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Susitna-Watana Hydroelectric Project
(FERC No. 14241)

River Productivity Study
Study Plan Section 9.8

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

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.
Alaska Cooperative Fish and Wildlife Research Unit,
University of Alaska Fairbanks

June 2014

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LIST OF ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

Abbreviation	Definition
°C	degrees Celsius
°F	degrees Fahrenheit
µm	micrometer
AEA	Alaska Energy Authority
AFDM	ash free dry mass
BMI	benthic macroinvertebrates
CPOM	coarse particulate organic matter
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
FA	Focus Areas
FBOM	fine benthic organic matter
FERC	Federal Energy Regulatory Commission
FPOM	fine particulate organic matter
ft^2	square feet
FWS	Fish and Wildlife Service
g	gram
GRP	growth rate potential
HSC	habitat suitability curve
HSI	habitat suitability index
IP	Implementation Plan
ISR	Initial Study Report
LWD	large woody debris
MDN	marine-derived nutrients
mm	millimeter(s)

Abbreviation	Definition
NAWQA	National Water-Quality Assessment
NMFS	National Marine Fisheries Service
OHWM	ordinary high water mark
OM	organic matter
PIT-tag	Passive Integrated Transponder tags used to individually identify animals and monitor their movements.
PVC	Polyvinyl chloride
QA/QC	quality assurance/quality control
RP	River Productivity
RSP	Revised Study Plan
SIA	stable isotope analysis
SPD	Study Plan Determination
TKA	Talkeetna River
TWG	Technical Workgroup
UAF	University of Alaska Fairbanks
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed its Revised Study Plan (RSP) with the Federal Energy Regulatory Commission (FERC or Commission) for the Susitna-Watana Project, FERC Project No. 14241, which included 58 individual study plans (AEA 2012). Included within the RSP was the River Productivity Study, Section 9.8. RSP Section 9.8 focuses on collecting baseline data to assist in evaluating the effects of Project-induced changes in flow and the interrelated environmental factors upon the benthic macroinvertebrate and algal communities in the Middle and Upper Susitna River.

On February 1, 2013, FERC staff issued its study plan determination (February 1 SPD) for 44 of the 58 studies, approving 31 studies as filed and 13 with modifications. FERC requested additional information before issuing a SPD on the remaining studies. The Susitna River Productivity Study Implementation Plan (RP IP) was presented and discussed during a Technical Work Group (TWG) meeting on February 14, 2013. With consideration of the comment and suggestions received from licensing participants, a RP IP was filed with FERC on March 1, 2013. On April 1, 2013 FERC issued its study determination (April 1 SPD) for the remaining 14 studies; approving 1 study as filed and 13 with modifications. RSP Section 9.8 was one of the 13 approved with modifications. In its April 1 SPD, FERC recommended the following:

Modified Sampling Locations

> *We recommend that AEA remove the proposed Upper River mainstem study stations (RP-248 and RP-233).*

Macrohabitat Replicates

> *We recommend that AEA sample in all unique macrohabitat types present at each proposed study station for river productivity sampling in the Middle River and Lower River segments. This would result in 16 sites in the Middle River and five sites in the Lower River. AEA should collect samples in each macrohabitat type as feasible using sampling methods and devices proposed in its RSP and final RP IP, with the modifications we recommend below in Turbidity and Vegetation Influence, Benthic Sampling Methods, Water Column and Surface Sampling, Organic Matter Sample Processing, Benthic Macroinvertebrate Sampling on Snags, Emergence Sampling, and Trophic Modeling.*

Turbidity and Vegetation Influence

> *We recommend that AEA conduct macroinvertebrate drift sampling upstream and immediately downstream of tributary mouths to collect information needed to assess the relative contribution of tributaries and the mainstem Susitna River to fish food resources.*

Benthic Sampling Methods

> *We recommend AEA collect BMI and algae samples in macrohabitats with fine substrate and low velocities using a bottom dredge or grab sampler. AEA should*

select the most appropriate sampler according to the bottom substrate, water velocity, and other conditions (see Klemm et al. 1990), but should endeavor to use the same sampler in all macrohabitats of this type to ensure consistency among samples. Additionally, AEA should sample benthic algae on cobble substrates at multiple depths up to 3 feet (e.g., depth categories of 0–1 foot, 1–2 feet, and 2–3 feet) at each macrohabitat site (main channel, tributary confluences, side channels, and sloughs), to the extent feasible given the limits of field safety.

Water Column and Surface Sampling

We recommend that AEA sample invertebrates in the water column and the water surface of still water areas in one side slough, one upland slough, and one tributary mouth (if present) at each study station in the Middle River and Lower River using a modified plankton tow or similar sampler. Five replicates should be collected along a single transect at each site.

Organic Matter Sample Processing

We recommend that AEA obtain AFDM measures of biomass from samples of benthic and transported organic matter, using generally accepted scientific methods (section 5.9(b)(6)).

Benthic Macroinvertebrate Sampling on Snags

We recommend that AEA sample BMI on measured and representative portions of LWD in situ by dislodging organisms by hand and collecting them in a net as they enter the water column at each sample site.

For consistency, we also recommend that AEA use of the term "large woody debris" (LWD) as defined here: "LWD must be at least 0.1 meter (4 inches) in diameter, and at least 1.0 meter (39 inches) of the LWD must be below the water's surface at bankfull flow" and apply it consistently when referring to "wood" and "snags" in its RSP and future study reports.

Emergence Sampling

We recommend that AEA sample aquatic insect emergence in ice free areas, if available, beginning in April, then remove the traps during ice breakup and redeploy them following ice breakup in late May or early June.

Trophic Modeling

For fish sampled for use in the growth and trophic modeling studies, we recommend that AEA measure, weigh, and mark the first 50 fish of each target species and age class captured within each sampled macrohabitat by PIT-tagging to identify the capture station and date. We recommend that AEA collect fish for the trophic modeling studies at all available macrohabitat types (up to five per study station) in each Middle River and Lower River study station. Growth data collected from fish marked and recaptured in the same macrohabitat site should be used (if possible) to validate AEA's proposed growth rate potential model. We also recommend that AEA *incorporate flow velocity into its foraging models and account for associated capture efficiencies when establishing consumption rate.*

Stable Isotope Analysis

We recommend that AEA consult with NMFS and FWS when identifying the appropriate two focus areas for stable isotope sampling, where within the focus areas each type of stable isotope samples would be collected, and the number of adult salmon tissue samples to be collected.

Talkeetna River Reference Study Station

We recommend that AEA consult with the TWG when selecting the Talkeetna River reference study station.

In accordance with the April 1 SPD, AEA has adopted the FERC requested modifications.

Following the first study season, FERC's regulations for the Integrated Licensing Process (ILP) require AEA to "prepare and file with the Commission an initial study report describing its overall progress in implementing the study plan and schedule and the data collected, including an explanation of any variance from the study plan and schedule." (18 CFR 5.15(c)(1)) This Initial Study Report (ISR) on River Productivity has been prepared in accordance with FERC's ILP regulations and details AEA's status in implementing the study, as set forth in the FERC-approved RSP, RP IP, and as modified by FERC's April 1 SPD (collectively referred to herein as the "Study Plan").

2. STUDY OBJECTIVES

The study objectives were established in the Study Plan (RSP Section 9.8.1). The overarching goal of this study is to collect baseline data to assist in evaluating the effects of Project-induced changes in flow and the interrelated environmental factors (temperature, substrate, water quality) upon the benthic macroinvertebrate and algal communities in the Middle and Lower Susitna River. Individual objectives that will accomplish this are listed below.

- Synthesize existing literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities.
- Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Lower Susitna River.
- Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.
- Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.
- Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.

- Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.
- Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).
- Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River.
- Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

3. STUDY AREA

As established by the Study Plan (RSP Section 9.8.3), the River Productivity Study entails field sampling throughout the Middle Segment and upper portion of the Lower Segment on the Susitna River, as well as within the lower portion of the Talkeetna River (Figures 3-1 and 3-2). The Middle Susitna River Segment encompasses the 85-mile section of river between the proposed Watana Dam site and the Chulitna River confluence, located at PRM 102.4 (RM 98.6) (Figure 3-1). Sampling activities within this segment are investigating the benthic communities that may be affected by the Project and its regulated flows. Sampling has been conducted at various distances from the proposed dam site to document longitudinal variability, and estimate the effects that the proposed Project will have on benthos in the river system downstream. The Lower Susitna River Segment, defined as the approximate 102-mile section of river between the Three Rivers Confluence and Cook Inlet (Figure 3-2), has been sampled in this study to document the current conditions within the upper portions of the segment, and estimate possible Project operation effects, if any, that would affect benthic communities on the mainstem Susitna River below the Three Rivers Confluence.

The Talkeetna River is an approximate 85-mile long tributary of the Susitna River, joining with the Susitna and Chulitna rivers at the Three Rivers Confluence (Figure 3-1). Sampling activities on the Talkeetna River are located approximately 8.5 – 9 miles upstream from the mouth, as an effort to assess the feasibility of the Talkeetna River as a reference site for post-Project monitoring activities.

4. METHODS AND VARIANCES IN 2013

This study employed a variety of field methods to build on the existing benthic macroinvertebrate and algal community information in the Middle Susitna River. The following sections provide brief descriptions of study site selection, sampling timing, the approach, and methods that were used to accomplish each objective of this study.

4.1. River Productivity Implementation Plan

This study report includes a description of the sampling scheme; however, the final sampling scheme was reported in the River Productivity Implementation Plan, which was filed with FERC on March 1, 2013 (R2 2013c).

The Implementation Plan included: (1) a summary of relevant macroinvertebrate and algal studies in the Susitna River, (2) an overview of the life-histories of the target fish species in the Susitna River that were selected for the trophic analysis, (3) a review of the preliminary results of habitat characterization and mapping efforts (Characterization of Aquatic Habitat Study, Study 9.9) and "Focus Areas" (FA) (Fish and Aquatic Instream Flow Study, Study 8.5), (4) a description of site selection protocols, (5) a description of sampling protocols, (6) a description of sample processing protocols, (7) a discussion of data analysis methods, (8) development of field data collection forms, (9) development of database templates that comply with 2012 AEA QA/QC procedures, and (10) FERC's requested modifications included in the April 1 SPD. The Implementation Plan included the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan included protocol documents, specific sampling station locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The Implementation Plan helped to ensure that field collection efforts occurred in a consistent and repeatable fashion across field crews and river segments. Objective-specific sampling methods are presented below.

4.2. Site Selection

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.2.4.).

Sampling was stratified by river segment and mainstem habitat type, as defined in the Project-specific habitat classification scheme (e.g., main channel, tributary mouth, side channel, side slough, and upland slough). Sampling occurred at five stations on the Susitna River, and one station on the Talkeetna River, each station with three to five sites (establishing sites at all macrohabitat types present within the station), for a total of 23 sites. In the Middle River Segment, two stations were located between the dam site and the upper end of Devils Canyon, and two stations were located between Devils Canyon and Talkeetna (Table 4.2-1; Figure 3-1). All stations established within the Middle River Segment were located at Focus Areas established by the Fish and Aquatic Instream Flow Study (R2 2013a; R2 2013b), in an attempt to correlate macroinvertebrate data with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) collected by other studies (e.g., Baseline Water Quality Study, Study 5.5), and for macroinvertebrate habitat suitability curve and habitat suitability index (HSC/HSI) development. Many of these Focus Areas were also used for collecting target fish species for trophic analysis (RSP Section 9.8.4.7).

To determine to what extent, if any, the Project operations may affect benthic communities, as well as the influence that the two tributaries may have on those communities below the confluence of the Three Rivers, one station was located in the upper portion of the Lower River (Figure 3-2). Station and site locations are discussed below.

4.2.1. Middle River Stations / Focus Areas

Within the Middle River, each one of the four sampling locations was located within a Focus Area (Table 4.2-1; Figure 3-1 and Figures 4.2-1 through 4.2-4). Two stations between the proposed dam site and Devils Canyon were established in FA-184 (Watana Dam) and FA-173 (Stephan Lake Complex). Between Devils Canyon and Talkeetna, two stations were established in FA-141 (Indian River) and FA-104 (Whiskers Slough).

FA-184 (Watana Dam) is located approximately 1.4 miles downstream of the proposed dam site and provides a mainstem site and a side channel site within its 1-mile extent (Figure 4.2-1; Table 4.2-1). In order to meet our objective of sampling sites at 3 or more habitats, it was necessary to move outside of the FA-184 (Watana Dam) to include a site at the mouth of Tsusena Creek. FA-173 (Stephan Lake Complex) is located approximately 11.7 miles downstream of the proposed dam site and contains a complex of main channel and off-channel habitats within a wide floodplain, thus represented the greatest channel complexity within its geomorphic reach (MR-2; Figure 4.2-2). FA-173 (Stephan Lake Complex) provided a mainstem site, a side channel site, a side slough site, and a small tributary mouth site within its 1.8-mile extent (Table 4.2-1).

Below Devils Canyon, FA-141 (Indian River) and FA-104 (Whiskers Slough) were selected due to the diversity of main- and off-channel habitats that they contained, and documented fish use in and nearby these Focus Areas. FA-141 (Indian River) includes the Indian River confluence, which is a primary Middle Susitna River tributary with high levels of fish use. FA-141 (Indian River) provided a mainstem site, a tributary mouth site, a side channel site, and an upland slough site within its 1.6-mile extent (Figure 4.2-3; Table 4.2-1). Focus Area FA-104 (Whiskers Slough) is located approximately 2.4 miles upstream of the confluence of the Chulitna and Susitna rivers, making it the downstream-most station in the Middle River for the River Productivity Study. This Focus Area contains the confluence of Whiskers Creek, side channels, and side slough habitats that have been documented as supporting juvenile and adult fish use. FA-104 (Whiskers Slough) provided a main channel site, a side-channel site, a side slough site, an upland slough site, and a tributary mouth site within its 1.2-mile extent (Figure 4.2-4; Table 4.2-1).

Two side slough sites were also established for storm event sampling. After review of historic data (ADF&G 1983c; Hale et al. 1984) regarding the mainstem discharge required to overtop various sloughs in the Middle River, slough sites were established in FA-104 (Whiskers Slough) and FA-173 (Stephan Lake Complex). Both side sloughs maintained at least some wetted habitat during the summer months, and were sampled as part of a seasonal sampling event (Section 4.2) just prior to the storm event occurrence in August 2013 making these sites ideal for the pre- and post-storm evaluation.

4.2.2. Lower River Station

Within the Lower River, one study station, with four sampling sites was established in conjunction with Fish Distribution and Abundance (Study 9.6) sampling activities on the Lower Susitna River around the Montana Creek mouth area (Table 4.2-1, Figures 3-2 and 4.2-5). This Lower River station (RP-81 [Montana Creek]) was located within a 1.2-mile reach beginning approximately 21 miles downstream of the confluence with the Chulitna and Talkeetna rivers.

This area was complex, with split channels, side channels, upland sloughs, and tributary mouths (Figure 4.2-5). Four sites were established at Station RP-81 (Montana Creek) including: 1) a mainstem site, 2) a side channel site, 3) an upland slough site, and 4) a tributary mouth site (Table 4.2-1).

4.2.3. Talkeetna River Station

One task within the River Productivity Study was to assess the feasibility of the Talkeetna River as a reference site for post-Project monitoring activities. Because the Talkeetna River is outside of the Project area, results from 2012 study efforts and historic information from the 1980s were limited. Review of the literature has revealed a single USGS study which reports on water quality and benthic macroinvertebrate data collected from the Talkeetna River, approximately 5 miles upstream from its mouth near a USGS gaging station (Frenzel and Dorava 1999). The USGS sampling reach was limited to the main channel, with benthic macroinvertebrate sampling taken off a cobble point bar. Unfortunately, access to this site was not permitted, due to its location within or adjacent to Cook Inlet Regional Working Group land. The selection of the station on the Talkeetna River for the feasibility study was initially limited to a review of topographic maps and available orthographic images. Candidate sites were then selected and visited with a site reconnaissance trip, in consultation with the TWG, on July 17, 2013. Sites with physical conditions similar to those of the Middle River Focus Areas were visited. The Talkeetna station selected featured both main channel and off-channel habitat types to allow for the establishment of a side channel site, a side slough site, and an upland slough site (Table 4.2-1, Figures 3-1 and 4.2-6).

4.2.4. Variances

4.2.4.1. Lower River Station

The Study Plan stated in IP Section 2.1.3 "*Within the Lower River Segment of the Susitna River, the River Productivity Study will establish one study station, with five sampling sites located in conjunction with individual sites proposed by the Instream Flow Study and Fish Distribution and Abundance sampling activities on the Lower Susitna River around the Trapper Creek area.*" During the study site selection process in May and June 2013, the Fish Distribution and Abundance study determined that Trapper Creek was unsuitable for the installation and proper functioning of a rotary screw trap. The screw trap, and its supporting crew activities, was therefore relocated to Montana Creek. Because the River Productivity study collaborated with the Fish Distribution and Abundance study (Study 9.6) for capturing target fish species and ages for trophic modeling (Section 4.7.1), stable isotope analysis (Section 4.7.2), and fish dietary analysis (Section 4.9), the Lower Segment study station was relocated to the area of the Lower Susitna River around the mouth of Montana Creek (approximately PRM 81). Due to the habitat composition within the Montana Creek study station, the potential number of sampling sites was reduced from five to four (main channel, side channel, upland slough, and tributary mouth). No side slough habitat was available for sampling. This site relocation has no effect on any of the study objectives, as it establishes one study station within the Lower River Segment. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.2.4.2. Middle River Stations / Focus Areas

As stated in the April 1 SPD (B-181), FERC recommended that AEA sample in all unique macrohabitat types present at each proposed study station for river productivity sampling in the Middle and Lower River. At Focus Area FA-173 (Stephan Lake Complex), one of the macrohabitat types present included an upland slough habitat. Lack of permission to access Cook Inlet Regional Working Group land prevented sampling at this site. However, habitat characteristics in the side slough that the upland slough flows into were similar to the upland slough site, and additional sampling for slow-water habitat was conducted as recommended in the April 1 SPD (B-186, 187). As such, this variance had no effect on accomplishing the study objectives. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.2.4.3. Storm Event Site Relocation

The Study Plan stated in RSP Section 9.8.4.3, "*Additional sampling will be conducted both before and after storm events that meet or exceed a 1.5-year flood event at two side slough sites, located in two separate Focus Areas in the Middle River Segment between Portage Creek and Talkeetna (AEA 2012 Section 8.5.4.2.1.2).*" Within the Study Plan (IP Section 2.1.2), side sloughs in FA-104 (Whiskers Slough) and FA-144 (Slough 21) were selected, based on historic data (ADF&G 1983c; Hale et al. 1984) that indicated that both side sloughs required similar levels of mainstem discharge for overtopping (ca. 22,000 to 25,000 cfs), and maintained at least some wetted habitat during the summer months.

Initial site reconnaissance visits to these two side sloughs revealed the FA-104 (Whiskers Slough) slough offered suitable riffle habitat for sampling with a Hess sampler, whereas FA-144 slough was largely low velocity, silted pools influenced heavily by a series of beaver ponds. As a result, the FA-144 slough was considered not suitable for Hess sampling. Further reconnaissance for a second side slough site for storm event sampling was planned for the end of the summer seasonal sampling event in August 2013, but the major summer storm event occurred near the conclusion of that sampling trip (August 22). In order to capture before-after data at two side sloughs for the storm event, the side slough within FA-173 (Stephan Lake complex) was substituted for the FA-144 slough. The two side sloughs were sampled previous to the storm event during the summer seasonal sampling event (FA-104 [Whiskers Slough] on August 12, FA-173 [Stephan Lake Complex] on August 19), and were subsequently sampled on August 30-31 to capture the pre- and post-storm conditions. These adjustments made it possible to accomplish the required sampling for the purpose of evaluating the effects of the storm event in 2013. By utilizing sampling sites already sampled for the three Index Periods, the study benefits from the extra data collection by providing a second post-flood event sampling during the Fall Index period, which may give further information on recovery times. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study.

4.3. Synthesize existing information on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities

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

Several reviews have been written on the effects that modified flows have on the benthic communities residing below dams (Ward 1976; Ward and Stanford 1979; Armitage 1984; Petts 1984; Cushman 1985; Saltveit et al. 1987; Brittain and Saltveit 1989). A majority of these reviews indicate that temperature and flow regimes are often the most important factors affecting benthic macroinvertebrates below dams. The type of dam and its mode of operation will have a large influence over the type and magnitude of effects on the receiving stream below. General information on the effects of hydropower on riverine habitats, especially glacially-fed river systems, as well as Project-specific information, was reviewed and synthesized in a white paper entitled Review of the Effects of Hydropower on Factors Controlling Benthic Communities. This document is included in this report as Appendix A. The white paper provides a literature review summarizing relevant literature on macroinvertebrate and algal community information in Alaska, including 1980s Susitna River data; reviews and summarizes literature on general influences of changes in flow, temperature, substrate, nutrients, organic matter, turbidity, light penetration, and riparian habitat on benthic communities; and reviews and summarizes the potential effects of dams and hydropower operations, including flushing flows and load-following, on benthic communities and their habitats.

4.3.1. Variances

No variances from the methods described in the Study Plan (RSP Section 9.8.4.1.) occurred during the 2013 study season.

4.4. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Lower Susitna River

4.4.1. Benthic macroinvertebrate sampling

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.4.3).

