	—				---	---			---	---	
Distribute preliminary findings of wintertime surveys to TWG						—	—			—			—	
Distribute preliminary results of HSC/HSI surveys and changes to draft HSC/HSI					—			---	---Δ					
TWG meeting on species and life stage HSC/HSI					—	—			---	---	---	---	▲	
Collect Physical and Hydraulic Data for Habitat Modeling						—	—	—	—	—	—	—		
Collect data for digital terrain model						—	—				---			
Collect x-section and stage:discharge data at Focus Areas and supplemental areas						—	—			---	---	---		
Collect substrate/cover data at Focus Areas and supplemental areas							—	—			---	---		
Provide summaries of data collection efforts									Δ				▲	
Coordinate with Geomorphology, Groundwater, Riparian, Ice, and Water Quality Data Collection and Modeling			—	—	—	—	—	—	—	—	—	—		
Hydraulic Model Integration and Calibration									—	—	—	—	▲	
Aquatic Habitat Modeling							—	—	Δ	---	---	---	▲	
Reporting				—					Δ				▲	
Alternate Scenario Post-Processing												—	—	→

Table 8.5-14 Proposed substrate classification system for use in development of HSC/HSI curves for the Susitna-Watana Project.

Substrate Code	Substrate Type	Size (Inches)	Size (mm)
1	Silt, Clay, or Organic		
2	Sand	<0.1	<2.5
3	Small Gravel	0.1-0.5	2.5-12.7
4	Medium Gravel	0.5-1.5	12.7-38.1
5	Large Gravel	1.5-3.0	38.1-76.2
6	Small Cobble	3.0-6.0	76.2-152.4
7	Large Cobble	6.0-12.0	152.4-304.8
8	Boulder	>12.0	>304.8
9	Bedrock		

Table 8.5-15 Example of table that will be developed as part of the stranding and trapping analyses to illustrate the frequency of potential stranding and trapping events by month for a given Project operational scenario.

	Existing Condition												Operating Scenario 1												Operating Scenario 2											
Evaluation Indicator	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
>1"/hour																																				
>2"/hour																																				
>4"/hour																																				

Table 8.5-16 Assessment of physical and biological processes and potential habitat modeling techniques.

Physical & 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	NA
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	NA

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.

8.5.10 Figures

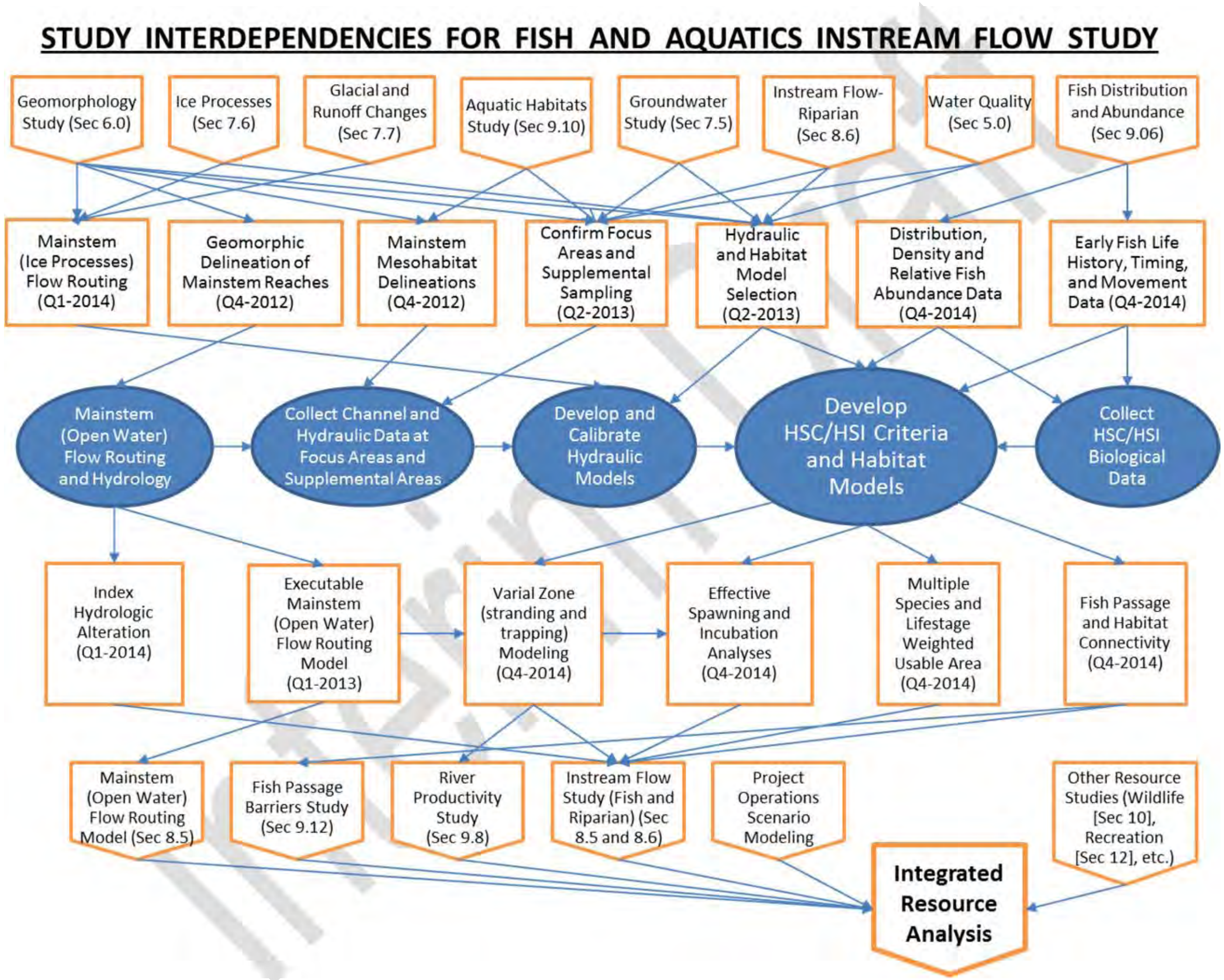


Figure 8.5-1 Study interdependencies for Fish and Aquatics Instream Flow Study.

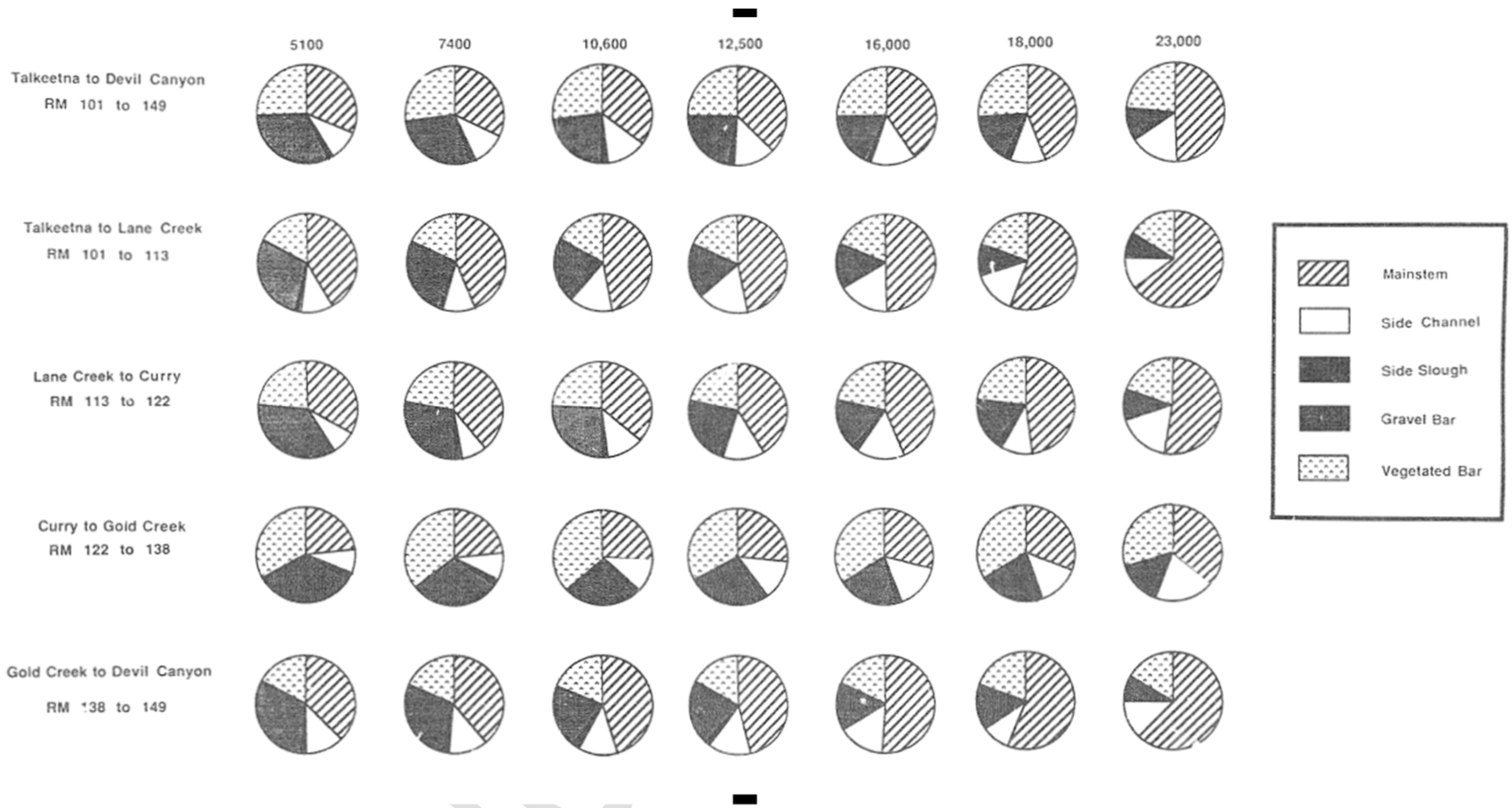


Figure 8.5-2 Relative amounts of habitat types in different areas of the Susitna River at seven mainstem discharges. Source: Klinger-Kingsley et al. (1985)

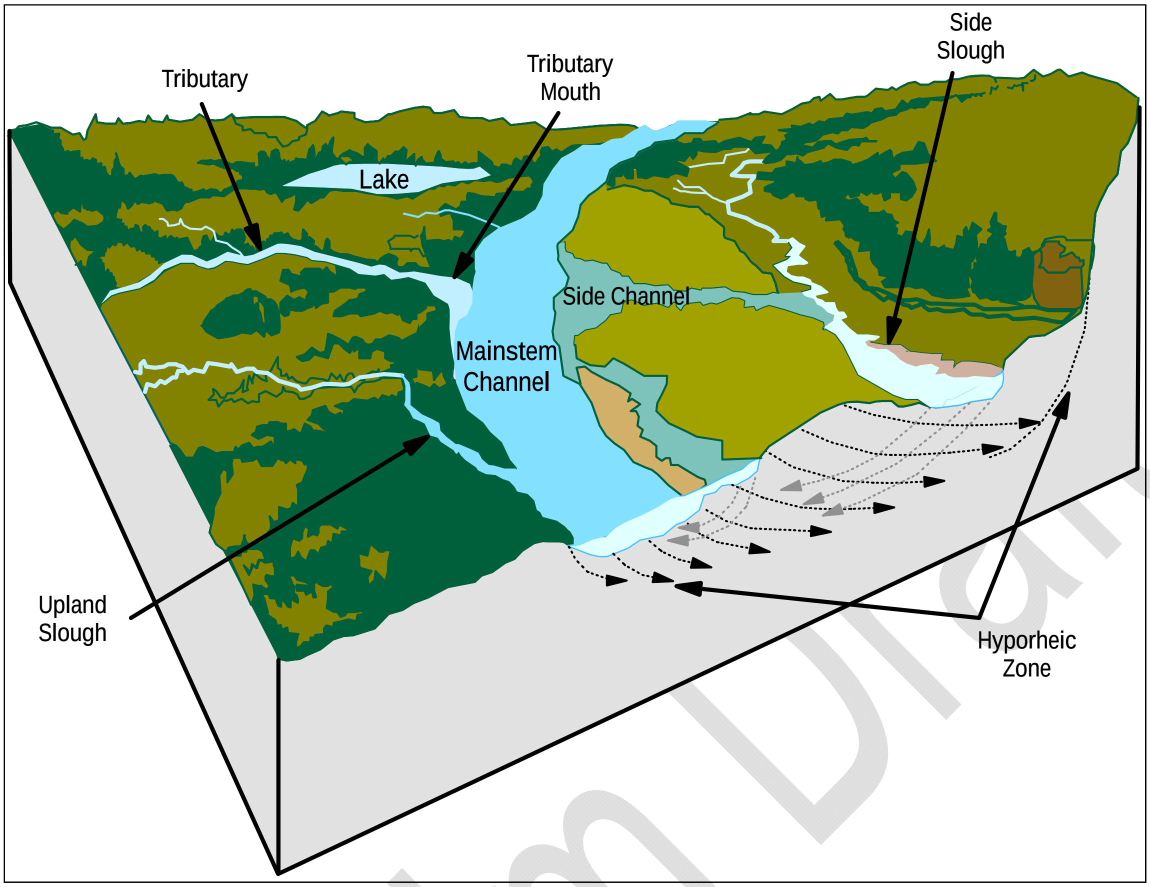


Figure 8.5-3 Habitat types identified in the middle reach of the Susitna River during the 1980s studies (adapted from ADF&G 1983, Trihey 1982).

