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SUSITNA-WATANA HYDRO

Susitna-Watana Hydroelectric Project (FERC No. 14241)

Draft Susitna River Fish Distribution and Abundance Implementation Plan

Prepared for

Alaska Energy Authority

SUSITNA-WATANA HYDRO

Clean, reliable energy for the next 100 years.

Prepared by

R2 Resource Consultants, Inc.

January 31, 2013

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LIST OF ACRONYMS AND SCIENTIFIC LABELS

Abbreviation	Definition
Active floodplain	The flat valley floor constructed by a river during lateral channel migration and deposition of sediment under current climate conditions.
ADF&G	Alaska Department of Fish and Game
AEA	Alaska Energy Authority
Age-0 juvenile	The description of an organism that, in its natal year, has developed the anatomical and physical traits characteristically similar to the mature life stage, but without the capability to reproduce.
Algae	Single-celled organisms (as individual or cells grouped together in colonies) that contain chlorophyll-a and are capable of the photosynthesis.
Anadromous	Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.
APA	Alaska Power Authority
APA Project	APA Susitna Hydroelectric Project
Backwater	Off-channel habitat characterization feature found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear.
Bank	The sloping land bordering a stream channel that forms the usual boundaries of a channel. The bank has a steeper slope than the bottom of the channel and is usually steeper than the land surrounding the channel.
Bankfull stage (flow)	The discharge at which water completely fills a channel; the flow rate at which the water surface is level with the floodplain.
Bankfull width	The width of a river or stream channel between the highest banks on either side of a stream.
Baseline	Baseline (or Environmental Baseline): the environmental conditions that are the starting point for analyzing the impacts of a proposed licensing action (such as approval of a license application) and any alternative.
Benthos (benthic)	Defining a habitat or organism found on the streambed or pertaining to the streambed (or bottom) of a water body.
Braided streams	Stream consisting of multiple small, shallow channels that divide and recombine numerous times. Associated with glaciers, the braiding is caused by excess sediment load.
Break-up	Disintegration of ice cover.
Cascade	The steepest of riffle habitats. Unlike rapids, which have an even gradient, cascades consist of a series of small steps of alternating small waterfalls and shallow pools.
Catch per unit effort	The quantity of fish caught (in number or in weight) with one standard unit of fishing effort.
cfs	cubic feet per second
Channel	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank stream flows.
Cross-section	A plane across a river or stream channel perpendicular to the direction of water flow.
Depth	Water depth at the measuring point (station).
Devils Canyon	Located at approximately Susitna River Mile (RM) 150-161, Devils Canyon contains four sets of turbulent rapids rated collectively as Class VI. This feature is a partial fish barrier because of high water velocity.
Distribution (species)	The manner in which a biological taxon is spatially arranged.

Abbreviation	Definition
et al.	"*et alia*"; and the rest
FERC	Federal Energy Regulatory Commission
Fishwheel	A device for catching fish which operates much as a water-powered mill wheel. A wheel complete with baskets and paddles is attached to a floating dock. The wheel rotates due to the current of the stream it is placed into. The baskets on the wheel capture fish traveling upstream. The fish caught in the baskets fall into a holding tank.
Flood	Any flow that exceeds the bankfull capacity of a stream or channel and flows out on the floodplain.
Floodplain	1. The area along waterways that is subject to periodic inundation by out-of-bank flows. 2. The area adjoining a water body that becomes inundated during periods of over-bank flooding and that is given rigorous legal definition in regulatory programs. 3. Land beyond a stream channel that forms the perimeter for the maximum probability flood. 4. A relatively flat strip of land bordering a stream that is formed by sediment deposition. 5. A deposit of alluvium that covers a valley flat from lateral erosion of meandering streams and rivers.
Focus Area	Areas selected for intensive investigation by multiple disciplines as part of the AEA study program.
Fork length	A measurement used frequently for fish length when the tail has a fork shape. Projected straight distance between the tip of the snout and the fork of the tail.
Fry	A recently hatched fish. Sometimes defined as a young juvenile salmonid with absorbed egg sac, less than 60 mm in length.
Fyke net	Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open.
Geomorphic reach	Level two tier of the habitat classification system. Separates major hydraulic segments into unique reaches based on the channel's geomorphic characteristic.
Geomorphology	The scientific study of landforms and the processes that shape them.
Gillnet	With this type of gear, the fish are gilled, entangled or enmeshed in the netting. These nets may be used to fish on the surface, in midwater or on the bottom.
GIS	Geographic Information System. An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes.
Glacier geometry changes	Changes in the size or shape of a glacier over time.
Glide	An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 % slope.
GPS	global positioning system. A system of radio-emitting and -receiving satellites used for determining positions on the earth.
Groundwater (GW)	In the broadest sense, all subsurface water; more commonly that part of the subsurface water in the saturated zone.
Habitat	The environment in which the fish live, including everything that surrounds and affects its life, e.g. water quality, bottom, vegetation, associated species (including food supplies). The locality, site and particular type of local environment occupied by an organism.
Hook and line	A type of fishing gear consisting of a hook tied to a line.
Hoop net	Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open.
Ice cover	A significant expanse of ice of any form on the surface of a body of water.
ILP	Integrated Licensing Process
Inclined plane trap	This trap consists of a revolving screen suspended between two pontoons. Downstream migrant fish reaching the back of the trap are dropped into a live box

Abbreviation	Definition
	where they can later be enumerated.
Instream flow	The rate of flow in a river or stream channel at any time of year.
Juvenile	A young fish or animal that has not reached sexual maturity.
licensing participants; Participants	Agencies, ANSCA corporations, Alaska Native entities and other licensing participants
Life stage	An arbitrary age classification of an organism into categories relate to body morphology and reproductive potential, such as spawning, egg incubation, larva or fry, juvenile, and adult.
Lower segment Susitna	The Susitna River from Cook Inlet (RM 0) to the confluence of the Chulitna River at RM 98.
m	meter(s)
m^2	square meter(s)
Macroinvertebrate	An invertebrate animal without a backbone that can be seen without magnification.
Main channel	For habitat classification system: a single dominant main channel. Also, the primary downstream segment of a river, as contrasted to its tributaries.
Main channel habitat	Level four tier of the habitat classification system. Separates main channel habitat types including: tributary mouth, main channel, split main channel, multiple split main channel and side channel into mesohabitat types. Mesohabitat tyes include pool, glide, run, riffle, and rapid.
Mainstem	Mainstem refers to the primary river corridor, as contrasted to its tributaries. Mainstem habitats include the main channel, split main channels, side channels, tributary mouths, and off-channel habitats.
Mainstem habitat	Level three tier of the habitat classification systems. Separates mainstem habitat into main channel, off-channel, and tributary habitat types. Main channel habitat types include: tributary mouth, main channel, split main channel, multiple split main channel and side channel. Off-channel habitat types include: side slough, upland slough, backwater, and beaver complex. Tributary habitat is not further categorized.
Major hydraulic segment	Level one tier of the habitat classification system. Separates the River into three segments: Lower River (RM 0-98), Middle River (RM 98-184), and Upper River (RM 184-233).
Mesh size	The size of holes in a fishing net.
Mesohabitat	A discrete area of stream exhibiting relatively similar characteristics of depth, velocity, slope, substrate, and cover, and variances thereof (e.g., pools with maximum depth <5 ft, high gradient rimes, side channel backwaters).
Middle segment Susitna	The Susitna River from the confluence of the Chulitna River at RM 98 to the proposed Watana Dam Site at RM 184.
Migrant (life history type)	Some species exhibit a migratory life history type and undergo a migration to from rivers/lakes/ocean.
Migration	Systematic (as opposed to random) movement of individuals of a stock from one place to another, often related to season.
Minnow trap	Normally composed of small steel mesh with 2-piece torpedo shape design, this trap is disconnected in the middle for easy baiting and fish removal.
N/A	not applicable *or* not available
Non-native	Not indigenous to or naturally occurring in a given area.
ºC	degrees Celsius
ºF	degrees Fahrenheit
Off-channel	Those bodies of water adjacent to the main channel that have surface water connections to the main river at some discharge levels.

Abbreviation	Definition
Off-channel habitat	Habitat within those bodies of water adjacent to the main channel that have surface water connections to the main river at some discharge levels.
Outmigrant trap	Several types of trapping equipment that can be used to estimate the abundance of downstream migrating anadromous salmonid smolts.
Overwintering	Freshwater habitat used by salmonids during the winter for incubation of eggs and alevin in the gravel and for rearing of juveniles overwintering in the stream system before migrating to saltwater the following spring.
pH	A measure of the acidity or basicity of a solution.
PIT	Passive Integrated Transponder tags used to individually identify animals and monitor their movements.
PM&E	protection, mitigation and enhancement
Pool	Slow water habitat with minimal turbulence and deeper due to a strong hydraulic control.
POW	palustrine open water (ponds under 20 ac)
PRM	Project River Mile(s) based on the digitized wetted width centerline of the main channel from 2012 Matanuska-Susitna Borough digital orthophotos. PRM 0.0 is established as mean lower low water of the Susitna River confluence at Cook Inlet.
Project	Susitna-Watana Hydroelectric Project
Radiotelemetry	Involves the capture and placement of radio-tags in adult fish that allow for the remote tracking of movements of individual fish.
Rapid	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0% slope.
Rearing	Rearing is the term used by fish biologists that considers the period of time in which juvenile fish feed and grow.
Resident	Resident fish as opposed to anadromous remain in the freshwater environment year-round
Riffle	A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section. Low gradient; usually 0.5-2.0% slope.
Riparian	Pertaining to anything connected with or adjacent to the bank of a stream or other body of water.
River	A large stream that serves as the natural drainage channel for a relatively large catchment or drainage basin.
River corridor	A perennial, intermittent, or ephemeral stream and adjacent vegetative fringe. The corridor is the area occupied during high water and the land immediately adjacent, including riparian vegetation that shades the stream, provides input of organic debris, and protects banks from excessive erosion.
River mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.
RM	River Mile(s) referencing those of the APA Project.
RSP	Revised Study Plan
Run (habitat)	A habitat area with minimal surface turbulence over or around protruding boulders with generally uniform depth that is generally greater than the maximum substrate size. Velocities are on border of fast and slow water. Gradients are approximately 0.5 % to less than 2%. Generally deeper than riffles with few major flow obstructions and low habitat complexity.
Run (migration)	Seasonal migration undertaken by fish, usually as part of their life history; for example, spawning run of salmon, upstream migration of shad. Fishers may refer to

Abbreviation	Definition
	increased catches as a "run" of fish, a usage often independent of their migratory behavior.
Screw trap	A floating trap that relies on an Archimedes screw built into a screen covered cone that is suspended between two pontoons is used.
Seine (beach)	A fishing net that hangs vertically in the water with its bottom edge held down by weights and its top edge buoyed by floats. Seine nets can be deployed from the shore as a beach seine, or from a boat.
Side channel	Lateral channel with an axis of flow roughly parallel to the mainstem, which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel. Side channel habitat may exist either in well-defined secondary (overflow) channels, or in poorly-defined watercourses flowing through partially submerged gravel bars and islands along the margins of the mainstem.
Side slough	Off-channel habitat characterization of an Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water,
Slope	The inclination or gradient from the horizontal of a line or surface.
Slough	A widely used term for wetland environment in a channel or series of shallow lakes where water is stagnant or may flow slowly on a seasonal basis. Also known as a stream distributary or anabranch.
Smolt	An adolescent salmon which has metamorphosed and which is found on its way downstream toward the sea.
Smoltification	The physiological changes anadromous salmonids and trout undergo in freshwater while migrating toward saltwater that allow them to live in the ocean.
Spawning	The depositing and fertilizing of eggs by fish and other aquatic life.
Split main channel	Main channel habitat characterization where three of fewer distributed dominant channels.
Stratified sampling	A method of sampling from a population. In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently. Stratification is the process of dividing members of the population into homogeneous subgroups before sampling.
Three Rivers Confluence	The confluence of the Susitna, Chulitna, and Talkeetna rivers at Susitna River Mile (RM) 98.5 represents the downstream end of the Middle River and the upstream end of the Upper River.
Tributary	A stream feeding, joining, or flowing into a larger stream (at any point along its course or into a lake). Synonyms: feeder stream, side stream.
Turbidity	The condition resulting from the presence of suspended particles in the water column which attenuate or reduce light penetration.
TWG	Technical Workgroup
Upland slough	Off-channel habitat characterization feature that is similar to a side slough, but contains a vegetated bar at the head that is rarely overtopped by mainstem flow. Has clear water.
Upper segment Susitna	The Susitna River upstream of the proposed Watana Dam Site at RM 184.
Watana Dam	The dam proposed by the Susitna-Watana Hydroelectric project. The approximately 750-foot-high Watana Dam (as measured from sound bedrock) would be located at river mile (RM) 184 on the Susitna River. The dam would block the upstream passage of Chinook salmon, possibly other salmon species, and resident fish that migrate through and otherwise use the proposed Watana Dam site and upstream habitat in the Susitna River and tributaries.

1. INTRODUCTION

On December 14, 2012, Alaska Energy Authority (AEA) filed its Revised Study Plan, which included 58 individual study plans, with the Federal Energy Regulatory Commission (FERC). Included within the RSP was the Fish Distribution and Abundance in the Upper Susitna River, RSP Section 9.5, and the Fish Distribution and Abundance in the Middle and Lower Susitna River study, RSP Section 9.6. RSP Section 9.5 focuses on describing the current fish assemblage including spatial and temporal distribution, and relative abundance by species and life stage in the Susitna River upstream of the proposed Watana Dam (RM 184). RSP Section 9.6 focuses on describing the current fish assemblage including spatial and temporal distribution, and relative abundance by species and life stage in the Susitna River downstream of the proposed Watana Dam (river mile [RM] 184) with emphasis on early life history of salmonids and seasonal movements of selected species.

In RSP Sections 9.5 and 9.6, AEA provided detailed information on goals and objectives, identification of study areas, sampling methods, standards, techniques, analytical approaches, implementation schedules, preliminary study site selection, and the interrelatedness of the fish distribution and abundance studies with other study areas.

In addition, for each of these plans, AEA proposed to produce a fish distribution and abundance implementation plan that provides further detail on data collection standards and specific study site selection in the form of an implementation plan. The implementation plan was described in both RSP Sections 9.5.4 and 9.6.4 as follows:

> *A final sampling scheme will be developed as part of a detailed Fish Distribution and Abundance Implementation Plan and will be submitted to FERC on March 15, 2013. Implementation plan development will include (1) a summary of relevant fisheries studies in the Susitna River, (2) an overview of the life-history needs for fish species known to occur in the Susitna River, (3) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9), (4) a description of site selection and sampling protocols, (5) development [of] field data collection forms, and (6) development of database templates that comply with 2012 AEA QA/QC procedures. The implementation plan will include the level of detail sufficient to instruct field crews in data collection efforts. In addition, the plan will include protocols and a guide to the decision making process in the form of a chart or decision tree that will be used in the field, specific of sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will address how sampling events will be randomized to evaluate precision by habitat and gear type. The implementation plan will also help ensure that fish collection efforts occur in a consistent and repeatable fashion across field crews and river segments.*

Consistent with these RSP Sections, this Implementation Plan describes in specific detail the study site selection process and field sampling procedures to be used for the proposed Study of Fish Distribution and Abundance in the Upper (RSP Section 9.5) and Middle/Lower (RSP Section 9.6) Susitna River. Specifically, this implementation plan provides: (1) a summary of

relevant fisheries studies in the Susitna River, (2) an overview of the life-history needs for fish species known to occur in the Susitna River, (3) a review of the preliminary results of the 2012 habitat characterization and mapping efforts, (4) a description of site selection and sampling protocols, (5) details regarding development of field data collection forms, and (6) details regarding development of database templates that comply with 2012 AEA QA/QC procedures.

2. STUDY GOALS AND OBJECTIVES

This Implementation Plan applies to both the Study of Fish Distribution and Abundance in the Upper Susitna River (RSP Section 9.5) and the Study of Fish Distribution and Abundance in the Middle/Lower Susitna River (RSP Section 9.6). As such, the goals and objectives of this implementation plan are the goals and objectives described in RSP Sections 9.5.1 and 9.6.1.

3. THE STUDY AREA

The study area for this Implementation Plan is described in RSP Sections 9.5.3 and 9.6.3.

4. BACKGROUND – SUMMARY OF RELEVANT FISHERIES STUDIES IN THE SUSITNA RIVER AND AN OVERVIEW OF THE LIFE-HISTORY NEEDS FOR FISH SPECIES KNOWN TO OCCUR IN THE SUSITNA RIVER

The fish and aquatic resources within the Susitna River have been widely studied in the past. In 1979, the Alaska Power Authority (APA) initiated a five-year study program for assessing the feasibility of a two-dam hydroelectric project on the Susitna River. This effort resulted in a large volume of historic data from the 1980s. More recently, ADF&G has conducted additional studies on the anadromous salmon in the basin including aerial surveys in the Lower River and periodic field surveys in the upper river. In 2012, AEA initiated additional fish and aquatic resource studies in the Susitna River Basin to support licensing efforts for its currently proposed Project. Of relevance to the 2013 and 2014 Study of Fish Distribution and Abundance in the Upper and Middle/Lower Susitna River, these previous studies have focused on: (1) resident and juvenile fish distribution and abundance in the Upper Susitna River (1980s and 2012); (2) adult salmon escapement and distribution (1980s and 2012); (3) salmon and trout incubation and emergence (1980s); (4) aquatic habitat delineation (2012); and (5) open-water flow routing modeling (2012).

In the subsections that follow, a summary of relevant existing fish and aquatic habitat information collected in the Susitna River study area is provided for each of these five study topics. Although an abundance of data has been collected, the information summarized below has been selected primarily to guide site selection and the development of sampling techniques that will be used to implement the Study of Fish Distribution and Abundance in the Upper and Middle/Lower Susitna River. The information within Sections 4.1, 4.2, and 4.3 is focused so as to help AEA evaluate the relative effectiveness of past sampling methods and to support decisions regarding appropriate sampling techniques and anticipated level of effort.

Detailed results relating to life history, periodicity, distribution, relative abundance, and fish-habitat associations are provided for individual species in Appendix 1: ***Species Profiles for Fish of the Susitna River***, to further support decisions regarding site selection, study timing, and other considerations.

Results of the 2012 mainstem and mesohabitat delineation efforts (Section 4.4) are provided to enhance the study site selection process, as well as sampling design considerations for fish-habitat associations. The open-water flow routing modeling results (Section 4.5 – placeholder pending completion) will be used to help determine the need to expand fish sampling in the Lower River. Lastly, documentation of TWG input for the site selection protocol is provided in Section 4.6 (placeholder pending February, 2013 stakeholder meeting).

4.1. Distribution and Abundance Data Collection Efforts

Based on historic efforts to investigate fish distribution and abundance in the Susitna River, twenty-one fish species may be encountered in the study area that encompasses the Lower, Middle, and Upper Susitna River (Table 4.1-1). Data collection efforts for resident and juvenile fish distribution and abundance studies in the Susitna River from the 1980s until 2012 are described below.

4.1.1. 1980s Data Collection

The ADF&G Aquatic Studies Program began in November 1980 and had three components: Adult Anadromous Fish Studies, Resident and Juvenile Anadromous Fish Studies, and Aquatic Habitat and Instream Flow Studies. In addition to work completed by ADF&G, the aquatic habitat and instream flow component was supported by work conducted by Trihey and Associates. The resident and juvenile anadromous fish study component, along with the relevant aquatic habitat and instream flow studies, are described herein, and a description of the adult anadromous fish study component is provided in Section 4.2.1.

4.1.1.1. Objectives

The objectives for the RJ and AH study components were to (Schmidt and Bingham 1983):

- RJ: Determine the seasonal distribution and relative abundance of selected resident and juvenile anadromous fish populations within the study area;
- AH: Characterize the seasonal habitat requirements of selected anadromous and resident fish species within the study area and the relationship between the availability of these habitat conditions and the mainstem discharge of the Susitna River.

Field studies were conducted during most months from November 1980 through October 1985, with the exception of periods of freeze-up and ice-off. A wide variety of fisheries field and habitat modeling studies occurred over the 5-year period when most studies were completed. In general, RJ and AH studies were broad-based during 1981 and 1982, representing the widest geographic scale and range of sampling methods of the overall study program. As the Aquatic Studies Program progressed, studies became more focused on acquiring specific information needs for habitat modeling and acquisition of specific biological data. In addition, the results of 1981 and 1982 sampling led to general conclusions regarding fish distribution and habitat utilization, such as the restriction of salmon species (except Chinook) to reaches below Devil

Canyon, relative differences in the use of slough, side channel, tributary, and main channel habitats for each species, and specific sites where relative abundance was greatest for a given species. Such information is provided in detail for each species in Appendix 1: *Species Profiles for Fish of the Susitna River*. For sampling after 1982, these initial conclusions allowed for more intensive sampling at fewer sites with known fish use and a reliance on fewer sampling techniques that had demonstrated effective fish capture success within habitats and field conditions found in the river. Sampling sites for RJ studies and AH studies were frequently the same during the 1983 and 1984 field seasons.

A major objective of the 1980s Aquatic Studies Program was to understand the seasonal use of six mainstem (macro-) habitat types by anadromous and resident fish. The six mainstem habitat types consisted of mainstem (main channel), side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1983). The distribution and frequency of these habitats varied longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. A representation of these historic habitat types is provided in Figure 4.1-1.

4.1.1.2. Study Sites and Techniques

Sampling for juvenile and resident fish from November 1980 through mid October1981 included a wide range of sites as well as multiple sampling techniques (Figure 4.1-2). By June of 1981, the Aquatic Studies Program had settled on 39 areas in the Lower and Middle segments, termed "habitat locations", that were the focus of sampling during the open water period (Delaney et al. 1981b, Delaney et al. 1981c). During the winter of 1980 to 1981, 29 of the habitat locations were sampled, plus an additional 48 "selected fish habitat sites" that were described as exploratory sampling. An understanding of habitat utilization by juvenile anadromous and resident fish was developed as part of focused studies during 1982, 1983, and 1984. During 1982, 17 sites referred to as Designated Fish Habitat (DFH) sites were surveyed twice monthly from June through September during the open water season (Estes and Schmidt 1983). Twelve sites were located in the Middle River (Whiskers Creek and Slough to Portage Creek Mouth) and five were located in the Lower River (Goose Creek and Side Channel to Birch Creek and Slough)(Table 4.1-2, Figure 4.1-3). Habitat zones were delineated in each site based upon the influence of mainstem flow, tributary flow, and water velocity.

A wide variety of fisheries field and habitat modeling studies occurred over the 5-year period when most studies were completed. A large number of sites (275 mainstem sites and 55 tributary and other slough sites) called Selected Fish Habitat (SFH) sites were also sampled in 1982, but these sites were usually sampled less frequently (1 to 3 times) and more opportunistically than DFH sites (Figure 4.1-4)

During 1983 and 1984, studies were focused on obtaining information needed for developing instream flow models under the AH component and sampling was coupled with obtaining additional distribution and abundance information desired for the AJ component (Schmidt et al. 1984, Suchanek et al. 1985). The instream flow models include Resident Juvenile Habitat (RJHAB) and Instream Flow Incremental Methodology (IFIM) models. The 1983 open water studies included 35 study sites (called Juvenile Anadromous Habitat Study or JAHS sites) in the lower Middle River; this was supplemented with 20 sites in the Lower River in 1984 (Table 4.1-3). Macrohabitat types included in the study were tributary, upland slough, side slough, and

mainstem side channel. Rationale for sites selected for the JAHS Study included (Dugan et al. 1984):

1. Sites where relatively large numbers of spawning adult salmon were recorded in 1982 (ADF&G 1982),
2. Sites where concentrations of rearing juvenile salmon were observed or collected in 1981 and 1982, and
3. Sites representing macrohabitat types associated with the Susitna River that are affected by changes in mainstem flow.

In addition to the combined AH and AJ sampling efforts, studies were implemented to better understand juvenile salmon outmigration and growth (Roth et al. 1984, Roth and Stratton 1985), resident fish distribution and abundance (Sundet and Pechek 1985), river productivity (Wilson 1985, Nieuwenhuyse 1985), and invertebrate food sources for Chinook salmon (Hansen and Richards 1985). A summary of these additional studies is presented in Table 4.1-4.

The 1983 and 1984 JAHS sites were sampled in a systematic fashion within grids delineated at each site (Dugan et al. 1984, Suchanek et al. 1985). As described in Dugan et al. (1984) and depicted in Figure 4.1-5:

> *Each of the study sites was divided into one or more grids. Grids were located to keep water quality (temperature, turbidity) within the site as uniform as possible and to encompass a variety of depth, velocity, cover, and substrate types. Each grid consisted of a series of transects which intersected the channels of the study sites at right angles. There were one to three cells (6 ft. in width by 30 ft. in length = 300 sq. ft.) at every transect within the grid. An attempt was made to confine uniform habitat within each cell. Fish were usually sampled from a minimum of seven cells within each grid at each site. The cells were selected to represent the complete range of habitat types available within the grid. Fish density was estimated by electrofishing or beach seining the entire cell, attempting to capture all fish. Catch per unit effort (CPUE) was defined as the catch (number of fish) per cell.*

The analysis utilized the percent distribution of each salmon species among the four macrohabitat types sampled as the evaluation metric. Analysis of variance (ANOVA) techniques were used to discern factors affecting habitat use by the different juvenile salmon species. In addition to site and sampling period, the factors collected in each cell following fish sampling included mean water depth, mean water velocity, mean percent cover, water temperature, and turbidity. Depth, velocity, and cover measures were averaged over the entire site because the cells were not randomly distributed.

During winter of 1984-1985, JH studies included a Chinook and coho salmon habitat study (Stratton 1986) and resident fish study (Sundet 1986). For the winter-time juvenile anadromous salmon study, Stratton (1986) sampled four locations in the Middle River (Indian River, Slough 9A, Slough 10, and Slough 22) using minnow traps and backpack electrofishing at an interval of ten to fifteen days from October through April. Captured Chinook and coho salmon were marked with a cold brand identifying the location and time period of capture.

For the winter-time resident fish study (Sundet 1986), 23 rainbow trout, 14 burbot, and five Arctic grayling were radio-tagged in the lower and middle Susitna River between early

September and October. An additional 15 rainbow trout radio-tagged during the spring were also tracked. Tracking surveys occurred primarily by airplane or helicopter, but occasionally included snow machines. Burbot spawning was also studied by deployment of trotlines in areas near where radio-tagged fish were located.