Three sampling events (also referred to as Index Events) were conducted from June through October in 2013 to capture seasonal variation in community structure and productivity. The timing of events was influenced by availability of open water for sampling. A late ice-breakup occurred in 2013, resulting in late Spring sampling that started on June 19, 2013. Information on the specific sampling timing within the three Index events is given in Table 4.4-1. Timing was also coordinated with fish sampling events for coho, Chinook salmon, and rainbow trout (target species for Objective 5, Section 4.7) and with Fish Distribution and Abundance sampling efforts within the focus areas (ISR Study 9.6).

Benthic macroinvertebrate sampling was largely conducted in fast-water mesohabitats (typically riffles/runs) within main channel (i.e., main channel, side channels, and tributary mouths) and off-channel macrohabitat types (i.e., side sloughs and upland sloughs), when present (Appendix B). Shoreline bathymetry was evaluated and noted at each site to evaluate the risk of sampling in areas that were not fully colonized as higher flows submerged new shoreline substrates. This localized information was used in conjunction with the USGS gages at Gold Creek and above Tsusena Creek to assess for conditions indicating adequate inundation levels for sampling. Sites with extensive and gradually sloping cobble shorelines were generally chosen so that ample underwater substrates accessible would be available in the event of a drop in surface water level.

Sampling was conducted using a modified Hess sampler (0.93 ft^2-area) with a 243-micrometer (µm) mesh net (Canton and Chadwick 1984; Klemm et al. 1990). Replicate samples (n=5) were collected at each site to allow for statistical testing of results for short- and long-term monitoring (see Appendix B for imagery of all sampling locations). A total of 271 Hess samples were collected from 19 of the 20 study sites in 2013 (Table 4.4-2). Measurements of depth, mean water column velocity, mean boundary layer velocity (near bed), and substrate composition were taken concurrently with benthic macroinvertebrate sampling at the sample location for future use in HSC/HSI development in the instream flow studies (Instream Flow Study, Study 8.5, Objective 6, Section 4.8). Hourly water temperatures were recorded by submerged temperature loggers deployed at all sampling sites. Temperature loggers were deployed during Index Event 1 and were retrieved during Index Event 3, usually in conjunction with emergence trap placements.

Some macrohabitats lacked adequate riffle/run mesohabitat (e.g., side sloughs and upland sloughs), and instead featured deeper pools with fine substrates and low velocity. Use of a Hess sampler in this type of slow-water habitat was not appropriate; therefore, a petite Ponar grab sampler was used (Table 4.2-2). Similar to Hess sample collections, replicate Ponar samples (n=5) were collected to allow for statistical testing of results for short- and long-term monitoring. A total of 70 Ponar grab samples were collected from 6 of the 20 study sites in 2013 (Table 4.4-2).

To determine both the timing and the amount of adult insect emergence (Cushman 1983), floating emergence traps were deployed at each site. The emergence trap design was a low-profile trap with a floating base (Figure 4.4-1), with a collection bottle or tray with alcohol preservation attached to the trap to collect adult specimens (Cadmus and Pomeranz unpublished). The trap was anchored to rebar stakes driven into the stream bed, or tied off to securely attached vegetation, by a length of rope. Ethanol (95 percent) with glycerol added was placed into the trap collection bottle, and samples were collected from deployed traps approximately every 2 weeks by field crews, from the initial deployment following ice breakup until the last seasonal sampling event (September-October). A total of 64 collection visits were made to retrieve and reset traps over the course of the 2013 open-water season, collecting 45 samples total (Table 4.4-3). A loss of 19 samples was recorded, due to a number of disturbances, including bear damage, boat traffic, and fluctuating flow conditions.

Due to the prevalence of large woody debris (LWD) in the Susitna River, woody snags, if present at a sampling site, were sampled as a substrate stratum for benthic macroinvertebrates. Sampling methods for LWD were semi-quantitative, based upon protocols established by the USGS (Moulton et al. 2002). For the purposes of this study, woody snags were defined as LWD, adopting the definition from the RSP Section 9.13.4.2.1: “LWD must be at least 0.1 m (4 inches) in diameter, and at least 1.0 meter (39 inches) of the LWD must be below the water’s surface at bankfull flow” (AEA 2012).

Suitable LWD had been submerged for an extended period of time so as to be clearly colonized. Up to five smaller, removable LWD samples, if present at the site, were removed from the water by using a saw and placed over a plastic bin or in a bucket, and all benthic macroinvertebrates were removed by handpicking, brushing, and rinsing. The removed LWD sections were allowed to dry for a period of time so that any missed organisms crawled out of the crevices and were collected. Removed sections sampled were measured for length and average diameter to determine surface area sampled. Each section originated from a separate piece of LWD, and therefore counted as a separate, replicate sample. In addition, up to five pieces of immobile LWD, if present at the site, were sampled *in situ* by dislodging organisms by hand and collecting them in a D-net positioned immediately downstream as they entered the water column. Pieces of LWD were not prevalent at all sites, resulting in a total of 155 samples collected from 16 of the 20 sites in 2013 (Table 4.4-2). Pieces of wood were mostly located in off-channel macrohabitats; main channel sites rarely provided suitable LWD.

Benthic macroinvertebrate replicate samples were stored in individual containers and immediately preserved in the field with 95 percent ethanol (non-denatured). Samples were shipped to and processed by Ecoanalysts, Inc. (Moscow, Idaho) using sample processing protocols established by the USEPA for the Rapid Bioassessment Protocols (Barbour et al. 1999) and modified for use in Alaska (Major and Barbour 2001).

In support of the bioenergetics modeling (Section 4.7.1), biomass estimates will be taken for primary invertebrate taxa collected for benthic and emergence sampling. The biomass of each invertebrate taxon will be estimated from length measurements and taxon-specific length-weight regression relationships. The body lengths (from head to abdomen, excluding antennae, legs, setae, and other appendages) of a representative subsample of each invertebrate taxon collected from each site are measured under a dissecting microscope using digital microscopy software (Leica Application Suite). Length measurements are then converted to dry mass using length-weight regression relationships developed specifically for each taxon. Additional benthic macroinvertebrates and organic matter samples were also collected for stable isotope analysis (Objective 5, Section 4.7.2).

4.4.2. Benthic algae sampling

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.4.3). To allow for correlation between collection, benthic algae was collected concurrently with benthic macroinvertebrate sampling at all five stations. In fast-water habitats, rock surfaces were sampled, based on the methods utilized by the USGS for the NAWQA program (Moulton et al. 2002), the USEPA for the Rapid Bioassessment Protocol (Barbour et al. 1999), and the USEPA for the Environmental Monitoring and Assessment Program (EMAP; Lazorchak et al. 2000; Peck et al 2006). For the purposes of this study, a PVC pipe area delimiter (1.65 in. diameter) with a rubber collar at one end was adopted, as recommended by the EPA methods (Barbour et al. 1999; Lazorchak et al. 2000; Peck et al. 2006).

For each algal sample associated with a Hess sample, five rock substrates were randomly collected. Rock substrates were evenly collected at multiple depths in one-foot depth categories (e.g., 0 – 1 foot, 1 – 2 feet, and 2 – 3 feet) to the extent feasible, given the limits of field safety. At each location where a cobble or rock substrate was collected, measurements of depth, mean water column velocity, mean boundary layer velocity, and area substrate composition were taken for future use in HSC/HSI development in the instream flow studies (Instream Flow Study, ISR

Study 8.5, RSP Section 8.5.4.5.1.2.3.). Light availability was measured at each sample location with an underwater light sensor to measure the photosynthetically-active radiation (PAR) available to the algal community. PAR readings were taken from just below the water surface to the stream bottom at regular 10-cm intervals. A turbidity measurement, using a portable turbidity meter, was also taken at the sampling site to determine water clarity at the time of collections.

For each rock, the area delimiter was placed on its upper surface, and the enclosed area on the substrate was scrubbed with a small brush to remove any algal growth. The removed algal material from the enclosed area and brush were then rinsed into a darkened sample container. The five discrete collections taken from five cobbles were combined to make a composited sample, which was placed on ice inside a cooler and kept in the dark until the sample was processed. Five composited samples (one for each Hess sample) were collected at each site, for a total of 309 composited algae samples in 2013 (Table 4.4-4).

In macrohabitats with deeper pools, low velocities, and finer substrates, the USGS NAWQA program protocols were followed for epilithic or epidendric sampling. As a result, rock substrates or pieces of woody debris, when present within the site, were used to collect algal samples with the area delimiter.

Procedures for processing algal samples were taken directly from the Quantitative Microalgae processing procedures (Moulton et al. 2002). An algae filtration apparatus was used to draw subsamples of the composite sample through a 1.85-inch diameter (47-mm) glass fiber filter. Two subsamples were taken from each composite sample to determine chlorophyll-*a* and ash free dry mass (AFDM) in the laboratory. The subsample filters were folded, wrapped in tinfoil, labeled, and stored in a freezer at -4° F until shipped overnight on dry ice to the processing laboratory in Kirkland, Washington. The remaining volume of the sample component was preserved in 10-percent formalin, and archived for additional analyses, if needed. Benthic algae samples were processed in a laboratory, using Standard Methods (Eaton et al. 1998; SM 10200H, SM 2540G).

Results generated from the collections include estimates of AFDM and chlorophyll-*a*. Each measure will have the mean and variability (95-percent confidence intervals) calculated for each site and index event.

4.4.3. Variances

4.4.3.1. Sampling site inundation requirements

The Study Plan stated that: "*Higher flows may inundate new shoreline substrates, which poses the risk of sampling in areas that are not fully colonized. The shoreline bathymetry for each site will be evaluated such that changes in water level due to increasing or decreasing flows must remain constant enough that the substrates accessible for sampling will be continually inundated for a period of at least one month, to facilitate colonization of those substrates*" (RSP Section 9.8.4.3.; IP Section 2.2.1.). While the preferred and intended practice was to conduct sampling at sites where all substrates had remained submerged for 30 days or more, such a condition was difficult to satisfy given the rapid and sudden changes in flow and river stage during the sampling season. Compliance with a 30-day inundation requirement would have prevented any spring sampling from occurring, due to the delayed ice-break up period, followed by record-high temperatures that increased glacial flows throughout the months of June and July. Summer sampling would have been postponed for another 30 days due to a drop in flows and river stage for a two-day period (August 8-9) a few days before the summer sampling period began (August 12). Instead, USGS gage data was reviewed daily and during periods of risk, sampling was conducted at the maximum water depths allowed by the Hess sampler (12 to 14 inches), when present and available, to pursue the highest probability of continuous inundation conditions. An examination of Hess sampling depths and the recorded USGS river stage gage data was conducted to estimate the potential exposures of Hess samples within the 30-days prior to sample collection (Appendix C). Estimates revealed that 24-percent of the Hess samples, specifically those in main channel macrohabitats, could have been potentially dewatered at some point during the preceding 30 days due to river stage changes (Appendix C).

The Study Plan also indicated that "*the shoreline bathymetry for each site will be evaluated*" at each site (RSP Section 9.8.4.3.; IP Section 2.2.1.). The Study Plan provided details that basic surveying transects would be used at each Hess sampling location, measuring depth and velocity at 3-foot intervals, both perpendicular and parallel to the shoreline. Initial transect measurement efforts during the spring sampling event resulted in over 100 measurements of depth and velocity at each site. A majority of the measurements had no direct relation to the samples collected, and were therefore of little use for the trophic model (Section 4.7) and HSC/HSI curve development (Section 4.8). At many sites, an established point at the ordinary high water mark (OHWM) was not possible, making it difficult to establish a point of reference for the shoreline position, especially when flows and river stages were prone to rapid changes. A formal surveying effort would be needed to provide a set of measurements to survey the shoreline bathymetry. From a logistics standpoint, the large number of transect measurements required a considerable amount of time at each site, resulting in the completion of only one sampling site per day. Given that the projected rate of progress needed to approach two completed sites per day in order to complete all sampling sites within a 10 to 14 day period, transect measurements for a site's shoreline bathymetry were reduced to taking measurements at each sample location. General notes on site features were recorded, and USGS gage data was reviewed before and during field sampling efforts. By reducing measurements to just sample locations within each site, all sampling efforts were able to be completed within a 14-day period, allowing for better comparability among sites sampled within each seasonal event, and sample-specific depth and velocity measurements were able to be made to satisfy the requirements for both the trophic modeling effort (Section 4.7), and the HSC/HSI development effort (Section 4.8). This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.4.3.2. Storm event sampling

The Study Plan stated in RSP Section 9.8.4.3, "*Additional sampling will be conducted both before and after storm events that meet or exceed a 1.5-year flood event at two side slough sites, located in two separate Focus Areas in the Middle River Segment between Portage Creek and Talkeetna (RSP AEA 2012, Section 8.5.4.2.1.2).*" Because of the timing of the late August storm event, pre-storm sampling was not able to collect samples at both the upstream and downstream ends of each slough, as stated in the Study Plan (RSP Section 9.8.4.3). Storm event sampling was limited to the summer sampling event and a repeated sample at two side slough sites located in the middle of the slough (Tables 4.4-2, 4.4-4, and 4.5-1). By utilizing sampling sites already sampled for the larger sampling efforts during the three Index Periods, repeating those sampling efforts allowed for a complete before-after data collection for comparison. The study further benefited by using the fall sampling event as a second post-flood collection, providing additional information on recovery times from sudden flow increases. These adjustments made it possible to accomplish the required sampling for the purpose of evaluating the effects of the storm event in 2013. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.4.3.3. Grab sampling in slow water areas

As stated in the Study Plan (April 1 SPD, B-187), it was recommended that AEA collect both BMI and algae samples in macrohabitats with fine substrate and low velocities using a bottom dredge or grab sampler. While the grab sampler is ideal for collecting macroinvertebrates in fine sediment, it is unsuitable for sampling algae because the sediment surface is disturbed in the process of collection and removal of the material from the grab sampler. The USGS National Water-Quality Assessment (NAWQA) Program protocol, which was the model for this study's co-located algal and macroinvertebrate samples, recommends algal sample collections from epilithic (natural, coarse-grained substrates) or epidendric (woody debris) habitats (Moulton et al. 2002; Hambrook Berkman and Canova 2007). The USGS NAWQA protocol for algal sampling from soft substrates uses the inverted petri dish method, but those samples are only analyzed for taxonomic identification, and not chlorophyll-a or ash free dry mass (AFDM), as is required for this study. Following the NAWQA protocols, this study therefore collected algae samples for chlorophyll-a and AFDM from epilithic and epidendric substrates, when present, in macrohabitats with fine substrate and low velocities, and collected benthic macroinvertebrates and organic matter with the Petite Ponar grab. With the use of these protocols, algae collections were possible in slow-water habitats, and samples were consistently collected as required for the study objective (Section 4.4.2). The adoption of this protocol as a standard approach allowed for study team to achieve the study objective. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.4.3.4. Dry mass and energy density measurements

The methods of determining the biomass and energy density of benthic macroinvertebrates were changed from the methods described in the Study Plan to improve accuracy and better achieve the study objectives. The Study Plan (RSP Section 9.8.4.3; IP Section 2.2.2) stated that the oven-dried biomass of benthic macroinvertebrates would be measured directly. Instead, the body lengths of a subsample of each macroinvertebrate taxon were measured to the nearest millimeter. The dry mass of each taxon was calculated from length-weight regression relationships derived from the literature (e.g., Rogers et al. 1976, 1977; Smock 1980; Benke et al. 1999; Johnston and Cunjak 1999; Sabo et al. 2002) and from recent studies of Alaskan stream invertebrates (M. Wipfli, UAF, unpublished data). This approach is more accurate than direct measurements of biomass from samples preserved in ethanol (Meyer 1989). This change also standardized the estimation of invertebrate biomass between specimens collected from the environment (i.e., benthic and drift samples) and those collected from fish stomachs.

The method of determining the energy density of invertebrates was also changed to improve accuracy. The Study Plan (RSP Section 9.8.4.3) stated that energy density (J/g wet weight) would be determined for a subsample of the benthic macroinvertebrate specimens from the percent dry mass (dry mass/wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). This method would have produced accurate measurements if fresh invertebrate samples could have been transported to the lab; however, this method was not suitable for samples preserved in ethanol, which can cause substantial bias in dry mass measurements (Leuven et al. 1985). Ethanol preservation was necessary for samples collected at many of the study sites due to the duration of the sampling trips and the remote locations of the sites. Therefore, taxon-specific energy density values were derived from the literature. These adjustments therefore increased accuracy, reduced sampling bias, and provided a standard methodology for estimating biomass and energy density while achieving the study objective. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.5. Estimate drift of invertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.5.1).

Invertebrate drift sampling was conducted concurrently with benthic macroinvertebrate sampling at all sites within the five established sampling stations to allow for comparisons between the drift component and the benthic macroinvertebrate community, as well as reveal the availability of terrestrial invertebrates for fish predation.

Sampling was conducted in fast-water habitats, if present, within all established sites (Tables 4.2-1 and 4.5-1). In addition, at all tributary mouth sites, a drift net pair was deployed upstream of the site, to collect information on the relative contribution of tributaries to fish prey resources in the mainstem Susitna River.

Invertebrate drift sampling was conducted based on the USEPA's EMAP drift net sampling protocols (Klemm et al. 2000). A set of two drift nets with a 250-µm mesh size were used to collect duplicate samples to allow for statistical testing of results for short- and long-term monitoring (Klemm et al 1990; Klemm et al. 2000). Drift sampling was conducted at the top of a site reach during daylight hours, preferably beginning shortly after arrival at a site. Water velocity was recorded with an in-net flow meter (General Oceanics) along with the start and stop times marking the amount of time the nets were actively sampling. In addition, current velocity was measured with a Pygmy current meter at the entrance of the net and at 60 percent of the depth at the start and ends of sampling. Measurements of depth, turbidity, and temperature were also taken with drift samples. A total of 92 drift samples were taken during the 2013 field season (Table 4.5-1).

The use of drift nets is not advised with currents less than 0.16 feet per second (0.05 meters per second); a plankton tow net (243-µm mesh net with a 8-inch opening) was used at still water sites, taking five replicate horizontal tows along transects across the channel. Two calibrated tow lines were attached to the tow net, one going to a crew member on each side of the channel. This arrangement allowed the collection of tows along shore-to-shore transects across the channel without repetitive crossing, or attempts to toss the net to the other side of the channel. Transect distance measurements were made upon retrieval of each tow. A total of 85 plankton tows were collected from 8 of the 20 sites (Table 4.5-1).

Invertebrate drift and plankton tow samples were shipped to and processed by Ecoanalysts, Inc. (Moscow, Idaho) using methods similar to those used for benthic samples (Barbour et al. 1999; Major and Barbour 2001). Organic matter (OM) content was retained and analyzed by size (coarse and fine particulate OM) as discussed in Section 4.10.

4.5.1. Variances

4.5.1.1. Plankton tow sampling in still water areas

As stated in the Study Plan (April 1 SPD, B-188), it was recommended that *"AEA sample invertebrates in the water column and the water surface of still water areas in one side slough, one upland slough, and one tributary mouth (if present) at each study station in the Middle River and Lower River using a modified plankton tow or similar sampler."* This effort would result in a potential of eleven sites identified in the Implementation Plan where plankton tows could be collected. However, the relocation of the Lower River Segment study station, and the lack of permission to access the upland slough site in FA-173 (Stephan Lake Complex), reduced the potential site number. In addition, most tributary mouth habitats did not present still water areas in which to take plankton net tows. Most River Productivity sites were established in riffle/run habitats, with measurable velocity. Upland sloughs were the exception, as they featured deeper pools with little to no stream velocities. During summer and fall low-flow conditions, side slough habitat also provided still water habitat areas for plankton tows. Therefore, as a general rule, in cases where stream velocities were not high enough to take drift net samples, plankton tows were used as a substitute. Plankton tows and grab samples were often taken together at sites with low velocity. By defining the use of plankton tows to those flow conditions where drift net sampling is not conducive (currents less than 0.16 feet per second), sampling of organisms in the water column was possible at all sites, regardless of current velocities. This adjustment provided a standardized approach for sampling the water column for invertebrates, depending upon the velocity, and allowed the study team to achieve the study objective. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.5.1.2. Dry mass and energy density measurements

The methods for determining the biomass and energy density of macroinvertebrates were changed as previously described above in Section 4.4.3.4.

4.6. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.6.1). In consultation with the TWG on July 16, 2013 (see Appendix D for documentation material), three sampling sites were established in the Talkeetna River in areas that were considered physically similar to those sampled in the Middle Susitna River (Figure 3-1). These site selections were presented to the TWG on September 23, 2013. One station was established with a mainstem site (side channel) and two off-channel habitat sites (side slough and upland slough) within it (Table 4.2-1). Sampling was conducted in riffle habitats in the side channel and side slough sites, and in low-velocity pools in the upland slough site (Figure 4.2-6; Appendix B).

Benthic and drift sample timing was consistent with Index Events in the Middle River (Objectives 2 and 3, Sections 4.4 and 4.5) (Table 4.4-1). Benthic macroinvertebrate, benthic algae, and drift sampling methods and processing protocols were identical to those used in sampling the Middle Susitna River (Objectives 2 and 3, Sections 4.4 and 4.5). A total of 30 Hess samples, 15 Ponar grab samples, 45 composite algae samples, 12 drift samples, and 10 plankton tows were collected in 2013 (Tables 4.6-1 to 4.6-3).