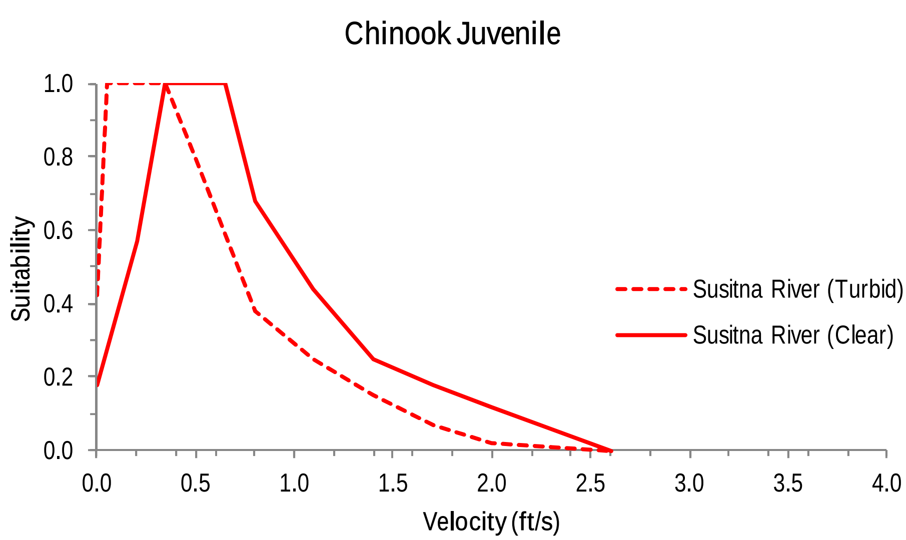


Figure 8.5-4 Example HSC curves for rearing juvenile Chinook salmon in the Middle Susitna River developed during the 1980s instream flow studies. Source: Suchanek et al. 1984b.

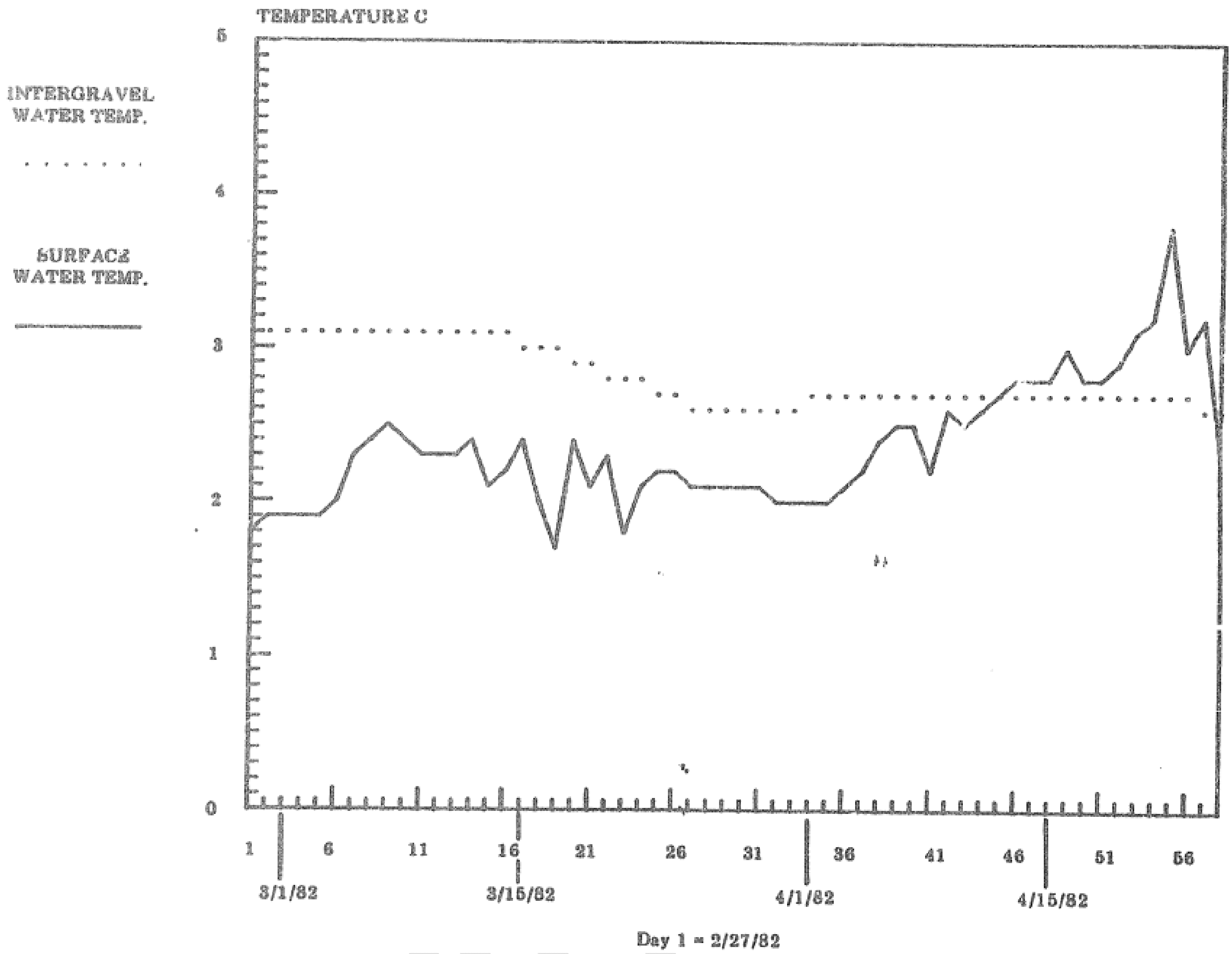


Figure 8.5-5 Mean daily intragravel and surface water temperature data from a spawning site in Slough 8A. Source: Trihey (1982).

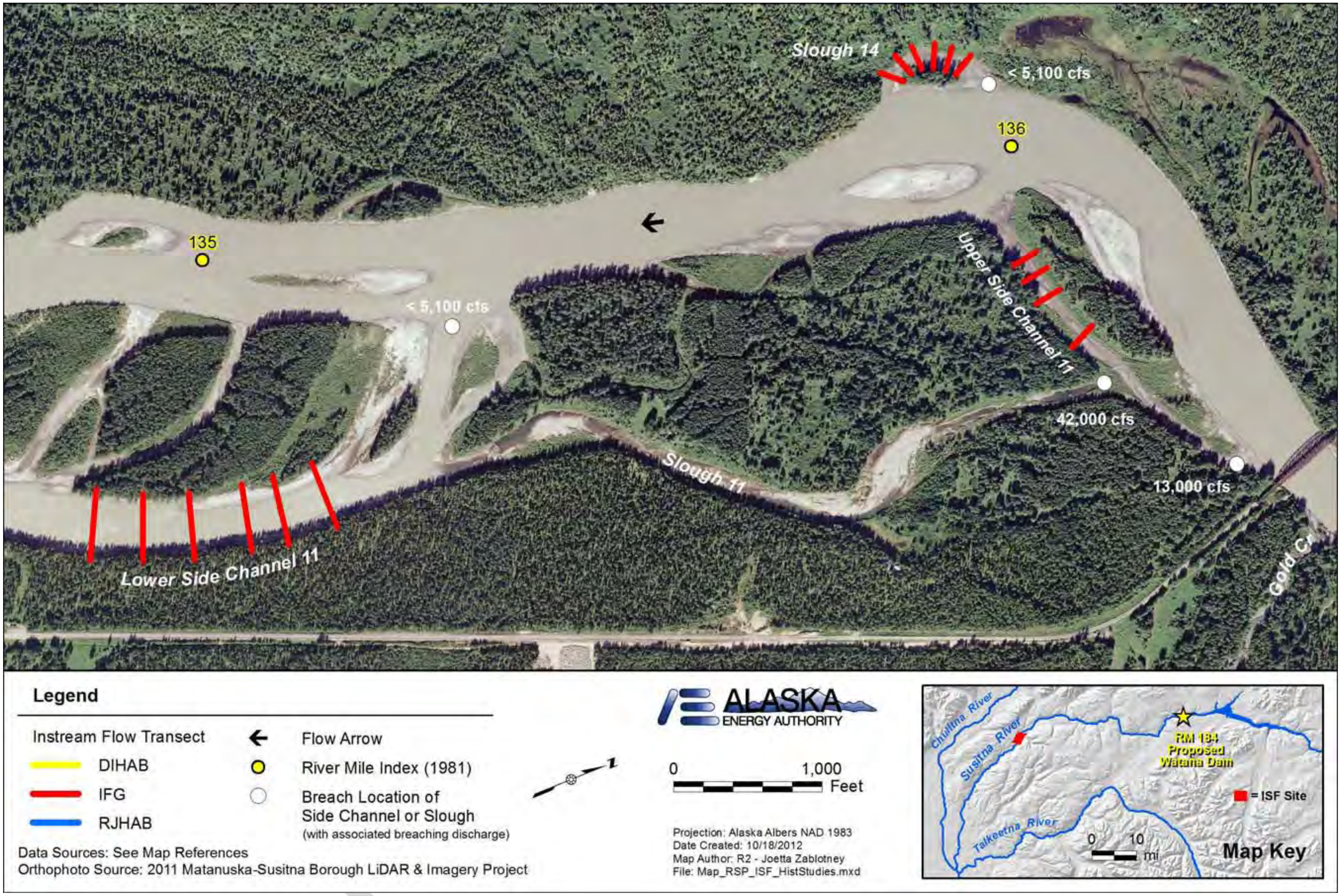


Figure 8.5-6 IFG instream flow modeling sites located in lower and upper Side Channel 11 and in Slough 14

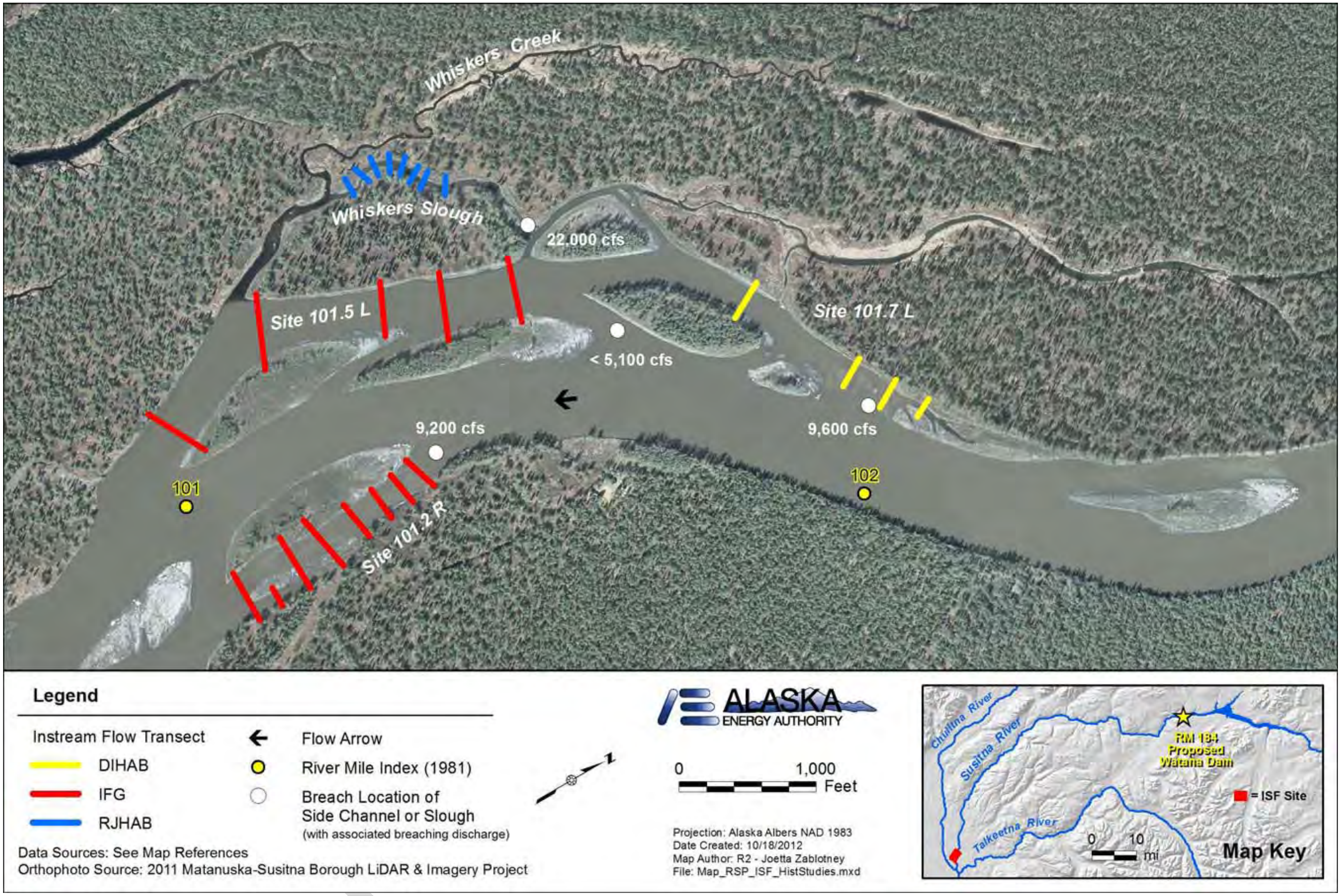


Figure 8.5-7 IFG, DHAB, and RJHAB instream flow modeling sites located near the Whiskers Creek confluence.