The open water season of 1985 included a study of juvenile salmon migration and growth (Roth et al. 1986) and continued monitoring of adult salmon escapement and spawning habitat use (Thompson et al. 1986). Outmigration was studied by deployment of fixed incline plane traps near Flathorn Station (HRMS 22.4 and 24.6) and at Talkeetna Station (HRM 103) and deployment of a mobile trap that sampled along a cross sectional transect at HRM 25.4. Coded wire tags were embedded into juvenile chum and sockeye salmon collected at selected sites upstream of Talkeetna. Chinook and coho salmon were cold branded at sites in the Indian Creek, Portage Creek, Side Channel 10A, and Slough 15. Mark-recapture programs were conducted at 22 tributary, slough and side channel sites in the Middle River to determine estimates of growth for marked fish (Roth et al. 1986).

The description above summarizes a variety of sampling techniques that were used during the 1980s. In the interest of evaluating these different sampling techniques, data collected in 1982 at DFH sites were compiled to allow a comparison of the catch-per-unit-effort (CPUE) for each sampling technique (Table 4.1-5). Sites were typically sampled twice per month from June through September, with some sites also sampled in late May and early October. Not all gear types were used during every sampling period. Although the sampling that occurred in 1981 was extensive, it was conducted in a less systematic fashion and data on actual catch and effort were not reported; therefore, those results are not included in Table 4.1-5. CPUE data provide a comparison of the relative efficiency that might be expected when using the historic sampling techniques and also provide an indication of the level of effort that may be required to meet sample size targets.

In terms of sampling events (i.e., the number of locations sampled times the frequency of sampling), the most frequently used gear types from June through September 1982 were in decreasing order: minnow trap, trotline, beach seine, boat electrofishing, and backpack electrofishing. Other methods included dip net, hook and line, hoop net, set gillnet, and fish trap. Table 4.1-5 shows the catch per sampling event for each gear type. Most fish were captured by beach seine, minnow trap, boat electrofishing, and backpack electrofishing. Notably, the median catch per sampling event was low. For example, half of beach seine sampling events captured 11 or fewer fish and half of backpack electrofishing sampling events captured 16 or fewer fish.

4.1.2. ADF&G 2003/2011 Efforts

In August 2003, ADF&G conducted a reconnaissance inventory in 19 study "reaches" upstream of Devils Canyon using backpack electrofishing (Buckwalter 2011). Juvenile Chinook salmon were found in four reaches of Susitna River tributaries: one reach of Fog Creek, two reaches of Kosina Creek, and one reach of the Oshetna River.

A subsequent effort was conducted in 2011 as part of the Alaska Freshwater Fish Inventory (AFFI) program, in which three 2-person teams inventoried fish communities by single-pass electrofishing in 60 stream reaches throughout the Susitna River basin upstream of the Talkeetna River confluence (Buckwalter 2011). Three sizes of streams were targeted, excluding streams upstream of obvious barrier falls. Mainstem (draining at least 1500 km^2) rivers, which were

sampled by boat electrofishing (Smith-Root GPP 2.5 generator-powered electrofisher mounted on a 13-ft inflatable cataraft), included the upper Susitna River mainstem (two reaches), Maclaren River (one reach), and Tyone River (one reach). Sampling in 19 intermediate (draining at least 200 km^2) streams (one reach each) was also conducted using boat electrofishing; 3 additional intermediate streams were not raftable but each had at least one headwater reach that was sampled by backpack electrofishing in 2003 or 2011. Sampling in 37 of 74 identified headwater (draining at least 50 km^2) streams (one reach each) was conducted using backpack electrofishing. Unsampled headwater streams included those with relatively little stream length (e.g., < 5 km), where anadromous fish (especially Chinook salmon) were least likely to occur (e.g., high elevation, high gradient, or still or slow-flowing with muddy bottom), where a nearby headwater stream was sampled and no anadromous fish found, or where helicopter access was not possible.

Of the 60 electrofished reaches sampled in 2011, juvenile Chinook salmon were found in the following four reaches: one reach in Fog Creek, two reaches in Portage Creek, and one reach in the mainstem Susitna River at Lane Creek, 16 miles upstream of Talkeetna (Buckwalter 2011). Only one (Fog Creek) of these four reaches was located upstream of Devils Canyon. Dolly Varden and humpback whitefish, which are considered optionally-anadromous species, were found in several reaches upstream of Devils Canyon. Whether these fish exhibit an anadromous life history remains unclear. However, otoliths were collected from these specimens to detect periods of saltwater residency and results are pending.

Both the 2003 and the 2011 efforts also included helicopter surveys to locate Chinook salmon spawning aggregations upstream of Devils Canyon (Buckwalter 2011). The results of these surveys are described in *Section 4.2 Historic Adult Salmon Escapement and Distribution Studies.*

4.1.3. 2012 Data Collection

In 2012, efforts associated with the 2012 Upper Susitna River Fish Distribution and Habitat Study Plan (AEA 2012) were undertaken to determine the distribution and relative abundance of juvenile Chinook salmon and other fish species present in the Susitna River, its tributaries, and lakes above Devils Canyon. The 2012 study area extended upstream to and including the Oshetna River. For Upper River tributaries, the study area extended up to an elevation (El.) of 3,000 feet above mean sea level (MSL).

4.1.3.1. Objectives

The objectives of this effort were to:

- Determine the distribution and relative abundance of fish species residing in tributary and lake habitats downstream of barriers, up to 3,000-foot elevation.
- Determine the distribution and relative abundance of fish species residing in accessible mainstem Susitna River habitats within the reservoir inundation zone, including the main channel, side channels, side sloughs, upland sloughs, and tributary mouths
- Characterize fish habitat for juvenile Chinook salmon where found in the study area
- Support the Alaska Department of Fish and Game (ADF&G) Chinook salmon genetic stock analysis by collecting tissue samples from individual juvenile salmon

- Determine whether Dolly Varden (*Salvelinus malma*) and humpback whitefish (*Coregonus oidschian*) in the study area have anadromous life histories
- Determine baseline tissue metal content for select fish species in the study area

4.1.3.2. Study Sites and Techniques

The study area included the Susitna River and its tributary stream drainages from Devils Canyon upstream to and including the Oshetna River (Figure 4.1-6). Sampling was conducted in a selected sample of accessible tributaries (n=26) from Cheechako Creek (HRM 152.4) upstream to the Oshetna River (HRM 233.5). Tributary sampling efforts were focused in stream habitats located downstream of adult salmon passage barriers but in some cases, were extended up to an El. of 3,000 feet above MSL when barriers were not identified. Passage barriers, as identified under a separate study component, truncated the extent of sampling in 11 of the 26 tributaries. Select mainstem Susitna River and lake habitats were also sampled in 2012.

Multiple fish collection techniques were used in 2012 including: backpack electrofishing, boat electrofishing, minnow traps, fyke nets, gill nets, angling, and snorkeling. An overview of the use and effectiveness of each of these gear types is described below. For comparative purposes, effectiveness is described as CPUE in terms of the total number of fish captured per unit time (i.e., minute or hour) of gear use and deployment. In addition, a brief discussion on the overall feasibility and logistics of using each gear type is provided.

Backpack Electrofishing: Backpack electrofishing was the most effective gear type used, accounting for 88 percent of total fish captures. This technique was used in 24 of the 26 tributaries, 12 tributary plumes sampled from the mainstem Susitna River, nine mainstem Susitna River locations, and one lake. A total of 2,067 fish were captured during the 929.15 minutes of effort expended. This equates to a CPUE of 2.2 fish per minute for all species captured during the 2012 study season. Electrofishing was successful at immobilizing fish in most areas sampled. However, netting efficiency was considered poor at many sample sites primarily due to turbidity and velocity. Tributary streams were typically flowing very swiftly, and white water turbulence severely limited the ability to see fish in many streams. Turbid water habitats, particularly in the mainstem Susitna River, were especially challenging for netting fish. It is likely that other fish had been stunned but not observed, especially bottom dwelling species such as sculpin. Backpack electrofishing was the only gear type that captured juvenile Chinook salmon in 2012. The equipment used in 2012 was reliable and, given the two-person crew size, easily transported in the R-44 helicopter.

Boat Electrofishing: Boat-based electrofishing surveys were conducted within three tributary streams, seven tributary plumes accessed from the mainstem Susitna River, one location in the mainstem Susitna River, and one lake. During these surveys, 121 fish were captured in the 141.43 minutes of effort expended; this equates to a CPUE of 0.86 fish per minute. Similar to backpack electrofishing, many fish were observed but not captured during the boat-based surveys. Boat based electrofishing was challenging due to turbid and fast-flowing waters with low conductivity. However, the boat-based operations allowed sampling to occur in habitat areas that would otherwise be inaccessible or were unsuitable for other gear types. Transport logistics for boat-based electrofishing required the use of an A-Star (preferably) or an R-44 helicopter for sling loading. The boat, which was a 16-foot cataraft, and its motor and electrofishing equipment weighed approximately 450 pounds.

Minnow Traps: A total of 41 minnow traps were used in 2012, including 18 traps set throughout two tributary stream drainages and 23 traps set in four lakes. Soak times varied from roughly one hour to several days due to helicopter logistics and inclement weather. Traps captured 46 fish over a total effort of 31,679 minutes (572.98 hours), which equates to a CPUE of 0.08 fish per hour. Minnow traps are light-weight and could be transported via an R-44 helicopter with relative ease.

Fyke Nets: Fyke nets were set on eight occasions in 2012; seven were set among four different lakes, and one was set in a tributary plume. Soak times varied from approximately 30 minutes to three days, primarily due to helicopter logistics and inclement weather. Fyke nets captured 75 fish in the 12,521 minutes (208.68 hours) that nets were used, which equates to a CPUE of 0.36 fish per hour. Fyke nets are typically an effective gear type for capturing a wide range of species and life stages in still or slow water habitats. The fyke nets selected for use in 2012 were relatively lightweight and fit in the backseat of an R-44 helicopter. However, transport of fyke nets required multiple trips using a single R-44, so use in 2012 was limited.

Gill Nets: Gill nets were used on only two occasions in 2012; both deployments were in side channels within the Kosina Creek drainage. Deployment times ranged from 50 minutes to 2.5 hours, and neither captured fish. An additional set targeting lake trout in Sally Lake was not completed due to the risk of entangling loons that were present and fishing nearby. Gill nets were easily transported via an R-44.

Angling: Limited angling was conducted in tributary, tributary plume, and lake habitats. A total of 49 fish were captured, including Dolly Varden (n=13), lake trout (n=5), and Arctic grayling (n=31). Angling effort was not recorded consistently, which precluded an estimate of CPUE for this sampling method. Angling gear is easily transportable.

Snorkeling: Snorkeling was conducted along a portion of one un-wadeable tributary stream by a two-person team on August 10, 2012. The entire width of the stream could not be sampled by one snorkeler, and velocity and depth precluded movement throughout certain portions of the stream channel. The snorkeler observed a total of 40 fish. Snorkeling effort was not recorded, which precluded an estimate of CPUE for this sampling method. As with angling gear, snorkeling equipment is easily transportable.

4.2. Adult Salmon Escapement and Distribution Studies

Studies of adult salmon escapement and distribution were conducted during the 1980s effort and more recently in 2012 in the upper segment of the Susitna River in support of the licensing efforts for the currently proposed Project. In the interim, ADF&G conducted basin-wide surveys of escapement or harvest for multiple salmon species (e.g., Merizon et al. 2010, Oslund and Ivey 2010, Fair et al. 2010, Westerman and Willette 2010, Cleary 2010, and Yanusz and Merizon 2010). The summary of historic studies provided below focuses on the 1980s and 2012 efforts, because they offer the greatest information specific to the Middle and Upper segments of the Susitna River. This section focuses on the scope and methods of adult salmon escapement and distribution studies; results from these efforts have been synthesized by species and are presented in Appendix 1: *Species Profiles for Fish of the Susitna River*.

4.2.1. 1980s Data Collection

Efforts to determine adult salmon escapement and distribution were conducted from 1981 through 1985 by ADF&G in support the previously proposed two-dam project.

4.2.1.1. Objectives

The objective of the Adult Anadromous Fish Studies component (AA) of the 1980s was to determine the seasonal distribution and relative abundance of adult anadromous fish populations produced within the study area (Schmidt and Bingham 1983).

4.2.1.2. Study Sites and Techniques

An understanding of the escapement and distribution of adult salmon during the 1980s Aquatic Studies Program was primarily based upon three sampling techniques:

- Fishwheels and sonar,
- Spawning surveys,
- Radio tracking.

Sampling at the fishwheels included fish length measurements, attachment of floy tags, and removal of scales for aging fish. Floy spaghetti tags or Petersen disc tags were used to study fish movements and to estimate escapement using Peterson estimation techniques. Adult periodicity information is primarily available from fishwheels and Bendix sonar stationed at a number of locations in the mainstem Susitna River and in the Yentna River (Table 4.2-1). Stations were generally deployed in early- to mid-June and fished through early- to mid-August. Spawning surveys occurred annually by foot, raft, airplane, or helicopter. The surveys included index streams/reaches that were checked once or twice each year at the time of peak spawning. Additional surveys were conducted specifically for the Aquatic Studies Program and varied in the level of intensity and location each year. In general, all side channels, sloughs and tributaries known to have spawning fish in the reach from Talkeetna to Devils Canyon were surveyed each year on a weekly basis during the salmon spawning season from 1981 to 1985. Radio tracking occurred in 1981 and 1982 and was used to identify spawning and holding locations and better understand migration rates (ADF&G 1981, ADF&G 1982). The number of fish tracked within a species was 18 or fewer fish. Tracking occurred at one to four day intervals depending on stream flow conditions and the distribution of fish (ADF&G 1981).

Jennings (1985) provides the following summary of the 1980s efforts related to adult salmon escapement and distribution. Five species of Pacific salmon utilize the mainstem and side channels upstream of the Chulitna confluence (HRM 98.6), primarily as a migration corridor (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Migration periods for adults of each species were:

- Sockeye: July through mid-September,
- Chum: mid-July through mid-September,
- Coho: mid-July through mid-September,
- Pink: mid-July through August, and

- Chinook: June through July.

From 1981 through 1984, escapement estimates indicate that the mainstem and side channels of: the Talkeetna-to-Devils Canyon area (HRM 98.6-152) serve as a migration corridor for less than 5 percent of the total Susitna River salmon escapement (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985).

Upstream migration generally corresponded with the summer high-flow season. However, peak river discharge events appeared to slow upstream movements until such flows subsided. Slowed upstream migration was observed in the Talkeetna-to-Devil Canyon area at flows greater than 40,000 cfs at Gold Creek (HRM 136.8) (Sautner et al. 1984).

Mainstem and side channel spawning upstream of RM 98.6 was observed for sockeye, chum and coho salmon (ADF&G 1981a, 1982a; Barrett et al. 1984, 1985). Chum salmon appeared to utilize mainstem margins and side channels for spawning more than coho or sockeye. Peak counts of chum salmon spawning in mainstem and side channel habitats were: 14 fish in 1981, 550 fish in 1982, 219 fish in 1982, and 1,266 fish in 1984. Only five coho and 44 sockeye were observed spawning in mainstem and side channel habitats from 1981 to 1984. Most mainstem spawning was observed in late August to mid-September. In 1984, about 5 percent of the 68,750 salmon spawning upstream of RM 98.6 used the mainstem for spawning (Barrett et al. 1985). Armored streambed material, high water velocities and infrequent upwelling sites appeared to limit spawning in mainstem habitat.

4.2.2. ADF&G 2003/2011 Efforts

On August 1, 2003, as part of a larger reconnaissance inventory (see Section 4.1.2) of the Susitna River basin upstream of Devils Canyon, ADF&G conducted a 1-day aerial (helicopter) survey of selected upper Susitna River tributaries between Devils Canyon and Jay Creek to identify potential spawning adult Chinook salmon (Buckwalter 2011). Adult Chinook salmon were identified in two streams, Fog Creek and Tsusena Creek. A subsequent helicopter survey was conducted on July 27, 2011 to identify locations of spawning Chinook salmon aggregations in Susitna River basin tributaries upstream of Devils Canyon (Buckwalter 2011); this effort identified one adult Chinook salmon in Kosina Creek.

4.2.3. 2012 Data Collection

Efforts in 2012 related to adult salmon escapement and distribution involved both aerial surveys upstream of Devils Canyon and a radiotelemetry study throughout the basin.

4.2.3.1. Aerial Surveys

In 2012, data collection efforts related to adult salmon escapement were conducted to determine the distribution and relative abundance of adult Chinook salmon in the Susitna River and its tributaries above Devils Canyon upstream to and including the Oshetna River. Much of the following description of this effort is taken directly from the unpublished draft report for the 2012 Upper Susitna River Fish Distribution and Habitat Characterization Study (HDR unpublished).

Specific objectives of the 2012 effort related to Chinook salmon were to: 1) determine the distribution and relative abundance of adult Chinook salmon (and any other Pacific salmon

present during the peak Chinook salmon spawning period) in the mainstem Susitna River and tributaries above Devils Canyon from Cheechako Creek upstream to and including the Oshetna River; 2) support the Alaska Department of Fish and Game (ADF&G) Chinook salmon stock analysis by collecting tissue samples from individual adult salmon for genetic analysis; and 3) characterize habitats at adult Chinook salmon spawning sites above Devils Canyon.

Twelve tributaries were surveyed in 2012. These were selected based on past documented presence of Chinook salmon (Buckwalter 2011), 2012 radio-tagged locations for Chinook salmon, and stream access:

1. Cheechako Creek,
2. Chinook Creek,
3. Devil Creek,
4. Fog Creek,
5. Unnamed (HRM 181.2),
6. Tsusena Creek,
7. Deadman Creek,
8. Watana Creek,
9. Kosina Creek
10. Jay Creek,
11. Goose Creek,
12. Oshetna River.

Surveys began at the downstream end of clear-water plumes in the mainstem Susitna River near tributary mouths and continued upstream in the tributaries to an upstream passage barrier or an elevation of 3,000 feet, whichever was encountered first. Based on available run time information and the detection of radio-tagged fish in or just downstream of Devils Canyon, a total of four aerial spawning ground survey events were scheduled at 5-day intervals from July 24 through August 11, 2012.

Surveys were conducted by a two-person crew. Observations were made from low altitudes, ideally 50 to 75 feet when trees and terrain allowed, and at an air speed of up to 25 miles per hour. An experienced survey pilot optimized aircraft positioning and helped minimize the effects of glare off the water. Polarized sunglasses were worn to reduce glare. The entire survey route was tracked with Global Positioning System (GPS) technology and the survey results mapped in a Geographic Information System (GIS). If adult salmon were observed in the vicinity of 3,000-foot elevation then surveys continued upstream until no adult salmon were observed or habitat was no longer suitable for spawning.

Chinook salmon was the only Pacific salmon species observed within the study area in 2012. Adult Chinook salmon were located in five tributaries:

1. Cheechako Creek (HRM 152.4),
2. Chinook Creek (HRM 157.0),
3. Devil Creek (HRM 161.4),
4. Fog Creek (HRM 176.6),
5. Kosina Creek (HRM 206.8).

No fish were observed in the clear water portions of the mainstem Susitna River that could be surveyed or within any of the secondary tributaries surveyed.

In general, counts of Chinook salmon were low in all tributaries where Chinook salmon were present and were fairly consistent across survey dates. Peak adult Chinook salmon counts for all five streams occurred during either the July 30 or the August 5 surveys. In Cheechako and Chinook creeks, adult Chinook salmon were observed during these two survey periods with peak counts of 5 and 4 fish, respectively. Adult Chinook salmon were found in Devils Creek during all four surveys with a peak count of 7 fish on August 5. Only one Chinook salmon was observed in Fog Creek during the July 30 survey event. The highest numbers of Chinook salmon were observed in Kosina Creek during all survey events with 15 counted during the first survey (July 25), 8 on the second (July 31), a peak count of 16 on the third survey (August 6), and 14 during the final survey (August 11). No fish carcasses were observed during the 2012 aerial spawning ground surveys.

Mesohabitat type and substrate composition was visually estimated from the helicopter at seven locations where adult Chinook salmon were thought to be spawning (three locations in Chinook Creek, three locations in Devils Creek, and one location in Kosina Creek) but no active spawning was observed and only one redd was actually identified. Riffles were the dominant mesohabitat type where Chinook salmon were likely spawning (57%) followed by run (29%) and pool (14%) habitat. At these same locations cobble was the dominant substrate averaging (44%) followed by gravel (30%) and boulder (26%).

Opportunistic tissue samples from near death (post-spawned) salmon to support the ADF&G Chinook salmon stock identification program were not taken. During the survey period, no adult Chinook salmon appeared to meet the post-spawned criteria and no fish carcasses were observed during the 2012 aerial spawning ground surveys. Using hook-and-line gear, ADF&G captured 10 Chinook salmon in Kosina Creek on July 31 and collected tissue samples and axillary tissue for DNA analysis (Habicht 2012).

4.2.3.2. Radiotelemetry Study

In 2012, a radiotelemetry study was conducted in which five species of Pacific salmon (*Oncorhynchus* spp.) were radio-tagged and tracked in the mainstem Susitna River to describe salmon migration behavior, identify salmon spawning locations, and evaluate techniques for future studies of salmon in turbid water. Much of the following description of this effort is taken directly from the unpublished draft study report ***Adult Salmon Distribution and Habitat Utilization Study*** (LGL unpublished). The study design was meant to enable comparisons to salmon distribution and habitat use in the 1980s, when similar studies were conducted for the Alaska Power Authority Hydroelectric Project. The 2012 study focused on the mainstem Susitna River due to possible effects both above and below the Project dam site, and separated the river into Lower (river mile [RM] 0 to 98), Middle below Devils Canyon (RM 98 to 150), Middle River above Devils Canyon (RM 150 to 184), and Upper (upstream of RM 184) River segments.

Radio telemetry was used to assign final destinations (either the mainstem Susitna River, or tributaries) for 79 to 100 percent of salmon tagged in the Lower River (near RM 22 and 30), depending on species. For each species, most final destinations were in tributaries outside the area presumably affected by the Project (82 percent of Chinook *O. tshawytscha*, 70 percent of chum *O. keta*, 82 percent of coho *O. kisutch*, 93 percent of pink *O. gorbuscha*, and 99 percent of sockeye salmon *O. nerka*). Fewer salmon had final destinations in mainstem habitats susceptible to flow effects from the proposed dam (2 percent of Chinook, 8 percent of chum, 6 percent of coho, 3 percent of pink, and 1 percent of sockeye salmon). An additional two Chinook salmon

(<1 percent of those tagged) had final destinations upstream of the proposed Project dam site. Spawning could not be visually verified in mainstem river habitats in the Lower River due to high water turbidity. Final destinations could not be determined for the remaining proportions of each species tagged in the Lower River.

In the Middle and Upper River, radio telemetry was used to assign final destinations for 67 to 90 percent of salmon tagged at Curry (RM 120), depending on species. Most final destinations were in tributaries downstream of the Project dam site (81 percent of Chinook, 63 percent of chum, 66 percent of coho, 67 percent of pink, and 14 percent of sockeye salmon). Fewer final destinations for salmon were in mainstem river habitats susceptible to potential flow effects from the Project dam (9 percent of Chinook, 20 percent of chum, 13 percent of coho, 4 percent of pink, and 53 percent of sockeye salmon). Some locations in the mainstem Susitna River had clear enough water to visually verify spawning, generally supporting locations identified using radio telemetry.

Chinook salmon was the only species identified migrating upstream of any of the three high-velocity impediments in Devils Canyon (RM 150–161). One tagged sockeye salmon and one tagged chum salmon approached the most downstream impediment (Impediment 1) but did not migrate above it. Of the 313 viable Chinook salmon tagged in the Middle River, 23 (7 percent) migrated above Impediment 1, 20 (6 percent) above Impediment 2, and 10 (3 percent) above Impediment 3. Four (1 percent) of these Chinook salmon had final destinations upstream of the Project dam site. An additional three Chinook salmon tagged in the Lower River migrated above Impediment 1; of these, two migrated above Impediment 3. Of all 26 tagged Chinook salmon (Lower and Middle River combined) that migrated upstream of Impediment 1, seven eventually migrated back downstream and were assigned to final destinations downstream of the lower end of Devils Canyon. Most Chinook salmon migrated through the Devils Canyon impediments in mid-July, when discharge in the Susitna River was between 17,000 and 21,000 cfs at the Gold Creek gage.

Run timing at Curry peaked in early July for Chinook salmon, early August for chum and pink salmon, and mid-August for coho salmon. Sockeye salmon run timing was more protracted and ranged from mid-July through mid-August. These results were similar those obtained across five seasons in the early 1980s; the Chinook salmon run at Curry was late relative to three of the five years in the 1980s (1981, 1983, and 1984) and most similar to the 1982 run. Near-record river discharge in June 2012 may have delayed the Chinook salmon run timing at Curry.

Sockeye and chum salmon were each seen spawning in five sloughs or side channels in the mainstem of the Middle River. Each of these species and locations was also documented in the 1980s. Many other Middle River spawning locations documented in the 1980s were not verified in 2012, in part because of high water turbidity. No mainstem river spawning locations were identified for Chinook and coho salmon in the 1980s. In 2012, radio telemetry was used to identify some potential mainstem spawning in the Lower or Middle River by Chinook, coho, and pink salmon, but these could not be visually verified due to water turbidity. Mainstem spawning by sockeye and chum salmon was documented only in the Middle River in both the 1980s and in 2012. In both time periods, most spawning was in the same three sloughs. Sonar was not effective for verifying spawning activity in turbid water.

4.3. Historic Incubation and Emergence Studies

Egg incubation is an important life stage for salmon and trout, because a substantial amount of the freshwater rearing period can be spent developing within redds. During this stage, eggs and alevin are buried under the gravel surface and relatively immobile. Consequently, there is no way to avoid factors, such as temperature, water quality, or fine particulate matter, that can adversely affect survival to emergence. In the 1980s, chum and sockeye salmon were the principle salmon species using side channels and side sloughs for spawning in the Susitna River (Sautner et al. 1984); thus, egg development and incubation studies were conducted for these two species, with a focus on chum salmon. Studies included monitoring surface and intergravel water temperatures, egg development, spawning substrate composition, and fry emergence. Because the 1980s studies related to incubation and emergence consisted of multiple discrete efforts, the following sections are organized by topic (i.e., egg survival and emergence timing) rather than by effort.