4.6.1. Variances

The Study Plan stated in IP Section 2.1.4.: *"The Talkeetna station will feature both main channel and off-channel habitat types to allow for the establishment of a main channel site, a side channel site, and a side slough site."* However, as stated in the April 1 SPD (B-201), it was recommended that AEA consult with the TWG when selecting the Talkeetna River reference study station and sites. Candidate sites were selected, and visited with a site reconnaissance trip, in consultation with the TWG, on July 16, 2013 (Appendix D). From that trip, a side channel, side slough, and upland slough were selected as sampling sites. Although no main channel site was established, the TWG representative agreed that a side channel was appropriate as a main channel habitat within that braided reach of the Talkeetna River where the study station was located. Given that the main channel habitat in the station location is primarily split main channel and multiple split main channel, the selection of a side channel would serve a better comparison with a Middle Susitna side channel. The inclusion of the upland slough as a sampling site adds in a second off-channel habitat type to compare to the Middle Segment sites, and therefore further assists in accomplishing the study objective of evaluating the Talkeetna River as a future reference site for evaluating Project effects within a monitoring program. This variance will be incorporated into the potential River Productivity Study sampling efforts in the next year of study, should 2013 results indicate that further sampling in the Talkeetna River is warranted.

4.7. Conduct a trophic analysis, using trophic modeling and stable isotope analysis, to describe the food web relationships in the current riverine community within the Middle and Lower Susitna River

4.7.1. Develop a trophic model to estimate how environmental factors and food availability affect the growth rate potential of focal fish species under current and future conditions

AEA implemented the methods as described in the Study Plan with no variances. To determine how water temperature, food availability, and food quality influence the growth of juvenile Chinook salmon, juvenile coho salmon, and juvenile and adult rainbow trout, field data from the Fish and Aquatics Instream Flow Study (Study 8.5), Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (Study 9.6), and this River Productivity Study will be analyzed using a bioenergetics approach. This analysis will allow comparisons of observed growth rates, estimated consumption rates, and estimated growth efficiency (i.e., the grams of growth achieved per gram of food consumed) among different habitats under the environmental conditions observed during 2013 and the next year of study.

In 2013, growth rates were determined from seasonal mean weight at age data (IP Section 2.7.3) by collecting fish scales in order to age juvenile Chinook salmon, juvenile coho salmon, and juvenile and adult rainbow trout (DeVries and Frie 1996). Scales were collected from the first eight fish of each species and age group captured at each sampling site, in conjunction with stomach content sampling (Section 4.9) conducted with the assistance of the Fish Distribution and Abundance Study (ISR Study 9.6). For field sampling purposes during 2013, rainbow trout with length less than or equal to 120 mm (4.7 in) were provisionally categorized as “juveniles” (ages 0 and 1) or as “adults” (ages 2 and above) if their fork length was greater than 120 mm (4.7 in) (ADF&G 1983b, pp. G-8, G-14; Sundet and Wenger 1984, part 5, pp. 69, 70). Approximately six scales were collected using forceps from the preferred sampling area on the fish (Scarnecchia 1979). Scales were stored dry in small paper envelopes and transported to the laboratory for analysis.

Fish ages were determined using scales and temporal length distribution data (DeVries and Frie 1996; Isely and Grabowski 2007). Seasonal length-frequency distributions were examined for juvenile Chinook salmon, juvenile coho salmon, and juvenile rainbow trout. If any species displayed distinct length modes, suggesting that age-0 and age-1 fish were distinguishable from each other and from older fish based on length and sampling date alone (e.g., Daum and Flannery 2011), this method was validated by aging scales from a random subset of 80 fish per size group. If seasonal length distributions did not contain distinct modes or if the length-frequency analysis failed to correctly assign at least 95 percent of the fish to the correct age based on the scale analysis, then all scales from that species were aged. Age classes of rainbow trout aged 2 years and older were expected to overlap in length, so all rainbow trout were aged by scale analysis only.

Scales of juvenile fish were removed from envelopes in the lab, soaked in water in a petri dish, and cleaned of any slime and foreign material. One suitable scale (neither regenerated nor damaged) from each fish was examined under a dissecting microscope. Scales were aged independently by two readers, with the final age assigned by consensus. Images of a subset of scales were captured and archived with a microscope-mounted digital camera interfaced with a desktop computer.

Growth rates of juvenile Chinook salmon, juvenile coho salmon, and rainbow trout were quantified in terms of mean weight at age based on field data from all specimens sampled, stratified by sampling period and station. To test whether size-selective mortality or migration introduced bias into these growth rate estimates, seasonal growth rates were also estimated for individual fish that were recaptured during the PIT tag study. The adopted growth relationships were used as inputs for the bioenergetics models for each species.

Water temperatures were obtained from temperature loggers deployed at sampling stations (Section 4.4). Diet composition was determined from stomach contents (Section 4.9). The energy densities of prey taxa were derived from the literature. Based on these inputs, the bioenergetics models estimated consumption rates and growth efficiency on a daily basis. These metrics were compared among habitats and seasons to determine whether growth was limited primarily by water temperature, food consumption, or food quality in the study area, and whether these limiting factors differed among habitats (McCarthy et al. 2009).

4.7.2. Conduct stable isotope analysis of food web components to help determine energy sources and pathways in the riverine communities

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.7.3). To better understand the trophic relationships in the Middle and Lower Susitna River, stable isotope sampling was conducted at four stations; one in the Lower River (RP-81 [Montana Creek]) and three in the Middle River (FA-104 [Whiskers Slough], FA-141 [Indian River], and FA-184 [Watana Dam]) (Table 4.2-1 and Figures 3-1 and 3-2). A total of 1,242 tissue samples were collected for stable isotope analysis (SIA) from multiple study components, including benthic macroinvertebrates, benthic algae, benthic organic matter, invertebrates and organic matter in drift samples, salmon carcasses, and fin clips from fish (Table 4.7-1). Samples were collected at all sites within these four stations, for a total of 16 sites, in conjunction with other related sampling efforts undertaken at each site/habitat type (Sections 4.4, 4.5, 4.9, and 4.10).

For collection of stable isotope tissues from benthic macroinvertebrates and benthic organic matter (BOM), qualitative sampling was conducted using either a modified Hess sampler or a 250-µm D-frame kick net. Three composite samples were collected from each site, yielding a targeted wet weight of approximately 10 g (0.35 oz) BOM, and 2 to5 g (0.07 to 0.17 oz) for each of four functional feeding groups of benthic macroinvertebrates. Separation of macroinvertebrates from organic matter, identification, and sorting into feeding groups was conducted using a dissecting microscope in the lab at the University of Alaska-Fairbanks (UAF). Macroinvertebrates were sorted into functional feeding groups that each comprised a single composited sample to be used for stable isotope analysis (Table 4.7-1). A total of 489 benthic macroinvertebrate sample components and 141 benthic organic matter sample components were collected for analysis in 2013.

Benthic algae samples used for stable isotope analysis were collected in addition to the quantitative algae samples collected for ash free dry mass (AFDM) and chl-a analysis (Section 4.4.2). Three composite samples representative of the periphyton assemblage present in each habitat type were collected at each site, targeting a wet weight of 10 g (0.35 oz). Each composite sample was collected by thoroughly brushing the top and side surfaces of five haphazardly selected rocks and retaining the loosened algal material for analysis in the lab at UAF. A total of 141 benthic algae sample components were collected for analysis in 2013 (Table 4.7-1).

For collection of stable isotope material from drifting invertebrates and organic matter (seston), qualitative sampling was conducted using a pair of drift nets with 250-µm mesh. Two composite samples were collected from each site where drift sampling could be conducted, yielding a targeted wet weight of approximately 10 g (0.35 oz) seston, and 2 to 5 g (0.07 to 0.17 oz) for each composite sample of benthic macroinvertebrates. A total of 102 drift sample components and 94 seston sample components were collected for analysis in 2013 (Table 4.7-1). All samples were preserved in 70 percent ethanol and returned to UAF for further analysis.

For collection of stable isotopes from emerging adult aquatic insects, sample material was taken from emergence trap samples collected as described in Section 4.4.1. Samples were sent to Ecoanalysts, Inc. in Moscow, Idaho, where adult insects were identified, to be sent to UAF upon completion, where insect tissues were used for stable isotope analysis.

Spawning salmon carcass tissue samples were collected as encountered between site RP-81 (Montana Creek) and FA-184 (Watana Dam) (Figures 3-1, and 3-2). A total of up to 40 tissue samples per year from a combination of pink, chum, coho, sockeye, and Chinook salmon were targeted for collection for stable isotope analysis of marine-derived nutrients (MDN). When and where possible, tissue samples were taken from spawning salmon carcass tissues by excising 2 to 5 g (0.07 to 0.17 oz) of muscle tissue approximately 1 to 3 inches behind the dorsal fin. A total of 14 carcasses were collected during summer and fall index events for stable isotope analysis (Table 4.7-1). All samples were preserved in 70 percent ethanol and returned to UAF for further analysis.

Stable isotope samples were collected non-lethally from fish selected and sampled as part of the fish diet analysis (Section 4.9) for targeted fish species (juvenile Chinook salmon, coho salmon, and rainbow trout). A total of up to 8 fish per target species per site were sampled, if present; a total of 261 samples were collected in 2013 (Table 4.7-1). Tissue samples were obtained by clipping a small portion (at least 0.25 cm^2 [0.04 in^2]) of the caudal fin with sterilized sharp scissors. Caudal fin tissue regenerates rapidly and is unlikely to affect the growth or survival of large fish; however it may cause a reduction in survival for fish smaller than 50 mm (2 in) FL. Therefore, fish smaller than this size selected for stable isotope sampling were euthanized, and used as a whole-fish sample. All samples were preserved in 70 percent ethanol and returned to UAF for further analysis.

All sample types for stable isotope analysis were oven dried at 60°C (140ºF) to a constant weight and ground to a homogenous powder. Subsamples of approximately 1-2 mg for algae, 0.3-0.4 mg for OM, and 0.2-0.3 mg for animal tissue were weighed to the nearest 0.001 mg on a micro-analytical balance and placed into tin capsules. Samples were combusted and analyzed in an isotope-ratio mass spectrometer interfaced with an elemental analyzer at the Alaska Stable Isotope Facility at UAF.

Results of stable isotope analysis will be used in conjunction with the bioenergetics model (Section 4.7.1) to describe and quantify the energy pathways and trophic relationships supporting salmonid production in the food web of the study area.

4.7.3. Variances

4.7.3.1. Stable Isotope Site Selection

The Study Plan stated in IP Section 2.11.1.: "*Isotope samples will be collected from two of the River Productivity Study sampling stations in the Middle Susitna River, with three habitat-specific sampling sites per station, for a total of six sampling sites.*" However, as stated in the Study Plan (April 1 SPD, B-181), it was recommended that AEA sample in all unique macrohabitat types present at each proposed study station for river productivity sampling in the Middle River and Lower River segments. As such, stable isotope sampling was expanded from the three habitat-specific sampling sites to all unique macrohabitat types. During the initial spring sampling event, stable isotope sampling was conducted at two focus areas in the Middle River below Devils Canyon (FA-104 [Whiskers Slough] and FA-141 [Indian River]) due to their importance to anadromous fish. The total number of sites for stable isotope sampling was therefore increased from six sites to nine sites.

Further consideration by AEA during the spring sampling event indicated that additional resolution along a gradient of high to low levels of marine derived nutrients (MDN) from spawning salmon would be valuable. Therefore, supplemental sampling was added to the study at two additional stations, Montana Creek at RP-81 and FA-184 (Watana Dam), bringing the total number of sites for stable isotope sampling to sixteen sites. This addition of the supplemental sampling stations is expected to provide a clearer understanding of any food web differences that may exist between stations with high and low densities of spawning salmon. Thus, the addition of these stations will better address the study objective of quantifying the relative influence of riverine, terrestrial, and marine energy sources to juvenile salmon and the broader river food web. Full stable isotope sampling efforts have been undertaken at the two original stations (FA-104 [Whiskers Slough] and FA-141 [Indian River]) as well as the two supplemental sites (FA-184 [Watana Dam] and RP-81 [Montana Creek]) for each of the three sampling events during 2013. All stable isotope samples collected from the two original sampling stations will be analyzed, as described in the Study Plan (RSP Section 9.8.4.9, and IP Section 2.11). Due to the substantial cost of stable isotope lab analysis, a subset of the samples from sites at the supplemental stations will be selected for analysis. This subset will be selected with the goal of minimizing the uncertainty in the stable isotope study results, based on preliminary results from the original sampling stations. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.7.3.2. Subcutaneous Dye Injection

Fish can move between macrohabitats to enhance their growth rates. To incorporate the movements of juvenile coho salmon and rainbow trout into the growth rate potential (GRP) models, the Study Plan stated that biotelemetry data from the Fish Distribution and Abundance in the Middle and Lower River Study (RSP Section 9.6.4.3.2) would be included in the analysis. Towards this goal, the April 1 SPD (p. B-199) recommended the following specific approach: *"In consideration of the above, for fish sampled for use in the growth and trophic modeling studies, we recommend that AEA measure, weigh, and mark the first 50 fish of each target species and age class captured within each sampled macrohabitat by PIT-tagging to identify the capture station and date."* In a footnote to this recommendation, it was noted that "*PIT tags can generally be implanted in fish > 60 mm in length and a macrohabitat-specific subcutaneous dye injection should be used on fish less than 60 mm in length."* The movements and individual growth trajectories of juvenile coho salmon and juvenile rainbow trout were quantified using PIT tags. However, smaller (less than 60 mm) fish were not marked with subcutaneous dye because this would have produced relatively little useful data on movements among macrohabitats or individual growth rates, while requiring a considerable effort.

Dye marking was judged to be of limited utility for the following reasons. First, the 1- to 2-month interval between River Productivity Study sampling trips would severely limit the inferences that could be drawn about habitat use between the initial marking and each recapture. Even for those fish that were recaptured in the same habitat in which they were marked, it would not be clear whether they had remained in that habitat for the entire interval, or moved away and then returned. In contrast, the PIT tag approach operated on a much finer temporal scale, capable of detecting diel horizontal migrations between macrohabitats. Such fine-scale movements between habitats have been shown to substantially enhance juvenile coho salmon growth rates in other Alaskan river systems. Second, dye markings would only be sufficient to mark groups of fish captured in the same macrohabitat on the same date, not to identify individuals. Thus, while overall net movements could be determined, this information would not be interpretable in terms of specific movements by individuals, the more useful metric for the GRP models. Finally, without the ability to identify individuals, growth trajectories could not be determined. For these reasons, the dye marking data would be much less useful for GRP model validation than the PIT tag data. Therefore, the study resources were focused on implementing a robust PIT tag study to most effectively document the movements and growth of individual fish, test the GRP models, and accomplish the objectives of the study.

Although data from the PIT tag study were not yet available during the preparation of this report, the size distribution of coho salmon and rainbow trout captured for stomach content sampling supported the focus on PIT tagging to quantify movements because most captured fish exceeded the 60 mm size threshold. Only 24 percent (29/119) of the juvenile coho salmon were less than 60 mm (fork length). Of these small fish, most were close to the size threshold: Seventeen were 55-59 mm and only one fish was less than 50 mm. None of the nine juvenile rainbow trout captured for stomach content sampling were less than 60 mm (fork length). These data suggest that the movements documented by the PIT tag study provided a reasonable representation of movements by the juvenile coho salmon and juvenile rainbow trout populations as a whole. Therefore, this variance had no effect on the study team achieving the study objective.

4.8. Generate habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site

AEA implemented the methods as described in the Study Plan with no variances. In 2013, data were collected in support of HSC/HSI models as described in Section 4.4.1. Approximately 300 Hess samples were collected with depth, velocity, and substrate composition measurements (Table 4.8-1). In addition, 150 samples of LWD ("snags") were collected with depth, velocity, and surrounding substrate composition estimates, and 1,745 rock locations taken for composite algae samples recorded depth and velocity (Table 4.8-1). Curve and model development will occur in the next year of study.

4.8.1. Variances

No variances from the methods described in the Study Plan (RSP Section 9.8.4.10.) occurred during the 2013 study season.

4.9. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component)

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.9.1.).

In support of the bioenergetics modeling (Objective 5, Section 4.7), stomach contents were collected from juvenile coho salmon, juvenile Chinook salmon, and rainbow trout. For the 2013 field season, rainbow trout smaller than 120 mm (4.7 in) fork length were considered "juveniles", and larger fish were considered "adults". The fish collections were coordinated with the Fish Distribution and Abundance in the Middle and Lower Susitna River Study (Study 9.6.) and methods used for collecting fish specimens are described in that study's Initial Study Report (ISR Study 9.6). Fish sampling was to take place within one week of River Productivity index event sampling, in order to ensure that fish diet data coincided with food prey availability data, i.e., the benthic sampling (Section 4.4) and drift sampling (Section 4.5).

Fish sampling was attempted at all study sites, although logistical difficulties in sampling coordination prevented all sites from being sampled during all index events, especially during spring (Table 4.9-2). These difficulties were largely due to lack of overlap in sampling schedules, resulting in fish collections taking place more than one week after River Productivity sampling events, and lack of overlap of sampling sites according to macrohabitat type, resulting in different locations than those visited by River Productivity crews. These difficulties were addressed to substantially improve sampling coverage during summer, and to achieve full coverage of the 21 study sites during fall. River Productivity index event times were rescheduled to coincide with fish distribution and abundance fish sampling events (ISR Study 9.6). In addition, River Productivity crews deployed up to 12 baited minnow traps (approximately 90 minute set times) within the sampling sites where no overlap in sampling sites during collection efforts was initially identified for Spring and Summer sampling, and further increased that effort with minnow traps set at all sites in Fall sampling. Target species were often rare or absent from catches at some sites, especially FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam), thus this sampling effort resulted in 260 samples total for 2013 (Tables 4.9-1 through 4.9-4).

Stomach contents were collected from the first eight fish per target species and age class that were captured at each sampling site during the index period (Tables 4.9-2 through 4.9-4). Fish were anesthetized with clove oil, measured for fork length (mm), weighed (g), and their stomach contents were flushed with a 10-mL (0.3 oz) syringe assembly (Meehan and Miller 1978). Stomach contents were flushed into a Whirl-Pak bag and preserved in at least 70 percent ethanol. Scale samples and tissue samples for stable isotope analysis were taken from the fish at this time as well, using methods detailed in Section 4.7.

Stomach content samples were examined under a dissecting microscope in the laboratory at UAF. Invertebrate prey were identified to life stage (i.e., larva, pupa, nymph, or adult) and family when possible, or otherwise to the lowest possible taxonomic level. Invertebrates were categorized as aquatic or terrestrial based on their taxon and life stage (Merritt et al. 2008). Fish prey were identified to species when possible, or otherwise to the lowest possible taxonomic level. The body lengths of intact prey organisms were measured to the nearest millimeter, and the lengths of partially digested prey were estimated based on intact individuals of the same taxon that appeared similar in size. The dry mass of prey organisms was determined from length-weight regression relationships developed for Alaskan aquatic invertebrates (M. Wipfli, UAF, unpublished data; Wipfli 1997). All stomach contents were archived in 95 percent ethanol for future verification.

4.9.1. Variances

4.9.1.1. Processing of empty stomach samples

The Study Plan stated in IP Section 2.8.1 that "*A fish that is lavaged and found to have an empty stomach will be replaced by the next fish of that species and age class that is captured*." This approach was found to be unworkable in the field. Field personnel were not confident that they could determine whether a stomach contents sample was empty of very small food items (e.g., zooplankton or insect parts) in the field without the aid of a microscope. Further, some samples that appeared to contain food in the field actually contained only non-food items such as plant parts and debris. Therefore, field crews did not attempt to determine whether stomach content samples were empty in the field. Instead, stomach contents were collected from the first eight fish per target species and age class that were captured at each sampling site, and all of these samples were analyzed in the laboratory. This variance helped in eliminating uncertainties in sample collection by standardizing the sampling effort and decision process, thus allowing the study crew achieve the study objective. While the approach does present the risk of accepting samples that may consist solely of non-food items, it also prevents the potential to discard viable samples. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.9.1.2. Dry mass measurements

The method of determining the mass of prey items in stomach contents was changed from the method in the Study Plan to improve accuracy and better achieve the study objective. The Study Plan (IP Section 2.8.2) stated that the blotted wet weight of each prey category would be recorded to the nearest 0.1 g using an electronic balance, and a representative subset of prey items in each category would be measured to the nearest millimeter and weighed to the nearest 0.01 g. Instead, the body lengths of intact prey organisms were measured to the nearest millimeter, and the lengths of partially digested prey were estimated based on intact individuals of the same taxon that appeared similar in size. The dry mass of prey organisms was determined from length-weight regression relationships derived from the literature (e.g., Rogers et al. 1976, 1977; Smock 1980; Benke et al. 1999; Johnston and Cunjak 1999; Sabo et al. 2002) and from recent studies of Alaskan stream invertebrates (M. Wipfli, UAF, unpublished data). This change improved the accuracy of diet composition estimates in two ways: 1) by correcting for partial digestion, to estimate the mass of organisms when they were initially consumed, and 2) by eliminating potential bias resulting from differential digestion rates of prey taxa with different amounts of schleritization (e.g., chironomid larvae versus coleopteran adults). This change also standardized the estimation of invertebrate biomass between specimens collected from the environment (e.g., with the Hess sampler) and those collected from fish stomachs (Wipfli 1997). This adjustment therefore increased accuracy, reduced sampling bias, and provided a standard methodology for estimating biomass while achieving the study objective. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

4.10. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River

AEA implemented the methods as described in the Study Plan with no variances. Organic matter is contributed from the terrestrial environment as both fine particulate organic matter (FPOM) and coarse particulate organic matter (CPOM). FPOM includes particles ranging from 0.45 to 1000 µm in size, and can occur in the water column as seston, or be deposited in lotic habitats as fine benthic organic matter (FBOM) (Wallace and Grubaugh 1996). CPOM is defined as any organic particle larger than 1 mm in size (Cummins 1974). In order to quantify the organic matter available in the Susitna River for river productivity, CPOM and FPOM (specifically FBOM) were collected directly from all benthic macroinvertebrate sampling, in Hess and Petite Ponar samples and drift net samples (Objective 2, Section 4.4; Objective 3, Section 4.5). Therefore, 301 Hess samples, 85 Ponar grabs, and 104 drift samples were processed for organic matter content (Tables 4.4-2, 4.5-1, and 4.6-1 through 4.6-3).