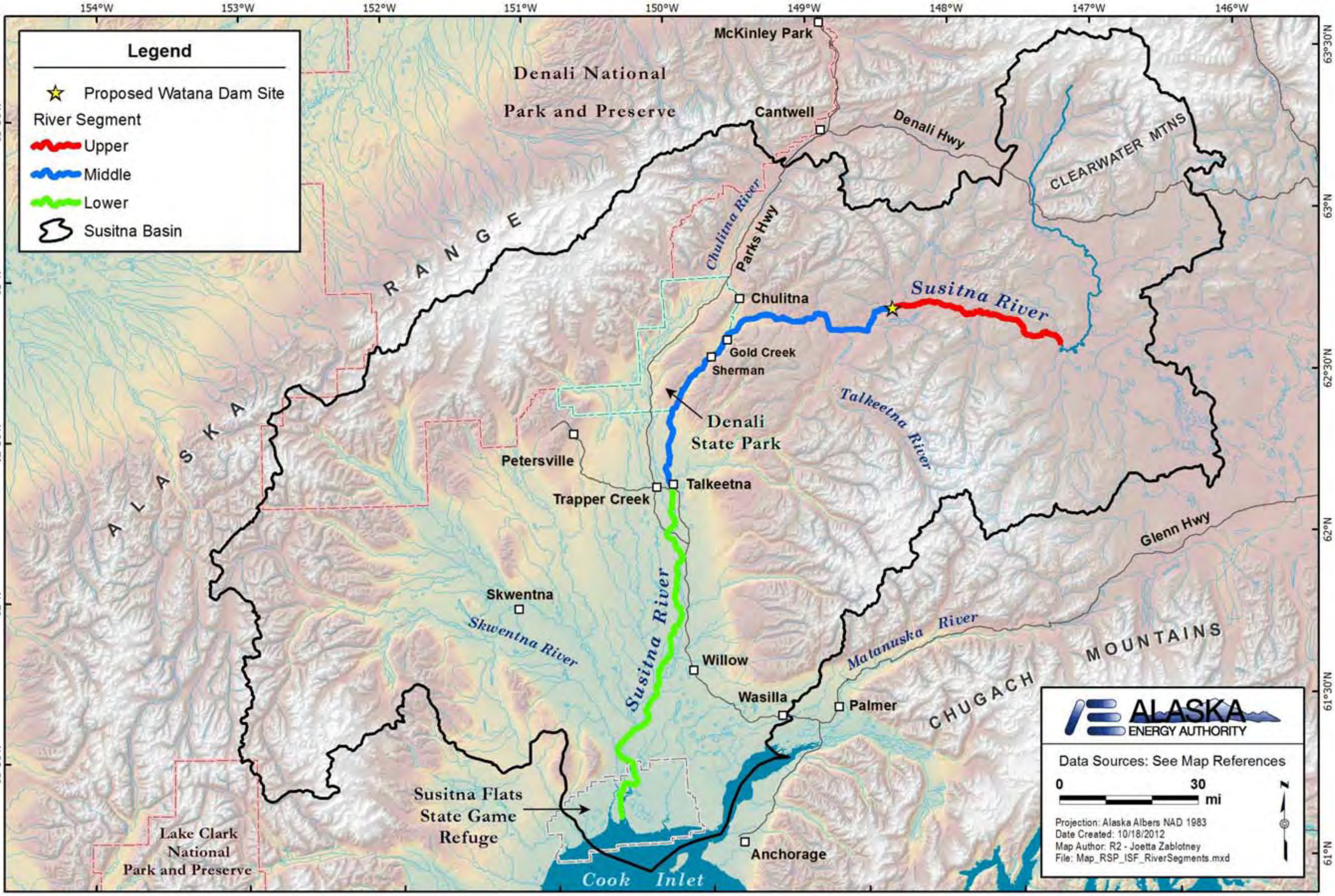


Figure 8.5-8 Map of the Susitna River influenced by Susitna-Watana Hydroelectric Project.

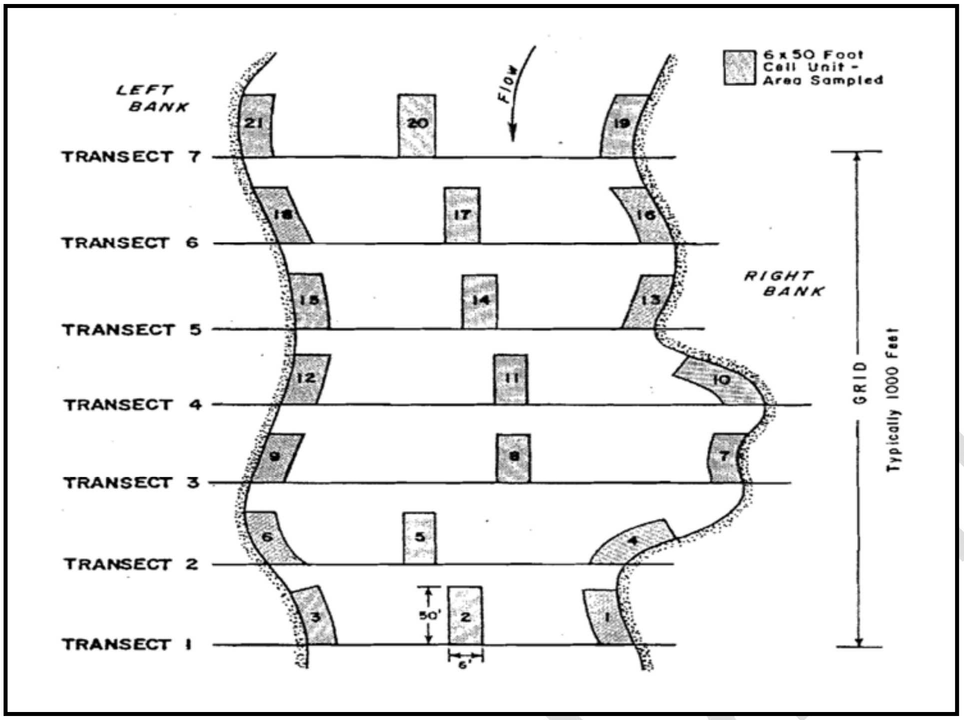


Figure 8.5-9 Transects and shoreline and mid-channel sampling cells associated with RJHAB modeling (Marshall et al. 1984).

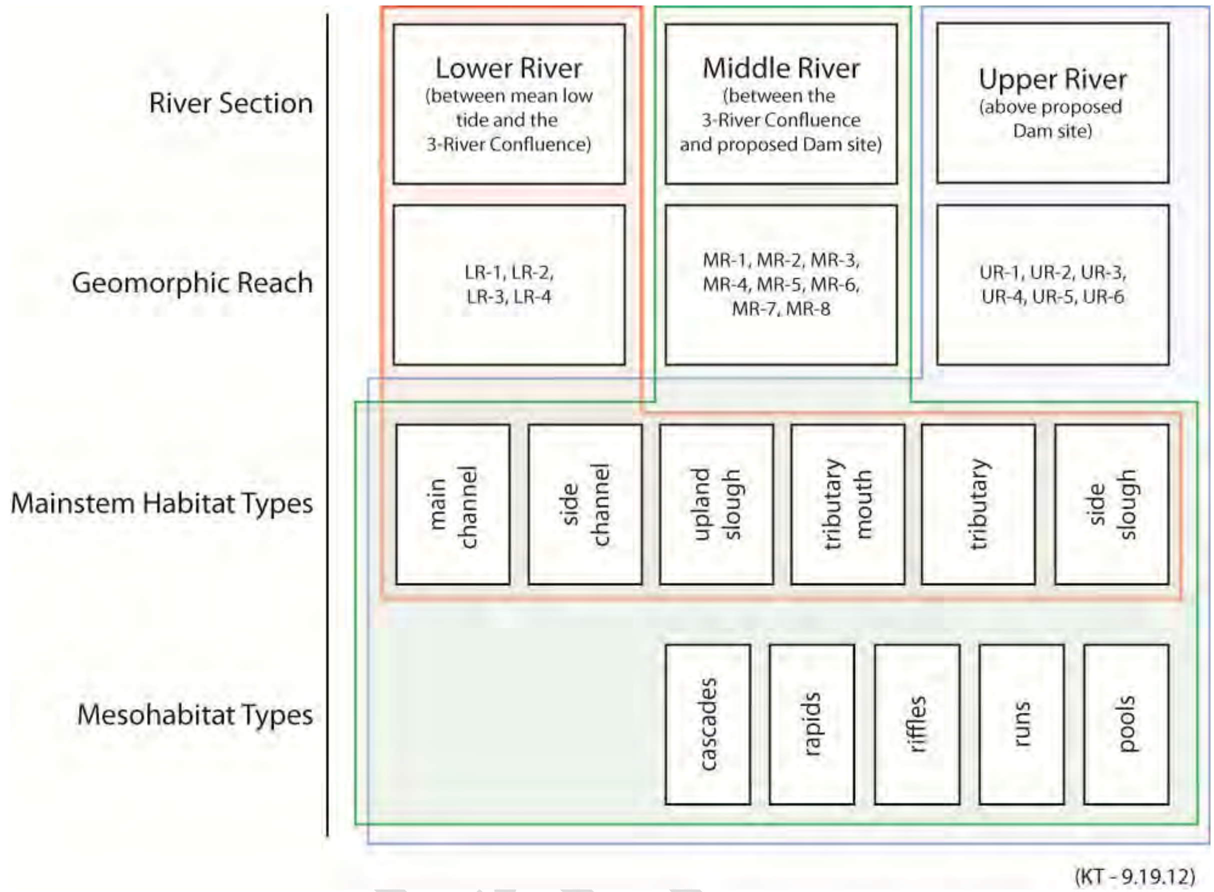


Figure 8.5-10 Conceptual diagram illustrating the hierarchical classification system for characterizing habitat categories.

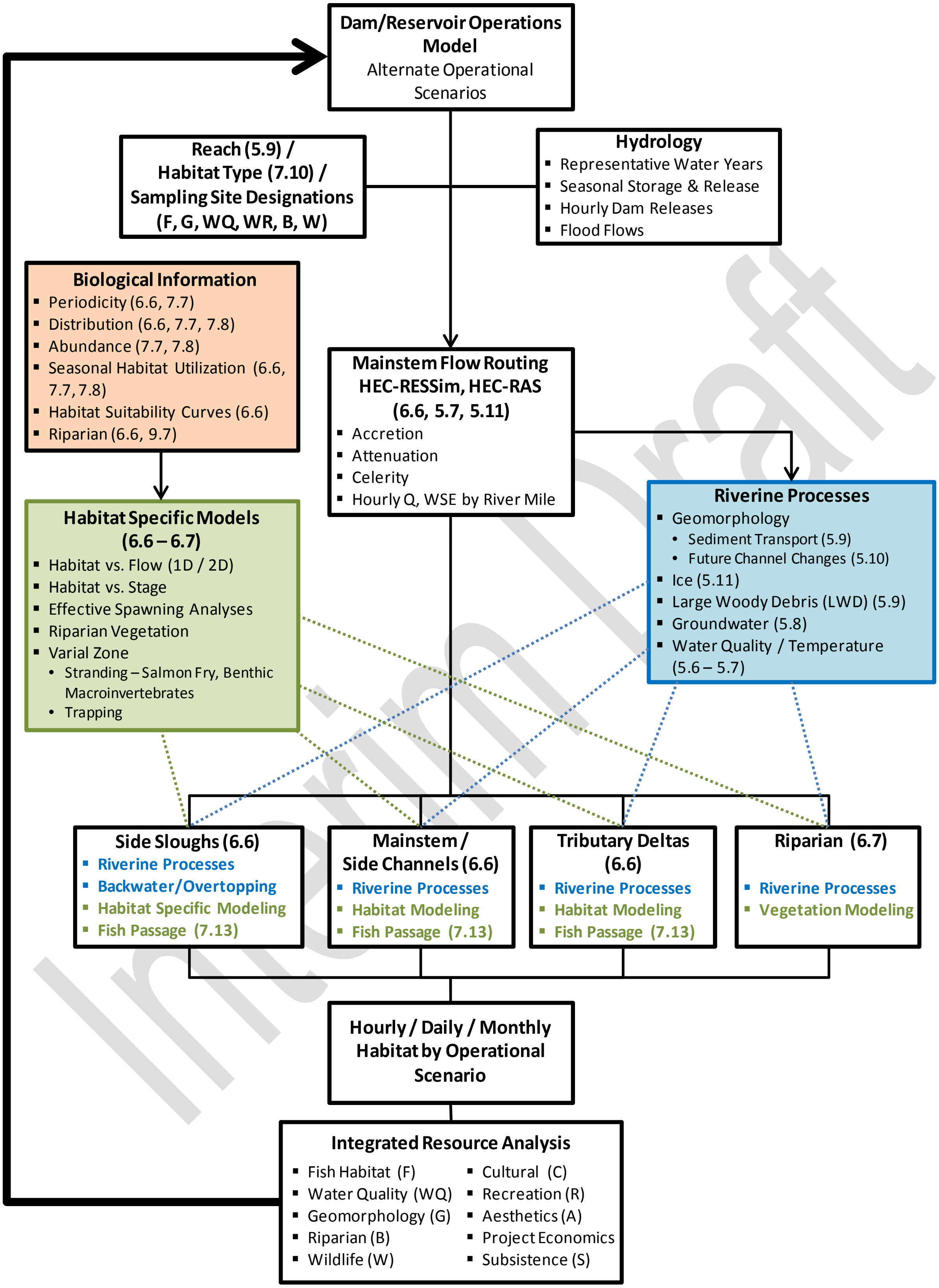


Figure 8.5-11 Conceptual framework for the Susitna –Watana Instream Flow Study depicting linkages between habitat specific models and riverine processes that will lead to an integrated resource analysis.

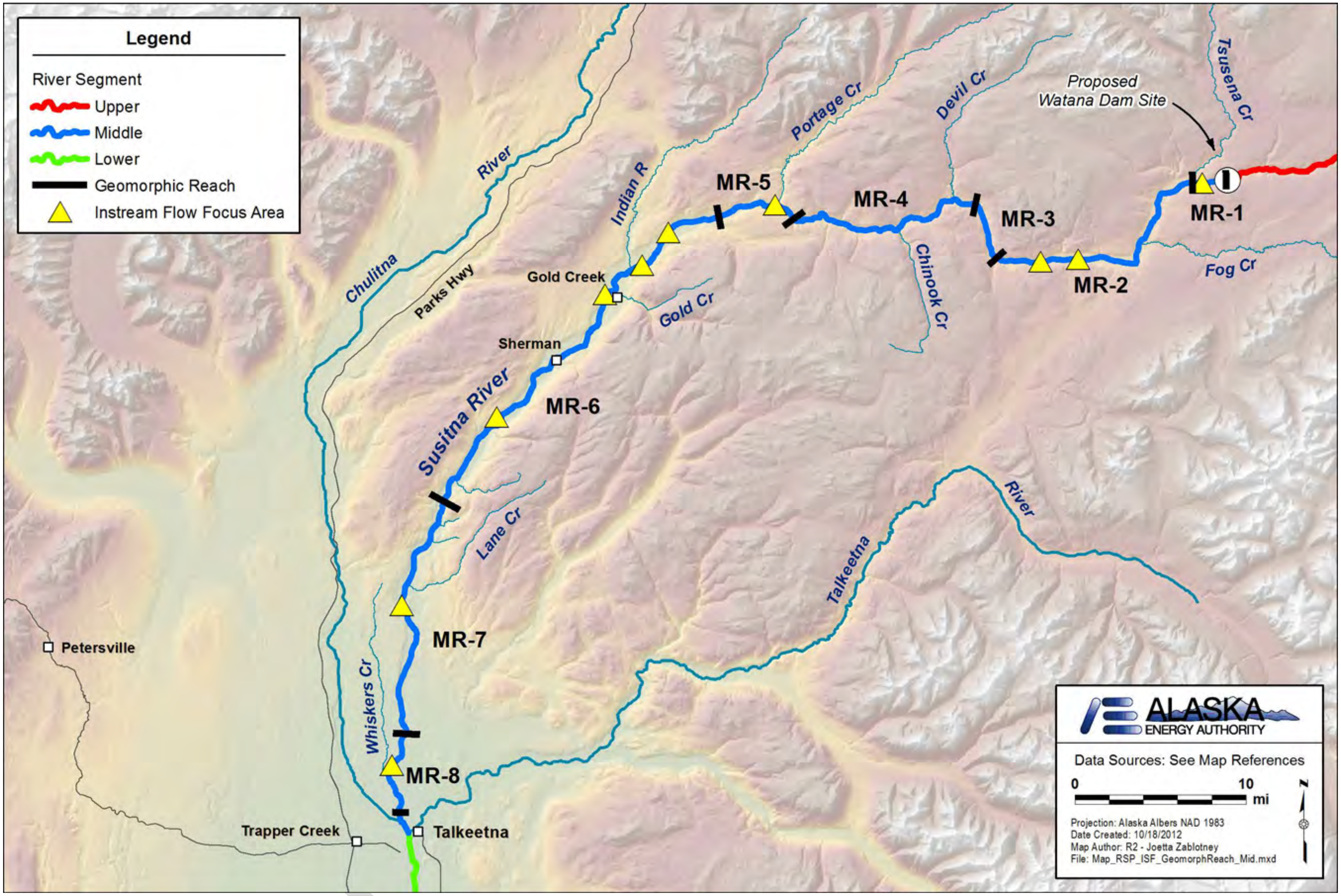


Figure 8.5-12 Geomorphic Reach Middle.