4.3.1. Egg Survival

Declines in mainstem flow levels following spawning can cause areas that were suitable for spawning to become dewatered or have an increased risk of freezing (Vining et al. 1985). Chum in the Susitna River frequently select areas of groundwater upwelling for spawning. Upwelling areas can have the dual effect of preventing redd freezing and providing a stable thermal regime for developing eggs.

To evaluate egg survival, Vining et al. (1985) had two objectives:

1. Monitor selected physical and chemical conditions at chum salmon incubation sites in selected slough, side channel, tributary, and mainstem habitats of the middle Susitna River; and,
2. Evaluate the influence of selected physical, chemical, and biological variables on the survival and development of chum salmon embryos placed in artificial redds in slough, side channel, tributary, and mainstem habitats of the middle Susitna River.

Vining et al. (1985) selected eight primary sites within slough, side channel, tributary, and mainstem habitats that included a range of spawning density, upwelling conditions, thermal conditions, and substrate conditions. Primary sites were sampled for water quality, substrate composition, continuous water temperature, embryo survival, and embryo development. The primary sites included:

- Fourth of July Creek (HRM 131.1),
- Slough 10 (HRM 133.8),
- Side Channel 10 (HRM 133.8),
- Slough 11 (RM 135.3),
- Upper Side Channel 11 (RM 136.1),
- Mainstem (HRM 136.1),
- Side Channel 21 (HRM 141.0),
- Slough 21 (HRM 141.8).

Chum salmon survival and development was studied by artificially spawning chum and placing 50 fertilized eggs in Whitlock-Vibert Boxes (WVBs) containing appropriately sized gravel. To evaluate egg survival, WVBs were subsequently placed into artificial redds dug at randomly selected locations from a grid pattern. To evaluate egg development WVBs at two sites were placed in a single artificial redd. Artificial redds at most sites were created shortly after the fertilization process on August 26, 1983. However, some artificial redds at the Mainstem HRM 136.1 were dug on October 1 because water depths were too high for digging. For these sites, eggs were temporarily incubated in streamside incubators prior to being buried in artificial redds. A major assumption of this effort was that the hydraulic characteristics at artificial redds were similar to those encountered at natural redds. However, because the methods used for preparation and placement of the WVBs within the substrate were designed to simulate natural incubation conditions as closely as possible, the authors concluded that this assumption appeared justified.

During the 1984-1985 winter study, chum egg survival in artificial redds ranged from 0.0 percent (Side Channel 21 subsite A) to 43.0 percent (Slough 21) (Vining et al. 1985). They concluded that freezing was the major factor affecting egg survival in the artificial redds and that upwelling was the main moderating factor. Upwelling contributed two important functions. First upwelling can provide water to spawning habitat if mainstem flows decline. Second, upwelling water was generally warmer than surface water flows, which reduced the potential for ice cover and deep freezing of substrate down to the level where redds are created. Areas that were most susceptible to high embryo mortality from dewatering and freezing were those that lacked upwelling and were most directly affected by mainstem stage when fish were actively spawning; these included the mouths of sloughs and tributaries, major portions of side channels, and peripheral mainstem areas (Vining et al. 1985).

Events at Side Channel 21 were particularly important to their conclusion (Vining et al. 1985). Egg boxes (40) were initially buried (subsite A) during a period when mainstem flows were high (27,000 cfs) and the berm at the head of the side channel was breached, which resulted in relatively high water elevations in the side channel. Two weeks later they returned when mainstem flows were 11,000 cfs and the berm was no longer breached. All redds previously dug that did not have upwelling were dewatered. At that time they buried an additional 20 egg boxes in an area (subsite B) that was still wet. Mainstem flows continued to fall throughout the winter. All of the eggs that were buried at subsite A died from dewatering and freezing while 16 percent survival was observed at subsite B. Vining et al. (1985) further concluded that effective spawning habitat that reflects flows and upwelling throughout the incubation period may be different than the amount of habitat available during spawning.

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

Vining et al. (1985) concluded that sediment composition was also a factor contributing to egg survival. They observed that slough habitats had the highest level of fines, followed by side

channel, tributary, and mainstem habitats (Figure 4.3-1). However, sediment composition sampled directly from redds were much lower (Figure 4.3-2). They suggested that egg survival approaches zero when fines (< 0.08 inches in diameter) in redds exceed 16 percent (Figure 4.3-3).

4.3.2. Emergence Timing

Water temperature is the most important determinant of egg development and the timing of emergence (Quinn 2005). Intergravel water temperature studies began in February 1982, which led to the development of the following three hypotheses (Trihey 1982):

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

In addition to the importance to incubating salmon eggs, groundwater inflows to sloughs were also considered potentially important to overwintering habitat. During 1982 intergravel temperature monitoring occurred at thirteen sites between HRM 125 and 143 that were identified from ADF&G 1981 spawning surveys and were believed to have groundwater upwelling. Measurements of surface and intergravel water temperature revealed that intergravel temperatures were higher and more stable than surface water temperatures.

More intensive winter studies were implemented in March 1983 (Hoffman et al. 1983) and 1984-1985 (Vining et al. 1985; described in the previous section). Hoffman et al. (1983) reported on surface and intergravel water temperature monitoring at seven sites during the winter of 1982 to 1983 and also conducted incubation and emergence studies. In addition to water temperature, Hoffman et al. (1983) also monitored dissolved oxygen, pH, and specific conductance levels. Continuous surface and intergravel monitoring sites were established at six sloughs (Sloughs 21, 19, 16B, 11, 9, and 8A) and the mainstem at LRX 29 and Gold Creek. Measurements were collected from late August 1982 through early June 1983. Sites were chosen because they were known chum and/or sockeye salmon spawning locations.

Incubation and emergence studies were conducted at seven sites (sloughs 21, 20, 11, 9 and 8A) and two side channels (A and B located at HRM 136.2 and 137.3, respectively) (Hoffman et al. 1983). Standpipes to measure intergravel water temperature and chemistry were located along each bank of the selected sloughs (10 per bank, 20 total per location). Sampling at these locations occurred during April 15 to18 and April 29 to May 2. Eggs were sampled once per month from September 1982 through May 1983 using high pressure water jet to dislodge eggs into a mesh sack. Sampling chum and sockeye redds for developing eggs by Hoffman et al. (1983) indicated that chum eggs deposited during late August and early September of 1982 were eyed by mid-December, hatched in late February and March and emergence occurred between early April through May. The development of sockeye eggs collected from field sites was not substantially different than that of chum salmon.

Egg development was also monitored by Vining et al. (1985). Hatching first occurred in Side Channel 11 during late to early January, followed by hatching in Slough 11 during January. Hatching at the mainstem site did not occur until April. Although interruptions in temperature monitoring prevented a quantitative comparison of temperature regimes, Vining et al. (1985)

attributed the different development rates to temperature and the effects of upwelling. Upwelling was relatively strong at Slough 11, present, but relatively weak at Side Channel 21, and not present at the mainstem site. Vining et al. (1985) concluded that the presence of upwelling is an important factor contributing to emergence timing and that the beneficial effects of upwelling are more prominent in sloughs compared to mainstem, side channel, and tributary habitats because higher surface flows in the latter habitats dilute upwelling.

Wangaard and Burger (1983) incubated chum and sockeye eggs fertilized on three different dates (September 3, 9, and 15) under four different temperature regimes. Two of the regimes simulated natural temperature regimes measured in mainstem Susitna River at HRM 136 near Gold Creek and at Slough 8A. The third regime tracked the regime at Slough 8A, but was 1°C lower. The fourth regime was incubation at a constant 4°C. In this study, egg development was evaluated based upon accumulated temperature units (ATUs). One ATU is one day of temperature at 1°C, two ATUs could be two days at 1°C or one day at 2°C. Consequently, a constant temperature of 4°C over a five-day period results in 20 ATUs. ATUs in Wangaard and Burger (1983) were based upon mean daily average temperature.

Chum salmon eggs incubated under the mainstem temperature regime required substantially longer and fewer ATUs to reach the 50% hatch and yolk absorption stages compared to the Slough 8A and constant temperature regimes (Figure 4.3-4) (Wangaard and Burger 1983). A similar pattern was observed for incubating sockeye salmon eggs. Following hatch, alevins required different amounts of ATUs to complete yolk absorption (Figure 4.3-5). Using data collected during the study and from the literature, Wagaard and Burger developed predictive regression equations for 50% hatch and complete yolk absorption for chum and sockeye salmon eggs based upon average incubation temperature (Table 4.3-1).

Bigler and Levesque (1985) monitored surface and intergravel water temperature, egg development, outmigration, and substrate composition at three side channels in the Lower Susitna River with relatively high levels of chum salmon spawning that had not been anticipated. The three sites included the Trapper Creek side channel (HRM 91.6), Sunset Side Channel (HRM 86.9), and Circular Side Channel (HRM 75.3). Chum salmon surveys and instream flow modeling were also conducted at these sites. Egg development was also monitored at the Birch Creek Camp Mainstem (HRM 88.6) site and a fyke net deployed for two days in early May 1984.

Similar to Hoffman et al. (1983), the Bigler and Levesque (1985) study observed that most of these chum salmon spawning areas had upwelling and intergravel temperatures were higher than surface water temperatures. In general, eggs developed thorough the alevin and emergence stage at all sites. The upper portion of the Sunset Side Channel did not have groundwater upwelling and eggs laid in this portion of the study site froze. Development of eggs ranged from the caudal bud free stage to pigmentation stage by late January. Fyke nets to capture emerging fry were deployed beginning April 15, 1985 and fished periodically in each of the three side channels monitored (primarily the Trapper Side Channel). Sockeye salmon fry were captured on the first day of deployment at the Trapper Side Channel and chum salmon fry were present in the catch beginning April 30.

4.4. Mainstem and Mesohabitat Delineation Results

In 2012, mainstem and selected tributary habitats in the Upper, Middle, and Lower Susitna River were mapped as part of the habitat mapping efforts under the Fish and Geomorphology Program. The type of analysis used for the different study areas (i.e., tributaries upstream of Devils Canyon, the mainstem Upper River, the mainstem Middle River, and the mainstem Lower River) varied based on general stream and reach characteristics, such as channel width and complexity. For example, in the wide and highly braided Lower River, a geomorphic features analysis (see Section 4.4.4) was used while in the tributary habitats upstream of Devils Canyon a mesohabitat type frequency analysis was applied (see Section 4.4.1). In the mainstem Upper and Middle Susitna River (see Sections 4.4.2 and 4.4.3), habitat types were delineated at the mainstem habitat type level (e.g., main channel, side slough, upland slough, tributary mouth). A summary of the results of these studies are provided below.

4.4.1. Tributaries Upstream of Devils Canyon

The study area for the tributary component of the 2012 Aerial Video Habitat Mapping included 16 tributary streams from the upper extent of Devils Canyon upstream to and including the Oshetna River. In September, 2012, helicopter surveys were conducted to obtain aerial videography for each of these 16 streams. For tributaries known to support Chinook salmon, videography was obtained up to an elevation of approximately 3,000 feet. For tributaries that are above the proposed Watana Dam site and that are not known to support Chinook salmon, video mapping terminated at a 2,200-foot elevation. For tributaries that are below the proposed dam site and are not known to support Chinook salmon, video mapping was terminated at the first anadromous barrier. After video processing, mesohabitat frequency data were derived by reviewing video frames at 5-second intervals and identifying the mesohabitat type present at each interval. Detailed study results specific to each of the 16 surveyed tributaries are presented in Appendix 2: Aerial Video Habitat Mapping of Susitna River Tributaries from the Upper Extent of Devils Canyon to the Oshetna River.

4.4.2. Mainstem Upper Susitna River

This section is a placeholder. It will be completed in the Final Implementation Plan.

4.4.3. Mainstem Middle Susitna River

In winter 2012-2013, the frequency and proportion of habitat in the mainstem Middle River was delineated using geo-rectified aerial imagery in combination with available aerial videography. The objective of Middle River mainstem mapping was to characterize and classify river habitat in the Middle River mainstem from the Chulitna River confluence to the proposed Watana Dam site. These data were used to support the selection of representative focus areas for instream flow studies and the approach for fish distribution and abundance site selection.

A hierarchical and nested classification system developed specifically for the Susitna River with input from the Fish and Aquatics Technical Working Group was used to classify habitat to the mainstem habitat level. The geo-rectified imagery in combination with aerial videography was sufficient to map the Middle Susitna River mainstem habitat to the mesohabitat level. However,

the imagery was not suitable for mapping off-channel or tributary habitats to this level. Thus, these habitats were delineated only to the level of mainstem habitat types in 2012(HDR 2013).

A summary of these results can be found in the Middle Susitna River Segment Remote Line Habitat Mapping Technical Memorandum (HDR 2013).

Main channel habitat varied by geomorphic reach within the Middle River Segment and generally increased in complexity from upstream to downstream locations. Mesohabitat in the main channel was generally dominated by a mixture of run and glide habitats. Glide and run habitats, which were not distinguished from each other at this level of classification, included smooth-flowing, low-turbulence reaches as well as areas with some standing or wind waves and occasional solitary protruding boulders. Run-glide mesohabitat dominated all reaches except MR4, where Devils Canyon is located. Riffle habitat was most prevalent in MR 4. Riffle habitat was lacking or found in very small amounts in the other Middle River geomorphic reaches.

Side channels were predominantly glide or run, with some riffle areas in the lower reaches. Many side channels were not completely inundated with flowing water and so identification of riffle or run habitat was not possible; these were classified as unidentified and were most prevalent in MR 6.

Cascade habitat was not found within any of the geomorphic reaches of the Middle River Segment. The geomorphic reach through Devils Canyon (i.e., MR 4) contained the only rapids in the Middle River, which accounted for 38 percent of the mainstem habitat in that reach. Only 3 pools were found in the Middle River, and all were located in MR 4 between rapids in Devils Canyon.

The habitat associated with the confluence of tributaries with the main channel river was documented as tributary mouth and clear water plume. Not all tributaries that entered the Middle River had tributary mouth habitat. Small tributaries where the vegetation line was close to the mainstem did not fan out and create the areas classified as tributary mouth habitat. In addition, small tributaries or tributaries that flowed into fast moving or turbulent sections of the mainstem did not produce clear water plume habitats. Clear water plume habitats were located in reaches MR 2, MR 3, MR 5, and MR 7, with the highest number in reach MR 2.

Off-channel habitat was assigned to one of three habitat types observed: upland sloughs, side sloughs, and backwaters. Upland and side sloughs were prevalent throughout the Middle River reaches outside of Devils Canyon and downstream of the uppermost reach at MR 1. Side sloughs were most abundant in MR 5, followed by MR 6. Upland sloughs were most abundant in MR 8, and generally increased in abundance towards the downstream reaches (Table 5). Backwater habitat was relatively rare and found in a few areas in the lower reaches from MR 6 through MR 8. A single backwater was also delineated in MR 2 and in MR4, but each accounted for less than 1 percent of the linear habitat within their respective reaches. The greatest total area of backwater habitat was in MR 7, but the greatest frequency was found in MR 6.

Beaver complexes were consistently associated with slough habitats and as such were not categorized as a habitat type but were noted as a characteristic of that slough habitat unit. Beaver dams were rarely present in side slough habitat, and slightly more prevalent in upland sloughs. Beaver dams were only observed in reaches MR 6 and MR 7.

4.4.4. Mainstem Lower Susitna River

The *Reconnaissance-Level Geomorphic and Aquatic Habitat Assessment of Potential Effects on the Lower River Study* (AEA 2012b) conducted in 2012 will be used to delineate different geomorphic features in the mainstem Lower Susitna River. The features used for this analysis are described in Table 4.4-1, and detailed results will be found in the technical memorandum currently under development for the geomorphology study.

In this section of the Final Implementation Plan, results of the geomorphology analysis will be summarized with respect to the geomorphic feature types, or habitats, that will be sampled for fish distribution and relative abundance in the mainstem Lower Susitna River. The geomorphic feature types (as defined in Table 4.4-1) of interest include: main channels, side channels, side channel complexes, side sloughs, upland sloughs, tributaries, tributary deltas, bar island complexes, bars/attached bars, and additional open water areas.

4.5. Open-water Flow Routing Modeling Results

This section is a placeholder to be completed in the Final Implementation Plan. The open-water flow routing results as they pertain to the fish distribution and abundance studies will be summarized here. A complete description of the model results can be found in the *Open Water HEC-RAS Flow Routing Model* technical memorandum (R2 2013).

4.6. Documentation of TWG Input to Site Selection Protocol

This section will be provided in Final Implementation Plan, following February 2013 consultation.

5. METHODS: DESCRIPTION OF SITE SELECTION AND SAMPLING PROTOCOLS

In this section, a detailed description of the methods to be used for the 2013 and 2014 Study of Fish Distribution and Abundance in the Upper and Middle/Lower Susitna River is provided. First, basic fish handling protocols (Section 5.1) for all field study components are discussed, such that field survey crews can quickly access information needed to ensure proper fish handling while in the field. Next, information for determining appropriate sample unit sizes (Section 5.2) is provided to facilitate consistency among survey crews and the implementation of a statistically rigorous study design. The subsequent sections (i.e., Sections 5.3 through 5.11) address additional details and considerations specific to various study components, such as fish distribution and abundance sampling, early life history studies, PIT tagging arrays, downstream migrant trapping, radio telemetry studies, fish tissue and gut content sampling, and winter sampling techniques. Lastly, data management and QA/QC standards, including the development of standardized field forms and relational database templates established by AEA for these studies are described in Section 5.12.

5.1. Fish Handling

It is necessary to provide consistent and reliable techniques that reduce potential negative effects of capture and handling on fishes while still allowing for species identification and enumeration. Special care should be taken to ensure that all fish are handled properly and that unintended mortalities are extremely low. In general, fish should be kept in cool, well-oxygenated water, and the amount of time spent away from the river environment should be minimized to the extent possible. All personnel that handle fish must be properly trained.

Strategies to minimize fish stress and mortality include the following:

1. Minimize handling to that necessary to meet Project objectives.
2. Minimize the time fish are held.
3. Minimize the time fish are held in anesthetic.
4. Start with low concentrations of anesthetic and then increase as necessary. Fish should be anesthetized only to the point at which they can be handled easily without strain.
5. Remove smaller or more sensitive fish from anesthetic first, followed by larger, less sensitive species.
6. Hold fish in fresh or flow through river water during examination.
7. Use wet transfers.
8. Monitor water temperatures and dissolved oxygen concentrations in closed systems regularly and adjust as necessary (see Section 5.1.2).

5.1.1. Fish Transfer and Holding

Fish transfers from capture to tagging or release sites will be executed using water-to-water methods whenever possible. Net transfers should not be done unless necessary and if done, should be done quickly. Hands, dip nets, and measuring boards should always be wet before coming in contact with fish. Each time a fish is netted, it may lose some scales; thus, the number of times a fish is netted should be kept to a minimum. When scooping up multiple fish, it is important to limit the number of fish in the net to minimize strain and pressure on fish in the bottom of the net.

Coolers (48-quart [45-liter]) and buckets (5-gallon [19-liter]) may be used for transferring fish or holding for short durations (e.g., during sorting or counting). Because buckets are easily carried, they are the preferred method for tending minnow traps, seining, and transporting fish to or from holding pens and tagging stations. A screw-top bucket can be easily modified to allow it to fill or drain by drilling a series of ¼-inch diameter holes 2 to 3 inches below the lip half way around the bucket. This type of bucket can also be used as a temporary holding pen if placed in an area with water circulation.

Net pens are the preferred method for holding fish. Net pens minimize stress and allow for good water circulation. Pens will be 3 to 4 feet square, cube shaped, and composed of ¼-inch nylon mesh. Net pens can be mounted on floating frames built with two-by-four lumber and foam floats. Net pens must always be tied to shore, so they do not float away. When dip netting fish, a holding pen can be gradually pulled up out of the water to concentrate fish for easier capture. When scooping fish from a net pen bring the net close to the side of the pen, but try not to touch the sides of the walls where fish can be pinned or scraped. The preferred method of capture is to herd fish into an area and use slow methodical movements to scoop up fish.

Fish will be observed closely during transport for signs of stress including darkening of color, gasping and crowding towards the surface, and increased jumping behavior. If fish exhibit behaviors that are indicative of stress water should be refreshed immediately. Care must be taken to ensure holding and freshwater temperatures of are within 2°C of each other. Cover all buckets and net pens with a screw-top lid or nylon mesh netting while in use.

5.1.2. Temperature and Dissolved Oxygen

Fish, especially young salmonids, are sensitive to changes in temperature, oxygen levels, sunlight, and a variety of other factors that may be encountered during handling. When using buckets, crews will locate buckets in shade, check holding water temperature regularly, and add river water when temperatures are 2°C greater than river water temperature. Partial emersion of buckets along the stream edge will help to maintain water temperature. When transferring fish between locations (e.g., hauling tank to river, bucket to holding tank, etc.), crews will check the temperature difference between environments. Differences greater than 2°C should be avoided, since this change can cause a loss of equilibrium and stress. Make sure fish are not over-crowded (i.e., <25 smolts or <50 fry per bucket; 100-150 individuals per standard-size cooler). Dissolved oxygen (DO) levels should be maintained between 7 and 10 mg/L, and an aerator should be used to help maintain DO levels. Use a DO meter to check holding water periodically, and refresh water if the DO concentration falls below 7 mg/L.

5.1.3. Anesthesia

Anesthetics will be used to immobilize fish as necessary for handling and surgical procedures by depressing their central and peripheral nervous systems. Sampled fish are to be anesthetized in clove oil/eugenol (AQUI-S®20E) prior to handling (Kennedy et al. 2007). Uptake of the chemical is through the gills during respiration. The effective solution strength may vary somewhat with water temperature, fish size, species, and purpose of anesthesia (measuring versus PIT tagging). A short induction time (i.e., 2–5 minutes) is desired for quicker recovery. In August 2012, the U.S. Food and Drug Administration approved the use of AQUI-S®20E (10% eugenol) as a sedative drug, to allow for the immediate release of freshwater finfish sedated as part of field-based fisheries studies.

Clove oil is insoluble in cold water (<15°C) and must be mixed with ethyl alcohol in order to be used in an anesthetic bath. For the use of clove oil prepare a 100 mg/ml solution with ethyl alcohol (75-95%) consisting of one part clove oil to nine parts ethyl alcohol. The 1:9 premixed solution should be kept in a dark bottle and out of direct sunlight. When preparing a bath, the clove oil solution should be mixed with fresh, well oxygenated river water to obtain a solution of 30-50 mg/l. Table 5.1-1 should be used as a guide when making an anesthetic bath with the 1:9 clove oil solution.

The following sensory and motor responses of the fish characterize progressively deeper levels of anesthesia:

1. Sedation: Decreased reactivity to visual and vibrational stimuli; gill activity reduced.
2. Total Loss of Equilibrium: Fish turns over; locomotion decreases; fish swims or extends fins in response to pressure on caudal fin or peduncle.
3. Total Loss of Reflex: No response to pressure on caudal fin or peduncle; opercular rate slow and erratic.

4. Medullary Collapse: Gill activity ceases.

When properly anesthetized, fish should be calm and will start to lose their balance (i.e., turning on their side) with gills pumping normally to rapidly. They should show reflexes when pressure is applied to the base of the tail. Over-anesthetized fish lose all balance and ability to swim. Overexposure, in either time or concentration, to clove oil will lead to death for fish. Observe gill activity; if opercula movement stops, the fish should be immediately transferred to a freshwater bath, and gills should be irrigated with fresh oxygenated site water until fish recovery. Always have a freshwater bath prepared when sedating fish.

Closely monitor time while fish are immersed in anesthetic bath. A rough estimate of safe exposure time can be made by multiplying the time required to reach sedation by 2.5. It is important to know the safe exposure time and to not exceed it. Following anesthesia, fish will be allowed to recover in a flow-through holding pen in river water or a well aerated vessel for a minimum of 20 minutes. When orientation and muscular control are regained, fish will be released in calm water near the site of capture.

In some instances, euthanasia may need to be performed on fish that are severely injured or prior to preservation. This can involve an overdose of an anesthetic, such as clove oil or tricaine methanesulfonate (MS-222), or for larger fish, a sharp blow to the base of the skull. Prepare a solution of MS-222 in water of sufficient concentration to achieve a final concentration of 200 mg/L in the vessel containing fish to be euthanized. Anesthetized fish should experience total loss of equilibrium in 0.5 to 2 minutes. Exposure to MS-222 should continue for a minimum of 5 minutes after opercular movement ceases (Summerfelt and Smith 1990). Following euthanasia, fish may be preserved as needed for subsequent studies.

5.1.4. Fish Identification

There are twenty-one fish species, including all five species of Pacific salmon, that may be encountered in the study area (Table 4.1-1). The goal is to always identify sampled fishes correctly, and a working knowledge of correct terminology is essential for quick and efficient fish identification. A training session will be conducted at the beginning of each field season to orient crews and train them in fish species identification. Individuals responsible for training will be fish biologists with fish identification experience in Alaska. Fish biologists conducting orientation and training will then work with crews in the field to check for accuracy and consistency. The resources "Field Identification of Coastal Juvenile Salmonids" by Pollard et al. (1997) and "Juvenile Salmonid and Small Fish Identification Guide" by Wiess (2003) will be used for field verification of juvenile salmonid species. Sculpin will not be identified to species in the field and will be recorded as "*Cottus* sp."

If a crew member is unsure of a fish after considering all of its characteristics, they should consult with the other persons on the sampling crew and come to a consensus. If uncertain of identification, the individuals in question should be photographed from dorsal, ventral, and lateral views, noted on the field data form, and brought to the attention of the Project Lead. In addition, crews will be instructed to collect representative voucher specimens for species that are challenging to identify.

5.1.5. Data Collection and Recording

All captured or observed fish will be identified to species and life stage when possible. As fish are being placed under anesthesia, a designated person should identify and sort captured fish by species and age/size class. For juvenile anadromous salmonids, a life stage index will be used for grouping life stages (e.g., alevin, fry/parr/smolt). When possible, resident fishes will be grouped as young-of-year (0+), juvenile (typically age 1+ and 2+), and adult (typically age 3+). Each time a gear is sampled, a random sample of 25 individuals per species, life stage, and site will be measured for fork length (FL) in millimeters. For species without a forked tail (e.g., sculpin and burbot), length will be measured laterally along the mid-line to the posterior edge of the tail. Fish should be selected randomly for measurement to prevent bias for or against the slow or larger fish in the container. A dip net should be used (versus bare hands) when catching fish to be measured. Hands, dip nets, and measuring boards should always be wet before coming in contact with fish. Length measurements should be done on a clean, smooth, wet board that has easy to read gradations in mm. The remaining fish of each species and age class will then be enumerated. To increase efficiency, fish should be sampled in groups of ten, and the sample routine followed in a stepwise manner: (1) identify species and life stage, (2) measure lengths, (3) remove tissue samples for genetic analysis, if applicable, and (4) if any mortalities occur, use these fish for sex identification and for collection of any ancillary data. Care will be taken to collect all data with a consistent routine and to record data neatly and legibly.