To streamline the collection efforts, Hess sampling devices, and sieves used to rinse and retain sample contents from Hess and grab samplers possessed a net mesh size of 250 µm in order to retain CPOM particles and FBOM in the 250–1,000 µm size range for analysis. All organic debris collected within each Hess and grab sample was retained with the sample and preserved in 95 percent ethanol. Suspended FPOM (seston) was collected from material in invertebrate drift samples, using drift nets with a 250-μm mesh size in order to retain CPOM particles as well as FBOM in the 250–1,000 μm size range for analysis. All organic debris collected within each drift sample was retained with the sample and preserved with 95 percent ethanol.

Processing of benthic macroinvertebrates involved subsampling to acquire a 300-organism fixed-count (±20 percent) subsample. All invertebrates were removed from debris with the aid of a dissecting microscope (7-45x), and sorted debris was retained in a labeled, 60-ml (2 oz) bottle and stored for later for QA/QC assessment and, for Hess samples, organic matter analysis. Organic matter retained from subsampling after organism sorting and processing was separated from inorganic material, rinsed through 1-mm and 250-μm nested sieves, to separate CPOM and FPOM components of the detritus, oven-dried (60°C [140°F]), and weighed. Dried components were combusted and reweighed to determine ash free dry mass (AFDM) weights.

4.10.1. Variances

No variances from the methods described in the Study Plan (IP Section 2.4, and April 1 SPD [B-189])occurred during the 2013 study season.

4.11. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna River Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

AEA implemented the methods as described in the Study Plan with the exception of variances explained below (Section 4.11.1).

In order to assess the influences of turbidity and temperature on the benthic community colonization rates, the first year of a two-year field study was conducted in 2013 to estimate potential benthic macroinvertebrate colonization rates for four different habitat types that reflect these conditions in the Susitna River. Due to the difficulty of isolating each of these conditions under natural conditions, colonization was examined under turbid/warm, clear/warm, turbid/cold, clear/cold conditions. "Warm" temperatures were defined as 13°C or higher, and "cold" temperatures were less than 13°C. Four sampling locations reflecting these condition combinations were established in FA-104 (Whiskers Slough) (Figure 4.2-4), following a review of 2012 study results, and from consulting with crews from the Instream Flow Study (Study 8.5), who had surveyed multiple Focus Areas in the Middle Segment, for possible candidate sites with clear/cold and turbid/cold conditions. The clear/warm site (RP-HD-1) was established in Whiskers Slough, downstream of Whiskers Creek (Figure 4.2-4; Appendix B, Figure B-5). The clear/cold site (RP-HD-2) was located in Whiskers Slough near the head, in proximity to side slough site RP-104-2 (Figure 4.2-4; Appendix B, Figure B-6). The turbid/cold site (RP-HD-3) was located at the upstream end of the side channel site RP-104-5, near the outflow of a small side slough, where colder water seeped out into the more turbid waters of the main channel (Figure 4.2-4; Appendix B, Figures B-9 and B-10). The turbid/warm site, RP-HD-4 was established upstream of FA-104 (Whiskers Slough) along the shoreline of a side channel (Figure 4.2-4; Appendix B, Figure B-10).

Sets of three Hester-Dendy multiplate samplers (Figure 4.4-1) were deployed incrementally for set periods of colonization time (e.g., 8, 6, 4, 2, and 1 week[s]), beginning on August 1 and 2, 2013, and then pulled simultaneously at the conclusion of the colonization period (September 20, 21, and 27, 2013) (Table 4.11-1). Hester-Dendy sets were deployed at two depths (1 ft and 2 ft) at fixed sites along the channel bed (Table 4.11-2). The location, depth, velocity (both 60 percent of depth and near-bed measurements), PAR levels, and turbidity were measured both during the deployments of each set, as well as during the retrievals.

Many samplers located at sites in main channel macrohabitats (RP-HD-3 and -4) were subjected to fluctuating water levels, and were exposed for short periods of time during the 8-week test run (Table 4.11-2). Flows rapidly declined during the last two weeks of the test run, resulting in large amounts of sediment deposited at RP-HD-3, both burying and exposing all samplers at that site (Figure 4.11-1). All samplers at RP-HD-3 were retrieved on September 20, 2013; to prevent additional losses due to dewatering, all sampler sets were retrieved from RP-HD-4 the following day, cutting the exposure times short by one week (Table 4.11-3). The clear water colonization test sites located in Whiskers Slough did not experience water level reductions as severe, and the final 1-week sampler sets were successfully deployed and retrieved at those sites (Tables 4.11-1 through 4.11-3).

A total of 105 Hester-Dendy samplers were collected during the 2013 test effort (Table 4.11-2), and were sent to Ecoanlysts, Inc. in Moscow, Idaho for processing. Benthic macroinvertebrate processing protocols are identical to those used in Objective 2 (Section 4.4). Specific details on sampling protocols are provided in the Implementation Plan (R2 2013c).

4.11.1. Variances

The Study Plan stated in IP Section 2.9.1: *"All Hester-Dendy samplers will be pre-conditioned prior to deployment by being placed for 4 weeks in the Susitna River (preferably at a project base camp) and then air-dried."* Due to manufacturing time and shipping time, the order of 120 Hester-Dendy samplers arrived shortly before the time at which the first sets, which remained in the river for eight weeks, needed to be deployed. As such, Hester-Dendy samplers were not pre-conditioned prior to their deployment. Pre-conditioning of the substrates may have better simulated the conditions of natural substrates in the shoreline areas, which are often inundated and then exposed, but may still exhibit desiccated organic layers of an epilithic film, which would encourage initial colonization (Mackay 1992). As a result, colonization rates during initial weeks of deployment may experience lower colonization rates, as epilithic growth develops, which may occur in the first two weeks (Osborne 1983). However, as time accrues, colonization rates may reach equilibrium, resulting in little difference in colonization in later periods (6 and 8 weeks). By introducing new, clean, and bare substrates at all stages of the experiment, all Hester-Dendy samplers were standardized, both in the surface areas each provided and it the condition in which it was introduced to the river for a start point in colonization. So, while results from the colonization periods of shorter duration may be underestimated in comparison to natural substrates, all Hester-Dendy samplers would display equal base colonization conditions, differing only in the factors of temperature, turbidity, depth, and velocity that would affect colonization rates. Therefore, the lack of preconditioning would not prevent an assessment the influences of turbidity and temperature on the benthic community colonization rates. This variance will be incorporated into the River Productivity Study sampling efforts in the next year of study, to allow for comparability with 2013 efforts.

5. RESULTS

5.1. Synthesize existing literature on the impacts of hydropower development and operations (including temperature and turbidity) on benthic macroinvertebrate and algal communities.

This synthesis document was completed and is included in Appendix A.

5.2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Lower Susitna River.

Benthic samples collected during the three index events in 2013 were comprised of 271 Hess samples, 155 LWD (snag) samples, 70 petite Ponar grab samples, and 45 adult emergence traps. These samples were successfully transported to the contracted taxonomic laboratory in 2013, and results are pending, upon completion of processing.

Benthic algae samples collected during the three index events in 2013 were comprised of 309 composite algae samples. These samples were successfully transported to the contracted taxonomic laboratory in 2013, which tested samples to determine chlorophyll-*a* and ash free dry mass (AFDM) values. Laboratory test results were used to calculate the average chlorophyll-a (mg/m^2) and ADFM (g/m^2) for each site for each index event period (Table 5.2-1; Figures 5.2-1 through 5.2-10).

Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr (ISR_9_8_RIVPRO_AlgaeLabResults). Overall chlorophyll-*a* levels sampled in 2013 ranged from an average of 0.04 mg/m^2 (near the minimum detectable testing level) at main channel sites RP-184-3 and RP-81-3 during summer and fall index events, to 65.7mg/m^2 at side slough site RP-104-2 during the fall index event (Table 5.2-1). Estimates of AFDM ranged from an average of 0.13 g/m^2 at main channel site RP-104-3 during the spring index event, to 17.89 g/m^2 at the side channel site RP-173-3 during the summer index event. In general, chlorophyll-*a* and AFDM estimates were lower in mainstem macrohabitats than in other macrohabitat types, especially off-channel habitats (side sloughs, upland sloughs) (Figures 5.2-3 through 5.2-10).

5.3. Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Lower Susitna River to assess food availability to juvenile and resident fishes.

Drift samples collected during the three index events in 2013 were comprised of 92 drift samples, and 85 plankton tow samples. These samples were successfully transported to the contracted taxonomic laboratory in 2013, and results are pending completion of processing.

5.4. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.

Benthic and drift samples were collected from three sampling sites established in the Talkeetna River, in conjunction with sampling during the three index event periods in 2013 at the 20 Susitna River study sites. A total of 30 Hess samples, 15 Ponar grab samples, 45 composite algae samples, 12 drift samples, and 10 plankton tows were collected from the Talkeetna sites. Benthic macroinvertebrate samples were successfully transported to the contracted taxonomic laboratory in 2013, and results are pending completion of processing.

Composite algae samples were successfully transported to the contracted taxonomic laboratory in 2013, which tested samples to determine chlorophyll-*a* and AFDM values. Laboratory test results were used to calculate the average chlorophyll-a (mg/m^2) and ADFM (g/m^2) for each site for each index event period (Table 5.2-1; Figures 5.2-11 and 5.2-12). Data developed in support of the ISR is available for download at http://gis.suhydro.org/reports/isr (ISR_9_8_RIVPRO_AlgaeLabResults). Chlorophyll-*a* levels ranged from an average of 0.39 mg/m^2 at side channel site RP-TKA-1 during the fall index event, to 81.3 mg/m^2 at side slough site RP-TKA-3 also during the fall index event (Table 5.2-1; Figure 5.2-11). Estimates of AFDM ranged from an average of 0.64 g/m^2 at side channel site RP-TKA-1 during the fall index event, to 19.2 g/m^2 at side slough site RP-TKA-3 also during the fall index event (Figure 5.2-12).

Fall index event estimates for AFDM at the upland slough site RP-TKA-2 averaged 242.6 g/m^2, a large departure from Susitna River algal test results. The preferred epilithic and epidendric substrates were not present at RP-TKA-2 during the fall index event for sampling chlorophyll-a and AFDM; therefore, composite samples were taken from the soft bottom substrate with the algae delimiter. High organic matter content in the sampled sediments would explain the high AFDM estimates at this site. In general, chlorophyll-*a* and AFDM estimates were higher at the side slough site than in the side channel and upland slough sites (Figures 5.2-11 and 5.2-12).

5.5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Lower Susitna River.

The trophic modeling analysis was initiated during the fourth quarter of 2013. However, the model requires inputs in addition to the data collected by River Productivity field teams. The additional model inputs include: fish movement data from the Fish Distribution and Abundance in the Lower and Middle Susitna River Study (ISR Study 9.6), fish stomach content and scale aging analyses, temperature logging data, and drift sample results. The trophic modeling analysis will proceed as soon as the necessary field data and laboratory data become available.

In 2013, tissue samples were collected for stable isotope analysis (SIA) from multiple study components, including benthic macroinvertebrates, benthic algae, benthic organic matter, invertebrates and organic matter in drift samples, salmon carcasses, and fin clips from fish (Table 4.7-1). Most sample components were processed and submitted for analysis in an isotope-ratio mass spectrometer at the Alaska Stable Isotope Facility at UAF. Additional SIA testing on emergent adult insects is pending completion of processing of emergent trap samples by the contracted taxonomic laboratory, and transport to UAF for testing.

5.6. Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.

Depth, velocity, and substrate composition measurements were taken in conjunction with Hess samples, LWD (“snags”) samples, and composite algae samples collected in 2013 (Section 5.2). Corresponding benthic macroinvertebrate results required for HSC/HSI development are pending completion of processing by the contracted taxonomic laboratory.

5.7. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).

The juvenile Chinook salmon, juvenile coho salmon, and rainbow trout sampled in this study consumed a wide variety of prey items, including benthic macroinvertebrates, terrestrial invertebrates, zooplankton, salmon eggs, and small fish. Detailed analysis and summary of the stomach content data is ongoing.

5.8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Lower Susitna River.

Organic matter samples were successfully transported to the contracted taxonomic laboratory in 2013. Organic matter results are pending completion of processing.

5.9. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

Hester-Dendy samples were successfully transported to the contracted taxonomic laboratory in 2013, and results are pending completion of processing.

6. DISCUSSION

At the time of writing this ISR, the River Productivity Study had not yet received the laboratory results from a majority of the samples collected in 2013. One component, benthic algae sampling, has been fully processed by the analytical laboratory, and results were available for inclusion in this report. All samples collected at all sites during each of the three sampling index events have corresponding results of chlorophyll-a and AFDM values, and that collection effort has been determined as complete and adequate for 2013. However, the results for Hess samples, Ponar Grab samples, LWD (“snag”) samples, emergence trap samples, drift net samples, plankton tow samples, the organic matter components of benthic samples, and Hester-Dendy samples for colonization study are all pending completion of their processing by the taxonomic laboratory. Processing is scheduled for completion by April 2014.

As such, the adequacy of data collection in 2013 cannot be fully assessed until results from the samples are received in 2014, and data analyses are conducted thereafter. Independent of sample results, three study objectives have been identified as having sampling deficiencies, or gaps in data collection in 2013: emergence trap sampling (Section 4.4), fish collection for stomach contents (Section 4.9), and Hester-Dendy sampling for colonization (Section 4.11).

The Study Plan states that “Adult aquatic insect emergence mass is a product of aquatic insect production from the stream, and is therefore a good surrogate for actual production. To measure insect emergence, floating emergence trap samplers will be deployed, with one trap per site” (IP Section 2.6). Collection efforts in 2013 found that the traps were prone to damage from wildlife, and were stranded on shorelines due to rapid changes in flow levels or from disturbances by boating activities (Section 4.4.1.). Due to the prolonged set times of approximately two weeks, the exact timing occurrence of a disturbance within that period was unknown, making any sample data that could be retrieved from the trap bottle qualitative, since the total sampling time was in question. To resolve this concern, emergence trap methods should be reviewed and refined for efforts in the next year of study. At a minimum, trap designs and deployment methods should be modified to better withstand flow and stage changes. In previous Alaskan studies, emergence traps have been deployed on smaller streams or water bodies with lower flow velocities. A review of the 2013 results when they are received from the processing laboratory in 2014, should provide additional information about the efficiency of the traps for collecting emerging adult insects from specific macrohabitat sites with higher velocities, namely the mainstem sites.

Fish collections for stomach contents, scales, and stable isotopes are required by the Study Plan, as detailed in RSP Section 9.8.4.11 and IP Sections 2.7, 2.8, and 2.11. The fish collection methods and scheduled sampling efforts in 2013 were coordinated with the Fish Distribution and Abundance in the Middle and Lower Susitna River Study (Study 9.6). The River Productivity Study protocol required that fish collections be conducted in the same macrohabitat site locations, and within one week of the River Productivity index events. Initial sampling coordination for the spring index event did not meet these requirements, due to distinct gaps in sampling schedules and the ongoing establishment and definition of study sampling locations that would overlap between the two studies. As a result, fish collections for River Productivity Study needs were missed at six out of 20 sites during the spring index event. In response, the River Productivity Study crew scheduled the summer and fall index event sampling in coordination with ISR Study 9.6 fish collection efforts to help ensure samples were collected within a week of each other. The River Productivity Study crew also increased its efforts by supplementing fish collection with baited minnow traps at selected sites during the spring and summer index events, and at all sites during the fall index event (Tables 4.9-2 through 4.9-4).

The River Productivity Study conducted all fish collections at study station RP-81 (Montana Creek) in the Lower Susitna River. Originally established in conjunction with anticipated Fish

Distribution and Abundance sampling activities on the Lower Susitna River around the Montana Creek mouth area (Section 4.2.4.1.), lack of land access prevented the deployment of a rotary screw trap near the creek mouth, and the trap was located 2.2 miles upstream in Montana Creek (ISR Study 9.6, Section 4.1.7.2). This prevented the use of fish from the trap for ISR 9.8 fish samples. As a result, the River Productivity crew deployed minnow traps at all sites except the split main channel site, where they would have been less effective in the higher velocities.

Numbers of fish collected in 2013 were lower than expected; FDA efforts at several of the River Productivity sites did not capture juvenile salmonids. Sampling at FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) did not capture any of the targeted species/lifestages, and sampling efforts in the main channel macrohabitat sites produced limited results as well (Tables 4.9-1 through 4.9-2). Given the gaps in collection coverage in 2013, coordination efforts and fish collection timing and locations requirements will be reviewed and refined for efforts in the next year of the study. River Productivity Study and Fish Distribution study efforts will coordinate schedules pre-field season to maximize both site and scheduling overlaps and facilitate collection of useable target fish. Additional options may include relaxing the collection requirements for timing (within a week's time) and simply matching the macrohabitat type in a Focus Area as opposed to exact site locations. Lastly, no coho salmon or rainbow trout were observed for fish sampling efforts above Devils Canyon in 2012 (HDR 2013) or in 2013 (ISR Study 9.6, Sections 5.1.1.3 and 5.1.1.12). Due to the lack of observations/collections of the target fish species (see also Study 9.6 ISR Section 5.1.2), the feasibility of collecting sufficient numbers of target species at FA-173 (Stephan Lake Complex) and FA-184 (Watana Dam) will be revisited and a decision will be made as to eliminate these sites from the models or utilize a different target species at these locations for ISR 9.8 models.

Benthic macroinvertebrate colonization rates were examined in 2013 using an experimental design to determine the effect of turbidity and temperature on colonization. The Study Plan states in RSP Section 9.8.4.9 that , "In order to assess the influences of turbidity and temperature on the benthic community colonization rates, a field study will be conducted for both study years. The field study was to estimate potential benthic macroinvertebrate colonization rates for four different habitat types that reflect these conditions in the Susitna River." The four sites established for this experiment required different levels of turbidity (clear or turbid), temperature (cool or warm), and depth (1- and 2- foot depth). Controlling for all three of these factors affected the occurrence of other confounding factors, velocity and substrate, that are equally, if not more, important to colonization. The site that required cool and clear waters was located in the side slough habitat, where upwelling ground waters supplied those conditions, but the habitat itself was a low velocity pool, with a cobble bottom that was layered in fine sediments. Sites with higher velocities were often lacking in depths of over 1 foot, and were therefore unsuitable for the required parameters. Due to the number of confounding factors involved, it may be difficult to isolate differences in colonization rates to different temperature and turbidity conditions. Colonization sampling sites established in 2013 were essentially placed at three of the five sampling sites established by the River Productivity Study for benthic and drift sampling (Figure 4.2-4.), sampling main channel, side channel, side slough above tributary mouth influence, and side slough below tributary mouth influence habitats. Therefore, a modification is proposed to investigate the overall differences in colonization rates and compositions between the five macrohabitat types within River Productivity sites in the next year of the study.

7. COMPLETING THE STUDY

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

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9. TABLES

Table 4.2-1. Locations and descriptions of Focus Areas selected as sampling stations for the River Productivity study in the Lower and Middle River Segments of the Susitna River. "X" indicates site established at that habitat type, "(x)" indicates no site established at that habitat type.

Focus Area ID / RivProd ID [1]	Common Name	River Productivity Study Use	Description	Geomorphic Reach	Location (PRM)		Area Length (mi)	Habitat Types Present						Additional Sampling	
					Upstream	Downstream		Main Channel	Side Channel	Tributary Mouth	Side Slough	Upland Slough	Beaver Complex	Stable Isotopes	Colonization Study
Focus Area-184	Watana Dam	Study Station (3 sites)	Area approximately 1.4 miles downstream of dam site	MR-1	185.7	184.7	1.0	X	X	X				X	
Focus Area-173	Stephan Lake, Complex Channel	Study Station (4 sites), Storm Event Site	Wide channel near Stephan Lake with complex of side channels	MR-2	175.4	173.6	1.8	X	X	X	X	(x)[2]			
Focus Area-141	Indian River	Study Station (4 sites)	Area covering Indian River and upstream channel complex	MR-6	143.4	141.8	1.6	X	X	X		X	(x)	X	
Focus Area-104	Whiskers Slough	Study Station (5 sites), Storm Event Site	Whiskers Slough Complex	MR-8	106.0	104.8	1.2	X	X	X[3]	X	X		X	X
RP-81	Montana Creek Area	Study Station (4 sites)	Area nearby the mouth of Montana Creek	LR-2	82	81	1.0	X	X	X	X	X	(x)	X	
TKA	Talkeetna River	Reference Station (3 sites)	Talkeetna River, above the Clear Creek confluence	N/A	9.3	8.5	0.8	(x)	X		X	X	(x)		

<u>Notes:</u>

1 Focus Area identification numbers (e.g., Focus Area 184) represent the truncated Project River Mile (PRM) at the downstream end of each Focus Area.

2 Upland Slough on CIRI lands, considered non-navigable waters, and access not permitted

3 Tributary Mouth macrohabitat too limited for index event sampling activities; sampling conducted in side slough immediately below the mouth.

Table 4.4-1. Sampling Stations and Seasonal Sampling Event dates of collection for the River Productivity study in the Lower and Middle River Segments of the Susitna River, and the Talkeetna River.