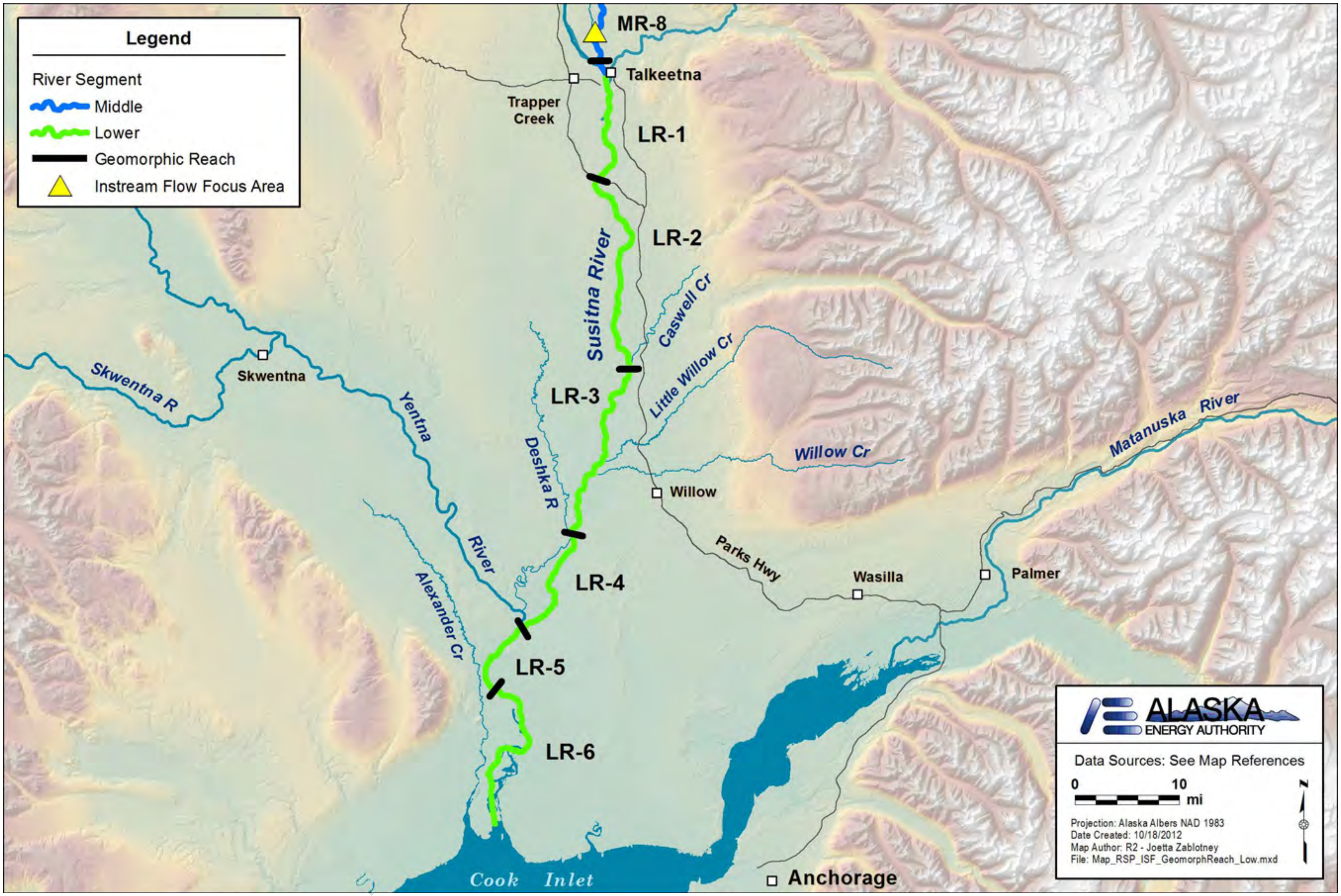


Figure 8.5-13 Geomorphic Reach Low.