5.1.6. Scanning for PIT tags

During fish measurement and counting, juvenile anadromous salmonids >60 mm FL, rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot will be scanned for PIT tags using a hand-held portable scanner (see Section 5.6 for PIT tag insertion procedures). Optimal PIT tag readability occurs when the tag is oriented perpendicular to the antenna field. In order to optimize tag readability, juvenile fish that are 60-250 mm in FL will be scanned in three passes. With the tag insertion site as the center point of the passes and with the unit touching the body, the scanner will be passed over the abdominal cavity in a cross-like pattern, such that the tag location is passed vertically twice and horizontally once. Adult resident fish >250 mm in FL will be scanned in the same manner but with the passes centered on the dorsal PIT tagging region (i.e., in the region of the pelvic girdle, directly below the dorsal fin on the left side of the body). Any electromagnetic field in the area (e.g., a running motor) or ferrous metal objects near the tag and/or reader may affect the read range. Readers can also be prone to various malfunctions or decreased read range, mainly due to battery issues and environmental conditions such as temperature and humidity. For this reason, field personnel will be required charge readers nightly and to test reader function by scanning a 'test tag' for each session in which fish are handled and scanned.

5.2. Sampling in Tributaries Upstream of Devils Canyon

Tributaries upstream of Devils Canyon (RM 150) that have been selected for fish distribution and abundance sampling include all known Chinook salmon-bearing tributaries and other tributaries that are not currently listed in ADF&G's Anadromous Waters Catalog (AWC; ADF&G 2012). A nested stratified sampling scheme using a generalized random tessellation stratified (GRTS) sampling method (Stevens and Olson 2004) will be used to select study units

within each tributary. Within each tributary, sampling locations will comprise a target of up to 25 percent of the length of the tributary to the 3,000-foot elevation contour; this target varies based on documentation of Chinook salmon presence in the tributary watershed (Table 5.2-1).

Initially 20 tributary streams were selected for sampling based on: AWC catalog listings, drainage basin, historical sampling efforts, and the potential for impact/inundation from the proposed Project (Table 5.2-2). These tributaries were screened for accessibility of sampling based on stream gradient, channel morphology (i.e., confined canyon), mesohabitat type (rapid and cascade) and physical access. The screening resulted in seven tributaries known to be accessible or to have substantial length of accessible reaches, nine tributaries that were largely inaccessible, and four tributaries where access was unknown. The seven accessible or partially accessible tributaries and the four tributaries where access conditions are unknown were subject to site selection using a generalized random tessellation stratified (GRTS) sampling design. The GRTS design was applied to the accessible portion of each of these 13 tributaries up to the 3,000 ft elevation.

The accessible portion of each selected tributary was divided into *population units* of equal lengths based on channel width and drainage basin area. A population unit length equal to 20 channel widths was expected to contain a good distribution of habitat types, which is useful for distribution and abundance sampling. However, recent channel width data were not available at this time, and the units within each tributary should be equal in length. For this reason, an additional stratification was used to divide tributaries into three different groups based on drainage areas and historic channel width data, where available (Saunter and Stratton 1983). Large tributary streams with a drainage basin greater than 1,000 km^2 and with channel widths of 35-45 meters were assigned 800-meter GRTS sampling units. Tributaries with drainage areas ranging from 300 to 1,000 km^2 and with channel widths of 15-35 meters were assigned 400-meter GRTS units. Tributaries draining less than 300 km^2 and with channel widths of 5-15 m were assigned 200-meter units. As a result of using this approach, each GRTS unit is approximately 20 channel widths in length. GRTS unit lengths for each of the selected tributaries are shown in Table 5.2-1.

The GRTS sampling method (Stevens and Olson 2004) was used to select population units to sample. Specifically, the *grts* routine in package *spsurvey* (Kincaid and Olsen 2012) for R (R Core Team 2012) was used to generate the GRTS samples. This sampling method is a compromise between random and systematic sampling that allows random ordering of population units with spatial balance. A systematic sample design would also work for the tributaries upstream of Devils Canyon. However, the accessibility of each selected location cannot be determined with certainty before sampling begins. With a systematic sample, loss of a sampling location in the field compromises the spatial coverage of the design and also the overall sample size. Using the GRTS samples, oversampling (i.e., selecting 10 samples but planning to use only the first 3) is allowed; if selected samples are determined to be inaccessible in the field, the next sample on the randomized list can be used while maintaining spatial balance in the final sample set.

For each selected tributary, the accessible length of tributary was divided into equal length population units as described earlier, and the GRTS sample was drawn. No estimates of variance in relative abundance on these tributaries are available at this time, so sample sizes were not estimated via statistical power analysis. Instead, the sample size is based on a targeted percent coverage of the accessible population for distribution sampling (Table 5.2-2) and 10 percent

coverage for abundance sampling. For example, if there are 100 population units on a given tributary, 25 were selected for distribution sampling, and the first 10 of these would also be used for relative abundance sampling.

The population units selected by the GRTS sample will be carefully examined for accessibility based on orthophotos and available video. Although efforts have been made to limit the units in the sampled population to accessible and safe areas, population units may have to be eliminated at this stage as well. If a unit is deemed inaccessible, oversampling allows for an alternative sample to be selected without losing the statistical properties of the sample (i.e., spatially balanced random sampling).

Each mesohabitat unit (e.g., pool, riffle, glide and cascade) within the selected sample unit will be counted and measured using video and aerial imagery from habitat mapping efforts. One of each mesohabitat unit will then be randomly selected for sampling. A 40-meter sub-sampling method will be used to acquire relative abundance estimates within each mesohabitat unit. If a unit is smaller than 40 meters in length, the entire unit will be sampled and a second random unit will be sampled until the target of 40 meters is obtained. Examples of GRTS units selected for sampling, and the type of sampling, are presented below for the Oshetna River, Goose Creek, and Kosina Creek (Figures 5.2-1, 5.2-2, and 5.2-3, respectively). Maps showing sample locations are provided for the Oshetna River and Goose Creek (Figure 5.2-4) and Kosina Creek (Figure 5.2-5).

The direct sampling methodology will be implemented on the nine tributary streams with minimal to moderate access and limited feasible sampling areas (Table 5.2-2). For these identified streams, an average effort of two days will be conducted. Sampling effort will be as follows: smaller streams will be sampled for a single day, moderate sized and accessible streams for two days, and larger more accessible streams for three days. The goal of sampling will be to distribute effort over the accessible study area in three locations. Where possible, the three locations will represent differences in elevation or other habitat features. Where aerial still or video imagery is available, proposed sample locations will be identified and reviewed prior to field activity. Habitat observed from the imagery at identified locations will be documented and field teams will attempt to sample pre-identified habitat units. Where imagery is unavailable, sampling location and effort may be determined during the first sampling effort for each tributary. Effort at each habitat unit will be considered done when the field lead judges that the unit was sufficiently represented or that additional sampling effort will not provide additional data. Sampling will occur seasonally (i.e., every other month from May through October).

Distribution results (i.e., fish observation locations) will be presented on maps. Relative abundance estimates (e.g., fish per unit area, CPUE) will be summarized by tributary and habitat type with appropriate statistical confidence intervals for GRTS samples. These estimates will apply only to segments of the tributary that were included in the statistical sample (i.e., the accessible portions of the tributary).

5.3. Sampling in the Mainstem Middle River

The Middle River habitat mapping effort completed in early 2013 provided delineation of mainstem habitat units in the mainstem and off-channel areas. The length data associated with the habitat unit delineation facilitated the use of a GRTS sampling approach in the Middle River. The GRTS sampling method allows for some field flexibility for missing samples. Each unit to

be sampled is placed in random order so that the random order is preserved if a sample needs to be skipped. GRTS design produces a probability sample with design-based variance estimators. It provides a spatially balanced, random sample, allows for unequal probability sampling, and can provide an over-sample of sample sites to accommodate field implementation issues (e.g., a location is not accessible or is too deep to be sampled and must be skipped).

In this river segment the GRTS design was used to select study sites based on a habitat stratified sampling scheme nested within Middle River geomorphic reaches MR 1 – MR 8. However, because geomorphic reach length and channel complexity vary greatly, not all habitat types will be found within each geomorphic reach. A summary of the Middle River habitat mapping results has been included in Section 4.4 of this plan.

For mainstem, off-channel habitat site selection, a GRTS sampling scheme was used for each mesohabitat type within each geomorphic reach. For each geomorphic reach the habitats were first stratified by within and outside of Focus Areas. Then for the area outside of Focus Areas the lengths of each mainstem habitat type was combined to generate the sample population by habitat type. Thus, the total length main channel, split main channel, multiple split main channel, side channel, upland slough, and side slough habitats in each geomorphic reach are represented by line segments for habitat mapping. Line segments for each habitat type were then partitioned into 40-meter lengths and the GRTS sampling routine was used to select three. Tributary mouths, tributary plumes, and backwaters, are less numerous and represented by point features for habitat mapping. When three or fewer are found within a geomorphic reach they were all selected for sampling, if more than three are present, the GRTS sampling routine was used to select three. This step was then repeated for sampling with all Focus Areas combined for the reach.

Middle River Geomorphic Reach MR 6 (RM 145-199) has undergone site selection and is presented here as an example (Figure 5.3-1 and Figure 5.3-2). Outside of Focus Areas in MR 6, GRTS was used to select three sites of the following habitat types: main channel, split main channel, multiple split main channel, side channel, upland slough, side slough, tributary, and tributary mouth. All tributary plumes (n=3) and backwaters (n=3) were selected for sampling. This results in 27 total sampling sites for geomorphic reach MR 6 outside of Focus Areas. While all sample sites will be used to provide information on fish distribution, one third of the GRTS selected sites (9 sites) were designated as relative abundance sites. Sample sites selected outside of Focus Areas in Geomorphic Reach MR 6 are presented below in Figure 5.3-1.

Within Focus Areas in MR 6, GRTS was used to select three sites of the following habitat types: main channel, multiple split main channel, side channel, upland slough with beaver complex, upland slough without beaver complex, side slough with beaver complex and side slough without beaver complex. In addition, there was only one backwater, one tributary plume, two tributaries, and two tributary mouths, so these all were selected. This results in 28 total sampling sites for Geomorphic Reach MR 6 within Focus Areas. Sample sites selected in combined Focus Areas in Geomorphic Reach MR 6 are presented in Figure 5.3-2. The number of sites in Focus Areas and non-Focus Areas are summarized in Table 5.3-1.

5.4. Fish Abundance Sampling

Fish distribution and relative abundance sampling in the mainstem Lower and Upper Susitna River will be conducted from RM 61 to 98.5 and from RM 184 to RM 233, respectively. This

survey area includes Geomorphic Reaches LR 1 (RM 98.5-84), LR 2 (RM 84-61), UR 3 (RM 233-223), UR 4 (RM 223-206), UR 5 (RM 206-201), and UR 6 (RM 201-184). Due to channel morphology in Upper and Lower River and corresponding limitations of habitat mapping therein, we are proposing a systematic transect approach whereby fish sampling sites will be selected within habitat units encountered along a transect. Using a random start for both the Lower and Upper River study areas (i.e., from RM 61 to 98.5 and from RM 184 to RM 233, respectively), transects will be equally spaced. In the Lower River, there will be five transects located at 6-mile intervals, and in the Upper River, 20 equally spaced transects will be established every 2.4 miles.

Because of the complex nature of the Lower River, many transects span multiple habitat types (e.g., main channel, side channel, upland slough, and side slough). One habitat unit of each type encountered will be selected along each transect, as exemplified in Figure 5.4-1. Where multiple habitat units of the same type occur, units will be randomized and one selected. Fish distribution and abundance sampling will then be conducted along a 40-meter-length of the unit, starting at the downstream end. If the randomly selected habitat unit is totally inaccessible to field crews, then a second randomly selected habitat unit will be sampled.

The same approach will be used for sampling across the Upper River transects. That is, at each transect, one randomly selected habitat unit of each type will be sampled over a length of 40 meters. Although the Upper River is less complex than the Lower River, the Upper River transects may span two or on rare occasions three habitat types. Based on preliminary mapping of the mainstem Upper River we has estimated that approximately one-third of the length of the Upper River mainstem that will be sampled will contain more than one, and up to three mainstem habitat types.

Distribution results (i.e., fish observation locations) will be presented on maps. Relative abundance estimates (e.g., fish per unit area, CPUE) within the Lower and Upper River mainstem will be summarized by mainstem habitat type with appropriate statistical confidence intervals.

5.5. Salmon Early Life History Movements

Early life history studies will take place in select Focus Areas where movements between spawning and early life stage rearing habitats are anticipated based on results of historic and recent studies. Five focus areas that meet these criteria have been identified for intensive study (Table 5.5-1). During bi-weekly fish distribution sampling, sites for sampling will include three designated 40-meter long sampling units immediately downstream of a documented Chinook, chum, or coho salmon spawning area (these may be tributary mouths or side sloughs at some Focus Area locations) and three 40-meter long rearing habitat sampling units. Rearing habitat sampling units will be generally stratified in side slough habitat to include upper slough, middle slough, and slough mouth areas where appropriate (Figure 5.5-1). Electrofishing, seining, fyke nets, and minnow traps will be the primary methods for collecting salmon during the early life stage. Snorkeling may also be used where appropriate. Stranding assessment and winter sampling efforts will utilize the same sampling locations but will be less frequent, approximately monthly instead of biweekly and for winter will be dependent on safe access and sampling methods (due to ice cover).

5.6. PIT Tagging

Passive integrated transponder (PIT) tags are small tags that are internally implanted in fish to monitor their movement, survival, and individual growth. PIT tags are radio frequency identification tags that transmit a unique alphanumeric code as they pass through the electromagnetic field emitted by a detection antenna (Prentice et al. 1990). In natural systems, PIT tags can be useful to document localized movements of fish, as well as growth and survival information across seasons and years. Fish movements and survival of tagged fish can be ascertained as fish swim past fixed antenna arrays or when tagged fish hare opportunistically re-captured in traps or during routine fish sampling. These opportunistic re-captures can also be used to collect growth data.

PIT antennas emit a weak electromagnetic field; therefore, the tags must be between about 10 and 100 cm from the antenna to be detected, depending on the tag and antenna system. To determine movement into and out of rearing habitats, will require that tagged fish pass within several feet of a stationary PIT tag interrogation system. This detectability distance constrains the use of fixed arrays to relatively small and shallow water bodies. For this study, PIT tag arrays will be focused in smaller tributary, slough or side-channel habitats.

The target species for PIT tagging are juvenile Chinook and coho salmon and the following resident fish species: rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot. We will attempt to PIT tag up to 1,000 fish per species per PIT tag interrogation site. In the Upper Susitna River, tagging will be attempted on all juvenile Chinook salmon captured.

5.6.1. Stationary PIT tag Interrogation Systems

Each stationary PIT tag interrogation system requires a power source, data logger, antenna and tuning capacitor. The power source will consist of a bank of three each 12 and 6-volt batteries (100 Ah) supplemented with solar power. This will allow the reader to operate at 18 volts. A solar panel and controller will be used to power the reader and charge the batteries. Readers are sensitive to electrical noise; controllers must be chosen that will not generate electrical noise. The reader will operate from a direct current (DC) power source with current consumption between 0.5 to 3 amps. When operating from batteries, the reader prevents damage by monitoring the supply voltage and it will stop scanning when the power level is too low. If operating at 1.5 amps, a reader with a 300 Ah battery bank will run for just over eight days provided no solar power charging. A field box enclosure will house the batteries and reader. Further testing will be performed to determine if propone powered thermoelectric generators are needed to supply power during the winter months. Data loggers will be downloaded every two to four weeks, depending on the need to replace batteries and the reliability of logging systems.

Multi-antenna (multiplexer) readers will be used and can power up to four antennas scanning one at a time. Multiple antennas will be used in some locations to determine the direction of movement by comparing the times of detection events at more than one antenna. However, multiplexer readers scan only one antenna at a time so the read rate is reduced and tag detection can be missed if the tagged fish moves quickly through the antenna field. Each antenna must have a tuning capacitor in order to adjust or tune the antenna resonation at the proper frequency. Antennas can be placed in protective housing such as PVC or plastic/rubber hosing for protection. Antennas will be inspected on a regular basis and replaced as necessary.

A variety of antenna configurations may be used including hoop antennas, swim-over antennas, single rectangle (pass-through) antennas, or multiplexed rectangle antennas to determine the directionality of movement. Pass-through antennas are most appropriate if the entire stream channel can be spanned for maximizing detection efficiency. As noted in Connolly et al. (2008, the pass-through orientation is likely to provide the best probability of detecting a PIT-tagged fish, and it is very suitable for: (1) stable-flow streams; (2) streams with little or no large debris; (3) sites with existing structures to mount antennas and (4) studies limited to investigating fish movement during low-flow periods. In other situations, it may be best to anchor antennas so that they are parallel with the stream substrate in a pass-by orientation. This orientation can perform exceptionally well during low-flow conditions and is less likely to break away during high flow events; however, the column of water available to fish during high flow events may be more likely to exceed the read range of the antenna (Connolly et al. 2008.). Detection efficiency under these conditions may be particularly reliant on the behavior of the fish (e.g., bottom vs. surface-oriented movers).

5.6.2. Efficiency Testing and Read Range

Efficiency, for the purpose of this study is the overall performance of a PIT interrogation system for detecting passing fish with PIT tags. Detection efficiency is an estimate of the percentage of PIT-tagged fish that were detected as they passed an interrogation system. Using the indirect method described by Connolly et al. (2008) detection efficiency and variance estimates will be determined for each array and interrogation system. Detection data will used to calculate detection efficiencies of the individual interrogation systems. Data will be sorted into upstream- and downstream-moving fish based on time of detection at two or more antenna arrays. Using the method developed by Connolly et al. (2008) overall estimate of detection efficiency for an interrogation system is greatly influenced by the detection efficiency of the individual antenna arrays in the system, and the precision of the estimate is much influenced by the number of PIT tags passing the system. Per this method, criteria will be established that differentiates a fish-detection event from a fish-passage event. The criteria will then be applied to a multiple array detection probability model that will (Lady et al. 2003) calculate the efficiency of detection of upstream- and downstream-moving fish.

5.6.3. Read Range

Antenna read range will be tested in situ using handheld 12 mm and 23 mm PIT tags prior to each data download. A predetermined and standardized location will be identified at each antenna for consistency among range tests. Measurements will be reported as “one-sided read range,” defined as the distance from the center of the antenna plane to where a PIT tag (oriented both perpendicularly and parallel) moving towards the antenna is first detected. When testing read range, it is important to consider the orientation of the tag’s long axis to the antenna loop plane. Two detection positions will be measured: (1) over the center of the loop with the long axis of the tag perpendicular to the antenna plane and (2) with the long axis of the tag parallel to the antenna plane. Water temperature, water velocity, depth, and stage-height will be noted each time read range is measured.

5.6.4. Opportunistic Recoveries

Fish sampling and trap monitoring crews working in the vicinity of PIT tag arrays will be trained to look for tagging scars and will be given hand held detectors to scan all specimen of target species that are captured. They will record the tag code, size and condition of the fish on re-capture data sheets as well as the date, time, location, and habitat type associated with the capture event.

5.6.5. Site Selection

PIT tag antenna arrays with automated data logging will be used at selected side channel, side slough, tributary mouth, and upland slough sites to detect movement of tagged fish into or out of the site. A total of six stationary PIT tag interrogation systems are proposed, two in the Upper River, three in the Middle River and one in the Lower River (Figure 5.6-1). Potential locations were evaluated based on a review of existing data on fish distribution and habitat, the anticipated physical conditions and debris load at potential sites, and logistics for deploying, retrieving, and maintaining the antennas (Table 5.6-1). Four systems are proposed for deployment in important spawning tributaries near their confluences with the Susitna River. Two systems are proposed for off-channel habitat to characterize the movements of fish into and out of these areas.

Two stationary interrogation systems are proposed in the Upper River study area, the Oshetna River near its confluence with the Susitna River (RM 233.4) and Kosina Creek at the confluence with Tsisi Creek. Upper River locations are co-located with outmigrant trapping efforts to maximize data collection at these remote sites. In the Upper River, Chinook salmon are the only anadromous salmon species present and have only been observed in limited numbers at a few locations. Therefore, suitable PIT interrogation sites that are in close proximity to areas where Chinook salmon spawning or juvenile rearing has been documented are scarce. In the Upper River, potential sites are limited to: Kosina Creek (adults and juveniles), Oshetna River (juveniles) (ADF&G 2003; Buckwalter 2011; HDR unpublished) or the main channel of the Susitna River between the confluence of the Oshetna River and the proposed dam site (RM 184). Of these sites, the Oshetna River, near its confluence with the Susitna River (HRM 233.4) and Kosina Creek (HRM 206.8) near its confluence with Tsisi Creek are proposed for PIT tag arrays (Table 5.6-1). These sites have been identified as locations where hydrologic conditions may be favorable and logistics may be feasible for antenna deployment. The placement of an interrogation system near the mouth of the Oshetna River also will help to gather information on resident species including Arctic grayling, Dolly Varden, and round whitefish (Buckwalter 2011; HDR unpublished). A second array located at the confluence of Tsisi Creek with Kosina Creek, would provide an opportunity to gather information on juvenile Chinook salmon in the Upper River study area as Chinook salmon spawning has been documented in Kosina Creek upstream of this location; lower reaches of the Kosina Creek are not easily accessible due to topography and steep gradient. Several target resident species are found in Kosina Creek including: Arctic grayling, Dolly Varden and round whitefish (Buckwalter 2011; HDR 2012.).

Three stationary PIT tag interrogation sites are proposed in the Middle River study area, Indian River (RM 138.6) near RM 1, Slough 8A (RM 125), and Whiskers Slough (RM 104). These sites were selected based on historic fish use data as well as to co-locate PIT arrays with Focus Areas and radio-telemetry arrays. Indian River is a primary tributary of the Middle River and is heavily used by both Chinook and coho salmon and a diversity of target resident fish species

(ADF&G 1984a; HDR unpublished). Slough 8A was selected because the side channel and side slough habitats present support high juvenile and resident fish use. Whiskers Slough was selected as a site where spawning and juvenile rearing habitat is present and resident fish were historically abundant. During the 1980s, the following target species were present in Whiskers Slough: juvenile Chinook salmon, juvenile Sockeye salmon, juvenile coho salmon, rainbow trout, humpback whitefish, round whitefish, burbot, Arctic grayling, Dolly Varden, and Arctic lamprey (Schmidt 1983).

In the Lower River, one stationary interrogation system is proposed for Montana Creek (RM 77) near its confluence with the Susitna. Montana Creek was selected because it is one of the major salmon producing tributaries in the Lower River study area and is one of the upstream most tributaries where northern pike presence is suspected (Ivy 2009).

PIT tag detectability under ice and winter power supply will be tested during the winter 2012–2013 Pilot Study. If the pilot testing is successful, swim-over antennas will remain at Focus Area sites (Whiskers Slough, Slough 8A, and Indian River) during ice-over and will be maintained throughout the winter months. During winter, downloading of data and battery replacement will occur every three to four weeks, weather permitting. Depending on the success of these sites during the winter of 2013–2014, more sites may be incorporated during the 2014-2015 winter field season.

5.6.6. Tag Specifications

Half-duplex PIT tags either 12 mm in length or 23 mm in length will be used, depending upon the size of the fish (Table 5.6-2). For increased performance and data collection, fish will be tagged with the largest tag size that their body size can carry with the least amount of stress. Each PIT tag has a unique code that allows for identification of individuals. Half-duplex tags have been selected over full-duplex tags due to the increased flexibility and reduced cost of working with the Texas Instruments technology. Texas Instruments has recently produced a smaller half-duplex tag (12 mm) comparable to the original full-duplex (11 mm) tag; this will allow tagging of fish down to approximately 60 mm. Increased read distance and reduced power consumption are additional advantages of the half-duplex tag. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

5.6.7. Tagging Size

The aim is to capture and PIT tag as many specimen of each target species as possible up to 1,000 individuals within the vicinity of the PIT array. The minimum size of fish that can be PIT tagged is a function of body size, body form, and robustness. The effects of PIT tags on fish growth, behavior and survival and minimum tagging sizes has been studied extensively (Prentice et al. 1990; Peterson et al. 1994; Ombredane et al. 1998; Gries and Letcher 2002; Zydlewski et al. 2003; Bateman and Gresswell 2006). The most common index used to determine minimum fish size is the weight of the tag (in air) relative to the weight of the fish. Recommendations vary, with older works suggesting the tag should be no more than 2% of the body weight of fish (Winter et al. 1996). However, some of the more recent work supports tag ratios of 6-12% (Brown et al. 1999). An intermediate tag ratio of between 3% and 6% will be used as a guideline

for determining minimum fish size based on the laboratory tests by USGS (Adams et al. 1998a, 1998b), NMFS (Prentice et al. 1990), and Battelle NW (Anglea et al. 2004).

The minimum size of juvenile salmonids that can be implanted with 12 mm (0.1 g) PIT tags is generally reported to be 60-65 mm (FL) (Achord et al. 1993; McCann et al. 1993; Zydlewski et al. 2006). For juvenile salmonids, this generally equates to a tag burden of 3-4% of body weight (Achord et al. 2005; Ebersole et al. 2009; Triton 2010). Some studies have tagged fish as small as 55 mm with little resulting mortality (Prentice et al. 1990) though other studies have shown evidence of increased predation or decreased stamina for smaller tagged fish (PTAGIS 1999). Because the primary objective of this PIT-tagging effort is to describe the seasonal movements of target species rather than to estimate survival, the implications of tagging effects on the study design are reduced. Moreover, the benefits of tagging fish smaller than 65 mm are apparent given the potential for these fish to exhibit seasonal movements that would otherwise remain undocumented. Thus, there is a tradeoff in selecting a minimum fish size for tagging in which tagging effects are reduced and the sampled population is maximized. Given this tradeoff, a minimum fish size for tagging of 60 mm was selected. This minimum size threshold will allow for tagging the vast majority of juvenile Chinook salmon caught; in 1981, the mean length of fish collected with minnow traps, beach seines and, electrofishing was 79.6 mm TL (Delaney et al. 1981). A conservative minimum size of 70 mm will be used for other fish species with similar fusiform body types.