	Seasonal Sampling Event		
Station	**Spring 2013**	**Summer 2013**	**Fall 2013**
FA-184 (Watana Dam)	7/12 – 7/13	8/20 – 8/21	9/22
FA-173 (Stephan Lake Complex)	7/9 – 7/11	8/19 – 8/20	9/23 – 9/24
FA-141 (Indian River)	6/25 – 6/27	8/17 – 8/18	9/25 – 9/26
FA-104(Whiskers Slough)	6/19 – 6/23	8/12 – 8/13, 8/16	9/28 – 9/30
RP-81 (Montana Creek)	6/29 – 7/1	8/14 – 8/15	10/1 – 10/2
TKA (Talkeetna Reference)	7/17 – 7/18	8/29	10/3

Table 4.4-2. Benthic macroinvertebrate sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) and Post-Storm sampling for sites in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

		Hess Samples					Ponar Grab Samples					LWD (Snag) Samples				
Site	Macrohabitat Type	Spr	Sum	Fall	Post-Storm	Total	Spr	Sum	Fall	Post-Storm	Total	Spr	Sum	Fall	Post-Storm	Total
RP-184-1	Tributary Mouth	5	5	5		15						5	2	3		10
RP-184-2	Side Channel	5	5	5		15							1			1
RP-184-3	Main Channel	5	5	5		15										
RP-173-1	Tributary Mouth	5	5	5		15						2	3	1		6
RP-173-2	Main Channel	5	5	5		15										
RP-173-3	Side Channel	5	5	5		15							3			3
RP-173-4	Side Slough	5	5	2	5	17	5	5	5	5	20	1	2	5		8
RP-141-1	Tributary Mouth	5	5	5		15						3	5	5		13
RP-141-2	Side Channel	5	5			10			5		5		5	1		6
RP-141-3	Mult Split Main Channel	5	5	5		15										
RP-141-4	Upland Slough	5	4	3		12	5	5	5		15	3	4	5		12
RP-104-1	Side Slough	5	5	5		15						2	5	5		12
RP-104-2	Side Slough	5	5	2	5	17			5		5	3	5	5	5	18
RP-104-3	Main Channel	5	5	5		15										
RP-104-4	Upland Slough						5	5	5		15	5	5	3		13
RP-104-5	Side Channel	5	5	5		15						2		5		7
RP-81-1	Upland Slough			5		5	5	5			10	5	2	5		12
RP-81-2	Tributary Mouth	5	5	5		15						5	5	5		15
RP-81-3	Split Main Channel	5	5	5		15							2	2		4
RP-81-4	Side Channel	5	5	5		15						5	5	5		15
	Totals	90	89	82	10	**271**	20	20	25	5	**70**	41	54	55	5	**155**

Table 4.4-3. Adult emergence traps deployment locations with install and removal dates, and count of number of collection visits with the number of successful samples collected in2013.

Station	Site	Install Date	Removal Date	Number of Collection Visits	Number of Samples Collected
RP- 81	RP-81-1	7/1/2013	10/1/2013	4	3
(Montana Creek)	RP-81-2	6/30/2013	10/1/2013	4	1
	RP-81-3	6/29/2013	10/3/2013	4	4
	RP-81-4	6/30/2013	10/3/2013	4	3
FA-104	RP-104-1	6/23/2013	9/27/2013	4	4
(Whiskers Slough)	RP-104-2	6/19/2013	9/27/2013	4	3
	RP-104-3	6/21/2013	9/30/2013	4	4
	RP-104-4	6/23/2013	9/28/2013	4	4
	RP-104-5	6/21/2013	9/28/2013	4	2
FA-141	RP-141-1	6/25/2013	9/25/2013	3	1
(Indian River)	RP-141-2	6/25/2013	9/26/2013	3	2
	RP-141-3	6/27/2013	9/25/2013	3	1
	RP-141-4	6/27/2013	9/26/2013	3	1
FA-173	RP-173-1	7/11/2013	9/23/2013	3	2
(Stephan Lake Complex)	RP-173-2	7/29/2013	9/23/2013	2	2
	RP-173-3	7/11/2013	9/23/2013	2	1
	RP-173-4	7/10/2013	9/24/2013	3	2
FA-184	RP-184-1	7/13/2013	9/22/2013	3	2
(Watana Dam)	RP-184-3	7/12/2013	9/22/2013	3	3
			Totals	**64**	**45**

Table 4.4-4. Composite algae sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) and Post-Storm sampling for sites in the Middle and Lower River Segments of the Susitna River, and Talkeetna (TKA) River for the River Productivity Study.

Site	Macrohabitat Type	Composite Algae Samples				
		Spr	**Sum**	**Fall**	**Post-Storm**	**Total**
RP-184-1	Tributary Mouth	5	4	5		14
RP-184-2	Side Channel	5	5	5		15
RP-184-3	Main Channel	5	5	5		15
RP-173-1	Tributary Mouth	5	5	5		15
RP-173-2	Main Channel	5	5	5		15
RP-173-3	Side Channel	5	5	5		15
RP-173-4	Side Slough	5	5	5	5	20
RP-141-1	Tributary Mouth	5	5	5		15
RP-141-2	Side Channel	5	5	5		15
RP-141-3	Mult Split Main Channel	5	5	5		15
RP-141-4	Upland Slough	5	5	5		15
RP-104-1	Side Slough	5	5	5		15
RP-104-2	Side Slough	5	5	5	5	20
RP-104-3	Main Channel	5	5	5		15
RP-104-4	Upland Slough	5	5	5		15
RP-104-5	Side Channel	5	5	5		15
RP-81-1	Upland Slough	5	5	5		15
RP-81-2	Tributary Mouth	5	5	5		15
RP-81-3	Split Main Channel	5	5	5		15
RP-81-4	Side Channel	5	5	5		15
	Totals	100	99	100	10	**309**

Table 4.5-1. Benthic drift and plankton tow sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) and Post-Storm for sampling sites in the Middle and Lower River Segments of the Susitna River, and Talkeetna (TKA) River for the River Productivity Study.

Site	Macrohabitat Type	Drift Samples				Plankton Tow Samples				
		Spr	Sum	Fall	Total	Spr	Sum	Fall	Post-Storm	Total
RP-184-1	Tributary Mouth	2	2	2	6					
RP-184-2	Side Channel	2	2	2	6					
RP-184-3	Main Channel	2	2	2	6					
RP-173-1	Tributary Mouth	2	2	2	6					
RP-173-2	Main Channel	2	2	2	6					
RP-173-3	Side Channel	2	2		2			5		5
RP-173-4	Side Slough					5	5	5		15
RP-141-1	Tributary Mouth	2	2	2	6					
RP-141-2	Side Channel	2	2	2	6					
RP-141-3	Mult Split Main Channel	2	2		2			5		5
RP-141-4	Upland Slough					5	5	5		15
RP-141-5*	Main Channel		2		2					
RP-104-1	Side Slough	2	2	2	6					
RP-104-2	Side Slough	2			2		5	5	5	15
RP-104-3	Main Channel	2	2	2	6					
RP-104-4	Upland Slough	2			2	5	5	5		15
RP-104-5	Side Channel	2	2		2			5		5
RP-81-1	Upland Slough			2	2	5	5			10
RP-81-2	Tributary Mouth	2	2	2	6					
RP-81-3	Split Main Channel	2	2	2	6					
RP-81-4	Side Channel	2	2	2	6					
RP-81-5*	Side Channel	2	2	2	6					
	Totals	36	34	28	**92**	20	25	35	5	**85**

Table 4.6-1. Benthic macroinvertebrate sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) for sites in the Talkeetna River (TKA) for the River Productivity Study.

Site	Macro-habitat Type	Hess Samples				Ponar Grab Samples			
		Spring	Summer	Fall	Total	Spring	Summer	Fall	Total
RP-TKA-1	Side Channel	5	5	5	15				
RP-TKA-2	Upland Slough					5	5	5	15
RP-TKA-3	Side Slough	5	5	5	15				
	Totals:	10	10	10	**30**	5	5	5	**15**

Table 4.6-2. Composite algae sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) for sites in the Talkeetna (TKA) River for the River Productivity Study.

Site	Macro-habitat Type	Algae Samples			
		Spring	Summer	Fall	Total
RP-TKA-1	Side Channel	5	5	5	15
RP-TKA-2	Upland Slough	5	5	5	15
RP-TKA-3	Side Slough	5	5	5	15
	Totals:	15	15	15	**45**

Table 4.6-3. Benthic drift and plankton tow sample totals for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) for sites in the Talkeetna (TKA) River for the River Productivity Study.

Site	Macro-habitat Type	Drift Samples				Plankton Tow Samples			
		Spring	Summer	Fall	Total	Spring	Summer	Fall	Total
RP-TKA-1	Side Channel	2	2	2	6				
RP-TKA-2	Upland Slough						5	5	10
RP-TKA-3	Side Slough	2	2	2	6				
	Totals:	4	4	4	**12**	0	5	5	**10**

Table 4.7-1. Itemized listing of sample components and the maximum potential number of samples possible for collection for Stable Isotope Analysis from the four sampling stations (16 sites total) in each study year in the Middle and Lower River Segments of the Susitna River for the River Productivity Study, and the actual number of samples collected and analyzed in 2013.

Category	Component	Sites	Seasons	Samples	Maximum Potential Number of Samples	Spring	Summer	Fall	Total Number Analyzed (2013)
Endmembers	Benthic Algae	16	3	3	144	45	48	48	*141*
	Organic Matter - benthic	16	3	3	144	45	48	48	*141*
	Organic Matter - drift	16	3	2	96	30	32	32	*94*
	Salmon carcass	-	-	40	40	0	8	6	*14*
Invertebrates	Benthic- grazers	16	3	3	144	48	48	49	*145*
	Benthic- collectors	16	3	3	144	34	33	29	*96*
	Benthic- shredders	16	3	3	144	30	48	39	*117*
	Benthic- predators	16	3	3	144	48	48	35	*131*
	Terrestrial Drift	16	3	2	96	27	36	39	*102*
	Emergents	16	3	1	48	*N/A**	*N/A**	*N/A**	*N/A**
Fish	Chinook salmon - juveniles	16	3	8	384	36	46	21	*103*
	Coho salmon - juveniles	16	3	8	384	25	47	46	*118*
	Rainbow trout - juveniles	16	3	8	384	9	0	0	*9*
	Rainbow trout - adults	16	3	8	384	4	17	10	*31*
				Total	**2,680**	381	459	402	**1242**

* Emergence sample results were not fully processed and enumerated by the reporting cutoff date of October 31, 2013.

Table 4.8-1. Number of Hess, algae, and snag samples collected with associated depth (D), velocity (V), and substrate composition (Sub) measurements for 2013 sampling during three index events (Spr= Spring, Sum=Summer, Fall) in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

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

Table 4.9-1. Itemized listing of the maximum potential number of fish gut content samples possible for collection for the River Productivity Study in each study year, and the number of actual samples collected and analyzed in 2013.

Target Species / Lifestage	Sites	Seasons	Samples	Maximum Potential Number of Samples	Total Number Analyzed
Chinook salmon - juveniles	20	3	8	480	103
Coho salmon - juveniles	20	3	8	480	117
Rainbow trout - juveniles	20	3	8	480	9
Rainbow trout - adults	20	3	8	480	31
			Total	1,920	260

Table 4.9-2. Number of fish collected for fish gut content, scales, and stable isotope tissue samples during the Spring Index Event for each target species / age class from each sampling site in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

Station	Sampling site	Habitat Type	Sampled By		Juvenile Chinook	Juvenile Coho	Juvenile Rainbow	Adult Rainbow
			FDA	RivPro				
					Spring Totals			
FA-184 (Watana Dam)	RP-184-1	Tributary Mouth		Y	0	0	0	0
	RP-184-2	Side Channel	Y	Y	0	0	0	0
	RP-184-3	Main Channel	Y		0	0	0	0
FA-173 (Stephan Lake Complex)	RP-173-1	Tributary Mouth	Y	Y	0	0	0	0
	RP-173-2	Main Channel	Y		0	0	0	0
	RP-173-3	Side Channel	Y	Y	0	0	0	0
	RP-173-4	Side Slough	Y	Y	0	0	0	0
FA-141 (Indian River)	RP-141-1	Tributary Mouth	Y		8	8	0	1
	RP-141-2	Side Channel			-	-	-	-
	RP-141-3	Mult Split Main Channel	Y		0	0	0	0
	RP-141-4	Upland Slough			-	-	-	-
FA-104 (Whiskers Slough)	RP-104-1	Side Slough	Y		8	0	0	3
	RP-104-2	Side Slough	Y		-	-	-	-
	RP-104-3	Main Channel	Y		0	0	0	0
	RP-104-4	Upland Slough	Y		-	-	-	-
	RP-104-5	Side Channel	Y		-	-	-	-
RP- 81 (Montana Creek)	RP-81-1	Upland Slough		Y	8	8	0	0
	RP-81-2	Tributary Mouth		Y	12	8*	9	0
	RP-81-3	Split Main Channel			-	-	-	-
	RP-81-4	Side Channel		Y	0	0	0	0
	Spring Totals				**36**	**24**	**9**	**4**

* One additional fish was collected for stable isotope tissues.

Table 4.9-3. Number of fish collected for fish gut content, scales, and stable isotope tissue samples during the Summer Index Event for each target species / age class from each sampling site in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

Station	Sampling site	Habitat Type	Sampled By		Juvenile Chinook	Juvenile Coho	Juvenile Rainbow	Adult Rainbow
			FDA	RivPro				
					Summer Totals			
FA-184 (Watana Dam)	RP-184-1	Tributary Mouth	Y	Y	0	0	0	0
	RP-184-2	Side Channel	Y	Y	0	0	0	0
	RP-184-3	Main Channel	Y		0	0	0	0
FA-173 (Stephan Lake Complex)	RP-173-1	Tributary Mouth	Y	Y	0	0	0	0
	RP-173-2	Main Channel	Y		0	0	0	0
	RP-173-3	Side Channel	Y	Y	0	0	0	0
	RP-173-4	Side Slough	Y	Y	0	0	0	0
FA-141 (Indian River)	RP-141-1	Tributary Mouth	Y		5	8	0	8
	RP-141-2	Side Channel			-	-	-	-
	RP-141-3	Mult Split Main Channel	Y		0	0	0	0
	RP-141-4	Upland Slough	Y*		8	3	0	0
FA-104 (Whiskers Slough)	RP-104-1	Side Slough	Y		8	8	0	0
	RP-104-2	Side Slough	Y		8	9**	0	9
	RP-104-3	Main Channel	Y		0	0	0	0
	RP-104-4	Upland Slough	Y		8	8	0	0
	RP-104-5	Side Channel	Y*		8	8	0	0
RP- 81 (Montana Creek)	RP-81-1	Upland Slough		Y	0	0	0	0
	RP-81-2	Tributary Mouth		Y	1	4	0	0
	RP-81-3	Split Main Channel			-	-	-	-
	RP-81-4	Side Channel		Y	0	0	0	0
	Summer Totals				**46**	**48**	**0**	**17**

* Sampling by the FDA study team covered the same macrohabitat types but different sites than the River Productivity sampling at RP-104 (side channel) and RP-141 (upland slough).
** One less fish was collected for stable isotope tissues.

Table 4.9-4. Number of fish collected for fish gut content, scales, and stable isotope tissue samples during the Fall Index Event for each target species / age class from each sampling site in the Middle and Lower River Segments of the Susitna River for the River Productivity Study.

Station	Sampling site	Habitat Type	Sampled By		Juvenile Chinook	Juvenile Coho	Juvenile Rainbow	Adult Rainbow
			FDA	RivPro				
					Fall Totals			
FA-184 (Watana Dam)	RP-184-1	Tributary Mouth		Y	0	0	0	0
	RP-184-2	Side Channel	Y	Y	0	0	0	0
	RP-184-3	Main Channel	Y	Y	0	0	0	0
FA-173 (Stephan Lake Complex)	RP-173-1	Tributary Mouth	Y	Y	0	0	0	0
	RP-173-2	Main Channel	Y	Y	0	0	0	0
	RP-173-3	Side Channel	Y	Y	0	0	0	0
	RP-173-4	Side Slough	Y	Y	0	0	0	0
FA-141 (Indian River)	RP-141-1	Tributary Mouth	Y	Y	6	8	0	2
	RP-141-2	Side Channel		Y	0	0	0	0
	RP-141-3	Mult Split Main Channel	Y	Y	0	0	0	0
	RP-141-4	Upland Slough		Y	0	1	0	0
FA-104 (Whiskers Slough)	RP-104-1	Side Slough	Y	Y	8	8	0	8
	RP-104-2	Side Slough	Y	Y	2	8	0	0
	RP-104-3	Main Channel	Y	Y	0	0	0	0
	RP-104-4	Upland Slough	Y	Y	1	5**	0	0
	RP-104-5	Side Channel	Y*	Y	3	9	0	0
RP- 81 (Montana Creek)	RP-81-1	Upland Slough		Y	1	4	0	0
	RP-81-2	Tributary Mouth		Y	0	2	0	0
	RP-81-3	Split Main Channel		Y	0	0	0	0
	RP-81-4	Side Channel		Y	0	0	0	0
	Fall Totals				**21**	**45**	**0**	**10**

* Sampling by the FDA study team covered the same macrohabitat type but a different site than the River Productivity sampling at RP-104 (side channel).
** One additional fish was collected for stable isotope tissues.

Table 4.11-1. Colonization study sites in FA-104 (Whiskers Slough), with temperature and turbidity conditions, and deployment and retrieval dates for Hester-Dendy multiplate sampler sets for the five colonization time periods.

Site	Condition	8-Wk	6-Wk	4-Wk	2-Wk	1-Wk	Retrieval Date
RP-HD-1 (Side Slough)	Clear, Warm	8/1/2013	8/16/2013	8/30/2013	9/12/2013	9/20/2013	9/27/2013
RP-HD-2 (Side Slough)	Clear, Cold	8/1/2013	8/16/2013	8/30/2013	9/12/2013	9/20/2013	9/27/2013
RP-HD-3 (Side Channel)	Turbid, Cold	8/2/2013	8/16/2013	8/30/2013	9/12/2013	-	9/20/2013
RP-HD-4 (Side Channel)	Turbid, Warm	8/2/2013	8/16/2013	8/30/2013	9/12/2013	-	9/21/2013

Table 4.11-2. Number of Hester-Dendy multiplate samplers deployed at the four colonization study sites in FA-104 (Whiskers Slough) for the five colonization time periods.

	8-Wk		6-Wk		4-Wk		2-Wk		1-Wk	
Site	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep	Shallow	Deep
RP-HD-1	3	3	2*	3	3	3	3	3	3	3
RP-HD-2	3	3	3	3	3	3	3	3	3	3
RP-HD-3	3**	3**	3**	3**	3**	3**	3**	3**	-	-
RP-HD-4	3	3	3**	3**	3	3	3	3	-	-

* only 2 replicates for the 6-week shallow sampler set because 1 set of sampler plates had come detached from the cinder block & could not be located
** Sampling set were exposed during their deployment for a short period of time.

Table 4.11-3. Actual deployment duration for Hester-Dendy multiplate samplers at the four colonization study sites in FA-104 (Whiskers Slough) for the five colonization time periods.

Site	8-Wk	6-Wk	4-Wk	2-Wk	1-Wk
RP-HD-1	8.1	6	4	2.1	1
RP-HD-2	8.1	6	4	2.1	1
RP-HD-3	7	5	3	1.1	-
RP-HD-4	7.1	5.1	3.1	1.3	-

Table 5.2-1. Mean chlorophyll-a and Ash Free Dry Mass (AFDM) values (n=5) from composite algae samples collected in 2013 during three index events for sites in the Middle and Lower River Segments of the Susitna River, and Talkeetna (TKA) River for the River Productivity Study.