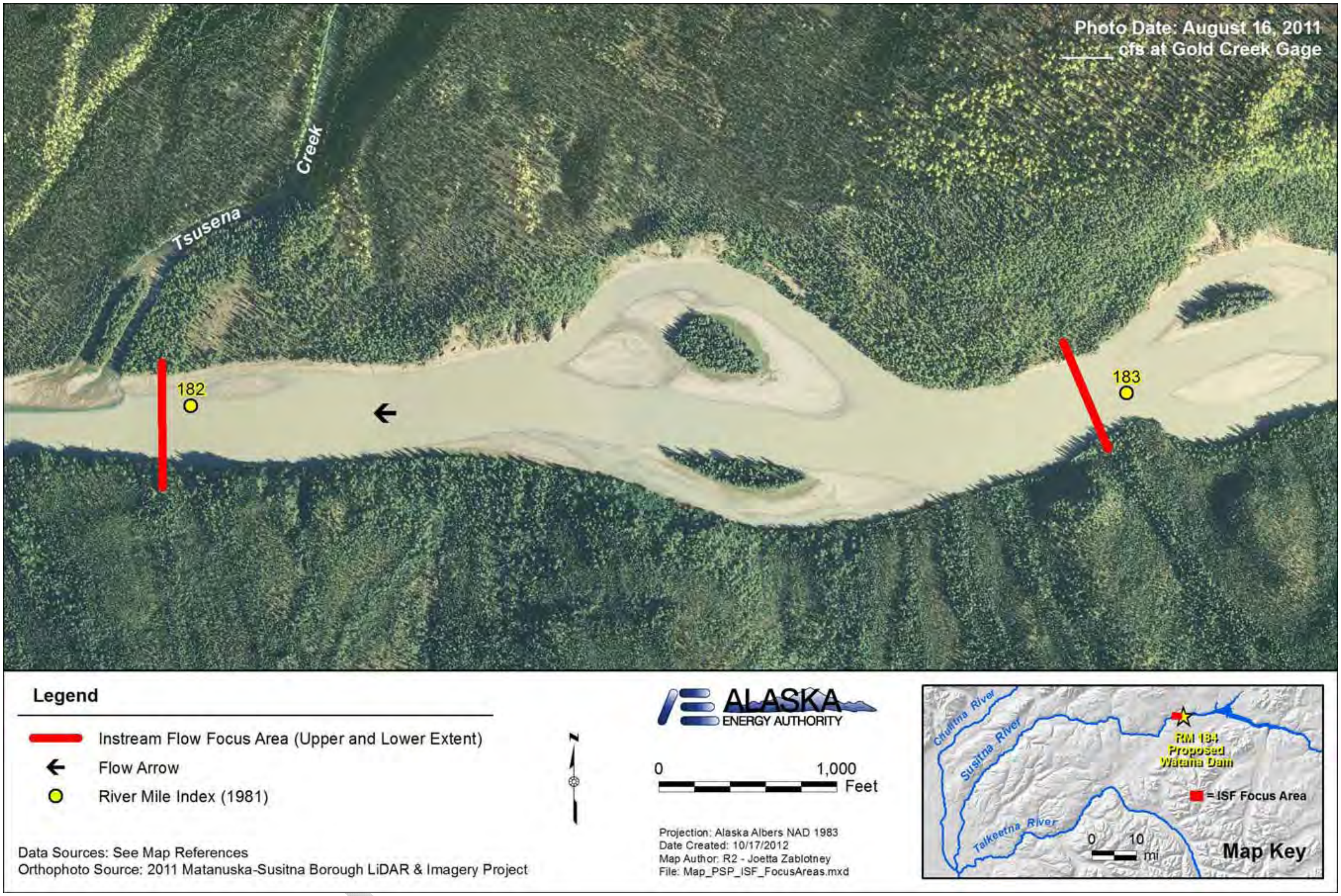


Figure 8.5-14 Map_RSP_ISF_FocusArea1_BelowDam_20121017

Figure 8.5-15 Map_RSP_ISF_FocusArea2_MR2Wide_20121017

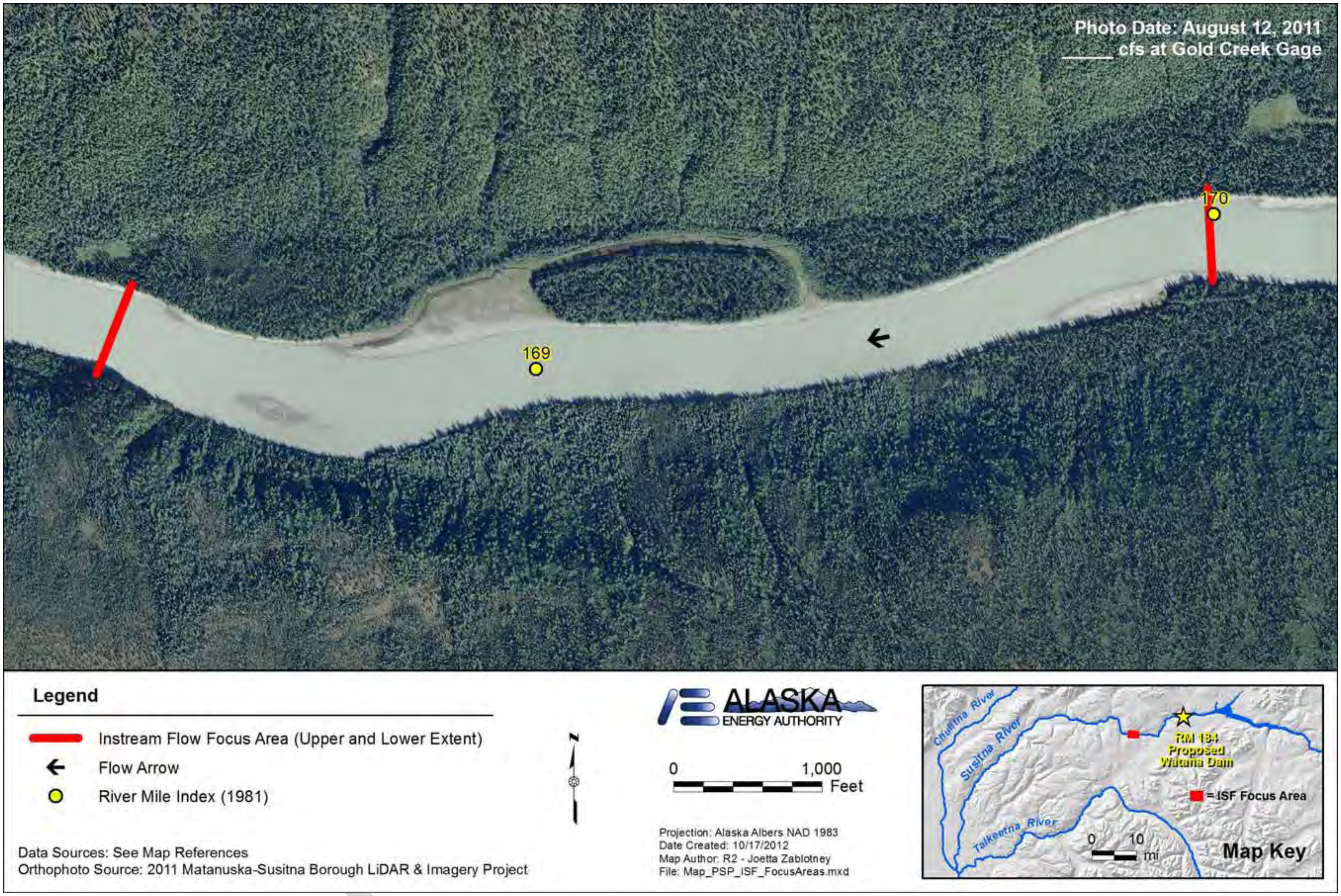


Figure 8.5-16 Map_RSP_ISF_FocusArea3_MR2Narrow_20121017

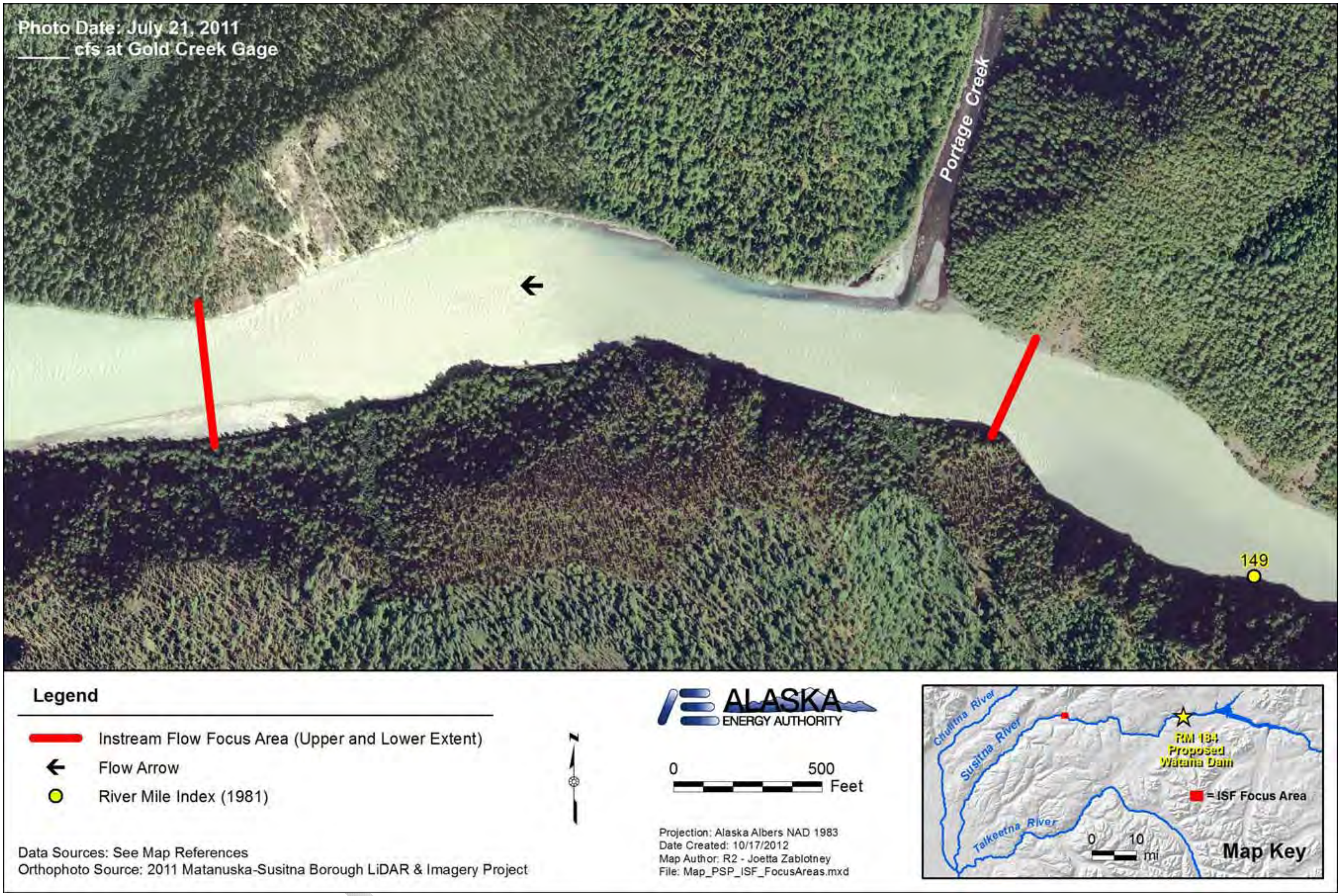


Figure 8.5-17 Map_RSP_ISF_FocusArea4_PortageCreek_20121017

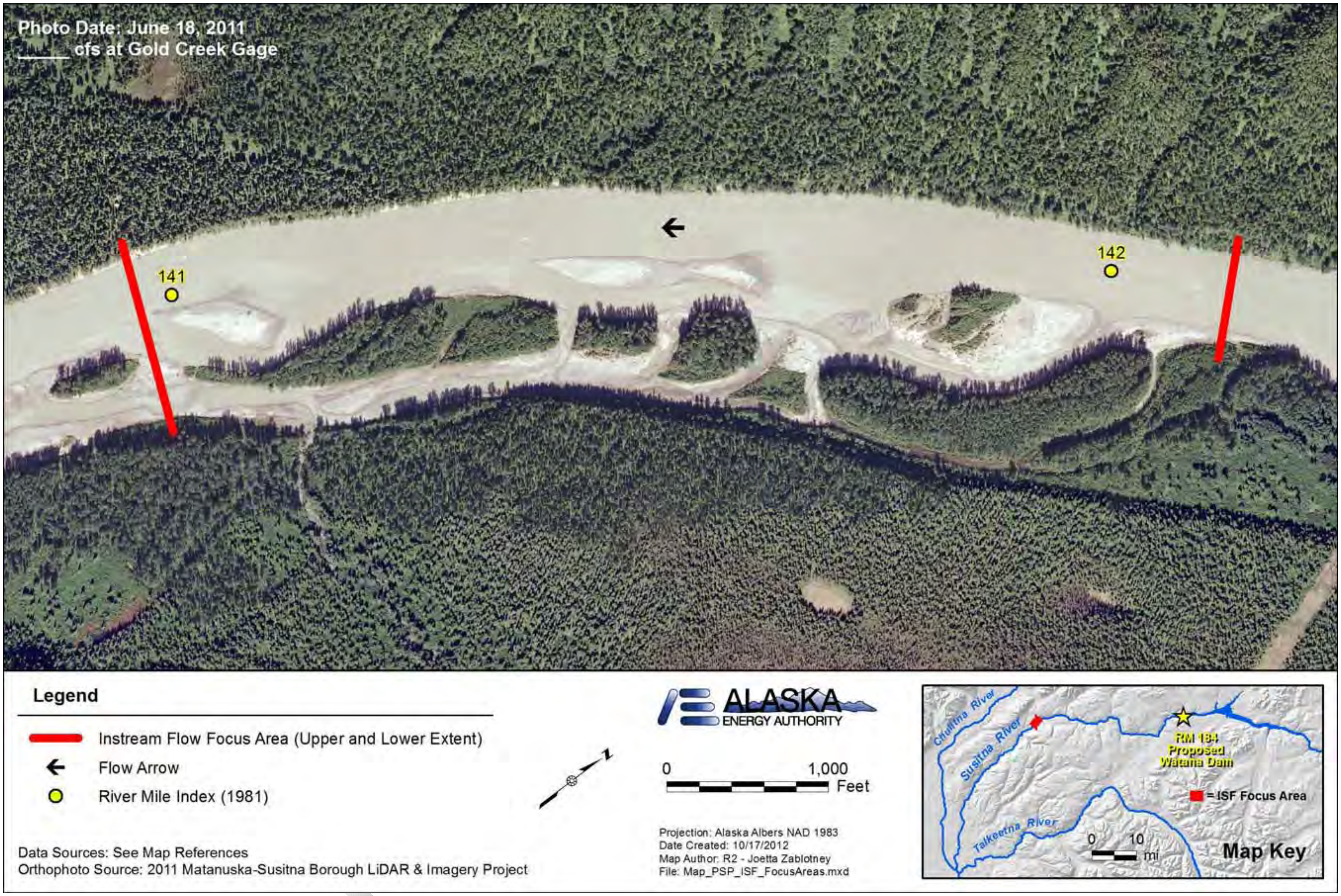


Figure 8.5-18 Map_RSP_ISF_FocusArea5_Slough21_20121017

Figure 8.5-19 Map_RSP_ISF_FocusArea6_IndianRiver_20121017

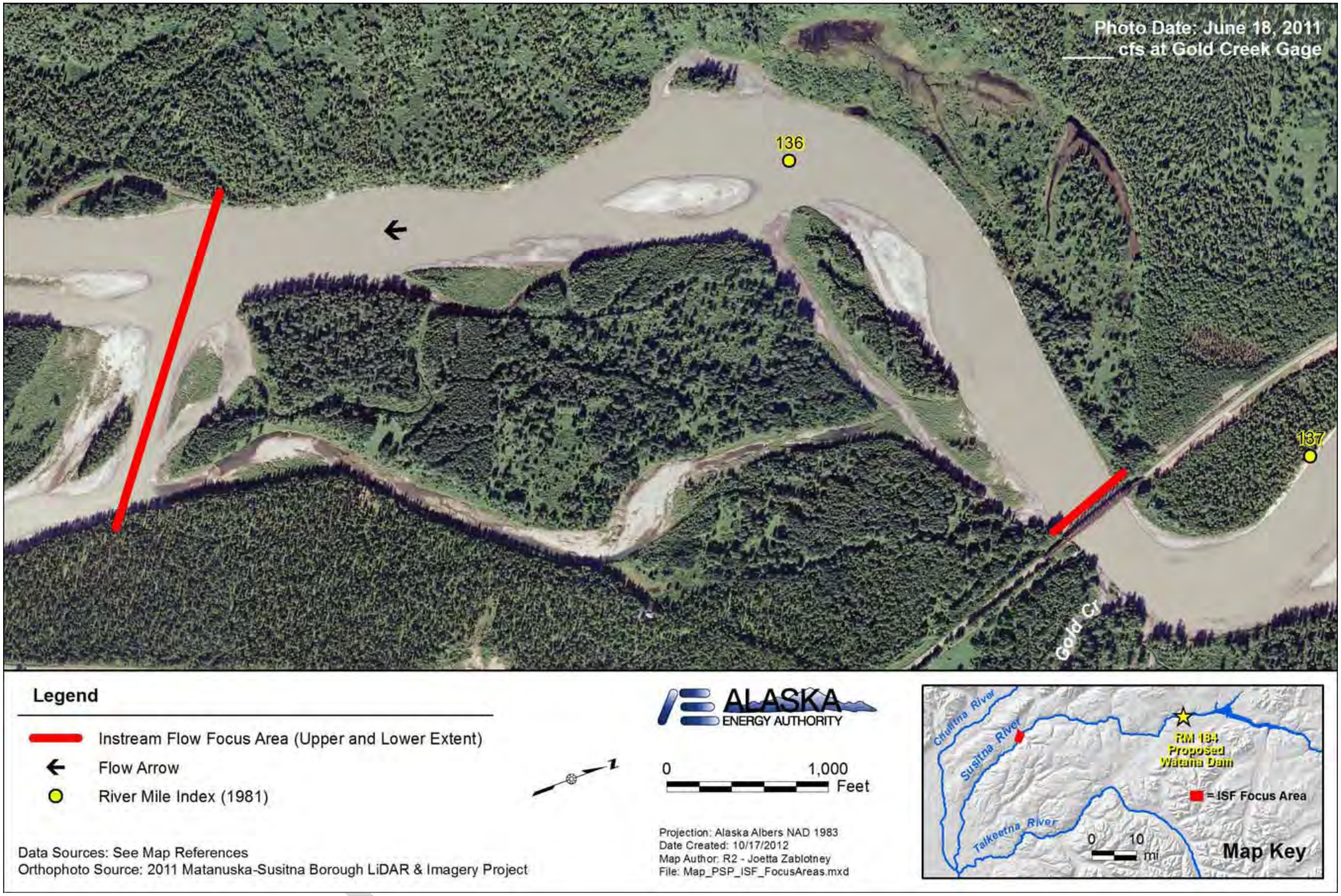


Figure 8.5-20 Map_RSP_ISF_FocusArea7_Slough11_20121017