The minimum size of juvenile salmonids that should be implanted with 23 mm (0.6 g) tags is generally reported to be around 100 mm (FL) (Moore 2005; Bateman and Gresswell 2006; Zydlewski et al. 2003). No detectable tag effect on growth or survival was reported for coho salmon and steelhead larger than 100 mm (Zydlewski et al. 2003). Some studies have tagged juvenile salmon as small as 75-90 mm with 23 mm tags resulting in slightly reduced survival compared control groups (Rossel et al. 2000; Bateman and Gresswell 2006).

Fewer investigations have studied tagging effects on northern pike with a sagittiform body type and juvenile lamprey with an anguilliform body type. Juvenile northern pike 42-65 mm FL have been successfully implanted with 11.5 mm/0.1 g PIT Tags (Cucherousset et al. 2009). Juvenile Pacific lamprey, 120–171 mm in length, have been successfully implanted with 12 mm PIT tags (Mueller et al. 2006); however, surgical procedures are not easily performed in the field. Juvenile Pacific lamprey, 130-140 mm in length and 4-5 grams in weight, have been successfully PIT tagged using 9 mm tags weighing 0.03 g (Mesa et al. 2013). Based on the recommendations of these studies, a minimum tagging size of 70 mm for northern pike and 150 mm for Arctic lamprey will be implemented in this study. This minimum size threshold will allow for tagging the majority of Artic lamprey caught; the mode length of Arctic lamprey from the Susitna River is about 150 mm (Delaney et al. 1981).

5.6.8. Fish collection techniques and proximity to receivers

The PIT-tagged fish will be captured opportunistically during fish distribution and abundance sampling. Thus, a suite of methods will be employed to capture fish for PIT tagging including: gill nets/set nets, electrofishing, angling, trotlines, minnow traps, Fyke nets, hoop traps, beach seines, fishwheels, and outmigrant traps. To increase the probability of collecting information on fish movements, fish will be captured and tagged in relatively close proximity to interrogation sites. Arrays located at Indian River, Slough 8A, and Whiskers Creek/Slough are located near or within Focus Area sites where increased effort will be directed towards tagging fish. PIT-tagged

fish will be released where they were collected; the release location will be described in the field notes and a GPS location will be recorded.

5.6.9. Scanning for PIT tags

Prior to tagging, target species will be scanned for PIT tags using a handheld portable scanner. Optimal PIT tag readability occurs when the tag is oriented perpendicular to the antenna field. In order to optimize tag readability, juvenile fish (60-250 mm FL) will be scanned in three passes in a cross-like pattern over the abdominal cavity so that the tag location is passed vertically twice and horizontally once, with the tag insertion site as the center point of the passes and the unit touching the body. Adult resident fish > 250 mm FL will be scanned in the same manner concentrating on the dorsal PIT tagging region injected with a PIT tag subcutaneously in the region of the pelvic girdle/musculature directly below the dorsal fin on the left side of the body. Any electromagnetic field in the area (such as a running motor) or ferrous metal objects near the tag and/or reader may affect the read range. Readers can also be prone to various malfunctions or decreased read range, mainly due to battery issues and operating environment (temperature and humidity). For this reason, samplers will be required to test reader function by scanning a "test tag" each session that fish are handled and scanned.

5.6.10. Tagging Procedures

PIT tags are typically inserted with a 12 gauge needle into the body cavity of smaller fish and musculature of larger fish. Sharp needles should always be used for tagging purposes. Prior to tagging, the hypodermic needle and PIT tag will be sterilized in 90% isopropyl alcohol. The PIT tag will then be inserted in the barrel of the hypodermic needle. While in the needle, the PIT tag will be interrogated with a handheld reader and the tag ID code will be recorded on the field data form. Depending on the size of the fish to be tagged, the tag insertion instructions below will be followed. Subsequent to tagging fish, the fish will be scanned with a handheld reader to verify that tag is functioning and the tag ID number matches the field data form. After tagging, fish will be allowed to recover in fresh water, transferred back to a live cage in the stream, and held for a minimum of 0.5 hours before being released as close as possible to the collection location. All fish handling done during PIT tagging will follow the procedures and guidelines described in Section 5.1 of the Implementation Plan.

5.6.10.1. Juvenile salmonids and small resident fish (60-250 mm):

Following similar protocols developed by Columbia Basin Fish and Wildlife Authority (1999) and Biomark (2011), PIT tags will be located in the ventral area of the abdominal cavity between the pyloric ceca and the pelvic girdle, generally in the fatty tissue just posterior to the pyloric ceca. The fish will be held abdomen up with the tail pointing away from the person. The needle will penetrate the fish's belly between the posterior tip of the pectoral fin and the anterior point of the pelvic girdle. The needle will be inserted just posterior of the tips of the pectoral fins, when the fins are laid along the side of the fish. The needle will be directed posteriorly so the tag is injected away from the heart and other vital organs, but not too far posterior, to avoid damaging the intestine. The puncture will be made one to two millimeters off the mid-ventral line. Using the middle finger of the hand holding the fish to add pressure, the tip of the needle will be placed on the belly of the fish 1-2 mm from the mid-ventral line. The bevel of the needle will be open toward the belly of the fish so the point of the needle is away from the internal

organs. The puncture will be made with a short, quick, jabbing motion. Maximum control is needed because the tip of the needle should move forward only about 1-2 mm. The angle of the needle should be 20-45° above the belly of the fish and the motion of the needle should be directed through the fish and at your middle finger. Once the needle has penetrated the abdominal wall, and with about 2-3 mm of the needle inside the fish (for fish up to about 150 mm), the tag will be injected. The depth of penetration of the needle will vary depending on the size of the fish being tagged. The depth should be deep enough to place the tag as far away from the needle hole as possible so tag rejection is minimized.

5.6.10.2. Juvenile Lamprey

Metamorphosed or juvenile lampreys have a limited internal body cavity and are relatively fragile making tag implantation more difficult. Following a protocol developed by Mesa et al. (2011) a 2–3-mm-long incision will be made 20 mm posterior to the gill pores on the left lateral side with a 3.0-mm microsurgical scalpel (Number 15 blade). A 12 mm PIT tag will then be inserted through the incision by hand and guided anteriorly. This method resulted in very little tag loss (Mesa 2013).

5.6.10.3. Adult resident fish (>250 mm)

Following the Protocol developed by Biomark Inc. (2011), fish over 250 mm FL will be PIT tagged in the dorsal musculature or dorsal cavity/sinus on the left side of the body. Initially, the needle will be pointed in an anterior direction when starting the injection, so the tip of the needle can be placed under the scales. The needle will then be rotated and inserted into the fish at a 10 to 20 degree angle to the body axis when using the dorsal sinus tag placement. Or, the needle will be rotated to a 45-to 90 degree angle when tagging in the muscle. The depth of penetration of the needle will vary depending on the size of the fish being tagged. The needle penetration depth should be no deeper than one inch (on larger fish) and no less than one half inch (on smaller fish). Large fish are often hard to penetrate with the needle. The point of the needle will often hit a scale and the scale will adhere to the needle, preventing penetration of the body wall. In this situation, the needle will be pulled away from the fish, the scale will be removed from the tip of the needle, and then the body wall will be penetrated where the scale was removed.

5.6.10.4. Post-Tagging Mortality and Short-Term Retention

A subsample of PIT-tagged fish and non-PIT-tagged (control) fish may be held and observed for a minimum of 24 hours to obtain information on post-tagging mortality and tag loss. Approximately 90 percent of the mortalities are anticipated to occur during days 1–3 (Bateman and Gresswell).

5.7. Downstream Migrant Trapping

To better understand downstream migration patterns of juvenile salmonids and resident fish, six rotary screw traps (E.G. Solutions©, Corvallis, OR) will be deployed in the Susitna River Basin during the 2013 and 2014 field seasons. Each trap consists of an eight-foot diameter funnel-shaped cone that is screened with a 3-mm diameter perforated plate. The cone is suspended above the water by an aluminum pontoon barge. A winch is used to adjust the fore elevation of the cone and lift the wide end out of the water when not actively fishing. Within the cone are

two tapered flights or baffles that are wrapped 360 degrees around a center shaft. The trap cone is oriented with the wide end facing upstream and uses the force of the river acting on the tapered flights to rotate the cone about its axis. Traps are usually positioned in the main flow or river thalweg and angled to catch the maximum amount of flow. Downstream migrating fish are swept into the wide end of the cone and are gently augured into a live collection box that is attached to the rear of the trap cone (Volkhardt et al. 2007).

Outmigrant trapping efforts will be useful for gathering information on migratory timing, size at migration, and growth for juvenile salmonids and resident fish. In addition, the traps will serve as a platform for PIT-tagging juvenile fish (see Section 5.6), recapturing previously tagged individuals, and collecting fish to support fish tissue and fish gut content sampling (see Sections 5.9 and 5.10). Trapping locations, as well as information pertinent to trap installation, operation, and maintenance, are described in the subsections below. Protocols for daily trap operation, field data collection, and trap efficiency testing are also provided.

5.7.1. Site Selection

As proposed in the RSP, two rotary screw traps will be located in the Upper River, three in the Middle River, and one in the Lower River. To identify specific trap locations within each of these Hydrological Segments, potential rotary screw trap locations were evaluated based on: (1) a review of existing data on fish distribution and habitat, (2) anticipated physical conditions and debris loads at potential sites, and (3) logistics for deploying, retrieving, and maintaining the traps (Table 5.6-1). This evaluation has resulted in the selection of the six sites shown in Figure 5.6-1. Four traps (i.e., two in the Upper River, one in the Middle River, and one in the Lower River) are proposed for deployment in important spawning tributaries near their confluences with the Susitna River. The other two traps are proposed for the mainstem Middle Susitna River in order to characterize the broad timing of outmigration from all upstream sources. The site selection process for the Upper, Middle, and Lower River is discussed below.

In the Upper River, Chinook salmon are the only anadromous salmon species present and have only been observed in limited numbers at a few locations. Therefore, suitable trapping sites in close proximity to areas in which adult Chinook salmon spawning activity or juvenile rearing has been documented are scarce. In the Upper River, potential downstream migrant trapping areas are limited to: Kosina Creek (adults and juveniles), the Oshetna River (juveniles; ADF&G 2003; Buckwalter 2011; HDR 2012), and the main channel of the Susitna River between the confluence of the Oshetna River and the proposed dam site (RM 184). Within these areas, the Oshetna River near the confluence with the Susitna River (HRM 233.4) and Kosina Creek (HRM 206.8) near the confluence with Tsisi Creek have been identified as locations where hydrologic conditions are thought to be logistically favorable for the deployment of outmigrant traps. In addition to juvenile Chinook salmon, a variety of resident species including Arctic grayling, Dolly Varden, longnose sucker, round whitefish, and slimy sculpin have been recently documented in the Oshetna River drainage (Buckwalter 2011; HDR unpublished). Thus, the placement of an outmigrant trap near the mouth of the Oshetna River may also gather information on resident species. The Tsisi Creek and Kosina Creek confluence, located approximately seven river miles upstream of the Susitna River, provides an opportunity to gather information on juvenile Chinook salmon in the Upper River study area. This trap location was chosen because the lower reaches of Kosina Creek are not easily accessible due to topography, and trap sighting would be difficult because of the steep gradient. In addition, Chinook salmon

spawning has been documented in Kosina Creek upstream of the Tsisi Creek confluence. Resident species found in Kosina Creek include: Arctic grayling, Dolly Varden, round whitefish, and slimy sculpin (Buckwalter 2011; HDR 2012.).

In the Middle River, proposed trap locations include the Indian River (RM 138.6) approximately one river mile upstream of Susitna River, the mainstem Susitna River at Curry (RM 120), and the mainstem Susitna River at Talkeetna Station (RM103). The Indian River is a primary tributary to the Middle River and is heavily used by Chinook and coho salmon and a diversity of resident fish species (ADF&G 1984c; HDR unpublished). In addition, the lower Indian River near its confluence with the Susitna River has historically been a focus of Middle River sampling efforts (ADF&G 1984c). The two mainstem river sites were selected, because they offer good hydraulic conditions for outmigrant trap operation and are located downstream of important Middle River spawning tributaries including Portage Creek and the Indian River. The site at Talkeetna Station has the added benefit of being associated with historic data from outmigrant trapping efforts in the 1980s (Roth et al. 1986). In 1985, inclined plane traps at Talkeetna Station had significantly higher catch rates on the west bank of the Susitna River than on the east bank (Roth et al. 1986); thus, the outmigrant trap for the 2013 and 2014 study will be located in a similar position. Lastly, each of the three proposed Middle River trapping locations will be located in close proximity to other proposed 2013 and 2014 field efforts; this co-locating of sites is expected to facilitate site accessibility, field logistics, safety, and effective trapping operations.

In the Lower River, the proposed trapping location is in Montana Creek (RM 77) near its confluence with the Susitna River. Montana Creek was selected because it is one of the major salmon producing tributaries in the Lower River study area and has a diverse resident fish assemblage. In addition, Montana Creek is suspected to have a population of non-native northern pike. Attempts will be made to tag and track pike at this location.

5.7.2. Trap Installation, General Operation, and Maintenance

Traps will be positioned along channel margins where they can be safely and effectively operated over the entire range of discharge conditions that may exist during a sampling season. Minimum water velocities for effective operation are approximately 0.6 meters per second (2.2 feet per second), and optimal water velocities are approximately 1.5 meters per second (4.9 feet per second; USFWS 2008b). To help meet these standards, traps will be located directly downstream of a riffle (as opposed to the downstream end of a pool), if feasible. Traps will be held in place with cable (≥6 mm in diameter) or Spectra© rope fastened to large, permanent structures on the bank.

Although trap attachment rigging will vary by site, a highline system setup off the front of the trap is preferred, because it allows for the trap to be easily manipulated across the width of the stream to optimize fishing under various flow regimes. With this arrangement, a bridle is attached to the front of the trap, and a main line from the bridle is routed through a pulley on the highline crossing the stream. The main line runs through another pulley attached to a tree or anchor on the bank. An additional rope-and-pulley setup is attached to the front of the trap and brought directly to the bank, which allows for the trap to be positioned from side to side. The disadvantage with this method is that a significant amount of tension is exerted on the cable that spans the stream, and the cable and anchors need to be sized accordingly. Alternatively, single lines may be led from each pontoon through blocks mounted on each shore. With this configuration, downstream force is spread between two lines instead of one main cable. Using

these rope riggings, operators can safely manipulate the position of the trap from the bank of the stream during high flow events (Volkhardt et al 2007). A safety cable will be attached to the rear of the trap, such that the trap will swing to shore if the other cables fail.

To initiate trap fishing, the winch system is used to lower the cone until the shaft is at the water's surface. Rotary screw traps will be outfitted with a mechanical hubodometer counter that tracks the number of revolutions the screw makes each sampling period. The total number of rotations per sampling period provides a tool for assessing trap operation. The volume and type of debris accumulation on or in the cone can affect rotation rate. During the morning trap check, the number of revolutions will be noted on the data sheet, and the counter will be reset after the live-box processing has been completed. The same procedure will be followed for the evening check; however, the counter will not be reset unless the trap has stopped operating due to debris build-up. If the counter is not functioning properly, or if the trap is clogged with debris and unable to rotate, the last counter reading will be recorded, the counter reset, and circumstances noted on the daily data sheet. If debris is present inside the cone or shaft, the screw trap must be winched out of the water prior to removal. Operators should never remove debris while cone is rotating and/or submerged in water.

Rotary screw traps and associated rigging are a possible hazard to boaters, swimmers, and others using the river. Wires and cables will be marked with bright colored flagging for increased visibility. Markers may be positioned both upstream and downstream of traps in areas where boaters may be present.

Rotary traps will be inspected daily when in use for damage and improper wear. The field crew will inspect the live-box seal for any cracks and proper seating around the cone. The cone shaft and bushings will be inspected for cracks and wear. The cone mesh will be inspected for any tears, and access doors will be inspected for proper closure. The winch system will be inspected for proper function, as well as cable and pulley wear. The counter system will be inspected for proper function. The anchor points and cabling system will be inspected for faults. The traps will be cleaned daily. Other things to look for include: worn bushings and seals, missing rivets or screws, worn or broken parts, and damage to straps, cables, blocks and other trap rigging. The cone, pontoons, and live-box will all be scrubbed and cleared of debris. Maintenance will be performed as warranted. Any problems with trap condition, operation, or safety should be noted on the field data sheet and reported to the Project Lead.

5.7.3. Daily Operational Guidelines for Outmigrant Trap Tenders

Flow conditions permitting, rotary screw traps will be fished on a cycle of a 48 hours on and 72 hours off throughout the ice-free period. Rotary screw traps will be checked at least once per day. Morning check (05:00-10:00) and evening (18:00-23:00) checks are preferred in order to determine if fish movement occurs primarily at night or during the day. During periods of migration or high flow, traps may need to be checked more often.

For each trap check event, field crews will be responsible for basic trap operation, daily maintenance checks, data collection, and fish processing. In addition, field crews must implement the trap efficiency testing procedures described in Section 5.7.4 below.

Prior to initiating work on each site, field staff should make sure that the following criteria are met.

1. A minimum of two people must be on site at all times.
2. Flow and lighting conditions are within safe operational parameters. For safety purposes, traps only be checked during daylight hours.
3. Check that all rigging equipment is sound.
4. When in a boat and on the trap, a personal flotation device (PFD) must be worn by all personnel.
5. Field crews should have all necessary field equipment and safety supplies, including:
    - PFDs and throw bags;
    - waders or dry suit;
    - tools and hardware (e.g., wrenches, sockets, shackles, clips, etc.);
    - fish measuring board;
    - datasheets, field books, and pencil(s);
    - watch with stopwatch setting;
    - camera;
    - brush for cone cleaning;
    - dip and minnow nets;
    - 5-gallon buckets and aerators;
    - clove oil (prepared as a 1:9 mix with ethyl alcohol; see Section 5.1.3);
    - Bismark Brown 'Y' dye (for trap efficiency testing; see Section 5.7.4);
    - flashlight or headlamp and fresh batteries for low-light work conditions; and
    - any additional gear as specified by the task lead.
6. Appropriate clothing must be worn; loose, baggy clothing and dangling jewelry could be entangled in the rotary screw trap.

Upon arrival the site, trap operators should perform maintenance checks (see in Section 5.7.2) as well as the following tasks.

1. Make sure trash screens are clean.
2. Look for means by which fish can escape the trap box.
3. Make sure pontoons and cone are not rubbing on rocks.
4. Make sure live-boxes are secure.
5. Check for the presence of predator fish in the trap box.
6. Collect and dispose of rubbish.

Field data forms will be used to record the date, time, crew, trap rotation rate, discharge and/or staff gage reading and location (if available), water temperatures, and trap operation and maintenance notes.

Fish will be removed from the live-boxes for processing using dip and minnow nets. Excess debris in the scoop net can injure fish and cause fish to be out of the water for too long while debris is sorted on the trap deck. To reduce fish losses from the live-box, fish refuge structures, flow deflectors, and debris separators may be installed to dissipate water velocities and reduce

predation. Before fish are removed from the live-box, it is important to net and remove floating and large submerged debris, checking each time to make sure no fish are discarded with the debris. When fish are removed from the live-box, care will be taken to not injure fish between the rim of the dip net and the wall of the live-box. The live-box corners are typically where fish can be injured and killed. Efforts will be made to chase fish out of live-box corners before netting them. During the evening check of the trap, fish do not need to be removed if there are <100 fish being captured each day.

Once removed from the live-box, fish will be sorted by species and age class and placed in 5-gallon buckets with supplemental aeration or a holding pen situated in flowing water. Avoid overloading holding buckets with fish (i.e., 25-50 individuals per bucket; see Section 5.1). For juvenile anadromous salmonids a life stage index will be used for grouping life stage classes (alevin, fry/parr/smolt). Resident species will be grouped by young-of-year (0+), juvenile (typically 1+ and 2+), and adult (typically 3+) based on known growth estimates for the Susitna River. Each time the trap is checked, a random sample of 25 individuals of each species and age class will be measured for length in millimeters. Fish will be selected randomly for measurement to prevent bias for or against the slow or larger fish in the container. A dip net will be used when catching fish to be measured. Hands, dipnets, and measuring boards should always be wet before coming in contact with fish. The remaining fish of each species and age class will then be enumerated. Fish will be anesthetized in a manner consistent with those described in Section 5.1.3. Target fish species from PIT tagging studies will be scanned for the presence of PIT tags (see Section 5.1.6). Any additional processing and data collection (e.g., tissue sampling, PIT tagging) may also be performed if applicable to the species, life stage, and site location. Fish will be held until fully recovered, and the time and water temperature (°C) at release will be recorded.

5.7.4. Efficiency Testing

To produce reliable estimates of relative abundance from rotary screw trap field data, estimates of trap efficiency are needed. Simple Peterson mark-recapture methods will be used to conduct a series of trap efficiency experiments over the course of the sampling season. Trap efficiency is estimated as the proportion of marked fish appearing in a random sample and equates to the proportion of marked fish in the total population, provided that certain assumptions are met. The basic assumptions of the Peterson method that apply to trap efficiency estimates include: (1) the population is closed; (2) all fish have the same probability of capture in the first sample; (3) the second sample is either a simple random sample, or if the second sample is systematic, marked and unmarked fish mix randomly; (4) marking does not affect catchability; (5) fish do not lose their marks; and (6) all recaptured marks are recognized.

Trap efficiency can change dramatically with variables such as discharge, turbidity, fish size, behavior, and species composition and thus requires frequent calibration. Species-specific efficiency trials will be performed throughout the sampling season to capture the greatest possible range of environmental conditions. When stream conditions cause a modification in trapping procedures, such as moving the trap to different positions within the channel cross section (e.g., high/low flow positions), new trap efficiency relationships must be established to estimate abundance for these periods.

A stratified mark-recapture design will be implemented to estimate the relative abundance of downstream migrants over short discrete time periods (i.e., 7 days) in which trap efficiency is

paired with a recapture period. If numbers are sufficient, a minimum of 100 fish representative of the day's catch will be marked and released weekly. If only a portion of the daily catch is to be used for efficiency trials, fish will be randomly selected, measured for length, marked, allowed to recover, and released during the time period of their migration (i.e., day or night). The release location of marked fish is to be located far enough upstream so that marked fish can evenly mix with unmarked fish moving downstream, yet not so far upstream as to cause an extracted period of migration of marked fish over multiple days and expose fish to predation. Based on recommendations by Volkhardt (2007) and Roper (1995) and estimated lengths of mesohabitat units, marked fish will be released 300 meters upstream of the trap location. Marked fish should be released evenly across the width of the river if feasible, or equally along each river bank in calm water. Fish holding time will be minimized to less than 48 hours.

For each rotary screw trap location, trap efficiency testing procedures are as follows.

Step 1: Establish the frequency of trap efficiency trials (i.e., weekly or as needed to capture variations in flow, debris, precipitation, turbidity, etc.) and the marking of fish for the monitoring site. When performing mark-recapture procedures, note on the field data forms the statistical/sampling design being used, the targeted frequency of efficiency trials, and the start and end dates for the stratum that the efficiency trial represents.

Step 2: Establish the numbers of fish to be marked for trap efficiency and mark-recapture activities.

Step 3: Perform separate trap efficiency trials for fish of different size classes and all target species.

Step 4: Select and process fish to be used for testing. Anesthetize, record lengths, mark, and allow sufficient time for recovery.

a. Selecting fish for efficiency trials: If only a proportion of the daily catch is used for the trap efficiency trial, ensure that the fish are a random sample from the entire catch of the targeted size class and species to meet this mark-recapture assumption. The potential size selectivity of dip netting fish at random from the live well can be tested by comparing the lengths of fish from the efficiency trial sample to the lengths of all fish of the species and size class captured for the day.
b. Anesthetize fish in a bath of anesthetic (see Section 5.1.3) and measure lengths to the nearest millimeter. Record all newly marked fish used in efficiency trials as "efficiency trial" on datasheet. It is preferable to measure all fish participating in trap efficiency trials. Where the numbers of fish participating in trap efficiency trials prohibits the measurement of all fish, a minimum of 100 fish should be measured for length.
c. Mark fish for trap efficiency trials consistent with the requirements of the statistical design being implemented at the site. Record the number of fish marked and any deficiencies in meeting the targeted quantity. If PIT tags are used, also note this on the field data form. Fish should be marked with Bismark Brown "Y" dye at a concentration of 0.25-0.4 g of powdered dye per 5 gallons of water. Fish to be marked should remain in dye solution in an aerated container for one hour and observed every 10 minutes.

d. Allow marked fish sufficient time for recovery in freshwater. Allow fish to recover in a live pen if site conditions allow prior to transport and upstream release. Record the time at which fish are released.

Step 6: Release marked fish upstream of the trap at an appropriate distance upstream. This protocol recommends an upstream release distance of 300 meters. Release sites that vary from the recommendations should be tested for conformity with the following assumptions: (1) migration is not delayed; (2) mortality is not increased, and (3) marked and unmarked fish are randomly mixed. Marked fish should be released evenly across the width of the river if feasible, or equally along each river bank in calm water.

Step 7: Release fish during the time strata in which they were captured to reduce predation. Fish captured overnight should be released after sunset, and those captured during the day should be released after sunrise.

Step 8: If sufficient numbers of fish area collected (i.e., ≥100 fish per species and size class), trials may be performed to estimate marking and handling mortality and mark loss for the test groups. Assumptions for mark-recapture methods include no increased mortality for marked fish in the efficiency trial, and no loss of marks between marking and recapture. These assumptions should be tested at the start and throughout the trapping season for each species, life stage, and type of mark utilized. It is recommended that tagging and handling mortality and mark retention trials should occur during the peak emigration period at each life stage and/or as changes in environmental stressors are expected to exert higher mortality (e.g., as temperatures begin to approach lethal limits). These two assumptions can be easily tested with the same group of marked fish prior to their use to estimate trap efficiencies. Fish should be held a minimum of 24 hours in aerated tanks or live wells and recounted; mortalities should be recorded, and marks or PIT tags inspected. Most handling mortality is stress induced and typically occurs within 24 hours (Barton et al. 1986, Thedinga et al. 1994).