Site	Macrohabitat Type	Chlorophyll-a (mg/m^2)			AFDM (g/m^2)		
		Spring	Summer	Fall	Spring	Summer	Fall
RP-184-1	Tributary Mouth	1.68	0.95	0.61	1.73	0.74	0.62
RP-184-2	Side Channel	0.37	5.76	0.14	1.13	1.30	0.81
RP-184-3	Main Channel	0.74	0.05	0.04	0.52	0.50	0.55
RP-173-1	Tributary Mouth	4.95	9.21	0.20	1.49	4.04	0.42
RP-173-2	Main Channel	0.66	0.06	0.06	0.61	0.30	0.35
RP-173-3	Side Channel	6.86	28.69	41.89	2.87	17.89	12.66
RP-173-4	Side Slough	13.86	14.46	21.14	5.40	13.77	10.18
RP-141-1	Tributary Mouth	0.61	11.22	2.03	0.29	2.17	0.50
RP-141-2	Side Channel	0.82	35.12	1.32	0.91	13.52	2.63
RP-141-3	Multi Split Main Channel	0.32	1.76	0.37	0.39	1.60	0.72
RP-141-4	Upland Slough	5.90	39.02	13.32	4.34	14.16	6.50
RP-104-1	Side Slough	3.77	2.37	46.14	3.92	2.17	11.45
RP-104-2	Side Slough	1.06	16.25	65.73	0.66	11.45	11.46
RP-104-3	Main Channel	0.12	0.20	1.79	0.13	0.46	0.67
RP-104-4	Upland Slough	3.58	3.74	6.02	4.02	5.05	8.98
RP-104-5	Side Channel	0.64	0.28	4.84	0.17	0.31	2.00
RP-81-1	Upland Slough	10.50	1.26	2.46	10.91	13.33	9.80
RP-81-2	Tributary Mouth	3.02	26.36	2.73	1.22	6.45	1.46
RP-81-3	Split Main Channel	0.11	0.04	0.04	0.26	0.28	0.34
RP-81-4	Side Channel	0.27	0.08	0.09	0.51	0.21	0.64
RP-TKA-1	Side Channel	2.90	6.60	0.39	3.54	3.01	0.64
RP-TKA-2	Upland Slough	0.55	5.20	9.41	0.68	6.71	242.64
RP-TKA-3	Side Slough	19.96	24.12	81.26	9.13	8.89	19.18

10. FIGURES

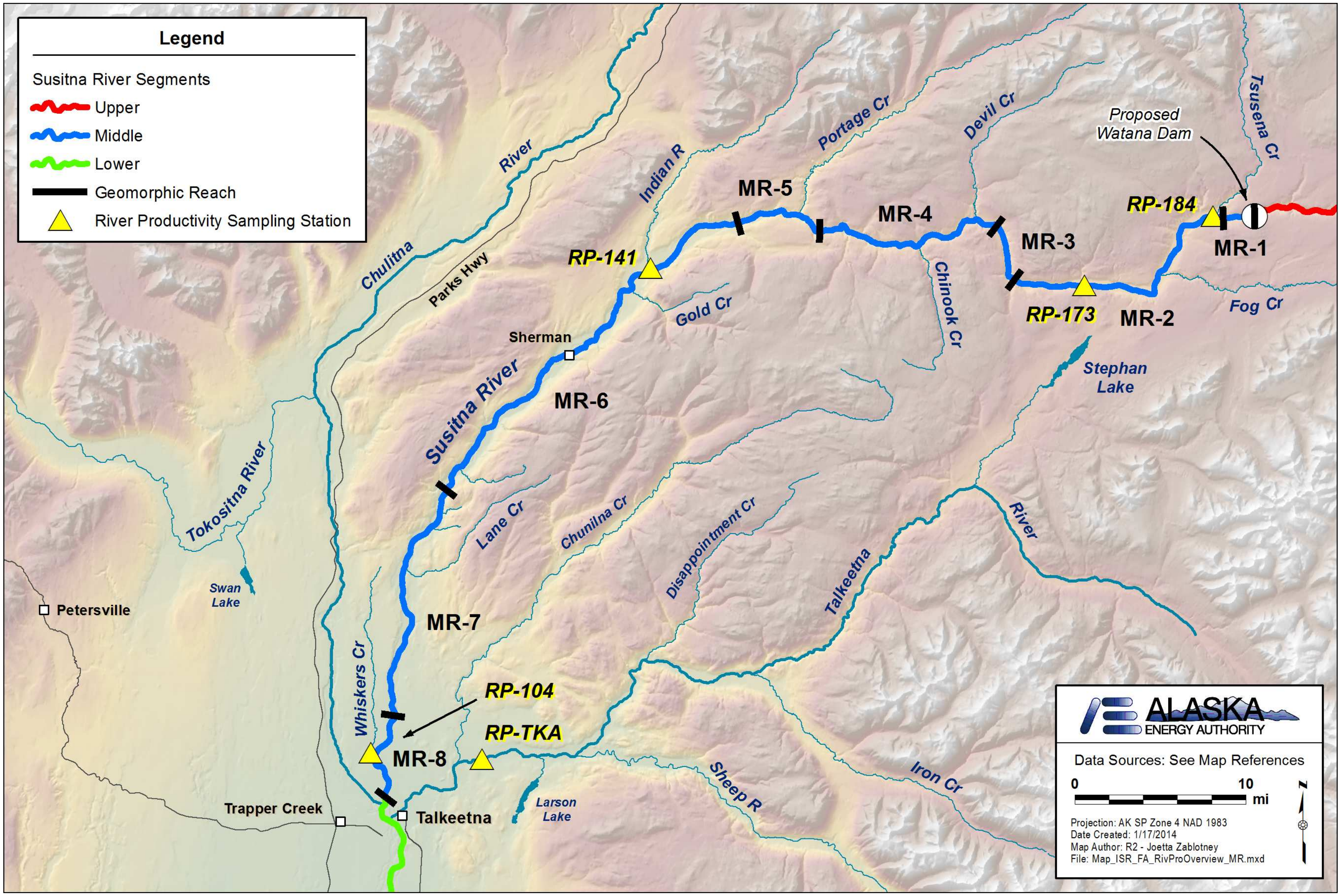

Figure 3-1. Middle Susitna River Segment, with the four River Productivity sampling stations /Instream Flow Focus Areas selected for the River Productivity Study, plus the sampling station for reference sites on the Talkeetna River.

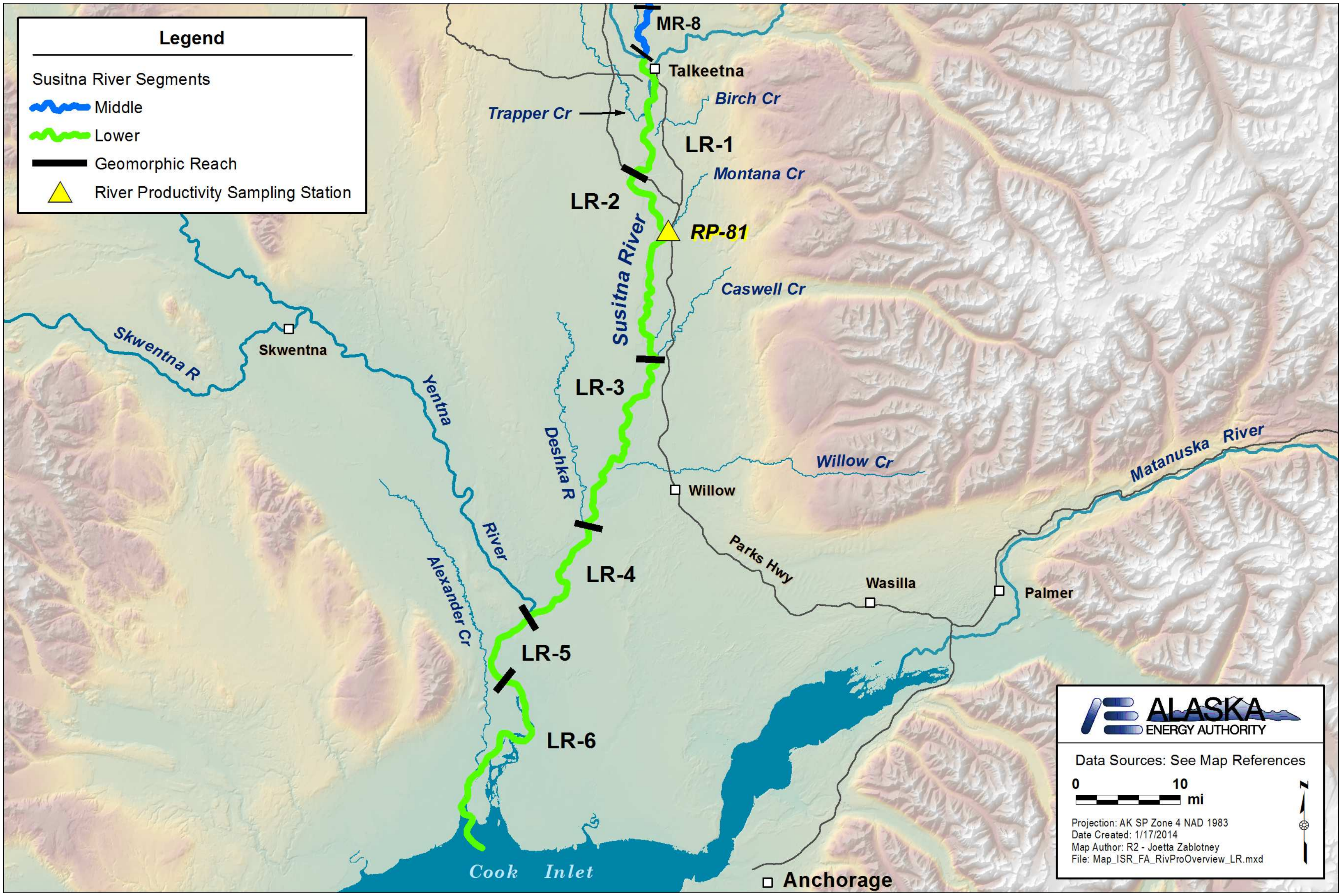

Figure 3-2. Lower Susitna River Segment, with Montana Creek area River Productivity sampling station selected for the River Productivity Study.

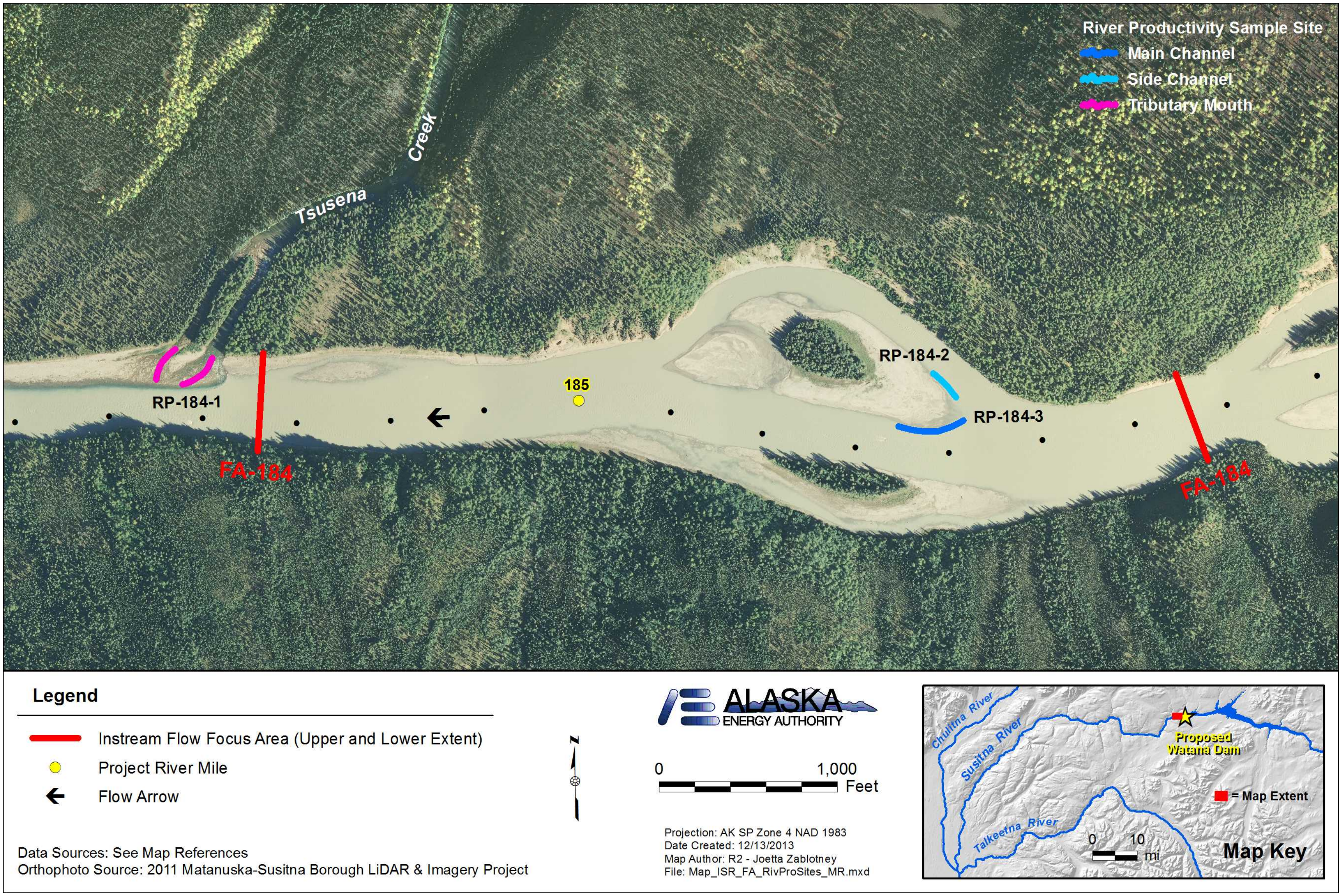

Figure 4.2-1. Focus Area 184 (Watana Dam), and the three River Productivity sampling sites.

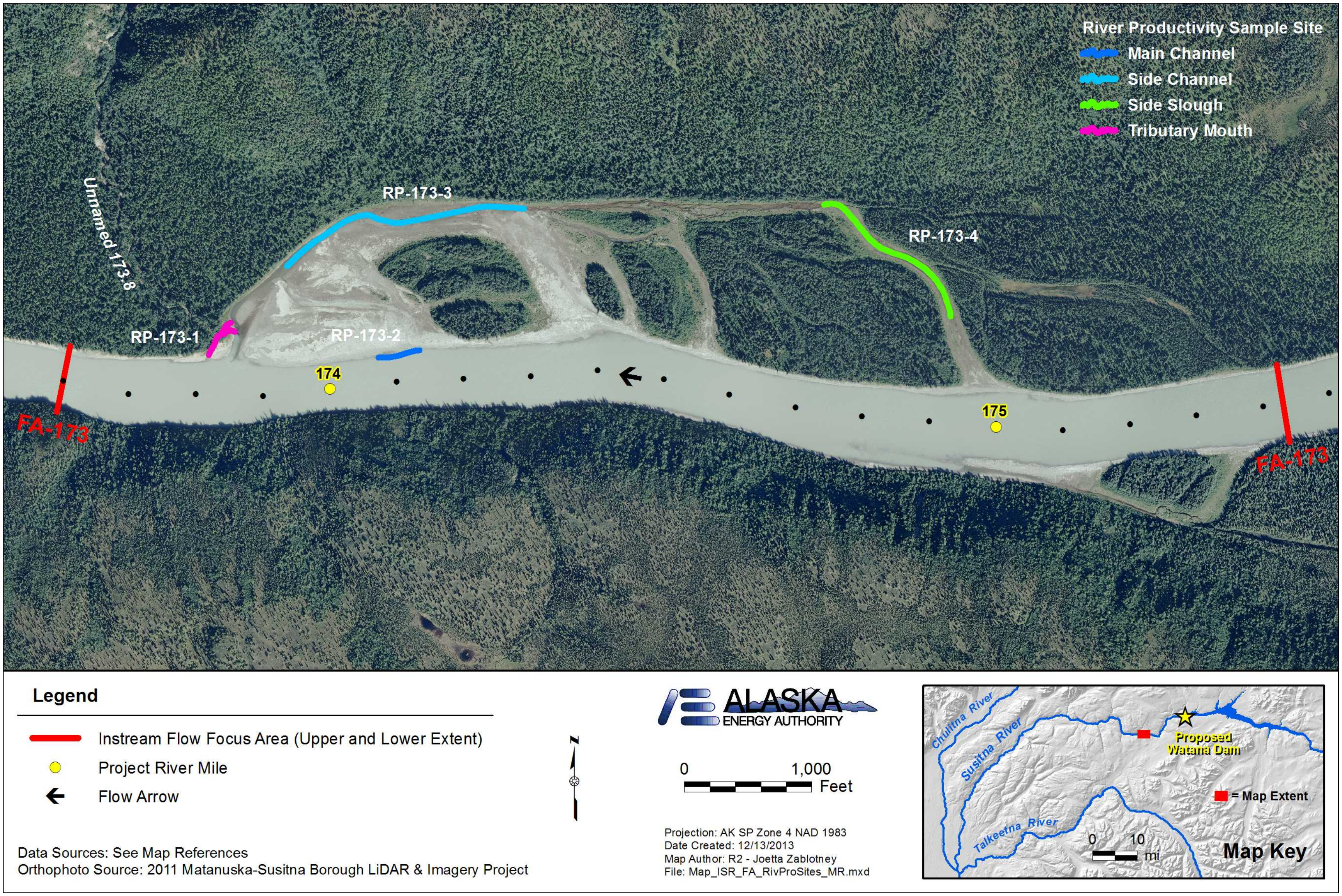

Figure 4.2-2. Focus Area 173 (Stephan Lake Complex), and the four River Productivity sampling sites.

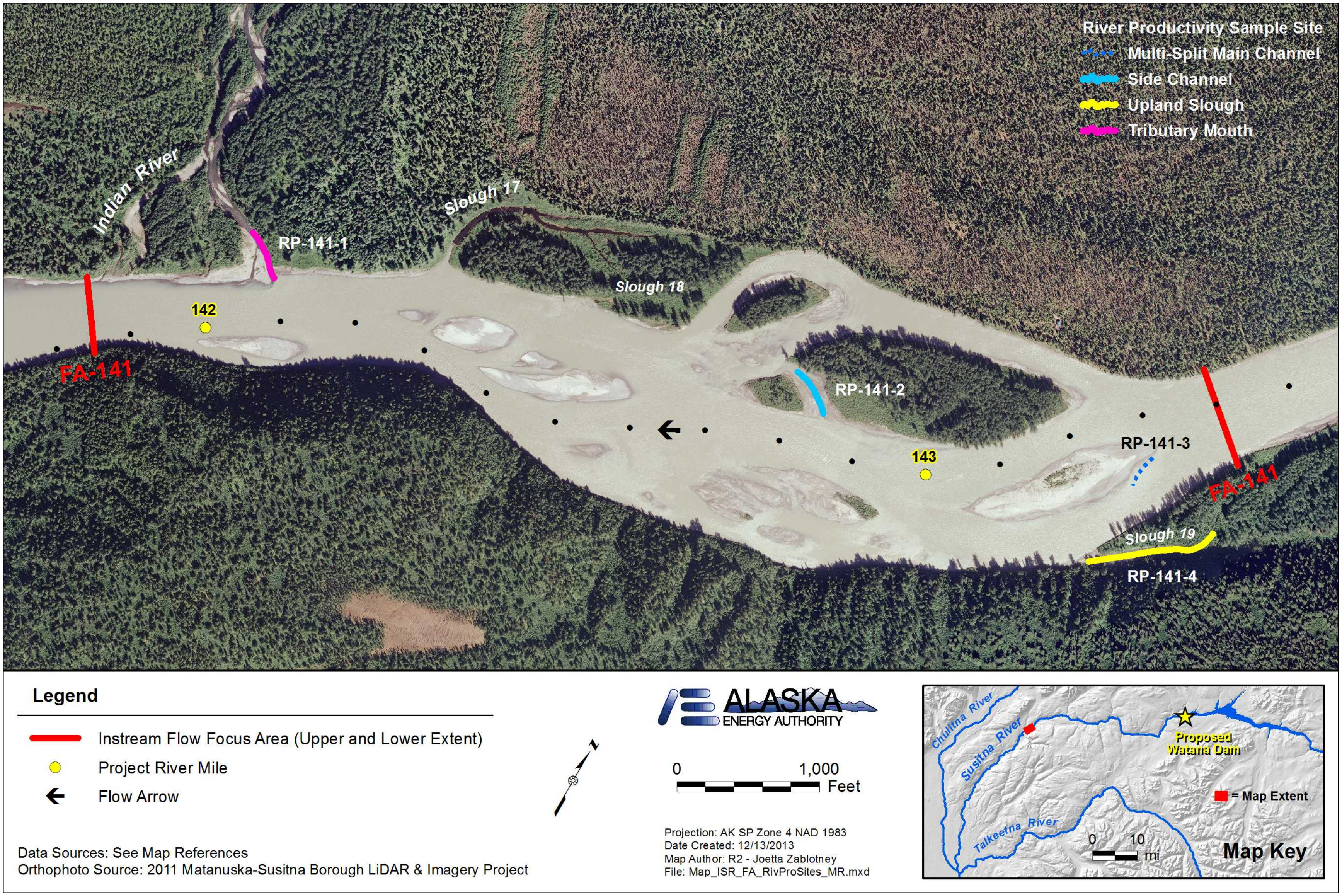

Figure 4.2-3. Focus Area 141 (Indian River), and the four River Productivity sampling sites.