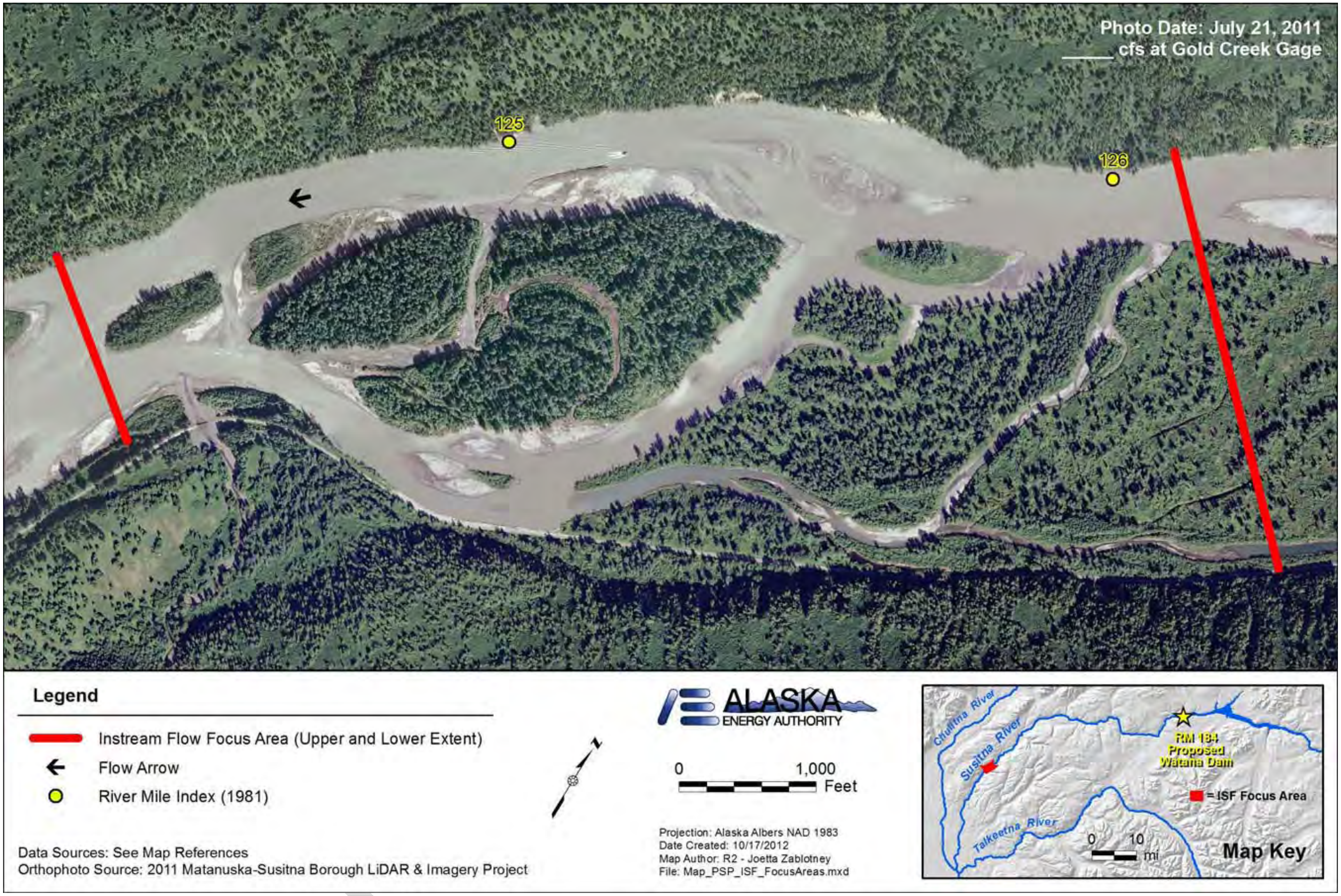


Figure 8.5-21 Map_RSP_ISF_FocusArea8_Slough8A_20121017

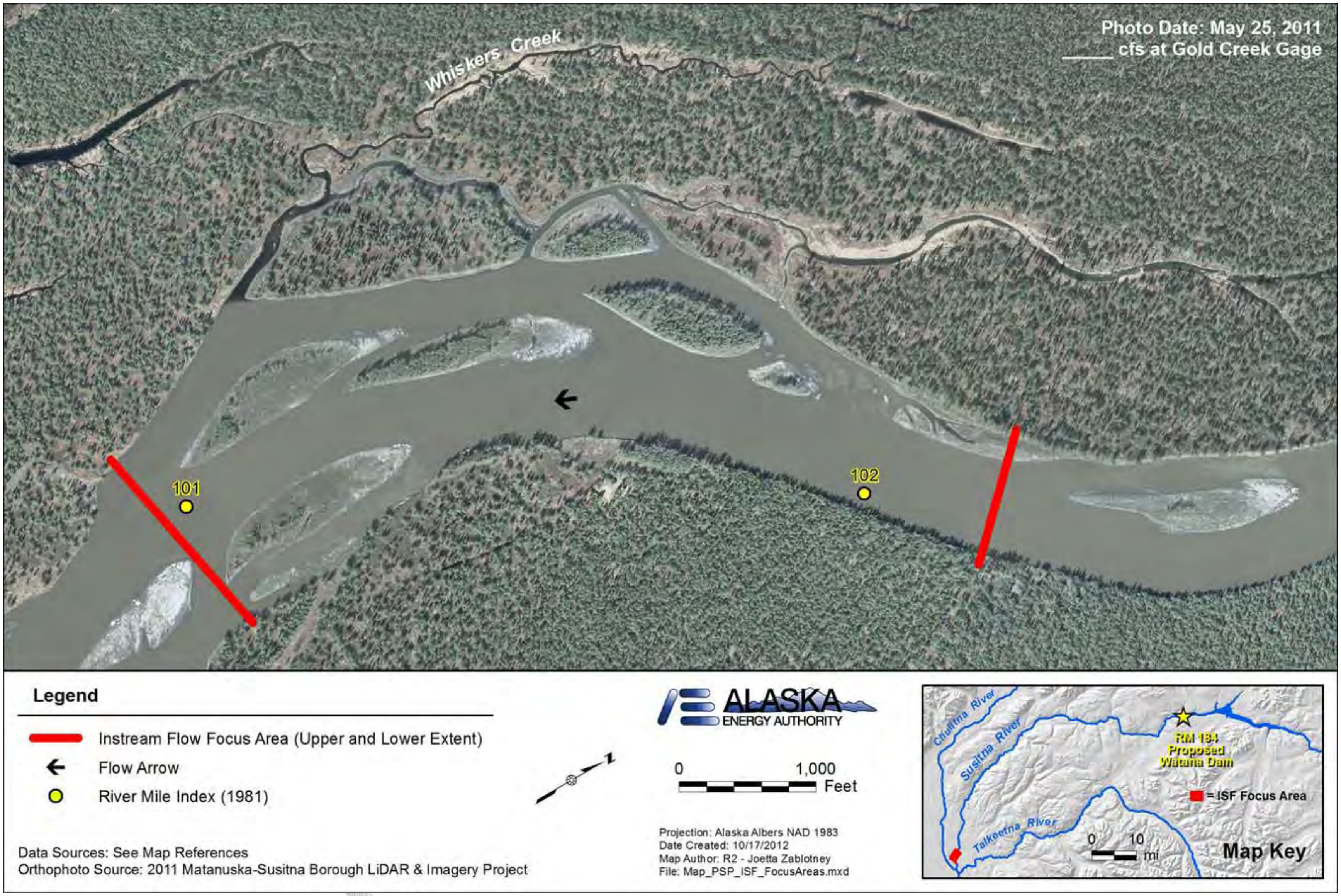


Figure 8.5-22 Map_RSP_ISF_FocusArea10_WhiskersSlough_20121017

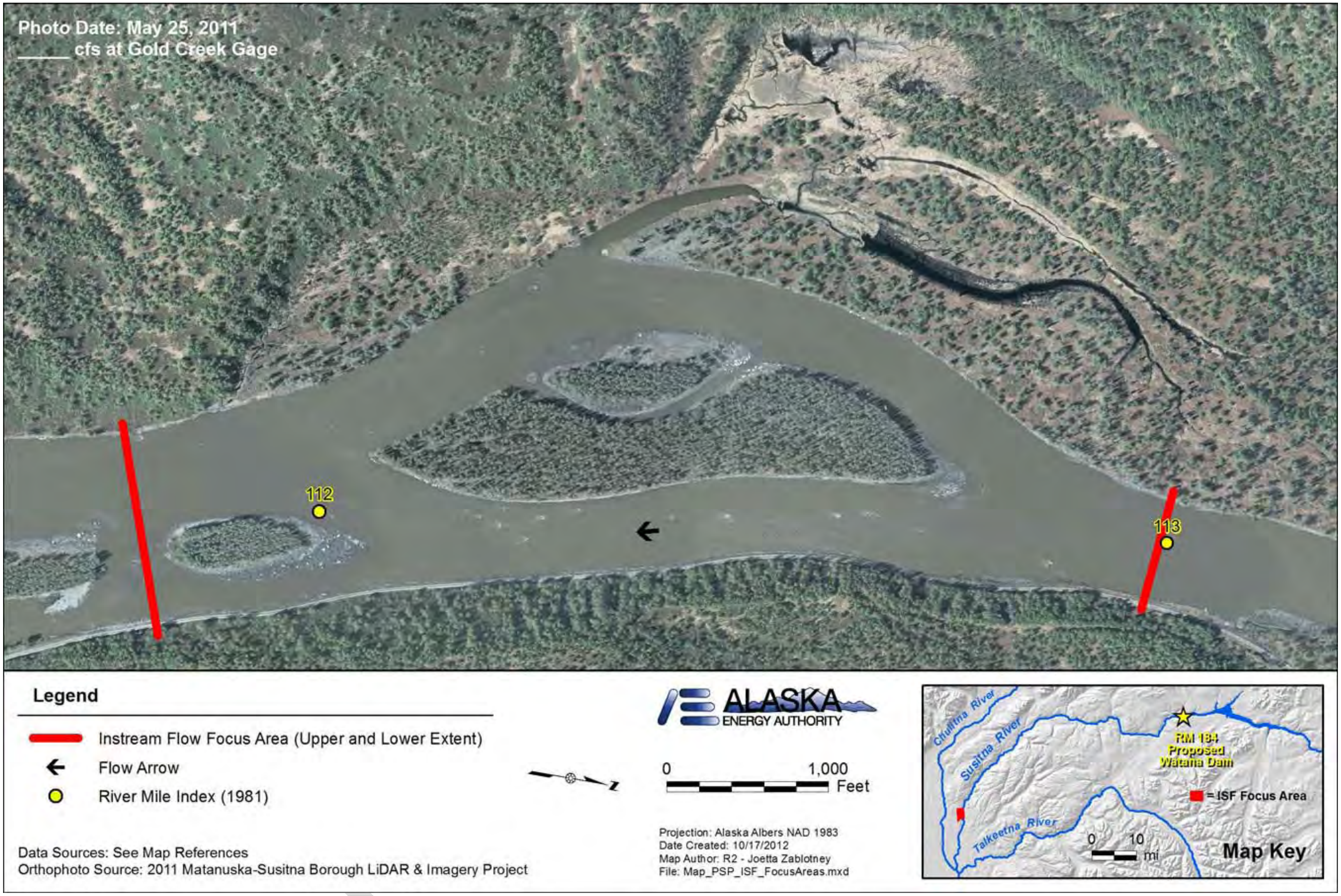


Figure 8.5-23 Map_RSP_ISF_FocusAreas9_Slough6A_20121017

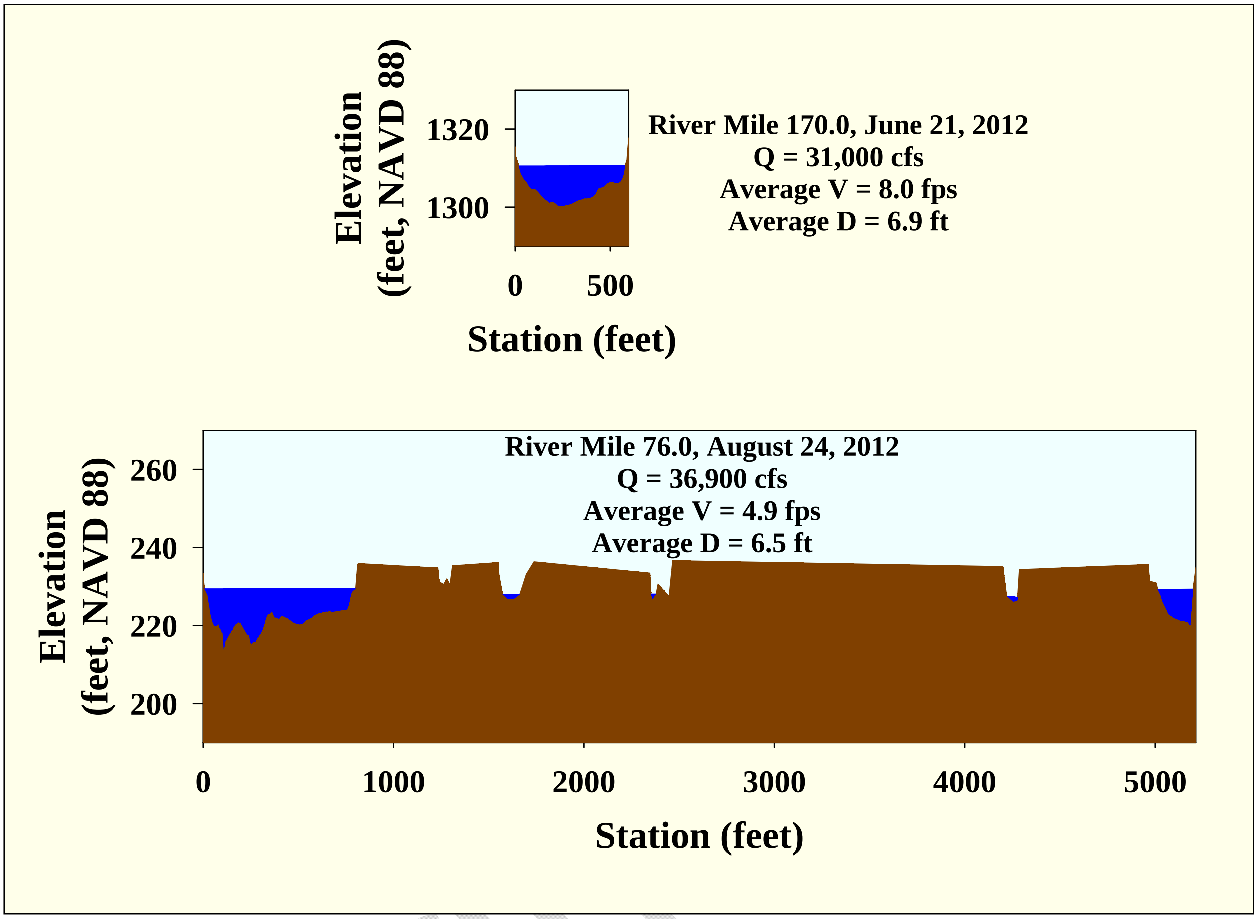


Figure 8.5-24 Examples of cross-sections established on the Susitna River in 2012 at River Miles 170 and 76.

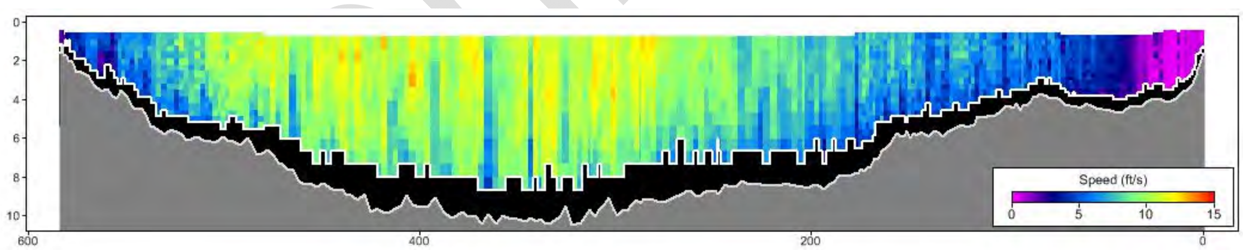
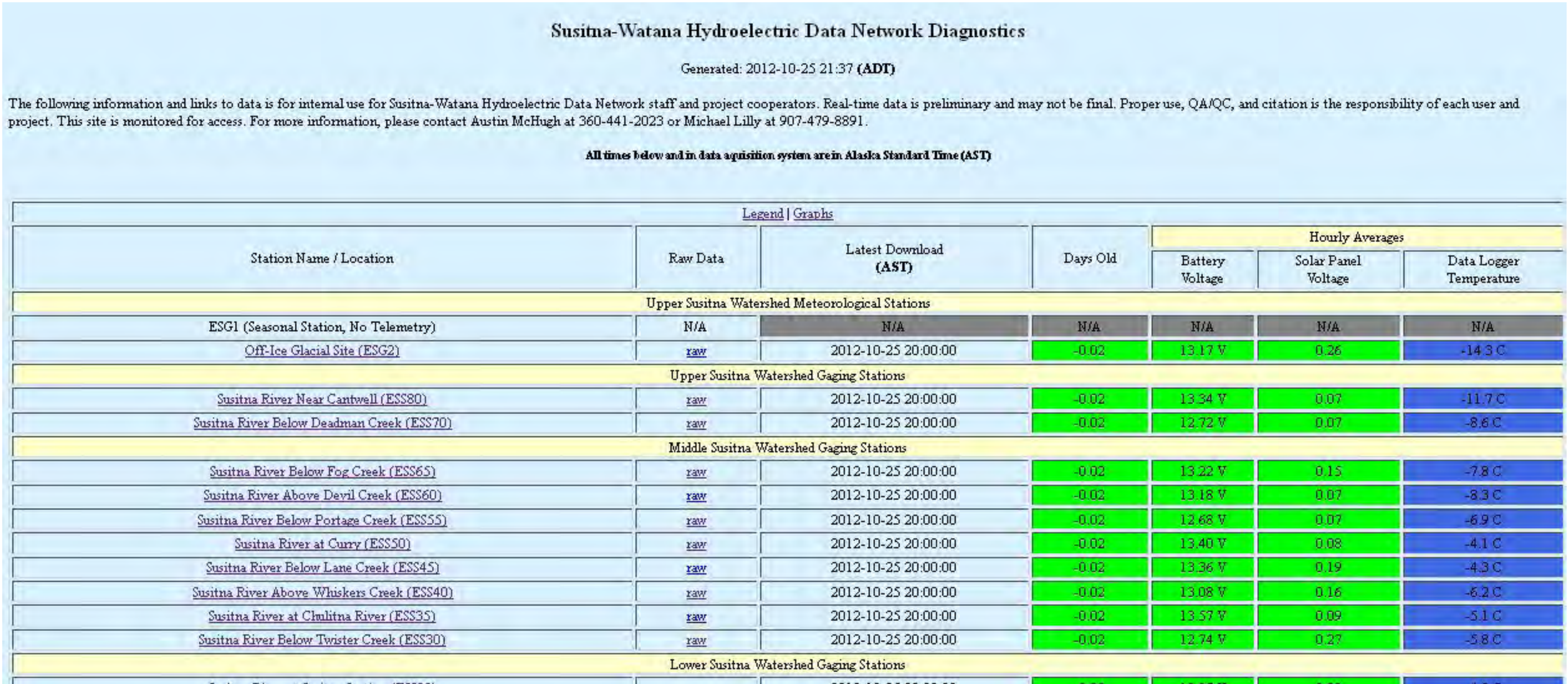


Figure 8.5-25 Output from ADCP from one pass across the Susitna River at River Mile 170 on June 21, 2012.