Because frequently too few fish are caught of certain species and/or size classes to determine an accurate trap efficiency estimate on a daily basis, a weekly estimate is generally calculated instead using the following formula:

$N_i = n_i/e_i$

where,

$e_i = r_i/m_i$

and

N_i = total number of migrants passing trapping location in week i

n_i = number of unmarked fish caught in trap in week i

r_i = number of marked fish recaptured in trap in week i

m_i = number of marked fish released above the trap in week i

The total number of fish migrating past the trap site for the season (N) is then estimated by:

$N = \sum N_i$

An estimate of variance can be calculated as described by Volkhardt et al. (2007) or estimated using bootstrap methodology (Thedinga et al. 1994).

5.8. Radio Telemetry

In addition to PIT tagging, radio telemetry will be used as a remote monitoring technique to provide fine- and large-spatial scale information on the location, speed of movement, seasonal movement patterns, and habitat utilization of individual resident and non-salmonid anadromous species. Fish movements will be tracked using a combination of stationary receivers located at key sites in the Upper and Middle/Lower River (tributary mouth, off-channel habitat, areas with groundwater influence, etc.) and mobile aerial, boat, and foot surveys. The target species to radio-tag include Arctic grayling, burbot, Dolly Varden, humpback whitefish, lake trout, longnose sucker, northern pike, rainbow trout, and round whitefish (Table 5.8-1).

The primary function of the telemetry component is to spatially and temporally track individuals of target fish species with a combination of fixed station receivers and mobile tracking. Time/date stamped, coded radio signals from tags implanted in fish will be recorded by fixed station or mobile positioning. ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com) telemetry gear (tags and receivers) will be used in this study.

Characterizations will include:

- Arrival and departure timing at specific locations/positions;
- Direction of travel;
- Residence time at specific locations/positions;
- Travel time between locations/positions;
- Identification of migratory corridors and holding areas and possible inference of seasonal habitat use such as: foraging, spawning, and overwintering habitats; and
- Inference of movements in and among habitats in relation to large-scale changes in water conditions (e.g., discharge, temperature, turbidity).

The fundamental reason for using radio telemetry as a method to characterize resident and non-salmonid anadromous species is that it can provide useful information to address the overarching goal of the study and several of its objectives. In particular, radio telemetry can provide data on seasonal distribution and movement of the target fish throughout the range of potential main- and off-channel habitats. Relocation data from the radio telemetry component of this study will be used to characterize the timing of use and degree of movement among habitats and over periods during which the radio-tags remain active (potentially two or three seasons for large fish). This objective may be achieved by the use of long-life tags (e.g., greater than one year) and shorter-life tags (e.g., three-month tags) applied to appropriate-sized fish over time. In general, successful radio telemetry studies use a tag weight to fish weight guideline of 3 percent (with a common range of 2 to 5 percent depending on the species). The range in size encountered for a particular species may be broad enough to warrant the use of different sized tags with different operational life specifications. Actual tag life will be determined by the appropriate tag for the size of the fish available for tagging.

In this regard, the range in weights for the nine target species to be radio-tagged has been estimated. Fish weights and the respective target weight of radio-tags (Table 5.8-1) were calculated using existing or derived length–weight relationships for Alaska fish and length frequency distributions for Susitna River fish, where available. This analysis illustrates that there is a relatively broad range of potential tag weights (0.5 g to 81 g) that are necessary to tag each species over the potential range in fish size (Table 5.8-1). Further, it is evident that some life stages will require tags with a relatively short (80- to 180-day) operational period (tag life).

The broad range in tag weight complicates the scope of the task in terms of technological feasibility. In general, there is a preference for using coded tags, because it allows the unique identification of a hundred tags on a single frequency. Conversely, standard tags (not coded) require a single frequency for each tagged fish to allow unique identification. The radio telemetry industry provides a variety of equipment to match research needs, but there are always trade-offs in terms of tracking performance and cost between different systems. This plan intends to capitalize on the use of the existing telemetry platform (ATS telemetry equipment) to sufficiently monitor the target species, but directly constrains the potential options for tagging and monitoring. More specifically, the smallest ATS coded tag weighs 6 g and thus requires fish to weigh at least 200 g for safe application (Table 5.8-2). For some species, such as Dolly Varden, only the largest individuals captured will likely be taggable (Table 5.8-1) based on its respective length–frequency distribution. It is likely that each of the nine target species will have a proportion of individuals that are too small to radio-tag.

To accomplish the goals of this study, four different sized radio tags will be used with expected operational lives ranging from 180 to 901 days. The ATS model 1810C, 1815C, 1820C, and 1830C tags have minimum tagging weights of 200, 233, 267, and 367 g, respectively (Table 5.8-2). The tags will be programmed to operate in "slow pulse" mode with 12 pulses per minute in order to extend the operational life of the tags as much as possible. All tags will be equipped with a motion sensitive mortality sensor to alert biologist when a tagged fish has died. Based on the number of tags to be released, it is likely that seven radio frequencies will be used for this study.

5.8.1. Capture and Tagging

Fish will be captured opportunistically during sampling events targeting adult fish and with directed effort using a variety of methods. Preference will be given to fish caught with more benign techniques that cause minimal harm and stress to fish. Fishwheels targeting adult salmon (RSP Section 9.7) located in the Middle River near Curry (RM 120) and in lower Devils Canyon at approximately RM 150-151 may be used to opportunistically collect some target species. Other techniques including angling, fyke nets, hoop traps, trot lines, and seines will be used in coordination with fish distribution and abundance sampling efforts or specifically directed at target species or locations for tagging purposes. Due to the opportunistic nature of radio-tagging, captured target fish of suitable size may be held until the end of fish sampling at a site before they are tagged. Taggable fish will be held in a suitable live container until the crew is able to perform the surgery.

Tags will be surgically implanted (see Appendix 5) in 60 fish of sufficient body size (i.e., ≥200 g) of each target species distributed temporally and longitudinally throughout the Upper and Middle/Lower River. For each species, 30 tags will be allocated to the Upper River and 30 tags to the Middle/Lower River. The program will assume that all nine target species could be

encountered in either section of the river. For the Middle/Lower river, spatial distribution of tagging for a species will be further partitioned to 25 tags applied below Devils Canyon and 5 above Devils Canyon up to the dam site. Further, there will be effort to apply up to 5 tags in focus areas, tributaries, and mainstem habitats where fish inventory activities are occurring. For the Upper River, application may include up to 10 tags at any tributary or tributary confluence where fish sampling is occurring. Temporal distribution will be determined by the sampling schedule of the Fish Distribution and Abundance Study program.

5.8.2. Tracking

Locating radio-tagged fish will primarily be achieved by fixed receiver stations and aerial surveys. Fixed stations will include those used for the Salmon Escapement Study (RSP Section 9.7). Five additional fixed stations will be established at strategic locations in the Middle/Lower River, and three additional stations will be added in the Upper River with input from the TWG (Figure 5.6-1). These stations will be serviced in conjunction with the Salmon Escapement Study during the July through October period and during dedicated trips outside this period. Fixed stations will be downloaded as power supplies necessitate and up to twice monthly during the salmon spawning period (approximately July through October). The Salmon Escapement Study will provide approximately weekly aerial survey coverage of the Middle/Lower River (approximately July through October) and coverage of the Upper River as salmon distribution dictates. At other times of the year, the frequency and location of aerial surveys will be monthly.

5.8.2.1. Stationary Tracking

Fixed-station receiver sites for the Salmon Escapement Study will be operated at ten strategic locations in the Middle and Upper River including: Lane Creek Station (RM 113.0), Gateway (RM 125.5), Fourth of July Creek (RM 131.1), Indian River (RM 138.5), Slough 21 (RM 141.1), Portage Creek (RM 148.8), Cheechako Station (RM 152.4), the Chinook Creek confluence (RM 157.0), Devils Station (RM 164.0, located upstream of the Devils Creek confluence), and the Kosina Creek confluence (RM 206.8). The locations for the eight proposed resident fish stations are included in Figure 5.6-1 and include: Montana Creek confluence (RM 77.0), Whiskers Creek confluence (RM 101), Indian River confluence (RM 138.6), Portage Creek confluence (RM 148.8), Fog Creek confluence (RM 176.7), Watana dam site (RM 184.0), Watana Creek confluence (RM 194.1), Oshetna River confluence (233.4). Both adult salmon and resident fish frequencies will be programmed on all radio telemetry receivers as appropriate in time and space.

Each fixed station will include a waterproof housing unit, telemetry receiver, reference radio tag, 12-volt battery, 50-watt solar panel, and 4-element Yagi antennas. The reference (or beacon) tags are deployed to provide a continuous record of known signal detections. Many sites will have additional antennas and a 4-way antenna switcher that allows the telemetry receiver to scan each antenna individually. Expected antenna orientation for each existing and proposed fixed station can be found in Table 5.8-3.

During the installation of the Middle River sites, a reference radio tag will be used to calibrate each receiver and verify that they are capable of detecting tags passing along the opposite river bank. Results from testing at these sites will be used as a guide when installing stations that are not accessible by boat.

All fixed stations will use ATS model R4500 telemetry receivers. The receivers have user-programmable settings for scan time and store rate, room for four or more frequency tables, and the ability to store up to 100,000 blocks of data. In general, a receiver will scan all available antennas for 3 seconds. If no radio tags are detected, it will skip to the next frequency in the table. If a radio tag is detected, the receiver will scan each antenna individually for 12 seconds before moving to the next frequency in the table. Antennas will be oriented to allow for determination of a fish's direction of migration, be it upstream, downstream, or in some cases into a tributary.

Data will be downloaded from the R4500 receivers using a field laptop computer equipped with ATS's ATSWinRec_C (Version 1.0.14) software. Raw telemetry files will be archived and then imported into custom database software for processing and summarizing throughout the season and for post-season reporting. Reference tag records will be checked using Telemetry Assessor (LGL) to ensure that all antennas are working properly. The date, time, battery voltage, file name, memory-bank status, and any changes made to the station will be recorded onto a data sheet kept at the station; a backup copy of the datasheet will be kept in the laptop case). A continuous record of station receivers and respective file downloads is maintained to ensure proper quality assurance accounting. All stations will be maintained through the majority of the salmon runs. As the days get shorter in the fall, more effort is needed to keep stations operational, and it is likely that only a subset of stations will be maintained from late fall to spring. Decisions on this will be made based on fish movements in the fall and environmental conditions.

5.8.2.2. Mobile Tracking

The Salmon Escapement Study will provide approximately weekly aerial survey coverage of the study area from approximately July to October and at least monthly during other periods. Using the guidance of fixed-station and aerial survey data on the known positions of tagged fish, specific locations of any concentrations of tagged fish that are suspected to be spawning will be visited to obtain individual fish positions. Aerial surveys targeting radio-tagged salmon will be conducted in the mainstem Susitna River from RM 22 to Kosina Creek (RM 206.8). If radio-tagged fish are detected moving upstream in the mainstem at the Kosina Creek telemetry station, aerial surveys will be geographically extended to locate those radio-tagged fish. In addition to aerial surveys, foot and boat surveys will be conducted from approximately July to October as part of the Salmon Escapement Study. Spatial and temporal allocation of survey effort will be finalized based on the actual locations and numbers of tagged fish for each species. Aerial surveys to track radio-tagged resident fish will be conducted at least monthly from November to June between RM 61 and RM 230.

The goal for helicopter-based surveys is to record a position within approximately 300 meters (1,000 feet) of a target tag, as well as to determine whether the fish is in off-channel or mainstem habitat. Forward and downward looking antennas will assist in determining tag locations effectively. At least four receivers will be used to minimize the number of frequencies scanned per unit. Geographic coordinates will be recorded for each detected signal using an integrated communication link between the telemetry receiver and a global positioning system (GPS) unit.

The position of the fish will be determined as the position of the aircraft at the time of the highest signal power. Range testing of the mobile aerial setup will be conducted in the Middle River to confirm detection ranges for typical flying heights, receiver gains, and antenna orientation, as

well as to work with the helicopter pilot to refine the methods for achieving the highest spatial resolution. Range testing includes deploying an active tag at a known location in the water, flying over and in proximity to it, and estimating the ground distance from the helicopter to the tag using a range finder.

The mainstem aerial surveys will need to cover over 150 river miles (RM 61 to RM 230) and multiples of that total when side channels and braids of the Lower River are included. Tributaries will be surveyed when fixed station data indicates a tag may have entered or when tagged fish have been released in or were previously located near a particular tributary. To allocate survey effort efficiently and to the highest priority needs, resolution will be a function of fish behavior. The highest priority and highest resolution needs will be for fish that appear to be holding or spawning. For migrating fish, resolution to the nearest 500 meters (approximately 1,500 feet) of river will generally be sufficient. The proposed frequency of surveys will provide a means of focusing a higher-resolution and time-intensive tracking effort on identifying exact locations of spawning and holding fish. To do this, the aerial survey team will have available the most recent observed river locations (to the nearest 1 kilometer [0.62 mile]) of all fish "at large". During the survey, the location of all detected fish will be compared to the last seen location from previous surveys to ascertain whether its position has changed by more than 2 kilometers (1.25 miles). When tagged fish are within 2 kilometers of their last seen location, the helicopter will circle at a lower altitude to pinpoint the fish location to mainstem, side channel, or slough habitats.

Mobile telemetry surveys may also be conducted by boat, snow machine, and on foot to obtain the most accurate and highest resolution positions of fish. Using the guidance of fixed-station and aerial survey data on the known positions of tagged fish, specific locations of any concentrations of tagged fish that are suspected to be spawning can be visited to obtain individual fish positions. Spatial and temporal allocation of survey effort will be finalized based on the actual locations and numbers of tagged fish for each species.

The channel location (mainstem, side channel, slough) and relative water turbidity at the location of the fish will be classified for each tag detected (time stamp, frequency, code, power level) during aerial surveys. If other fish can be seen in the area of the tag position, their relative abundance will be visually estimated to provide context for the tag observation.

Tag identification, coordinates, and habitat type data will be archived and systematically processed after each survey. A data handling script will be used to extract unique tag records with the highest power level from the receiver files generated during the survey. These records will be imported into a custom database software application (Telemetry Manager) and incorporated into a Geographic Information System (GIS) based mapping database.

Geographically and temporally stratified data of radio-tagged fish will be provided to the habitat and instream flow study teams to inform their field sampling efforts.

5.9. Fish Tissue Sampling

In 2013 and 2014, fish captured during the fish distribution and abundance studies in the Upper, Middle, and Lower Susitna River will be used to collect tissue samples to support specific objectives of the Baseline Water Quality Study (RSP Section 5.5), the Mercury Assessment and Potential for Bioaccumulation Study (RSP Section 5.7), the River Productivity Study (RSP Section 9.8), and the Genetic Baseline Study for Selected Fish Species (RSP Section 9.14; Table

5.9-1). The objectives shown in Table 5.9-1 are described in detail in their respective RSP sections, and each relates to one of three fish tissue sampling components: baseline fish tissue metal and mercury concentrations, trophic (stable isotope) analysis, or fish genetics. In the subsections that follow, an overview of the target sampling locations, species, and life stages for each of these three fish tissue sampling components is provided. Moreover, field protocols to be utilized by the fish distribution and abundance survey crews for fish tissue sample collection are described.

5.9.1. Baseline Metal and Mercury Concentrations

Fish tissue samples for determining baseline metal and mercury concentrations will be collected during fish distribution and abundance surveys in the vicinity of proposed Susitna-Watana Reservoir site. Given the opportunistic nature of the fish tissue sample collection, specific fish tissue sampling sites have not been preselected. However, the target sampling area includes the Upper Susitna River and its tributaries and is contained within the study area for the Upper Susitna River fish distribution and abundance surveys. Specific details regarding study site selection for the fish distribution and abundance surveys are provided in Sections 5.3 and 5.4.

Sample collection targets for the Mercury Assessment and Potential for Bioaccumulation Study include a minimum of seven tissue samples from each of the following species: Dolly Varden, Arctic grayling, stickleback, whitefish species, long nose sucker, lake trout, burbot, and resident rainbow trout. Consistent with the study design described in RSP Section 5.7, field crews will attempt to collect samples from larger, older fish, which are more likely to have higher mercury concentrations due to increased trophic transfers. To further increase the likelihood of obtaining fish tissue samples with the highest concentrations of methylmercury, all fish used for analysis will be captured between late August and early September when water temperatures and methylmercury tissue concentrations are likely to be greatest. If larger, older fish of the target species are not present in the vicinity of the proposed Watana Reservoir site, younger fish may be used for analysis. Filets are the primary type of tissue samples that will be collected; however, for smaller fish (e.g., stickleback), whole-body samples may be used to ensure sufficient tissue amounts are obtained for analysis. Assuming the target of seven fish per species is obtained during the 2013 field season, laboratory results will be used to determine whether additional sampling is needed in 2014 to augment the 2013 sample sizes. If the target sample sizes are not met in 2013, tissue sample collection efforts will be continued in 2014.

For the baseline metal analysis of the Water Quality Study, the only identified target species is burbot. A minimum of seven liver samples will be collected and sent to a laboratory for arsenic, cadmium, and selenium analysis. The liver samples will be collected from the same burbot individuals used for the mercury assessment. Similar to the mercury analysis, sampling will be continued in 2014 if the target sample size of seven fish has not been met, or if 2013 laboratory results indicate that additional sampling is warranted.

Detail regarding tissue sample collection protocols, including sample processing protocols, can be found in RSP Sections 5.5 and 5.7 and in their associated Sampling and Analysis Plans (SAPs) and Quality Assurance Project Plans (QAPPs; RSP Attachments 5-1 and 5-3).

Fish capture methods (see Section 9) for collecting fish tissue samples will be dependent on the specific tasks or objectives of the fish distribution and abundance studies that are being conducted at the time of the opportunistic tissue sampling. However, preferred capture methods

include those that cause minimal handling stress, and in accordance with EPA recommendations, only live and intact fish with minimal exterior lacerations and lesions will be retained for tissue analysis (USEPA 2000). Prior to deployment, all fish sampling gear will be cleaned and rinsed with ambient river water. All captured fish will be identified to species and life stage and measured for length. Fish selected for tissue analysis will then be handed over to the trained technician for tissue sample collection and field processing. The fish survey crew will document which fish have been selected for metal and mercury analysis in their field notes.

5.9.2. Trophic (Stable Isotope) Analysis

Fish tissue samples for use in trophic analysis will be collected during fish distribution and abundance surveys conducted at two of the four Middle Susitna River Focus Areas that have been selected for the River Productivity Study (see the River Productivity Study Implementation Plan). The primary role of the fish distribution and abundance survey crew for this study is to provide captured fish to a trained field technician, who will be responsible for fish tissue sample collection. The field technician will be provided by the River Productivity study team. Fish tissue samples will be collected from adult salmon carcasses, as well as juvenile Chinook salmon, juvenile coho salmon, and juvenile and adult rainbow trout. To account for temporal variability in isotopic signatures, samples will be collected at the selected focus area sites during the spring, summer, and fall season.

Fish capture methods (see Section 9) for collecting fish tissue samples for stable isotope analysis will be dependent on the specific tasks or objectives of the fish distribution and abundance studies that are being conducted at the time of the opportunistic tissue sampling. All captured fish will be identified to species and life stage and measured for length by the fish survey crew. Fish selected for use in trophic analysis will be transferred to the trained technician for sample collection and processing. Detailed fish tissue sampling protocols for stable isotope analysis are provided in the River Productivity Study Implementation Plan. The fish survey crew will document which fish have been selected for isotopic analysis in their field notes.

5.9.3. Genetic Sampling

The study area for the Genetic Baseline Study for Selected Fish Species encompasses the Susitna River and its tributaries from Cook Inlet upstream to the Oshetna River confluence (RM 233.4). In support of this study's objectives (Table 5.9-1), fish tissue collection efforts will be focused primarily on: (1) Pacific salmon spawning in the Upper and Middle River Susitna River, (2) juvenile Chinook salmon habitat use in the Lower Susitna River, and (3) resident and non-salmon anadromous species in the Upper and Middle River Susitna River. Specific details regarding target sample locations, species, life stages, and annual sample sizes for the Genetic Baseline Study have been previously identified in RSP Section 9.14 and are summarized in Table 5.9-2 below. To facilitate the collection of this vast number of samples (i.e., >3,600 genetic tissue samples per study year), fish tissue samples will be collected opportunistically by fish distribution and abundance crews during surveys in the Upper, Middle, and Lower Susitna River. Information on study site selection for the fish distribution and abundance surveys, including information on downstream migrant trap locations, are provided in Sections 5.3, 5.4, and 5.7. In addition to support from the fish distribution and abundance study crews, the Salmon Escapement Study (RSP Section 9.7) will aid in the collection of tissue samples for genetic analysis from spawning ground and fishwheel sites.

Genetic tissue samples will be collected for the target species, life stages, and locations described in Table 5.9-2. Specific fish capture methods (see Section 9) for collecting tissue samples will vary according to the tasks or objectives of the fish distribution and abundance studies that are being conducted at the time of the opportunistic tissue sampling. After identifying each fish to species and life stage and obtaining length measurements, the fish survey crew will collect one of three types of genetic tissue samples depending on species and fish size: axillary process samples will be collected for adult salmon; caudal fin clips will be collected for fish >60 mm; and whole-body samples will be collected for fish ≤60 mm. Axillary process samples will be collected using the ADF&G Protocol for Genetic Sampling (see Appendix A of Loewen and Bradbury 2010). The axillary process will be collected by first wiping it with a paper towel and then using dog toenail clippers to remove the entire axillary process. The axillary process will be placed directly into a sample collection bottle (125-250 ml capacity) containing at least 1 ml of ethyl alcohol for each axillary process. To avoid double-sampling adult salmon, samples will be consistently collected from the same side of each fish. Caudal fin clips will be obtained using a pair of scissors to remove a small portion of the fin, and fin clips will be placed directly into a collection bottle similar to that used for the axillary process samples. Nail clippers and scissors will be rinsed with ambient stream water between sampling locations. Whole-body samples collected for genetic analysis will be placed into sample collection bottles containing ethyl alcohol.

Composite samples may be used for each site and species, although sample tissue types (i.e., axillary process, caudal fin clip, and whole-body) should not be mixed. Each sample collection bottle will be clearly and securely labeled with the following information: the collection date, time, and location; species; sample type (i.e., axillary process, caudal fin clip, or whole-body); number of samples in the container; and the name of the individual and firm who collected the sample. This same information will be recorded in the field notes, along with other fish survey data pertinent to the related fish distribution and abundance study.

The genetic tissue samples will be transported to the field camp, and after 24 hours, the ethyl alcohol in each sample container will be refreshed to ensure proper preservation. Samples will be stored at room temperature, away from heat, and out of direct sunlight, until delivery to the ADF&G Gene Conservation Laboratory in Anchorage, Alaska can be made. All submitted samples will be accompanied by chain-of-custody forms, and contact with the laboratory will be made to confirm sample receipt.

5.10. Fish Gut Content Sampling

In 2013 and 2014, juvenile Chinook salmon, juvenile coho salmon, and juvenile and adult rainbow trout captured during the fish distribution and abundance studies in the Upper and Middle Susitna River will be used for stomach content samples in support the River Productivity Study objectives (see RSP Section 9.8). Stomach content sampling will be performed by a trained field technician provided by the River Productivity study team. The technician will accompany fish survey crews to selected study sites, where planned fish distribution and abundance surveys will be occurring. In the Middle Susitna River, gut samples will be collected at the four Middle River Focus Areas that have been selected for the River Productivity Study (see the River Productivity Study Implementation Plan for details). In the Upper Susitna River, stomach content sampling will be conducted on a more opportunistic basis. That is, initial fish distribution and abundance study findings may be used to increase the likelihood of encountering

target species and life stages in the Upper Susitna River prior to the stomach sampling technician accompanying the fish survey crew in the field. However, the fish survey crew will adhere to the site selection and sampling designs described in Sections 5.3 and 5.4 in order to avoid biased results and thus, will not actively target species for stomach content sampling.

Fish capture methods (see Section 9) for collecting fish stomach samples will be dependent on the specific tasks or objectives of the fish distribution and abundance studies that are being conducted at the time of the opportunistic stomach content sampling. All captured fish will be identified to species and life stage and measured for length by the fish survey crew. At each sampling site, the first eight fish per target species and life stage that are captured will be transferred to the trained technician for gut sample collection and processing. The fish survey crew will document which fish have been selected for stomach content analysis in their field notes.

5.11. Unique Applications for Winter Sampling

Over the 2012-2013 winter, pilot studies will be conducted at the proposed Whiskers Slough Focus Area (HRM 101-102). This site was selected because: (1) it contains a diversity of habitat types, (2) because sampling in the 1980s and 2012 revealed for the presence of spawning and rearing salmon and resident fishes (ADF&G 1983b), and (3) it is relatively accessible from Talkeetna. A winter sampling pilot study will be initiated in early 2013 to evaluate the effectiveness and feasibility of winter sampling methods including: underwater fish observations via DIDSON sonar and underwater video, minnow traps, seines, electrofishing, trotlines, PIT tags, and radio tags. This study will also be used to evaluate the feasibility of sampling during spring break up; assess winter sampling logistics, including safety, sampling methods in different habitat types under varying degrees of ice cover, transportation and site access logistics, travel time, and winter-specific gear needs, and develop recommendations for subsequent winter studies beginning in the late fall of 2014. Ultimately, the objectives of the winter fish studies are to: (1) document the distribution of juvenile salmonids and non-salmonid resident fish in winter; (2) describe seasonal movement, timing, and habitat use by juvenile salmonids at selected Focus Areas in winter; and (3) determine diurnal activity of juvenile salmonids at selected Focus Areas in winter.

5.11.1. Underwater Fish Observations

Under-ice fish observations will be made using DIDSON sonar and underwater video cameras. The two systems will be run concurrently to determine which method is more effective for underwater fish observations in varying degrees of water clarity. Underwater video and DIDSON sonar observations will be made during the February–April 2013 sampling period. Video sampling will occur in both slough and side channel habitats in the same general study sites as the intergravel temperature recorders (Figure 5.11-1). Observation will take place in 5 locations in Whiskers Slough. A stratified random sampling program over a 24-hour period will be developed to observe underwater activity during day- and night-time conditions and ultimately to characterize juvenile overwintering behavior in support of stranding and trapping analyses. Deployment techniques will follow those described by Mueller et al. (2006). Mueller et al. (2006) found that DIDSON cameras were useful for counting and measuring fish up to 52.5 feet (16 meters) from the camera and were effective in turbid waters. In contrast, they found that video cameras were only effective in clear water areas with turbidity less than 4 nephelometric

turbidity units (NTUs). Depending on image quality, video may also be helpful in characterizing microhabitat attributes such as the presence of anchor ice, hanging dams, macrophytes, structure, and substrate type.