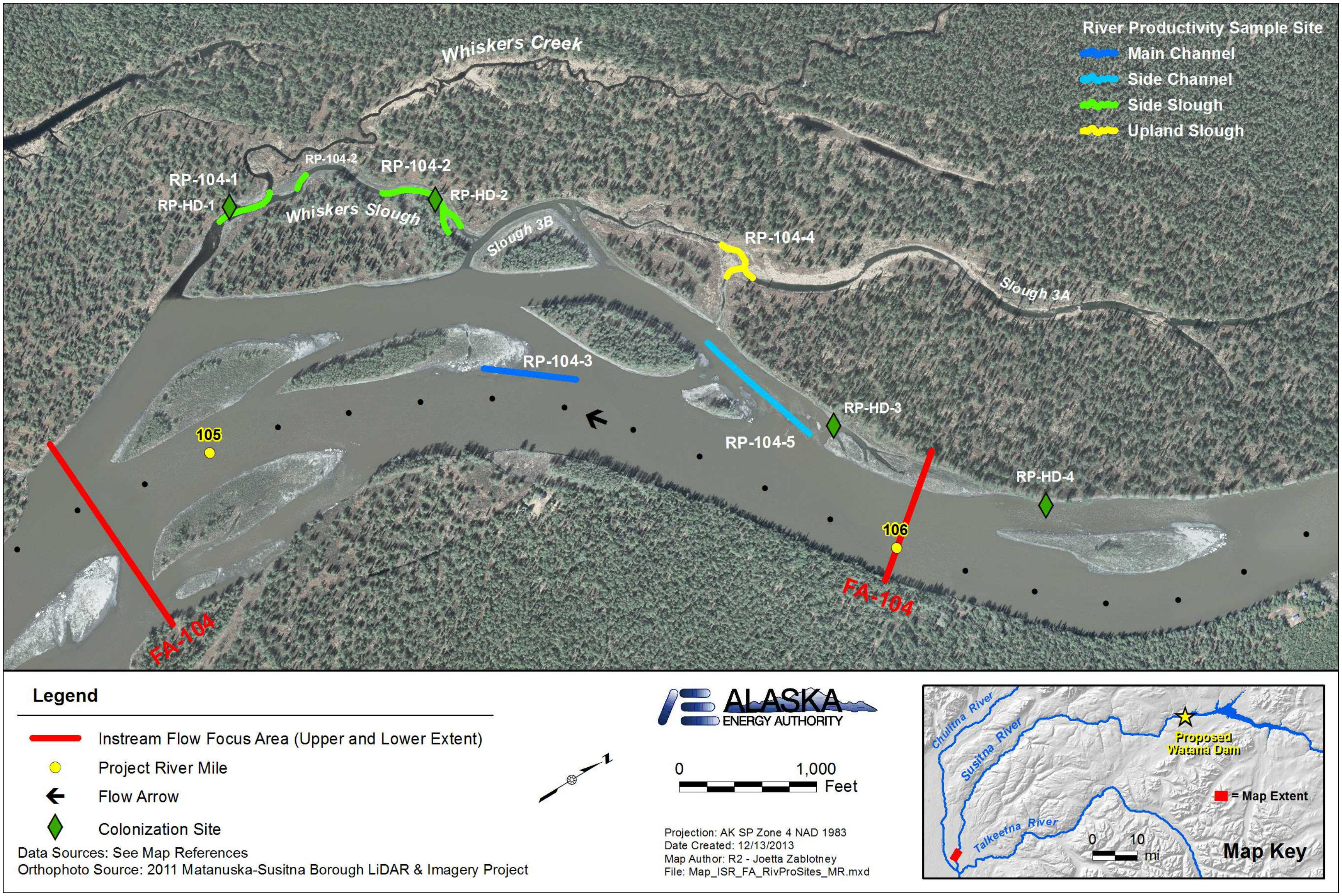

Figure 4.2-4. Focus Area 104 (Whiskers Slough), and the five River Productivity sampling sites.

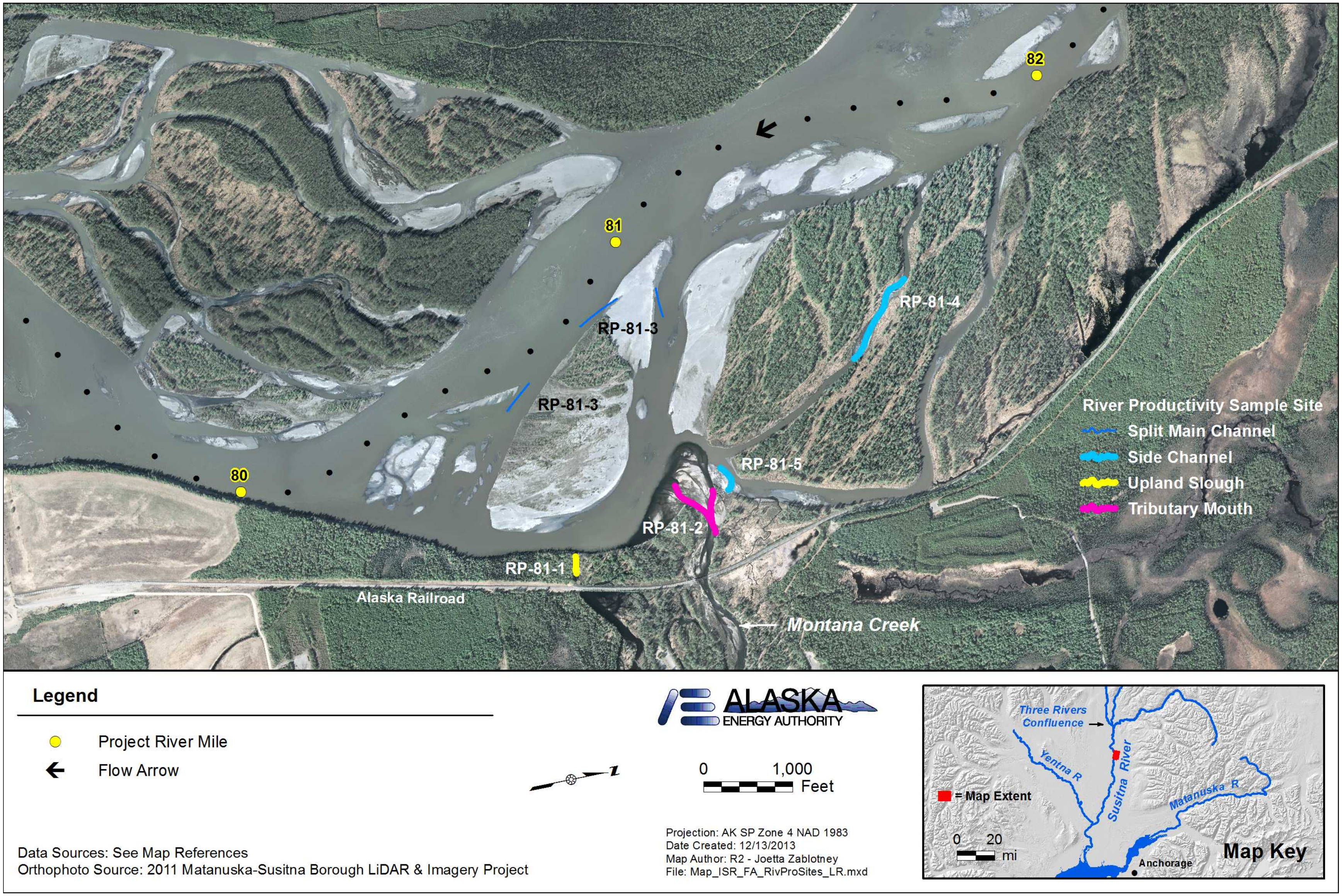

Figure 4.2-5. Station RP-81 (Montana Creek), and the four River Productivity sampling sites.

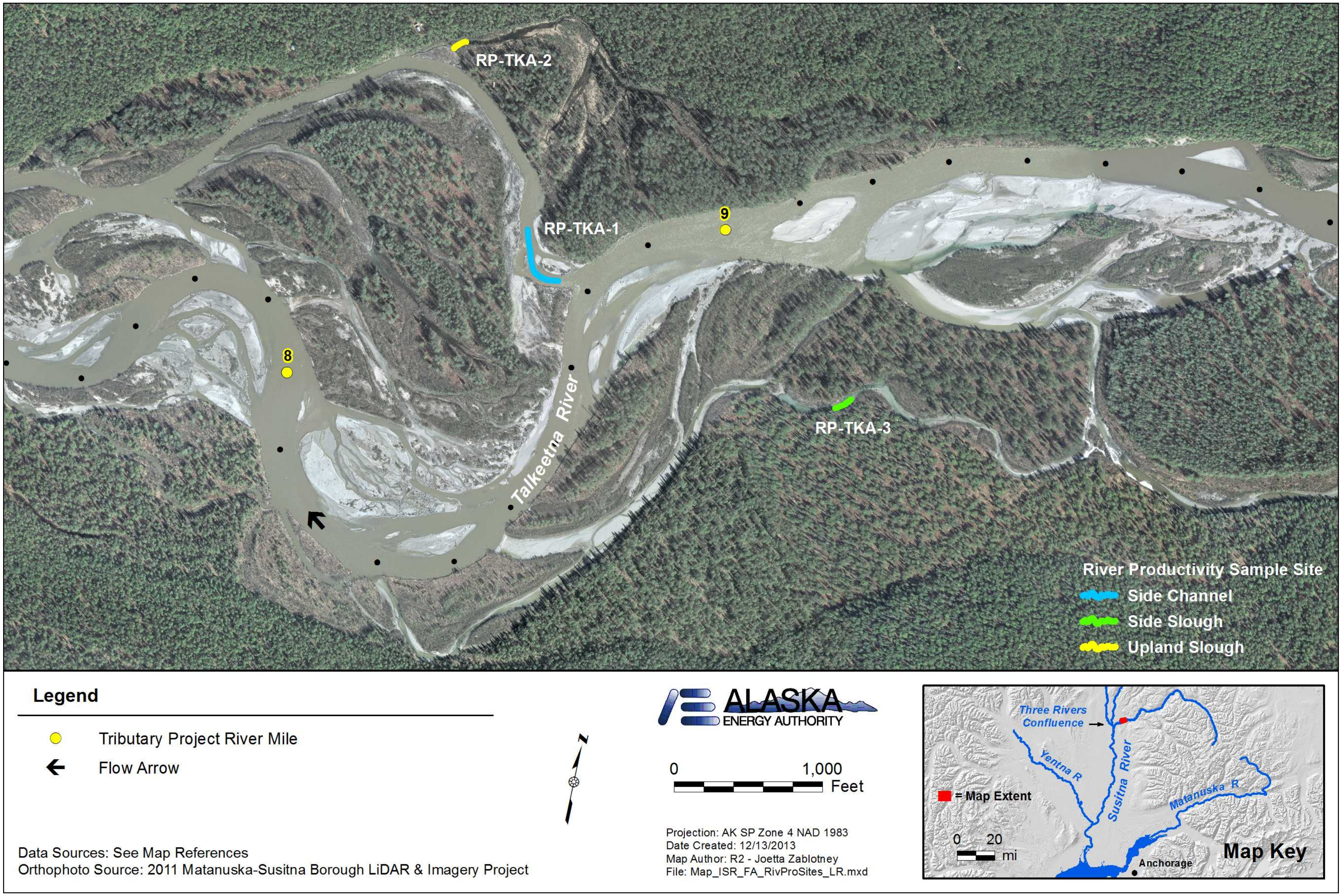

Figure 4.2-6. Talkeetna Station (TKA), and the three River Productivity sampling sites.

Figure 4.4-1. Sampling equipment used to collect benthic macroinvertebrates in streams and rivers. Top left: Hess stream sampler. Top right: drift nets. Bottom left: floating aquatic insect emergence trap. Bottom right: Hester-Dendy multiplate sampler.

Figure 4.11-1. Hester-Dendy multiplate sampler set retrieved at RP-HD-3 on September 20, 2013. Declining flows over the previous week resulted in both large amounts of sediment deposited at the site, which was then dewatered.

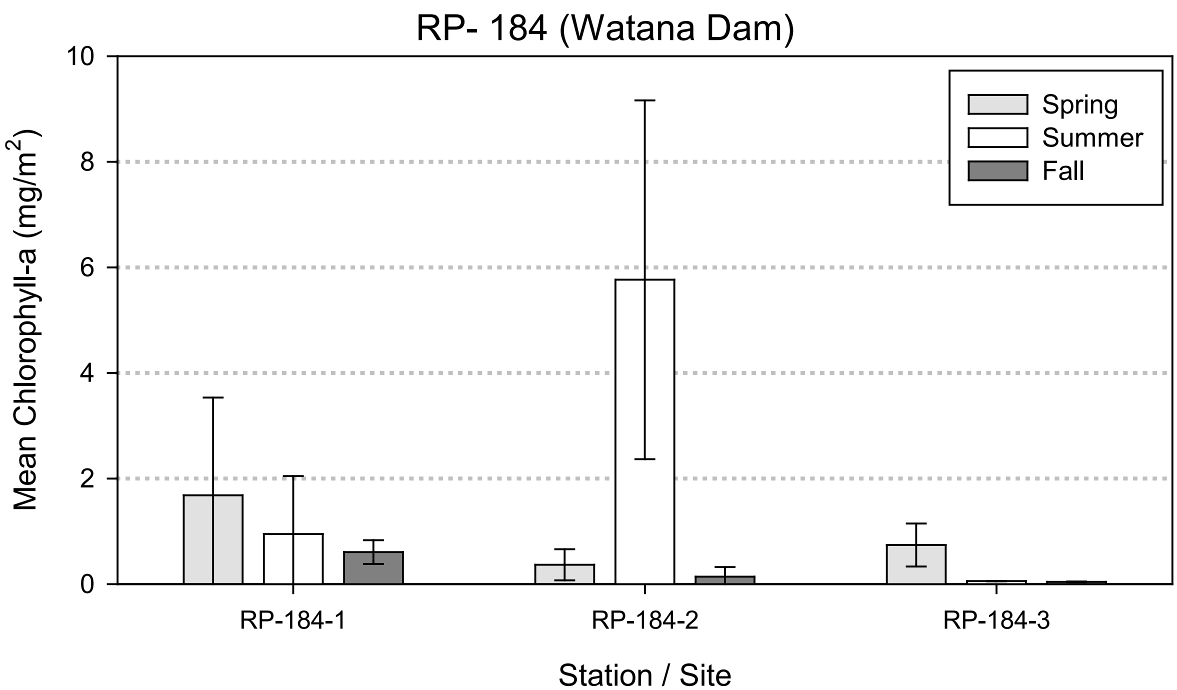

Figure 5.2-1. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-184 (Watana Dam) in the Middle River Segment of the Susitna River.

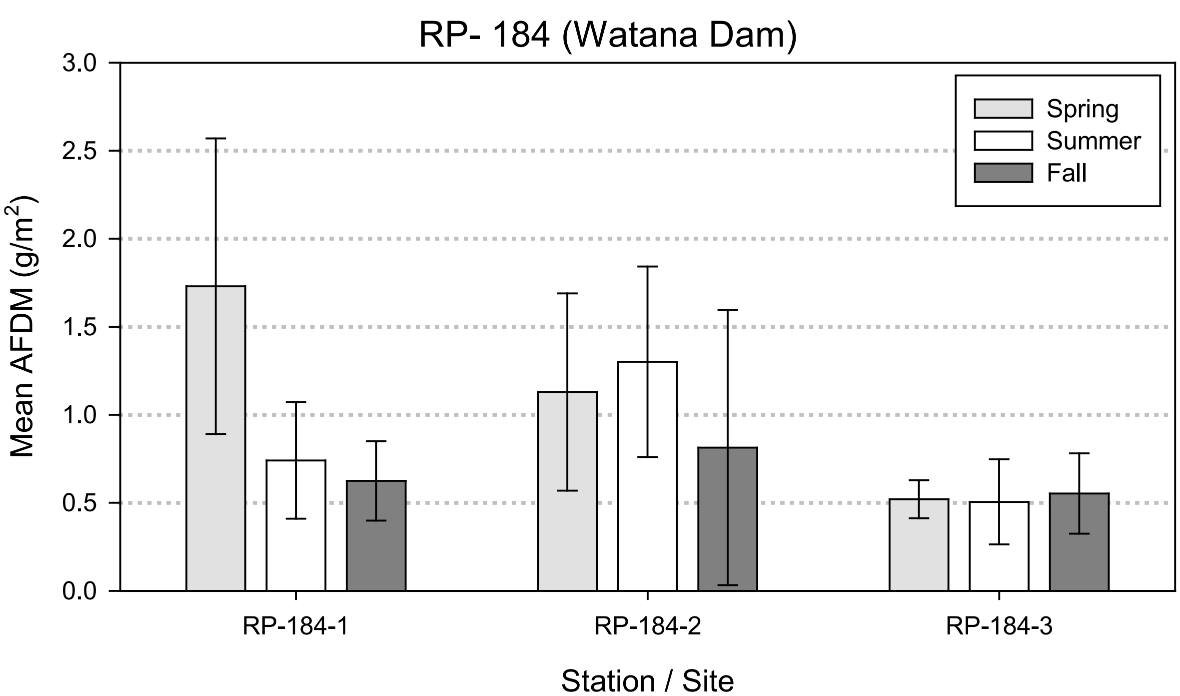

Figure 5.2-2. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-184 (Watana Dam) in the Middle River Segment of the Susitna River.

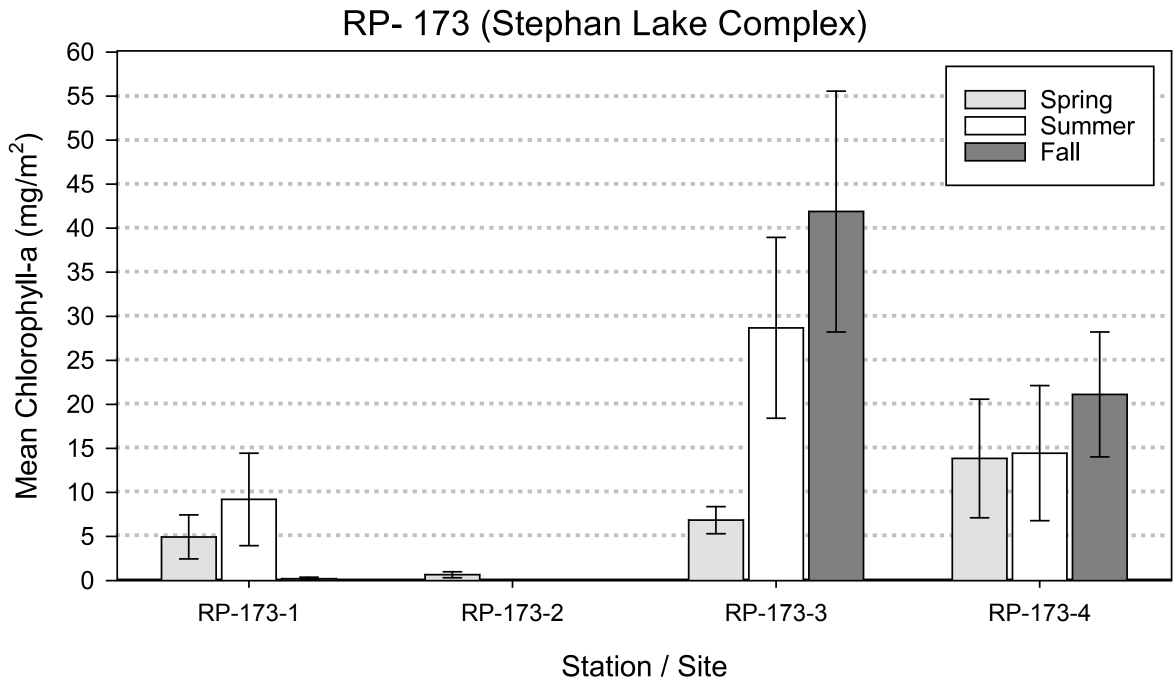

Figure 5.2-3. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-173 (Stephan Lake Complex) in the Middle River Segment of the Susitna River.

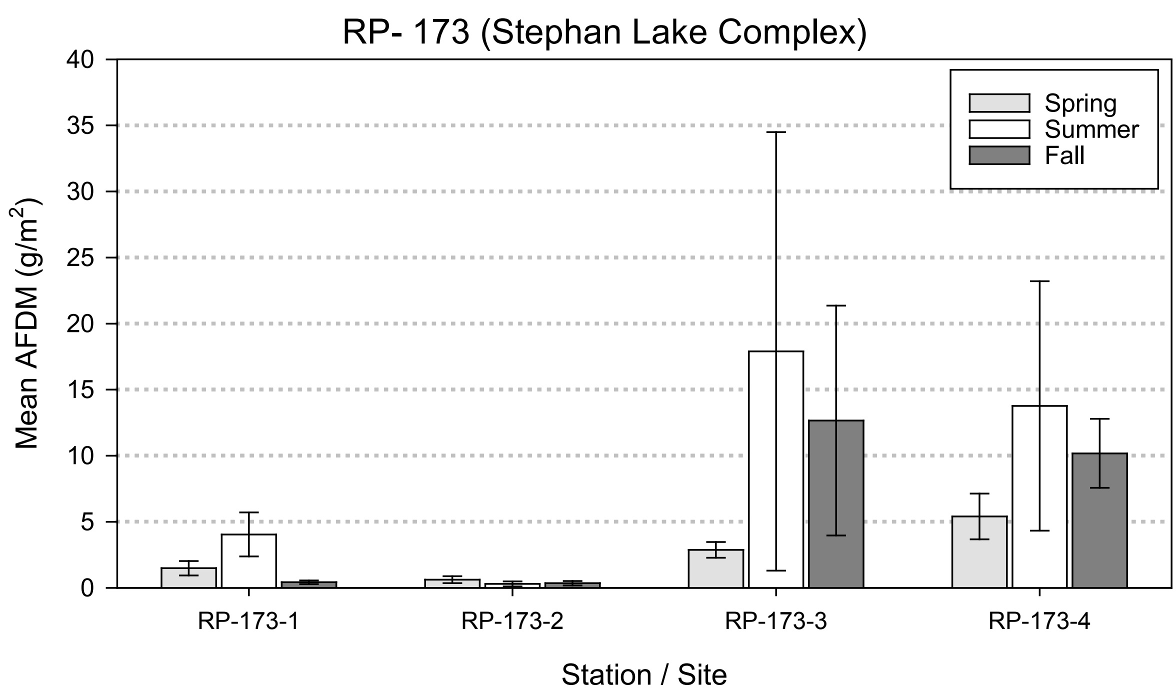

Figure 5.2-4. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-173 (Stephan Lake Complex) in the Middle River Segment of the Susitna River.