Susitna-Watana Hydroelectric Data Network Diagnostics

Generated: 2012-10-25 21:37 **(ADT)**

The following information and links to data is for internal use for Susitna-Watana Hydroelectric Data Network staff and project cooperators. Real-time data is preliminary and may not be final. Proper use, QA/QC, and citation is the responsibility of each user and project. This site is monitored for access. For more information, please contact Austin McHugh at 360-441-2023 or Michael Lilly at 907-479-8891.

All times below and in data aquisition system are in Alaska Standard Time (AST)

Legend | Graphs

Station Name / Location	Raw Data	Latest Download **(AST)**	Days Old	Hourly Averages		
				Battery Voltage	Solar Panel Voltage	Data Logger Temperature
Upper Susitna Watershed Meteorological Stations						
ESG1 (Seasonal Station, No Telemetry)	N/A	N/A	N/A	N/A	N/A	N/A
Off-Ice Glacial Site (ESG2)	raw	2012-10-25 20:00:00	-0.02	13.17 V	0.26	-14.3 C
Upper Susitna Watershed Gaging Stations						
Susitna River Near Cantwell (ESS80)	raw	2012-10-25 20:00:00	-0.02	13.34 V	0.07	-11.7 C
Susitna River Below Deadman Creek (ESS70)	raw	2012-10-25 20:00:00	-0.02	12.72 V	0.07	-8.6 C
Middle Susitna Watershed Gaging Stations						
Susitna River Below Fog Creek (ESS65)	raw	2012-10-25 20:00:00	-0.02	13.22 V	0.15	-7.8 C
Susitna River Above Devil Creek (ESS60)	raw	2012-10-25 20:00:00	-0.02	13.18 V	0.07	-8.3 C
Susitna River Below Portage Creek (ESS55)	raw	2012-10-25 20:00:00	-0.02	12.68 V	0.07	-6.9 C
Susitna River at Curry (ESS50)	raw	2012-10-25 20:00:00	-0.02	13.40 V	0.08	-4.1 C
Susitna River Below Lane Creek (ESS45)	raw	2012-10-25 20:00:00	-0.02	13.36 V	0.19	-4.3 C
Susitna River Above Whiskers Creek (ESS40)	raw	2012-10-25 20:00:00	-0.02	13.08 V	0.16	-6.2 C
Susitna River at Chulitna River (ESS35)	raw	2012-10-25 20:00:00	-0.02	13.57 V	0.09	-5.1 C
Susitna River Below Twister Creek (ESS30)	raw	2012-10-25 20:00:00	-0.02	12.74 V	0.27	-5.8 C
Lower Susitna Watershed Gaging Stations						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Figure 8.5-26 Susitna Network Stations Diagnostics Screen. Data fields are color coded to allow quick scans for evaluating station conditions. Email and text messaging are used to communicate warning conditions and non-reporting stations.

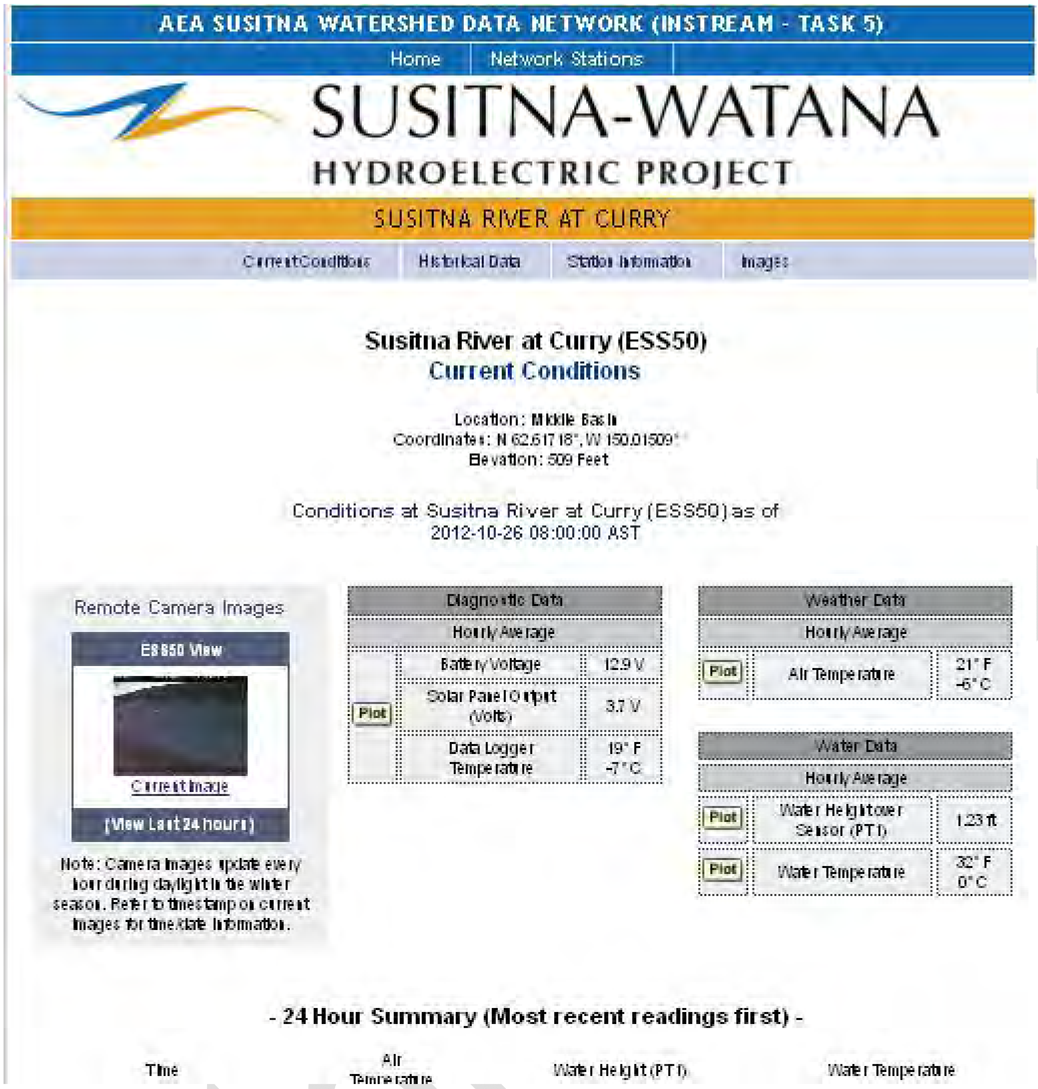


Figure 8.5-27 Typical AEA gaging station current conditions reporting page.

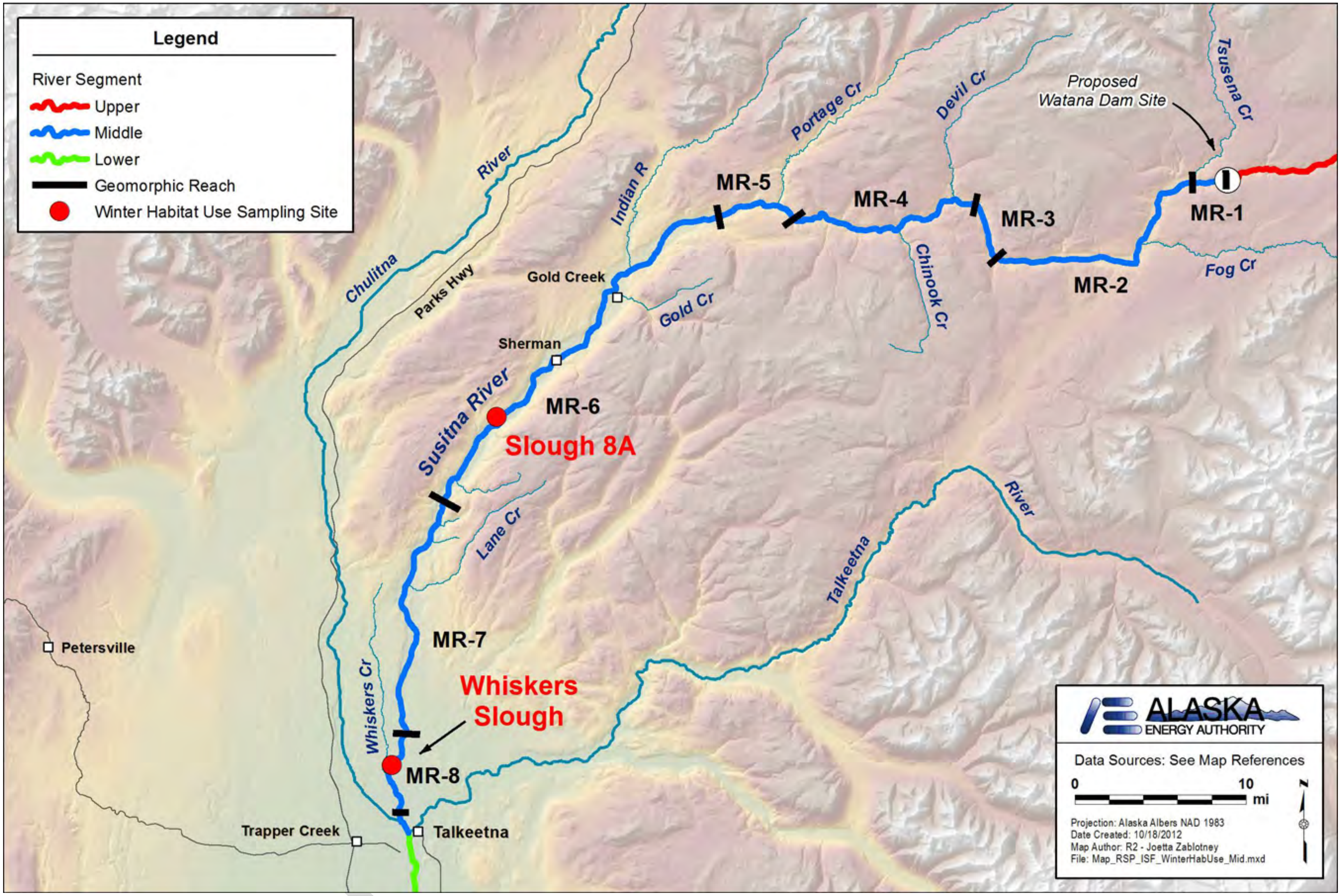


Figure 8.5-28 Geomorphic reaches and winter time habitat use sampling areas in the Middle River segment of the Susitna River.

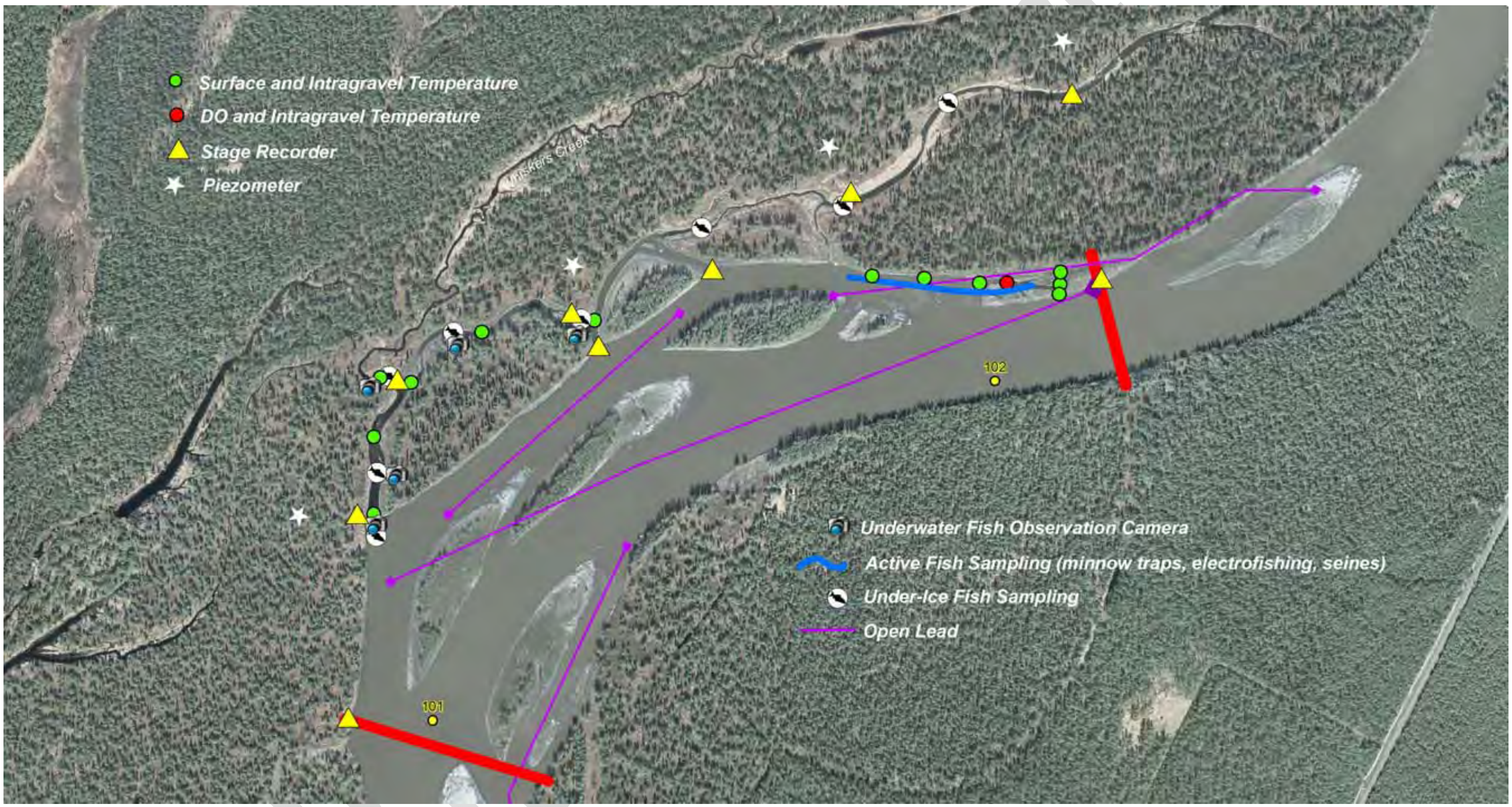


Figure 8.5-29 Location of proposed wintertime fish habitat use sampling sites at Whiskers Slough (HRM 101.4) in the Middle River segment of the Susitna River.