5.11.1.1. DIDSON

Dual-frequency Identification Sonar (DIDSON) is a multi-beam high-resolution imaging system (Belcher et al. 2001) capable of sampling for fish in dark, turbid conditions (Maxwell and Gove 2004; Johnson et al. 2011). DIDSON has become a standard technique for estimating salmon escapement in Alaska (Maxwell et al. 2011) and is often used at hydropower projects to assess fish passage and behavior (e.g., Johnson and Le 2011). This tool has recently been shown to be an effective method for sampling fish under the ice. In a study assessing habitat association in the Athabasca River, northern Alberta, Canada, Johnson et al. (2012) used DIDSON to image fish, estimate size, and identify some fish to species (e.g., northern pike and burbot). The Athabasca River study represents the first use of DIDSON sampling under ice in a quantitative assessment involving fish and associations with multiple habitat types. Mueller et al. (2006) conducted surveys with DIDSON in the Sagavanirktok River Delta, Alaska in the winter under the ice. These surveys demonstrated effective use of the technology for imaging fish in such environments but the nature of the work was qualitative. Brown et al. (2010) reported DIDSON was used to count and estimate size of broad whitefish in a pool under the ice in the Sagavanirktok River. In addition, DIDSON was used in feasibility studies to assess its utility for imaging Arctic lamprey in the Yukon River, Alaska and Alaska blackfish in an unnamed lake in Goldstream Valley, Alaska (Bruce McIntosh, Alaska Department of Fish and Game, personal communication).

During the 2012-2013 winter pilot study, DIDSON deployment will take place for 3-7 days during both March and April sampling events. If determined to be feasible and useful, monthly winter sampling events may be appropriate for each month of stabile ice cover (typically December through April) during subsequent study seasons.

DIDSON deployment will require three 10" diameter holes drilled into the ice in a triangular pattern. The holes will be connected using an ice saw to make the sample hole large enough to accommodate the DIDSON. Sample locations will be along 20-m long transects within each off-channel habitat type. A total of three sample holes will be drilled equidistant (10 m) from one another along each transect. At each location, a DIDSON unit mounted on an extendable aluminum pole (Figure 5.11-2) will be lowered to an elevation just above the stream bottom and aim it with a slight downward tilt angle so the sampling beams spread across the substrate to obtain imagery of the river bottom (Figure 5.11-3). A dual-axis rotator attached to the DIDSON will be used to remotely control pan and tilt angles and ensure optimal placement and aiming of the sample volume in order to obtain high-quality imagery along the substrate. Aiming direction will depend on several factors including proximity to river bank, presence of obstructions (e.g., submerged logs or boulders), and bed slope. Various aiming and tilt angles will be tested at each location to obtain an unobstructed sample volume that allows for imaging along the substrate throughout the entire sampling range. Data will be collected using a 10-meter window length to sample for fish presence/absence and fish density. The DIDSON system will be configured to sample with the highest possible frame rate (up to 10 frames / second) to provide the maximum imagery resolution based on sample window length. All appropriate data collection parameters will be noted on field data collection forms. For daytime sampling, data will be collected in

successive 10-minute files throughout each 60-minute sample period at each location and ported directly to external hard drives. For diel sampling, data will be collected in successive 10-minute files continuously throughout a 24-hour period. Data will be copied to additional hard drives for archival and backup.

The DIDSON system will consist of the sonar head, SoundMetrics' X2 dual-axis rotator, data transmission cable, topside control box, Ethernet cable, laptop computer, and external hard drives. The laptop will be loaded with SoundMetrics' data acquisition software and X2 rotator user interface. Portable Honda generators will be used to power the system. All topside electronic components will need to be housed in a portable shelter to keep them dry and out of the wind. DIDSON sampling under the ice in the Athabasca River indicated that very cold air temperatures could affect functionality of electronic gear (Johnson et al. 2012). Heating pads will be used to keep the laptop warm enough to maintain operation. The sonar head will be kept under the ice or in a water bath to prevent ice from forming in the lens housing.

All sample locations will be between 0.5 and 2.5 meters in depth. At least 0.5 meters of water below the ice is needed to allow for deployment of the DIDSON and rotator. Depths greater than 2.5 meters will be difficult to sample given the weight of the DIDSON and rotator and the length of pole needed for deployment. It is unlikely current velocities in the off-channel habitats will be too high to sample.

Data will be processed using a randomized scheme involving sub-sampling one-third of each 60-minute sample. For each sample, two 10-minute files will be randomly chosen for processing. DIDSON data will be manually reviewed using SoundMetrics' playback software. The review process will involve using a background subtraction algorithm in the software that allows for the removal of all static imagery so when the data are played back, only moving targets are visible. For each 10-minute sub-sample, the relative density of fish will be estimated at 30-second intervals (e.g., 30, 60, 90, 120 seconds, etc.) to calculate mean hourly estimates, along with 95% confidence limits about the mean. For each fish target detected, the following will be noted: estimated size (measured using the software sizing tool), behavior (schooling, foraging, etc.), direction of movement, and if possible identification to species or family level. Density estimates will be segregated by size using the following classifications: small (> 4 and ≤ 15 cm), medium (> 15 cm to < 50 cm), and large (≥ 50 cm). Historical length frequency data for juvenile coho and Chinook salmon indicate that in winter juvenile salmonids range between 4 and 15 cm total length (Delaney et al. 1981c; Stratton 1986).

Species identification with DIDSON is typically problematic, and separating the different juvenile salmonids based on DIDSON imagery will not be possible. However, it may be possible to identify salmonids from other resident fish based on estimated sizes and swimming behaviors. Fish with distinctive body morphology or swimming motion (e.g., burbot and lamprey) can be readily identified with DIDSON (Johnson and Le 2011; Johnson et al. 2012).

5.11.1.2. Underwater Video

Underwater video imaging can record images in real-time over short intervals and can provide information on fish species presence in the immediate vicinity. Video systems can also be configured to record images for longer periods of time using time lapse or motion triggered recorders. Video can be used to assess fish presence without any handling of the fish species, reducing potential stress on fish. Although water clarity and lighting can limit the effectiveness

of video sampling, a distinct advantage of video over DIDSON is the ability to clearly identify fish species. In clear water under optimal lighting, video can capture a much larger coverage area than DIDSON (Mueller et al. 2006). Using a combination of DIDSON and video cameras may be beneficial when studying fish in moderately turbid waters. Although video cameras have limited range, they can be used to survey fish that are within the visible range of the acoustic camera. Therefore, identification of fish targets or a sub-sample of targets may be possible. Light levels decrease in the water column as surface ice thickens and particularly when snow covers the ice. Video is often combined with a white or infrared (IR) light source especially under ice and in low light northern latitudes; however, some types of light lighting may affect fish behavior. Since night-time surveys will be required to identify possible diurnal changes in fish behavior and habitat use, the video system will be fitted with IR light in the form of light-emitting diodes surrounding the lens of the camera. Muller et al. (2006) reported that most fish are unaffected by IR lights operated at longer wavelengths, because it falls beyond their spectral range (Bowmaker and Kunz 1987; Lythgoe 1988). However, infrared light dissipates quickly in water and does not result in high image quality.

A combination of high-resolution, low-light capable underwater cameras with associated equipment will be used to monitor fish presence and behavior at the same locations and side by side where DIDSON will be deployed. A variety of cameras including the Aqua-Vu Micro Plus underwater video camera will be used for making underwater observations. The video system will be equipped with a digital video recorder for reviewing and archiving footage of fish observations for later playback and data recording. The unit is capable of holding 360 minutes of footage on an internal 8-gb DVR memory card. To enable viewing during the night and low-light periods, underwater infra-red illuminators (880 nm) will be used in conjunction with the camera. This wavelength is beyond the spectral visual range of juvenile salmonids (Bowmaker and Kunz 1987; Lythgoe 1988).

Camera viewing range will be measured using an object of known distance from the camera. A long section of 2.5-cm-diameter white PVC (or other material) will be lowered down a 5-cm-diameter hole at measured distances from the camera. Additional holes can be drilled in a direction away from the camera, and the range determination can be repeated until the pole is no longer visible.

During each footage period, reviewers will count the total number of fish swimming in view of the camera, identify fish if possible, and keep track of the amount of time required to review each section of footage. The time should be recorded for each observation as well as the playback speed used to review the footage.

Footage and counts will then be compared to DIDSON to assess the utility of underwater videography as a sampling tool. Based on the efficacy of this technique during the pilot study, underwater video or camera may be combined with DIDSON, adapted for sampling habitats that have limited turbidity during the open water season, or deployed at select locations to record long-term fish presence/absence using time lapse methods.

5.11.2. Winter Fish Sampling Techniques

Winter fish sampling will employ multiple methods to determine which are most effective for each fish species, lifestage, and habitat type. Because sampling efforts will occur at both open leads and ice covered sites, methods will vary depending on conditions. In ice-covered sites the

primary sampling methods will be trotlines and minnow traps. In open leads, fish capture methods will include baited minnow traps, electrofishing, and beach seines. Remote telemetry techniques will include radio telemetry and PIT technology. Both of these methods need to be tested for tag detectability under ice cover.

All fish sampling will occur approximately monthly from February through April 2013 and will be coordinated with the intergravel temperature monitoring and the underwater fish observation components.

5.11.2.1. Trotlines

Trotlines will be fished during the February through April sampling period. Trotlines will be set in slough and side channel habitats at Whiskers Slough (Figure 5.11-1). Sites will be marked with a hand-held GPS to ensure that sites can be relocated and resampled during future sampling events.

Trotline construction and deployment will follow the techniques used during the 1980s ADF&G (1981a) and described in Section 9.4. Holes will be drilled in the ice with a two-man ice auger and trotlines will be lowered to the bottom. Trotlines will be checked and re-baited after 24 hours and pulled after 48 hours. Sites will be marked with a hand-held GPS to ensure that sites can be relocated and resampled during future sampling events. In addition, each trotline will be flagged and identified with the permit holder's name and company address. All captured fish will be identified to species and measured for length, and gonads will be examined to determine spawning status. The gonads for all sampling mortalities will be preserved for laboratory examination.

5.11.2.2. Minnow Traps

Minnow traps were a common winter sampling method utilized by ADF&G in the 1980s and were found to be effective for juvenile salmonids (Stratton 1986), as well as non-target species such as sculpin, lamprey, and stickleback. Minnow traps will be deployed at 8 sites at Whiskers Slough monthly from February through April 2013. Minnow trapping locations will be marked with hand-held GPS units in order to resample the same habitats each month.

The minnow traps will be baited with salmon roe, deployed in the same holes drilled for trotlines, and set for 24 hours. Baited traps will be placed on the stream bottom, parallel to stream current. To prevent the loss of traps, each trap will be anchored to the ice surface by a tether line connected to the minnow trap and flagged. All captured fish will be identified to species, measured, and released to the stream unharmed.

5.11.2.3. Beach Seines

Beach seines will be used to collect a range of anadromous and resident fish species that may be present in open-water habitats during the winter. Beach seines will be used in shallow, open-water reaches that are free of woody debris and boulders and will be swept through the water walking upstream. Seines used experimentally for winter sampling will be 15 and 25 feet wide by 5 feet deep with 0.25- to 1.5-inch mesh. Single passes with beach seines will occur at multiple mesohabitats on a monthly basis from February through April. Seining locations will be marked with hand-held GPS units such that surveys are standardized and repeatable. All fish

captured by beach seining will be identified to species, measured for length, and returned to the stream unharmed.

5.11.2.4. Electrofishing

Single-pass backpack electrofishing surveys will be conducted in shallow, open-water leads (i.e., sloughs and side channels) in an attempt to capture a range of anadromous and resident fish species. The location of each electrofishing transect will be mapped using a hand-held GPS unit. All captured fish will be identified to species, measured for length, and returned to the stream unharmed.

5.11.2.5. PIT Tag Arrays

Using 12- and 23-mm PIT tags and a mobile antenna array, PIT tag detection will be tested under varying ice thickness. This pilot effort will help determine the maximum depth of ice at which PIT tags can be detected and inform future PIT tagging studies in 2013 and 2014. Holes will be drilled in the ice and PIT tags will be attached to floats at the end of a tethered fishing line and allowed to drift downstream under the ice. The orientation of a PIT tag relative to the antenna array field will affect the tag detection rate, so the position of all test PIT tags will be fixed within the float for each test. Mobile antenna arrays will be used to determine the maximum ice thickness and distance at which PIT tags can be detected.

5.11.2.6. Radio Tags

The primary function of the telemetry component is to track tagged fish spatially and temporally. Radio telemetry is intended to provide detailed information from relatively few individual fish. Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, snow machine, and foot; see Section 5.8). Although wintertime radio tracking of adult fish was successfully completed during the 1980s studies, there is some question as to the limitations of detecting radio tags under ice cover. The process for testing the detectability of radio tags will follow similar methods as outlined above for testing PIT tags. Holes will be drilled in the ice and radio tags will be attached to the end of a fishing line and allowed to drift downstream under the ice. Mobile antenna arrays will be used to determine the maximum ice thickness and distance radio tags can be detected.

5.12. Data Management – QA/QC

The goals of data management are to establish a data QA/QC protocol to be applied by study teams at logical stages of data collection and processing and to ultimately create a relational database of all QC'd fish distribution and abundance data collected for the Susitna-Watana Project.

5.12.1. Established QA/QC Protocol

Five levels of QC (QC1 to QC5) were established Project-wide during the 2012 data collection efforts; these will be followed throughout the licensing study program. Each QC level is tracked either within tabular datasets (as for Excel and database tables), or within file path names (as for raw field data files). This allows for quick determination of the QC status of all data.

Details for the QC Protocol are found in Appendix 10: Susitna Field Data Standards.

The QC levels, briefly, are as follows:

QC1 – Field Review: Review of field forms before leaving the field, or the QC level of raw data collected via field equipment such as thermistors, cameras, GPS units, etc.

QC2 – Data Entry: Data from paper forms are entered into an electronic format and verified.

QC3 – Senior Review: Final review by senior professional before submitting field data to AEA, or the QC level of raw data cleaned up for delivery to AEA.

QC4 – Database Validation: Tabular data files are verified to meet project database standards.

QC5 – Technical Review: Data revision or qualification by senior professionals when analyzing data for reports.

5.12.2. Relational Database

A database template is being designed to store the fish distribution and abundance data from all consultants and studies, providing a centralized data tool for users. The final database will be maintained in MS Access software and will include data collected in 2012 and new data from future studies in 2013 and 2014. The database will be available for querying and analysis by parties assigned by AEA.

A data dictionary describing the database entities and attributes will be compiled, to accompany the database and to provide an understanding of data elements and their use by anyone querying or analyzing the data.

See Appendix 9 for a template of the Fish Distribution and Abundance database. See Appendix 10 for the detailed Field Data Standards document. This template and document will be finalized prior to commencing field efforts.

6. SAFETY AND PUBLIC AWARENESS

The potential exists for members of the general public to encounter study fish, sampling equipment, or staff associated with various components of the Fish Distribution and Abundance Implementation Plan. While the remote nature of most sampling sites suggests that such encounters will be infrequent, steps will be taken to ensure that any potential risks to the public will be minimized to the extent possible.

A particular concern voiced by project stakeholders was the potential for study fish implanted with radio-tags or PIT tags to be harvested for human consumption. To minimize any risk of injury associated with the consumption of tagged fish, a public awareness effort will be implemented using one or more of the following measures:

- Publishing notices in local newspaper(s),
- Posting of notices at common accessible angling locations and local tackle shops,
- Providing notices to local fishing guides/charters, and

- Attaching labeled anchor-tags on radio-tagged fish that explain tag presence and provide contact information to facilitate tag return and/or exchange of information related to fish capture.

The notices listed above will constitute a single page and include text and figures (e.g., drawings, photos, or maps) describing the species of fish tagged and likely locations where they may be encountered. Notices will also include information to facilitate tag return and/or the exchange of information related to capture events with the intent of maximizing fish movement data collection.

Several components of the Fish Distribution and Abundance Implementation Plan require the anesthetization of study fish. The position of the ADF&G Department of Sport Fish is that food grade clove oil is the most logical choice for use as a fish anesthesia in fisheries studies, as it represents the least concern for liability related to human consumption. Therefore, study fish released alive after processing will only be anesthetized using clove oil. While the U.S. Food and Drug Administration (FDA) prohibits the use of MS-222 on any fish that may be eaten by humans within 21 days of treatment, MS-222 may still be used to euthanize fish as needed for lethal sampling efforts. The remains of such study fish will be destroyed in a manner that prevents human consumption.

To reduce the potential for vandalism or interference with sampling equipment, deployed sampling gear that is unattended for prolonged periods will be labeled as research equipment and include the name and contact information for appropriate staff.

The measures described above have been widely used in fisheries studies to minimize public safety risks. In addition, these measures will raise public awareness regarding field efforts associated with Fish Distribution and Abundance Implementation Plan.

7. SCHEDULE

The schedule for this implementing these RSP studies, including this implementation plan, is described in RSP Sections 9.5.6 and 9.6.6.

8. FIELD TECHNIQUES

A combination of active and passive fish sampling techniques will be used to document fish distribution and abundance. Active sampling requires the sampler to physically move the capture gear through target habitats to capture fish. Passive sampling involves capturing fish by placing stationery gear into which fish enter or simply observing fish without physical capture. Gear types to be used include: gillnets, beach seines, fyke nets, angling, trotlines, electrofishing, minnow traps, fishwheels (RSP Section 9.8), outmigrant traps, snorkeling, DIDSON sonar, and underwater video camera techniques. The techniques selected include those used during ADF&G study efforts in the 1980s as well as more advanced technologies that have become available. Use and comparison of multiple sampling methods provides the opportunity to sample a wide variety of physical habitats, identify potential biases, highlight strengths and weaknesses of each method, and ultimately improve estimates of fish distribution and relative abundance.

Selected methods will vary based on habitat characteristics, season, and species/life histories of interest (Sections 5.3 and 5.4). Logistical and safety constraints inherent in fish sampling in a large river in northern latitudes also play a role in selecting appropriate techniques under various site conditions. Some survey methods may not be used in the mainstem river immediately upstream of hazards such as cascades and rapids. All fish sampling and handling techniques described within this Implementation Plan will be conducted under state and federal biological collection permits, as applicable. Limitations on the use of some methods during particular time periods or locations may affect the ability to make statistical comparisons among spatial and temporal strata. Additional specialized techniques, such as downstream migrant trapping, biotelemetry, and underwater fish observations using sonar DIDSON and video cameras, are described in Section 5.6 (PIT Tagging Arrays), Section 5.7 (Downstream Migrant Trapping), Section 5.8 (Radio Ttelemetry), and Section 5.11 (Unique Applications for Winter Sampling).

8.1. Drift and Set Gill Nets

Often used in conjunction with other methods, gillnets can be an effective technique when sampling for the presence and relative abundance of fish populations for a wide range of anadromous and resident species, life stages, and habitat types (Crawford 2007). Gillnets are designed to collect fish by entangling them as they try to swim through the net mesh. As a result, gill nets are not species selective and are able to collect a combination of both targeted and non-targeted species and life stages. The mesh size should vary depending on the species and life stage targeted, with smaller mesh being more effective for juvenile life stages and smaller-bodied species (Crawford 2007). Gillnets can be deployed in a range of habitat types in streams, rivers and lakes. In open water and at sites with high water velocity, gillnets will be deployed as drift nets, and in slow water habitats (e.g., sloughs), gillnets will be deployed as set (fixed) nets. Depending on conditions, gillnets may also be deployed in ice-free areas and under the ice during winter months. Winter studies by ADF&G conducted in the 1980s found fixed gillnets to be an effective method for sampling resident fish (Sundet 1986). One limiting factor of gillnets is that because they are designed to intentionally entangle fish in the net mesh, fish mortality can be high. Thus, gillnets are not an appropriate method when mortality is a concern. However, a smaller mesh size can be used, or nets can be soaked for shorter periods of time to limit mortalities. Gillnets should not be deployed in locations with a lot of debris where nets could become tangled (Crawford 2007).

In all study sites, drift and set gillnets will be fished perpendicular to the stream channel (Crawford 2007). Gillnets will be attached to the shoreline and slowly dragged across the stream channel, making sure not to tangle it on any debris that may be present. If the water column is too deep, a raft may be needed to help set the far end. Ideally, nets will cover the entire depth of the stream channel where set. The length of the net and the density of the mesh will be consistent with nets used by ADF&G in the 1980s (ADF&G 1981). A range of gillnet sizes will be used from 50 to 125 feet in length and 6 to 8 feet in depth. Variable monofilament mesh sizes ranging from 0.5 to 2.5 inches will be used to target a range of fish species and sizes. Net sizes will include but not be limited to: 51'x7'x2", 100'x6'x1.75", and 125'x6'x0.5". During each sampling event, sampling unit, soak time, location, GPS coordinates, temperature, dissolved oxygen, and discharge (from nearest gaging station) will be recorded. The location of each gill net set will be marked using hand-held GPS units and marked on high-resolution aerial photographs. In order to reduce the variability between sites, sampling efforts will be

standardized by using similar soak times. Set gillnets will be fished in a single location for an extended period of time, usually overnight (ADF&G 1981). In contrast, drift gillnets will be fished moving in a downstream direction through swift habitat types for 30 minutes or until the net becomes saturated with fish (ADF&G 2011). All fish captured will be identified to species, handled, and released if unharmed.

CPUE will be calculated to take into account variation in sampling effort and net size, following methods outlined by ADF&G (2011). The following formula will be used: CPUE = [((100 fathom* 60 minutes) * (n))/(L*T)] where n = number of fish caught, L = length of net in fathoms, and T = the minutes the net fished. The following formula will be used to determine sampling effort (time): T = ([(set time + retrieval time)/2] + soak time).

8.2. Electrofishing

Electrofishing is a widely used method to assess fish presence, relative abundance, and distribution. Electrofishing is effective for a wide range of fish species, life stages, and habitat types. Electrofishing is a non-lethal method that utilizes electricity to stun fish which are then captured with dipnets. Electrofishing is an especially effective method for sampling juvenile life stages and small bodied-fish species and can also be used to sample adult fish as long as they are not in spawning condition (Temple and Pearsons 2007). Electrofishing can be conducted in a range of habitat types and the approach varies depending on the type of stream type sampled. Specific methods are described in greater detail below. Electrofishing often requires less time and effort than other sampling methods (e.g., minnow trapping) and is easier to standardize than some other methods (e.g., seines; Barbour et al. 1999). Electrofishing can be an effective technique in habitats that are not easily sampled by nets, especially for benthic fish (e.g., sculpin) or species that hide in undercut banks (Temple and Pearsons 2007). Because electrofishing is a non-lethal technique, it can also be used as a fish collection method when conducting mark-recapture or radio-tagging studies (Barbour et al. 1999).

However, electrofishing does have some limitations and can be harmful if not conducted properly. Electrofishing is selective towards certain species and can be biased towards smaller life stages of fish (Barbour et al. 1999). An ADF&G-generated table that recommends target voltage settings for juvenile salmonid sampling in cold water was used as a reference at the onset of sampling (Buckwalter 2011). Electrofishing may not be effective in some glacial systems subject to high turbidity and low conductivity (Temple and Pearsons 2007). Suspended materials in turbid water can affect conductivity, which may result in harmful effects on fish, especially larger fish due to a larger body surface in contact with the electrical field (Temple and Pearsons 2007). Sudden changes in turbidity can also create zones of higher amperage, which can be fatal to young-of-year fish as well as larger fish (Temple and Pearsons 2007). Electrofishing in swift currents can also be problematic, because stunned fish can be swept away before they can be netted and possibly injured (Barbour et al. 1999). As a result, electrofishing should be replaced with another method in turbid and swift water habitats.

8.2.1. Backpack Electrofishing

Backpack electrofishing can be a good way to assess fish population composition and size in wadeable streams that are relatively narrow, characterized by moderate flows, and have a streambed comprised of substrate that is not so coarse as to allow shocked fish to fall between

rocks and become irretrievable (Temple and Pearsons 2007). ADF&G studies conducted in the 1980s determined that backpack electrofishing units were effective at sampling rearing juvenile life stages of anadromous and resident fish and benthic species such as sculpin (Temple and Pearsons 2007). All backpack electrofishing procedures will follow NMFS (2000) *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act*. Personnel operating electrofishing units will be trained and certified per ADF&G permit requirements.

A Smith-Root LR-24 backpack electrofishing unit will be operated by a trained field crew leader and assisted by two people with dipnets. Each backpack unit will be fitted with a standard Smith-Root cathode and a single anode pole with a steel ring. Electrofishing may be paired with snorkel surveys, where snorkel surveys are conducted first as a reconnaissance to make sure there are no large salmonids in the area. Single-pass fish distribution electrofishing surveys will be conducted through the selected study reach moving in an upstream direction. For relative abundance surveys, CPUE may be determined or a multiple-pass depletion estimate derived (following Lockwood and Schneider 2000). A depletion estimate may be made if the sampling unit is small and allows for block nets to be practically installed at the upstream and downstream ends of the study reach to ensure that fish do not escape during the survey (Temple and Pearsons 2007). Three removal passes are then made. Fish from each pass are held in separate containers for processing. If the subsequent passes yield large numbers of fish, the technique may not be appropriate for the site. Depending upon stream width, an additional crew leader may operate a second electrofishing unit. All stunned fish are then captured with dipnets away from the electric field and held in buckets for later processing.

Backpack electrofisher settings will be determined in the field based on water quality conditions, professional judgment, and the overall goal of minimizing impacts to fish health (Temple and Pearsons 2007). Prior to electrofishing, ambient water chemistry will be recorded including conductivity (microSiemens), turbidity (nephelometric turbidity unit [NTU]), and surface water temperature (°C) with a digital meter at the downstream end of sampling site to help determine initial backpack electrofishing unit settings. In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by the manufacturer (Smith-Root 2009), ADF&G (Buckwalter 2011) and NMFS (2000). The location of each electrofishing unit will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. Start and stop times will be recorded to quantify sampling effort between surveys. Habitat measurements will also be collected at each study site location. All captured fish will be identified to species, measured for length, and returned to the stream unharmed. For each sample unit, fish capture data and sampling effort (e.g., electrofishing 'power on' recorded in seconds) will be documented separately so that CPUE can be calculated.