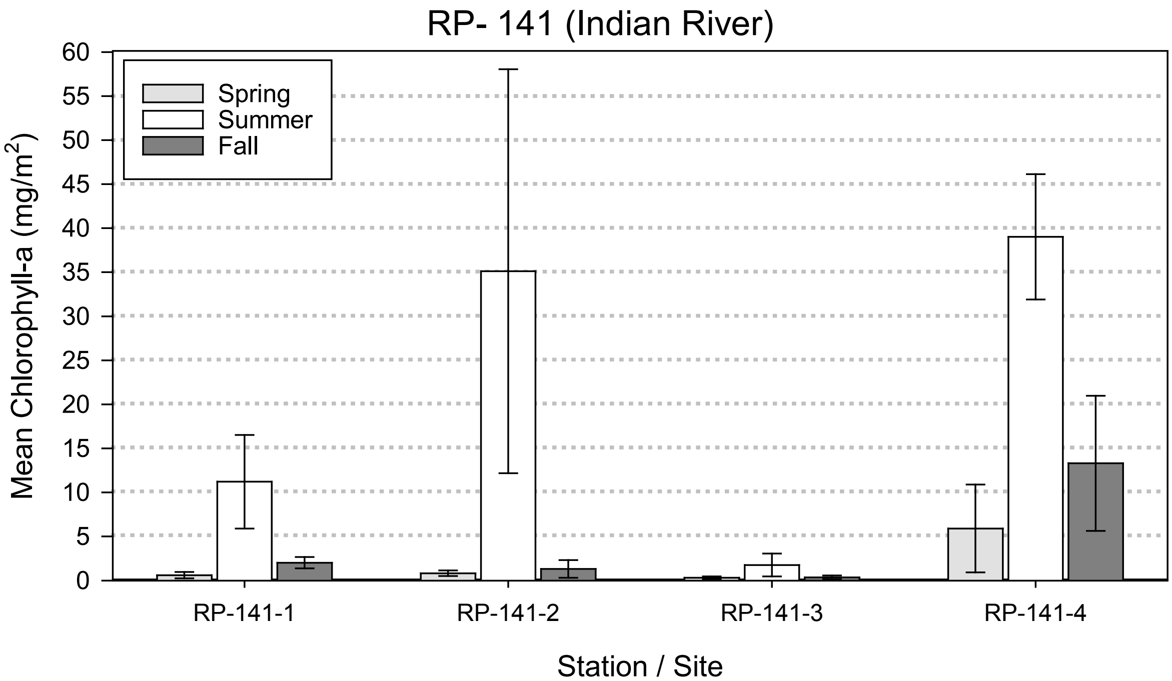

Figure 5.2-5. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-141 (Indian River) in the Middle River Segment of the Susitna River.

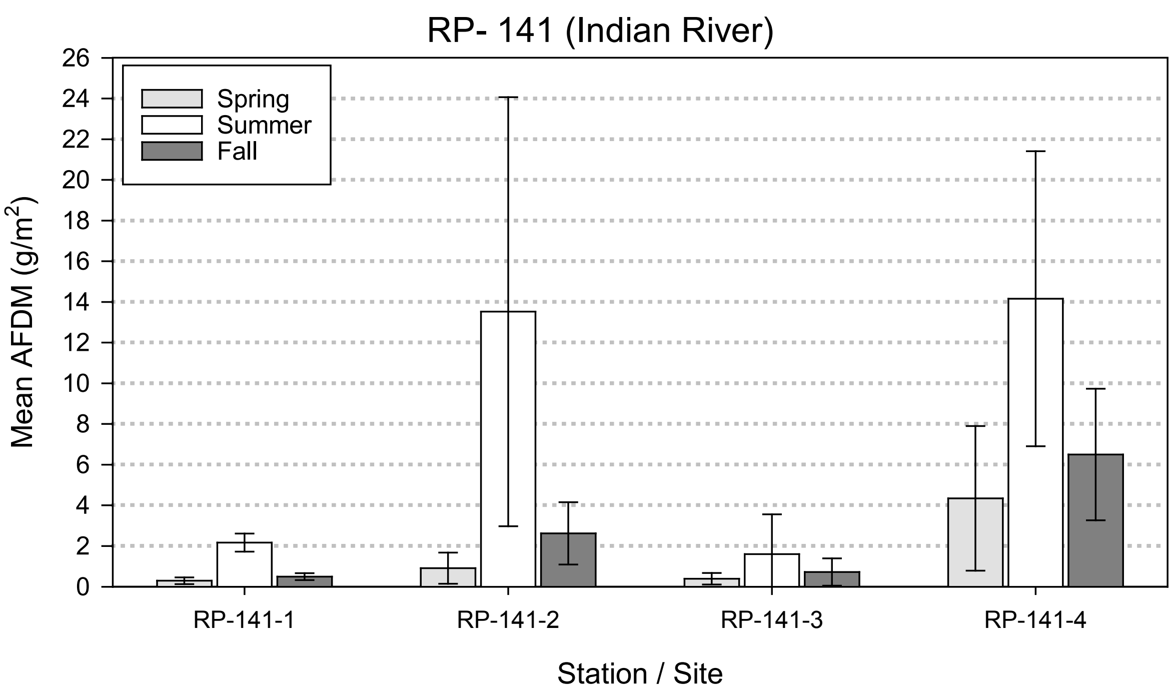

Figure 5.2-6. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-141 (Indian River) in the Middle River Segment of the Susitna River.

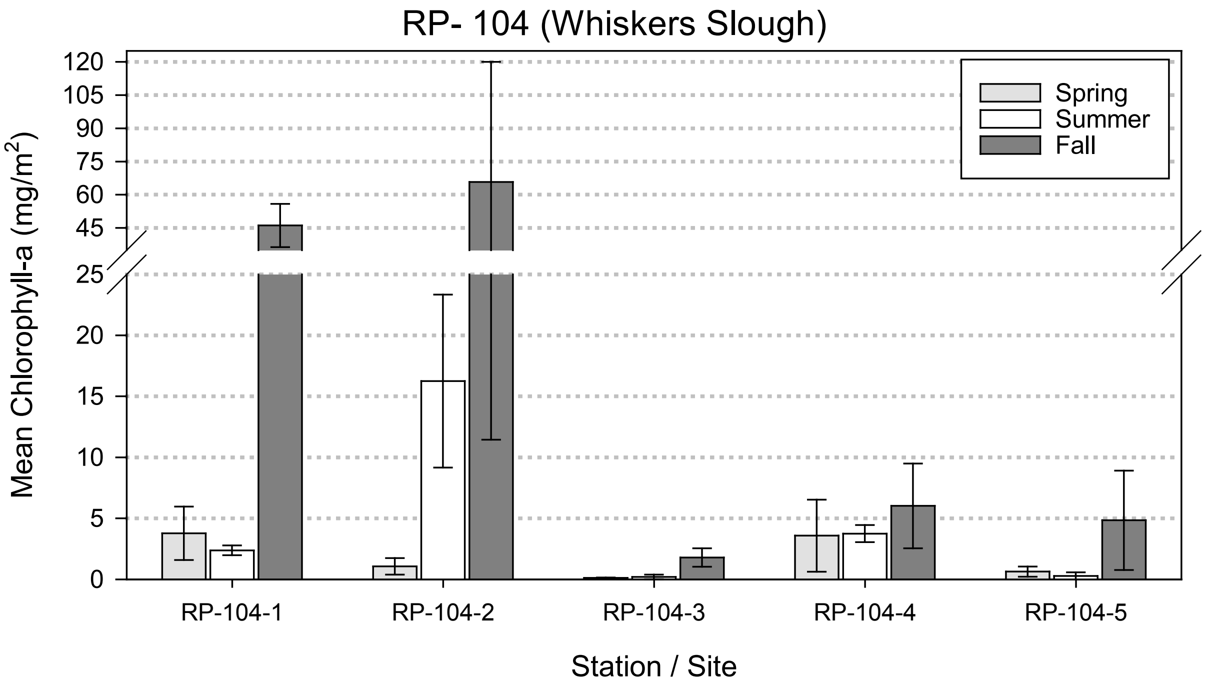

Figure 5.2-7. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-104 (Whiskers Slough) in the Middle River Segment of the Susitna River.

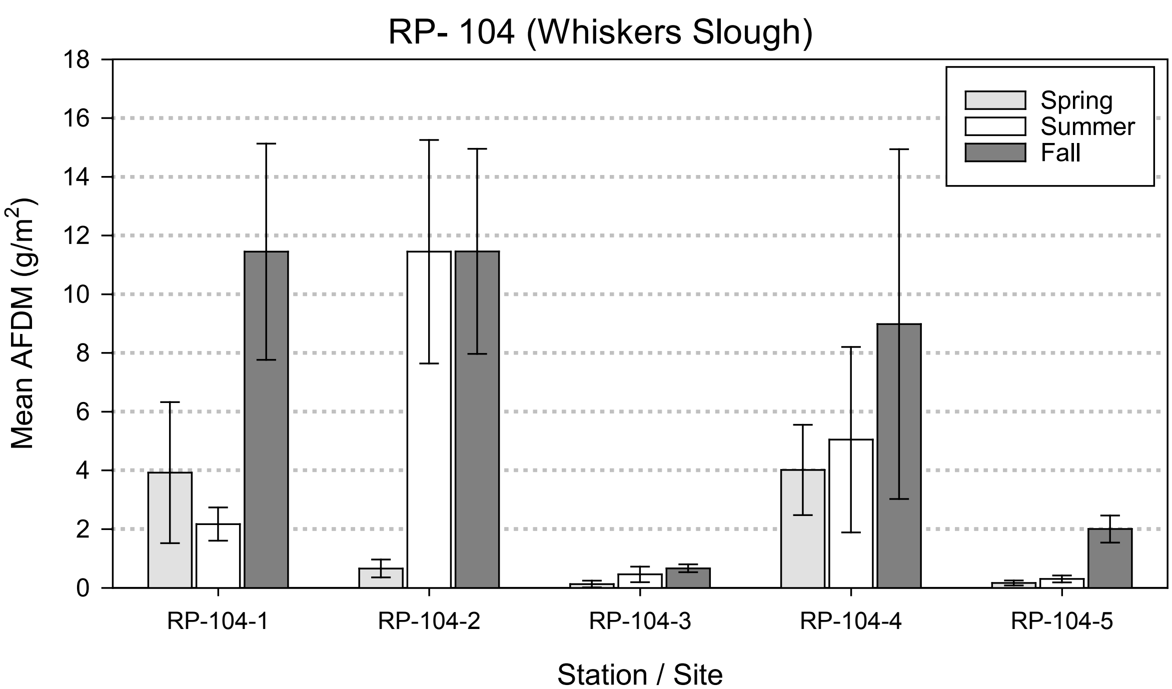

Figure 5.2-8. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within FA-104 (Whiskers Slough) in the Middle River Segment of the Susitna River.

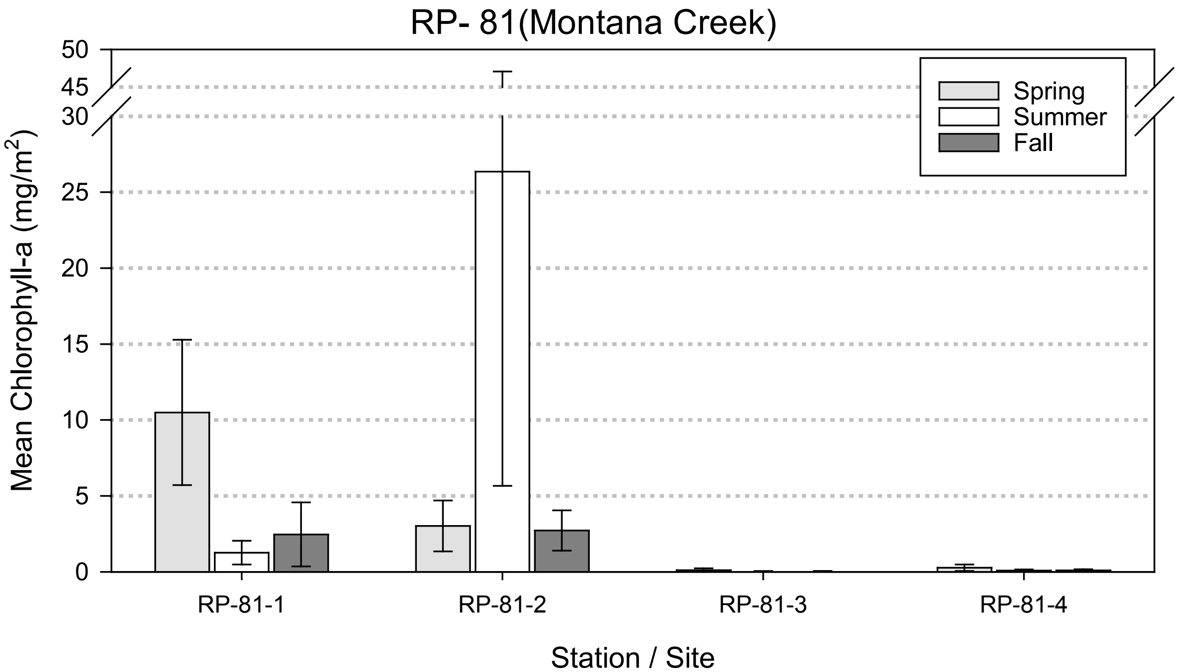

Figure 5.2-9. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within RP-81 (Montana Creek) in the Lower River Segment of the Susitna River.

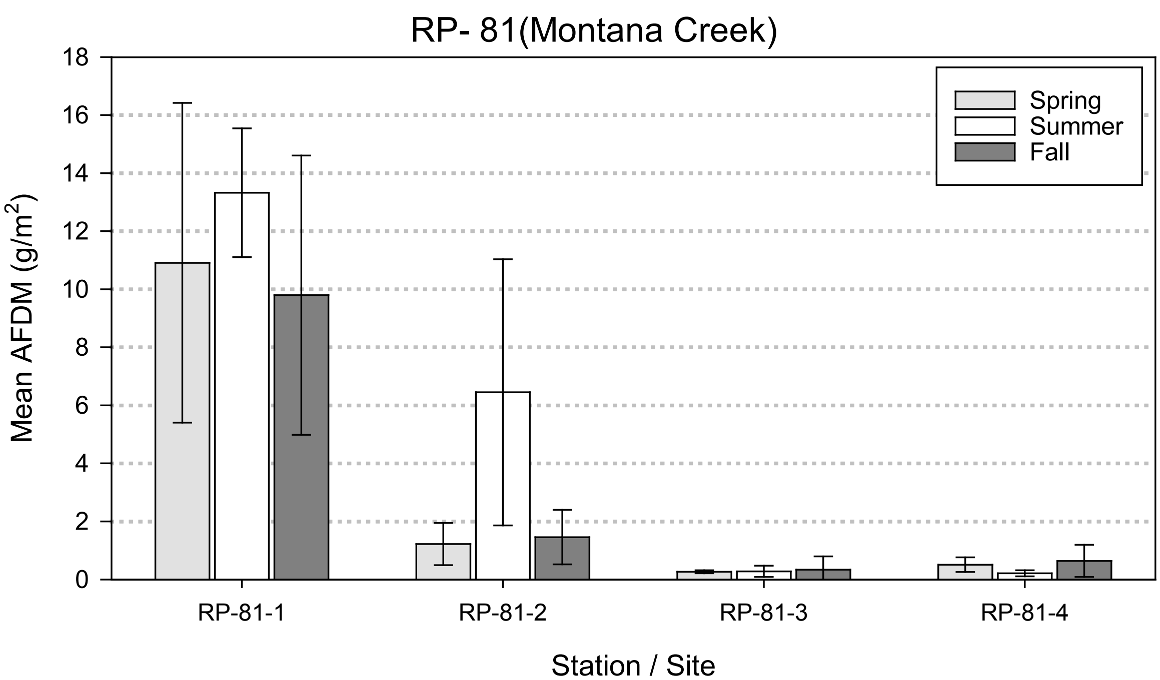

Figure 5.2-10. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within RP-81 (Montana Creek) in the Lower River Segment of the Susitna River.

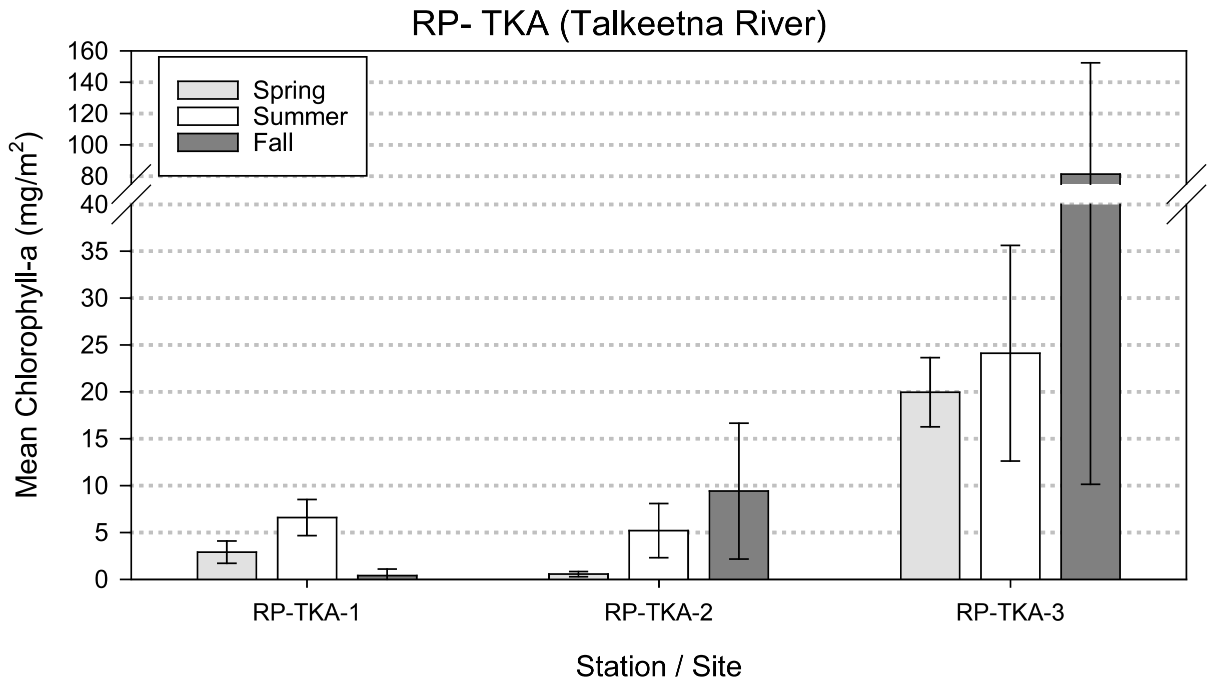

Figure 5.2-11. Mean chlorophyll-a values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within the Talkeetna River study station.

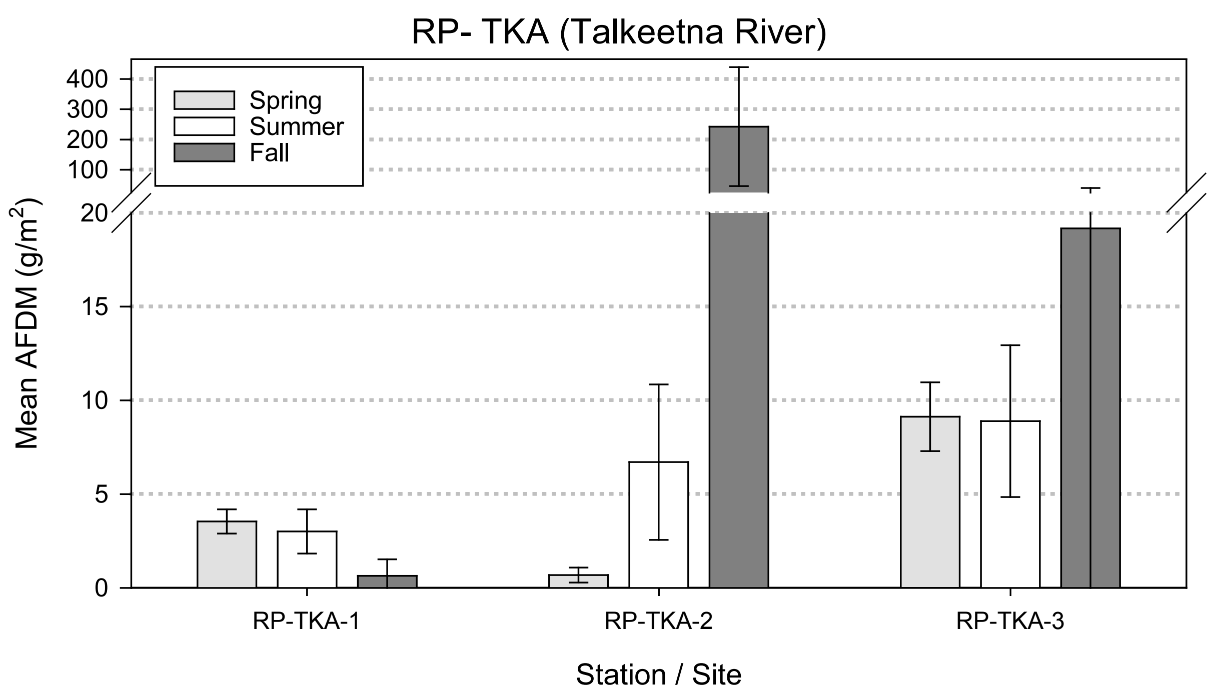

Figure 5.2-12. Mean Ash Free Dry Mass (AFDM) values (n=5) with 95 percent confidence intervals from composite algae samples collected during three index events in 2013 for sites within the Talkeetna River study station.

PART A - APPENDIX A: REVIEW OF THE EFFECTS OF HYDROPOWER ON FACTORS CONTROLLING BENTHIC COMMUNITIES

[See separate file for Appendix]

PART A - APPENDIX B: SITE-SPECIFIC SAMPLE COLLECTION LOCATIONS

[See separate file for Appendix]

PART A - APPENDIX C: ANALYSIS OF POTENTIALLY DEWATERED RIVER PRODUCTIVITY SAMPLING SITES IN 2013

[See separate file for Appendix.]

PART A - APPENDIX D: TALKEETNA SITE SELECTION CONSULTATION DOCUMENTATION

[See separate file for Appendix.]