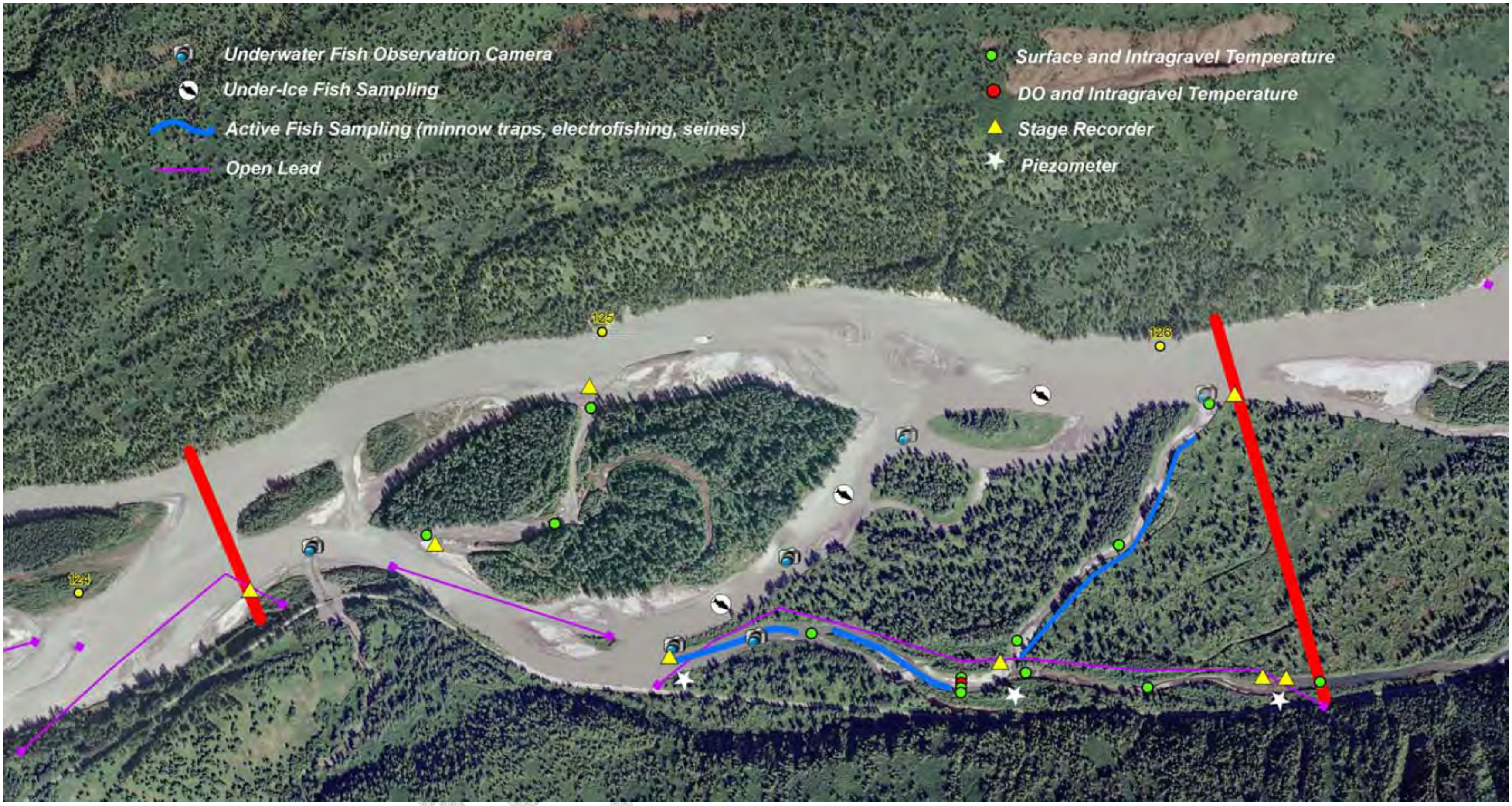


Figure 8.5-30 Location of proposed wintertime fish habitat use sampling sites at Slough 8A (HRM 125.3) in the Middle River segment of the Susitna River.

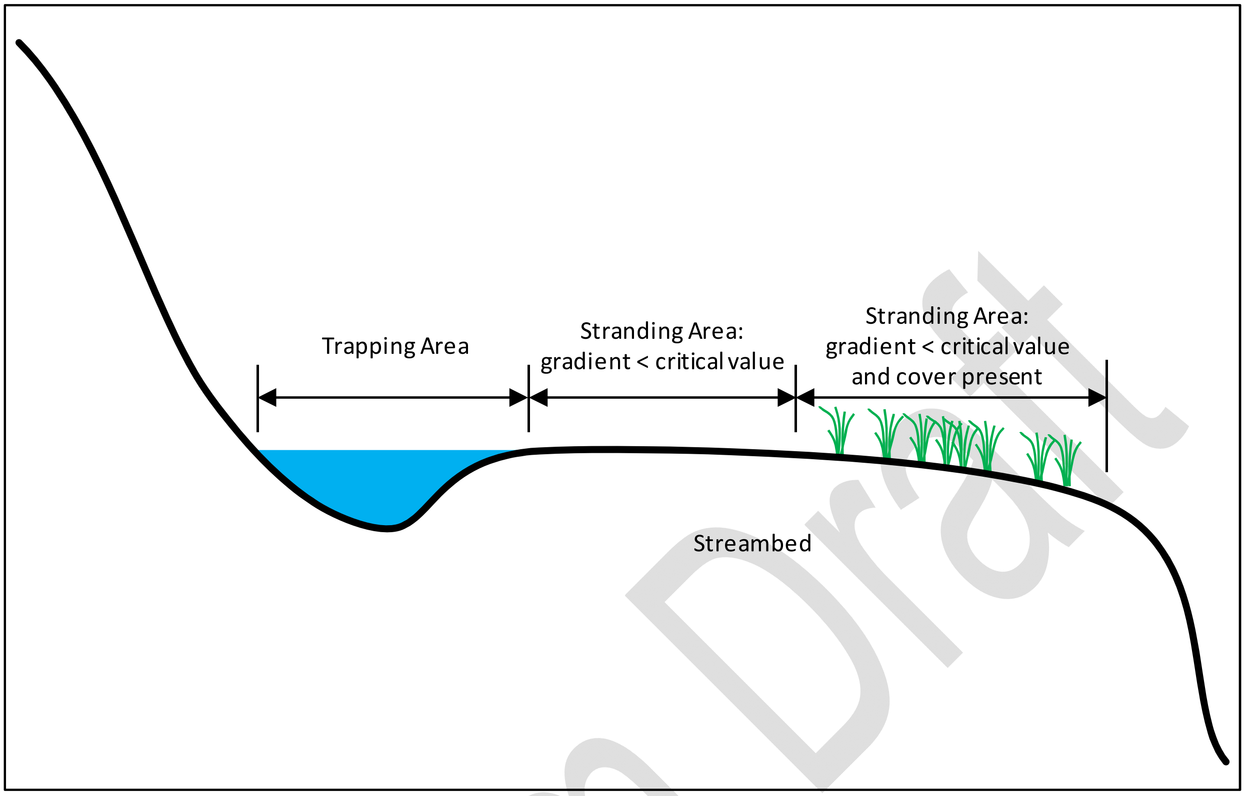


Figure 8.5-31 Cross-sectional conceptual diagram illustrating stranding and trapping areas.

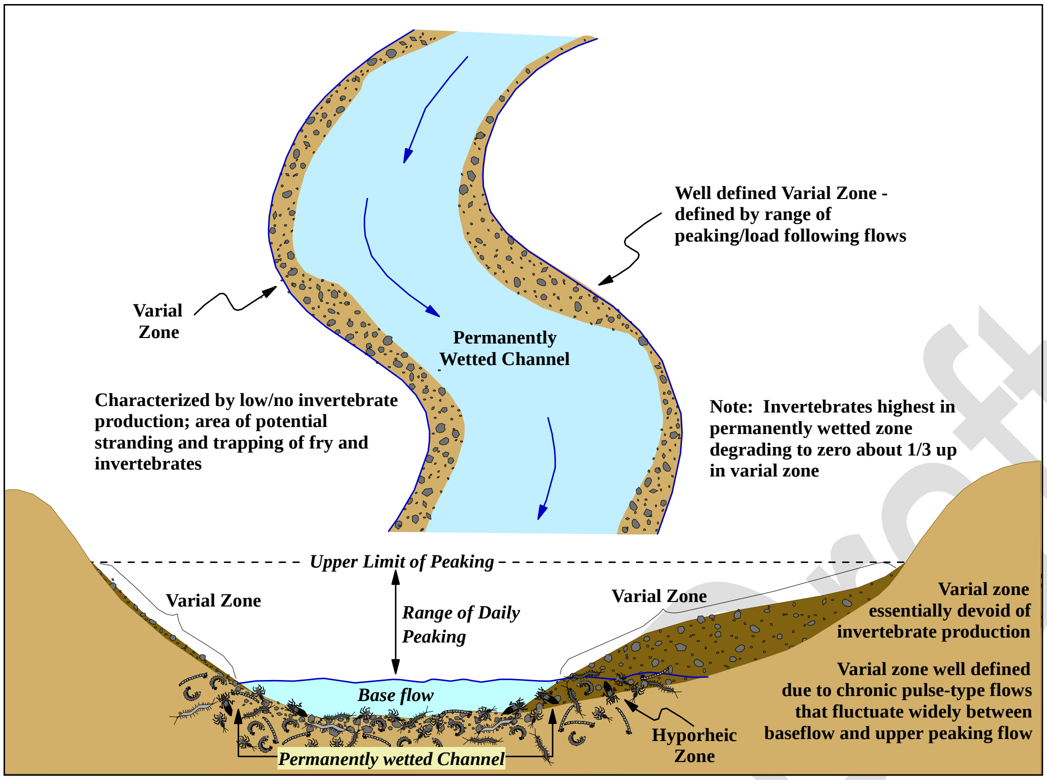


Figure 8.5-32 Schematic diagram illustrating the formation of a varial zone within a river channel.

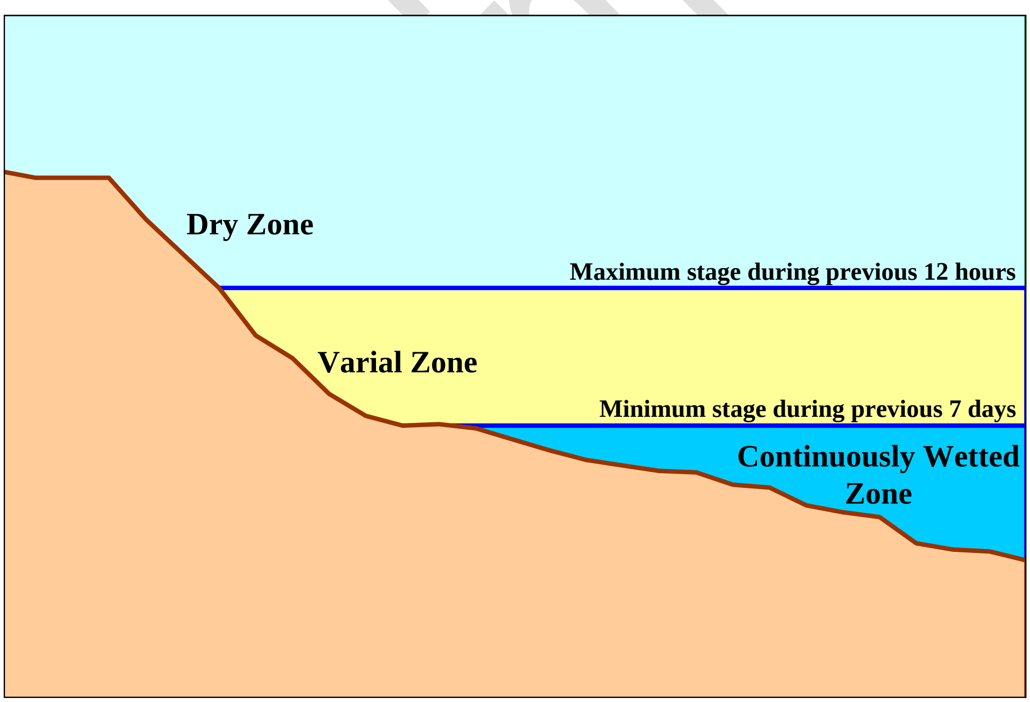


Figure 8.5-33 Conceptual framework of the varial zone model.