8.2.2. Boat Electrofishing

In study site locations that are too deep or too swift to safely operate a backpack electrofishing unit, boat-based electrofishing may be used as a fish sampling technique. Boat-mounted electrofishing is the most effective means of capturing fish in deeper waters (10 feet maximum depth), along steep stream banks, and within larger side channels that are inaccessible via wading (Temple and Pearsons 2007). Boat-based electrofishing was a frequent method used by ADF&G in the 1980s and was found to be effective for sampling adult resident fish including Arctic grayling, round whitefish, and longnose sucker (ADF&G 1985). Although boat electrofishing

techniques facilitate sampling in locations inappropriate for backpack units, the effectiveness of the boat-based units can still be limited due to low conductivity, high turbidity, and swift water (Temple and Pearsons 2007). Sampling with the boat electrofishing unit is not possible in areas of high velocity areas due to the high prevalence of boulders and whitewater (Temple and Pearsons 2007).

Boat-based electrofishing will be conducted while drifting in a downstream direction by an experienced three- or four-person field crew. One person will operate the boat, while the field crew leader operates the electrofishing unit and one or two netters capture stunned fish. In locations close to town, drift boats will be used, while in more remote locations, an inflatable cataraft with a collapsible aluminum frame will be used. The boat will be outfitted with either a Smith-Root 2.5 Gas-Powered Pulsator (GPP) electrofisher powered by a smaller generator for use in low-conductivity waters or a 5 GPP electrofisher for use in higher-conductivity waters. As standard practice, low frequency pulse settings will be selected initially to avoid exposing fish to more harmful higher pulse frequencies.

Boat electrofisher settings will be determined in the field based on water quality conditions, professional judgment, and the overall goal of minimizing impacts to fish health (Temple and Pearsons 2007). Prior to electrofishing, ambient water chemistry will be recorded including conductivity (microSiemens), turbidity (NTU), and surface water temperature (°C) with a digital meter at the downstream end of sampling site to help determine initial backpack electrofishing unit settings (Temple and Pearsons 2007). In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by Smith Root and ADF&G (Buckwalter 2011). The field team will record a GPS location at the upstream start of each stream or sample segment prior to moving downstream to sample. Start and stop times will be recorded to quantify sampling effort between surveys. Habitat measurements will also be collected at each study site location. All captured fish will be identified to species, measured for length, and returned to the stream unharmed. For each sample unit, fish capture data and sampling effort (e.g., electrofishing 'power on' recorded in seconds) will be documented separately so that CPUE can be calculated.

8.3. Angling

Angling with hook and line can be an effective way to sample fish presence, relative abundance, and seasonal distribution, and collect fish for tagging or mark-recapture studies. Angling surveys will provide an alternative sampling technique when other methods are ineffective due to excessive water depth or velocity. However, because it is labor- and time-intensive, angling is best used as an alternative method if other more effective means of sampling are not available. Angling is an effective method for sampling adult life stages and as a result, can be biased against sampling juvenile fish unless a smaller hook size is used. In the 1980s Susitna River studies conducted by ADF&G, angling was common within deep pools of larger streams, at tributary mouths of small streams, and at clear water plumes from major tributaries to the Susitna River (ADF&G 1984). Lakes can also be sampled from their shorelines using angling methods. ADF&G efforts found angling to be especially effective for adult resident fish species such as rainbow trout, Arctic grayling, whitefish, and pike (ADF&G 1981).

Hook-and-line angling will be conducted on an opportunistic basis using artificial lures or flies with single barbless hooks, in conjunction with other sampling methods (e.g., electrofishing,

seine nets, etc.). Spinning gear will be used for all angling efforts, which will include collapsible pack rods, spinning reels, and lightweight fishing line. Terminal tackle will consist primarily of various sizes of spinners and spoons; however, if these are ineffective, bobbers with a variety of fly patterns will be used. All lures and flies will be single hooked and barbless to reduce the likelihood of fish injury. Steel leaders will be used for when pike are the target species. Fish will be landed carefully and managed with a mesh net when possible.

Fishing time will be recorded in 0.25-hr increments. All hook sizes, bait types, and lure sizes will be recorded for each sampling site. In addition, the time will be recorded when fishing begins and ends, every time a fish is landed, and if/when any equipment changes (e.g., bait, lure, or hook) or a move to a new site are made (ADF&G 1981). All captured fish will be identified to species, measured to length, and released near the point of capture. Handling procedures may also include the installation of radio tags or marking depending on the objective of the study. To standardize angling efforts, CPUE will be quantified either by units of time or level of effort (e.g., number of casts). All angling survey locations will be recorded with a hand-held GPS unit, and general habitat and environmental conditions will be documented including habitat type, water temperature, water chemistry, and site dimensions.

8.4. Trotlines

Trotlines can be an effective method for capturing adult resident fish species such as burbot, rainbow trout, Dolly Varden, grayling, and whitefish. In addition, trotlines are considered to be the most effective method for sampling burbot (Paragamian and Bennett 2008). Typically, trotlines are long lines with a multitude of baited hooks that are anchored at both ends and set in the water for a period of time. Trot lining is a versatile technique that can be deployed in open water and through ice similar to a set line. Trotline sampling was one of the more frequently used methods during the 1980s Susitna River studies (ADF&G 1981; ADF&G 1984). Although an efficient method for capturing fish, it also tends to be a lethal method and therefore not ideal for mark-recapture or radio telemetry studies.

Trotline construction and deployment will follow the techniques used during the 1980s as described in ADF&G (1981). Trotlines will consist of 30 to 36 ft of seine twine with six leaders and hooks lowered to the river bottom using 24-oz and 8-oz sinkers. On one end of the 30 ft seine line a 2/0 snap swivel will be connected and an 8-oz sinker will be attached. From there, another 2/0 snap swivel will be connected 15 ft from the other end and a 24-oz sinker will be attached. Six leaders will be connected between the two sinkers, roughly every 3 ft. Trotlines will be set up with a range of hook sizes from 10 to 4/0. This is to ensure that trotlines are not biased towards fish species with larger mouth sizes (e.g., burbot) and can also catch fish with smaller mouths such as grayling and whitefish (ADF&G 1981). No individual trotline hook will have a gap between shank and point that is greater than 0.75 in (ADF&G 2013). Trotlines will be checked and rebaited after 24 hours and pulled after 48 hours. Hooks will be baited with salmon eggs, herring, or whitefish. Salmon eggs are usually effective for salmonids, whereas herring and whitefish are effective for burbot (ADF&G 1981). As per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized with a 10-minute soak in a 1/100 Betadyne solution prior to use. Sites will be marked with a hand-held GPS to ensure that sites can be relocated and resampled during future sampling events. In addition, each trotline will be flagged and identified with the permit holder's name and company address. All captured fish will be identified to species and measured for length, and gonads will be examined

to determine spawning status. The gonads for all sampling mortalities may be preserved for laboratory examination.

8.5. Minnow Traps

Minnow traps are an effective method for passive capture of juvenile salmonids and other juvenile resident fish species in slow moving water habitats such as pools and sloughs (Bryant 2000). In swift waters, minnow traps are ineffective unless they can be secured or placed in slow-moving margins or eddies of riffles. Minnow traps were a common under-ice winter method utilized by ADF&G in the 1980s and were found to be effective for juvenile salmonid species (Stratton 1986) and also were able to catch non-target species such as sculpin, lamprey, and stickleback. In reaches where both electrofishing and snorkeling would be ineffective due to stream conditions such as deep, fast water, baited minnow traps will be used as an alternative to determine fish presence.

Wire and fabric collapsible minnow traps will be used. The wired two-piece minnow traps are 16.5 in long, 9 in diameter, and has a 1 in opening. The collapsible traps have a length of 18 in and a width of 10 in. The openings of the collapsible trap have a diameter of 2.5 in. Minnow traps will be baited with commercial processed salmon roe. Per ADF&G Fish Resource Permit stipulations, all salmon eggs used as bait will be commercially sterilized or disinfected with a 10-minute soak in a 1/100 Betadyne. After roe has been sterilized, 1 Tbsp of roe will be measured out and placed in a 1-oz plastic Whirl-Pak bag (Fort Atkinson, WI, USA). Filled plastic bags will be perforated using a fork or utility knife before bait is placed inside the trap. Pending the size of the habitat unit, between 5 and 10 minnow traps will be deployed. Traps will be deployed adjacent to preferred juvenile fish habitats including deep pools and areas with woody debris, undercut banks, and/or overhanging vegetation. Traps will be placed on the stream bottom, parallel to stream current. To prevent the loss of traps, each trap will be anchored to the stream bank by a tether line connected to the minnow trap and flagged. Baited and set minnow traps will be allowed to soak for 90 minutes before checked (Bryant 2000). After 90 minutes, traps will be removed and all fish will be measured and identified to species. Fish will be held in a live well and released unharmed to the same site where they were originally captured.

8.6. Snorkeling

Snorkeling is the underwater observation and study of fish in flowing waters. One of the positive aspects of snorkeling is it is often feasible in places where other methods are not (e.g., deep, clear water with low conductivity which makes electrofishing ineffective). Snorkeling requires minimal equipment, making it easy to perform in remote locations where it may be difficult to use other methods, such as traps, nets, and electrofishing. Because fish are not handled and disturbance is minimized, snorkeling is especially useful for sampling rare or protected stocks. Snorkel surveys provide an alternative to traditional and more disruptive methods, such as electrofishing and gillnetting (Mueller et al. 2006). The technique is commonly used for juvenile salmonid populations but can also be used to assess other species groups. Generally, snorkeling works well for detecting presence or absence of most species. Limitations occur when water is turbid or deep due to an inability to see the fish or when the water is too swift to safely survey (Dolloff et al. 1993, 1996).

Single pass snorkel surveys (Dolloff et al. 1993) will be conducted by a three-person field crew trained in snorkel survey methods and fish species identification. For relative abundance sampling, each site will be sampled with three passes (Dolloff et al. 1996). Before beginning a survey, climatological and hydrological conditions, such as air and water temperatures, cloud cover, and water clarity/visibility, will be documented. Snorkelers will use a plastic salmonid silhouette with parr marks to evaluate visibility as the horizontal underwater distance at which the parr marks were visible. As the snorkeler approaches the model, the distance at which the parr marks on the silhouette became visible will be measured. Similarly, during retreat, the distance at which the parr marks are no longer visible will be measured, and visibility will be calculated as the average of these two distances (Thurow 1994). Habitat units will be snorkeled by starting at the downstream end of the sample area and working upstream unless water velocity precludes upstream movement. Snorkeled distance will depend on the length of the habitat unit being sampled. The entire habitat unit will be sampled for fish if the unit length is less than or equal to 40 m. When habitat units are greater than 40 m in length, only 40 m of the unit will be sampled.

Snorkel surveys will consist of a single snorkeler when wetted stream widths are less than 5 m. Observations will be made by counting fish on both sides of the stream channel while alternating from left to right counts. For streams with wetted widths greater than 5 m, the entire area of the stream will be sampled by two or more snorkelers moving upstream in tandem. Snorkelers will visually identify and count all species encountered, and fish counts will be grouped by species and size class estimated in 20 millimeter (e.g., 1-20 mm, 21-40 mm, etc.) increment bins. Snorkel observations will be called out to a non-snorkeling team member and recorded on a field data sheet. For most of the snorkel surveys in this study, two experienced biologists will be designated snorkelers, while a field technician will act as a recorder. A hand-held GPS unit will be used to record the downstream and upstream extent of the area surveyed and marked on high-resolution aerial photographs.

If relative abundance estimates from snorkel surveys are to be compared to other sampling methods (e.g., minnow trapping or electrofishing), block nets are needed to ensure a closed population within a single habitat unit, by preventing fish from leaving or entering the unit (Hillman et al. 1992). To facilitate relative fish abundance estimation, the survey length and average wetted width of the sample area will be measured and recorded.

8.7. Fyke/Hoop Nets

Fyke/hoop nets are passive, low stress methods for sampling the presence and relative abundance of juvenile and adult anadromous and resident fish (O'Neal 2007). In general, a fyke net consists of a large hoop net with wings that act as funnels to direct fish into the network of hoops. A hoop net has a similar set up, but lacks wings for directing fish into the net. Fyke/hoop nets are typically used in shallow, lentic habitats (e.g., sloughs, estuaries, and off channel habitats) but can also be used in deep-water habitats (e.g., ponds, pools, and lakes; O'Neal 2007). Fyke/hoop nets tend to be the most useful in capturing cover-seeking mobile species and migratory species that follow the shorelines and have been used to a sample juvenile salmon in estuary habitat in the Skagit River in Washington (E. Beamer, Skagit River System Cooperative, personal communication). When habitats contain woody and/or organic debris or boulders, fyke/hoop nets provide alternative fish capturing methods to seine nets or snorkel surveys. Since fyke/hoop

nets induce less stress on captured fish than do entanglement gears (e.g., gill nets; Hopkins and Cech 1992), and most captured fish can be released unharmed.

Fyke/hoop nets will be deployed to collect fish in sloughs and side channels with moderate water velocity (i.e., < 3 feet per second). After a satisfactory location has been identified at each site, the same location will be used during subsequent collection periods. The nets will be operated continuously for up to two days. The fyke/hoop nets will be approximately 40 ft long and consist of two rectangular steel frames (3 ft wide by 2.5 ft high), and four steel hoops, all covered by 0.25-in delta stretch mesh nylon netting. A 26 ft long by 4.1 ft deep leader net made of 0.33-in delta stretch nylon netting will be attached to a center bar of the first rectangular frame (net mouth). The second rectangular frame will have two 4 in wide by 28-in high openings, one on each side of the frame's center bar. The four hoops follow the second frame. The throats, 4-6 in diameter, will be located between the second and third hoops. The net ends in a cod end bag 8 ft long with an 8-in opening at the end, which will be tied shut while the net is fishing (O'Neal 2007). Each fyke/hoop net will be configured with two wings, set perpendicular to the shore, to guide the majority of water and fish to the net mouth. Where possible, the guide nets will be configured to maintain a narrow open channel along one bank. Where the channel size or configuration does not allow an open channel to be maintained, the area below the fyke/hoop net will be checked regularly to assess whether fish are blocked and cannot pass upstream. A live car will be located at the downstream end of the fyke/hoop net throat to hold captured fish until they can be processed. The fyke/hoop net wings and live car will be checked at least once a day while fishing, to record and measure captured fish (Klemm et al. 1993). The location of the fyke/hoop net sets will be mapped using a hand-held GPS unit and marked on high-resolution aerial photographs.

8.8. Hoop Traps

Hoop traps are a passive method for sampling the presence and relative abundance of juvenile and adult anadromous and resident fish. They are essentially a hoop net that is baited with fish or salmon roe to attract fish into the net (Larson 2000). Hoop traps can also be known as fyke traps if they include the wings to help funnel fish into the trap (Larson 2000).

Commercially available hoop traps have been used successfully by ADF&G on the Tanana River as a non-lethal method to capture burbot for tagging studies, and to sample adult (> 200 mm) Dolly Varden in Kenai Lake (Evenson 1993; Stuby and Evenson 1998; Larson 2000). Hoop traps may have between 4 to 7 hoops. Smaller traps consist of four 0.25-in steel hoops with diameters tapered from 3 ft at the entrance to 2.25 ft at the cod end. Larger traps consist of seven 0.25-in thick steel hoops inside with diameters tapered from 2 ft at the entrance to 1.5 at the cod end. Both the four- and seven-hooped traps have two necks inside and are made up of 0.25-in diameter knotless delta mesh. Each trap is kept stretched open with two sections of PVC pipe spreader bars attached by snap clips to the end hoops. Bernard et al. (1991) provides an account of the efficacy of the small and large traps.

Hoop traps may be useful for capturing burbot for radio-tagging when deployed in mainstem areas with lower water velocity. The traps will be anchored to the bank and allowed to fish with the opening facing downstream. Deploying hoop traps should occur in late afternoon or evening and be allowed to soak overnight but not for more than 12 hours (M. Evenson, ADF&G, personal communication, 2012).

8.9. Beach Seine

Beach seines are an effective method to capture a range of fish species and life stages in a multitude of slow-water habitats. In addition, seining allows the sampling of relatively large areas in short periods of time as well as the capture and release of fish without significant stress or harm. Limitations to beach seining include: fast flows, water depth, coarse substrates, and woody and organic debris (Hahn et al. 2007). Woody debris and boulders can create snags and lift of the lead line allowing the fish to escape. Ideal habitats for beach seining are wadeable, slow moving water (e.g., rivers, estuaries, and near-shore lake, reservoir, and marine habitats; Pierce et al. 1990), with level uniform substrate (e.g., gravel and/or sand).

The methodology of seining is dependent on habitat type and the target species. Typically, speed and coordination is an essential part of successful seining. Fish should be given the least amount of time to flee and attempt escape. The size and swiftness of the target fish should influence both the length of the seine used and the speed at which it is deployed and retrieved. However, pulling the seine net too fast can create opportunities for fish to escape. To prevent fish escapement, it is important to lead with the lead line (Hahn et al. 2007). In wadeable systems, smaller nets are used and deployed by hand with one end of the net anchored to the shore and the other end extended out from shore and then looped around to encircle the fish as the ends are pulled in against the beach or gravel bar. With most seine sets, lead and cork lines should be withdrawn at approximately equivalent rates until close to shore. Once the lead line approaches the shore, it should be withdrawn more than the cork line until a secure pond or corral is formed in the bag of the net and the lead line is on the beach or gravel bar (Hahn et al. 2007). Fish may then be allowed to rest within the bag until they are withdrawn for sampling. For some methods (e.g., circle set), vegetation may need to be removed methodically and inspected for fish before the seine can be pursed. Once all fish have been withdrawn from the net, the net will be cleaned of all leaf litter, sticks, rocks, and other debris, checked for damage, and reloaded for the next set. Damage to seines can be repaired following instructions in Gebhards (in Murphy and Willis 1996).

Beach seining can be used to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon (Hayes et al. 1996). Relative fish abundance is assessed by the repetitive seining over time with standardized net sizes and standardized deployment in relatively similar habitat. To the extent possible, the same area will be fished during each sampling event; net sizes and soak times will be standardized. Seine nets of various sizes are available for use that range from 14 to 120 ft long, 3 to 6 ft wide, and have mesh diameters that range from 0.125 to 1 in. The largest and smallest available nets are 120'x5' x0.5" mesh and 14'x6'x0.125" mesh, respectively.

With this range in net sizes a large variety of fish and habitats can be sampled; as long as the area sampled is noted, the net size is noted, and the net is deep enough to fill the water column, then comparisons can be made. The location of beach seining will be recorded using a hand-held GPS unit, in addition to being marked on high-resolution aerial photographs. The area seined will be delineated using fiberglass measuring tapes and/or a marked wading rod.

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10. TABLES

Table 4.1-1. Anadromous and resident species present in the Susitna River.

Common Name	Latin Name	Life History[1]	Behavior[2]	Distribution in Susitna River[3]
Alaska blackfish	*Dallia pectoralis*	F	U	U
Arctic grayling	*Thymallus arcitcus*	F	O, R, P	Low, Mid, Up
Arctic lamprey	*Lethenteron japonicum*	A	O, M2, R, P	Low, Mid
Bering cisco	*Coregonus laurettae*	A	M2, S	Low, Mid
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up
Chinook salmon	*Oncorhynchus tshawytscha*	A	M2, S, R	Low, Mid, Up
Chum salmon	*Oncorhynchus keta*	A	M2, S, R	Low, Mid
Coho salmon	*Oncorhynchus kisutch*	A	M2, S, R	Low, Mid
Dolly Varden	*Salvelinus malma*	A, F	O, P	Low, Mid, Up
Eulachon	*Thaleichthys pacificus*	A	M2, S	Low
Humpback whitefish[4]	*Coregonus pidschian*	A, F	O, R, P	Low, Mid, Up
Lake trout	*Salvelinus namaycush*	F	U	U
Longnose sucker	*Catostomus catostomus*	F	R,P	Low, Mid, Up
Northern pike	*Esox lucius*	F	P	Low, Mid
Pacific lamprey	*Lampetra tridentata*	A, F	U	U
Pink salmon	*Oncorhynchus gorbuscha*	A	M2, S, R	Low, Mid
Rainbow trout	*Oncorhynchus mykiss*	F	O, M2, P	Low, Mid
Round whitefish	*Prosopium cylindraceum*	F	O, M2, P	Low, Mid, Up
Sculpin[5]	*Cottid*	M1[6], F	P	Low, Mid, Up
Sockeye salmon	*Oncorhynchus nerka*	A	M2, S, R	Low, Mid
Threespine stickleback	*Gasterosteus aculeatus*	A, F	M2, S, R, P	Low, Mid

Notes:

1 A = anadromous, F = freshwater, M1 = marine

2 O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M2 = migration

3 Low = Lower River, Mid = Middle River, Up = Upper River, U = Unknown

4 Whitefish species that were not identifiable to species by physical characteristics in the field were called humpback by default. This group may have contained Lake (Coregonus clupeaformis), or Alaska (Coregonus nelsonii) whitefish.

5 Sculpin species generally were not differentiated in the field. This group may have included Slimy (Cottus cognatus), Prickly (Cottus asper), Coastal range (Cottus aleuticus), and Pacific staghorn (Leptocottus armatus).

6 Pacific staghorn sculpin were found in freshwater habitat within the Lower Susitna River Segment.

Table 4.1-2. Designated Fish Habitat Sites surveyed twice monthly from June through September 1982. Source: Estes and Schmidt (1983).

Reach	Site	Historic River Mile	Project River Mile
Lower River	GOOSE CREEK 2 AND SIDE CHANNEL	73.1	
	WHITEFISH SLOUGH	78.7	
	RABIDEUX CREEK AND SLOUGH	83.1	
	SUNSHINE CREEK AND SIDE CHANNEL	85.7	
	BIRCH CREEK AND SLOUGH	88.4	
Middle River	WHISKERS CREEK AND SLOUGH	101.2	
	SLOUGH 6A	112.3	
	LANE CREEK AND SLOUGH 8	113.6	
	SLOUGH 8A	125.3	
	SLOUGH 9	129.2	
	4TH OF JULY CREEK-MOUTH	131.1	
	SLOUGH 11	135.3	
	INDIAN RIVER—MOUTH	138.6	
	SLOUGH 19	140	
	SLOUGH 20	140.1	
	SLOUGH 21	142	
	PORTAGE CREEK-MOUTH	148.8	

Table 4.1-3. JAHS sample sites for the AJ and AH components of the Aquatic Studies Program during 1983 and 1984.

Site	Historic River Mile	Project River Mile	Macro-habitat Type	1983/1984 Sampling1			1982 DFH Site	1982 SFH Site	1981 Sample Site
				Fish Distribution Site	RJHAB Modeling Site	IFIM Modeling Site			
Eagles Nest Side Channel3	36.2		SC	X	X				
Hooligan Side Channel3	36.2		SC	X	X				
Kroto Slough Head	36.3		SS	X	X				
Rolly Creek Mouth	39.0		T	X	X			X	
Bear Bait Side Channel	42.9		SC	X	X				
Last Chance Side Channel	44.4		SC	X	X				
Rustic Wilderness Side Channel	59.5		SC	X	X				
Caswell Creek Mouth3	63.0		T	X	X			X	X
Island Side Channel	63.2		SC	X	X	X			
Mainstem West Bank	74.4		SC	X		X			
Goose 2 Side Channel	74.8		SC	X	X		X		
Circular Side Channel	75.3		SC	X		X			
Sauna Side Channel	79.8		SC	X		X			
Sucker Side Channel3	84.8		SC	X	X				
Beaver Dam Slough3	86.3		T	X	X				
Beaver Dam Side Channel3	86.3		SC	X	X				
Sunset Side Channel3	86.9		SC	X		X			
Sunrise Side Channel3	87.0		SC	X	X				
Birch Slough3	89.4		T	X	X		X		X
Trapper Creek Side Channel	91.6		SC	X	X	X			
Whiskers Creek Slough	101.2		SS/SC	X	X		X		X
Whiskers Creek4	101.2		T	X			X		X
Slough 3B	101.4		SS	X					
Mainstem at head of Whiskers Creek Slough4	101.4		SC	X					
Chase Creek	106.9		T	X				X	
Slough 5	107.6		US	X	X				
Oxbow I	110.0		SC/SS	X					
Slough 6A	112.3		US	X	X		X		X
Mainstem above Slough 6A4	112.4		SC	X					

Site	Historic River Mile	Project River Mile	Macro-habitat Type	1983/1984 Sampling1			1982 DFH Site	1982 SFH Site	1981 Sample Site
				Fish Distribution Site	RJHAB Modeling Site	IFIM Modeling Site			
Lane Creek4	113.6		T	X			X		X
Slough 8	113.6		SS	X	X		X		
Mainstem II	114.4		SC/SS	X					X
Lower McKenzie Creek4	116.2		T	X				X	
Upper McKenzie Creek4	116.7		T	X				X	
Side Channel below Curry4	117.8		SC	X					
Oxbow II4	119.3		SC/SS	X					
Slough 8A	125.3		SS	X		X	X		
Side Channel 10A	127.1		SC	X	X				
Slough 9	129.2		SS/SC	X		X	X		
Slough/Side Channel 10	133.8		SC/SS	X		X		X	X
Lower Side Channel 114	134.6		SC	X		X			
Slough 11	135.3		SS	X			X		X
Upper Side Channel 114	136.2		SC	X		X			
Indian River - Mouth	138.6		T	X			X		X
Indian River-TRM 10.1	138.6		T	X					
Slough 194	140.0		US	X			X		
Slough 204	140.1		SS/SC	X			X		X
Side Channel 21	140.6		SC			X			
Slough 21	142.0		SS/SC			X	X		
Slough 22	144.3		SS/SC	X	X				
Jack Long Creek4	144.5		T	X				X	
Portage Creek Mouth	148.8		T	X			X		X
Portage Creek TRM 4.2	148.8		T	X					
Portage Creek TRM 8.0	148.8		T	X					

Notes:

1 Sites from HRM 36.2 to HRM 91.6 were sampled in 1984 (Suchanek et al. 1985, APA Doc 2836). Sites from HRM 101.2 to 148.8 were sampled in 1983 (Dugan et al. 1984, APA Doc 1784).

2 SC = side channel, SS = side slough, US = upland slough, T = tributary (tributary channel vs. mouth indicated in site name)

3 Located within representative side channel or slough complexes mapped by Ashton & Klinger (1985)

4 Sites sampled less than 3 times in 1983

Table 4.1-4. Summary of studies conducted during the 1980s supplemental to AH and AJ sampling efforts.

Study	Topic	Type of data collected	Sampling Duration	Methods	Sample Sites (n)	General locations sampled
Roth et al. (1986)	Juvenile salmon outmigration and growth	Relative abundance, outmigration time, growth	May - October 1985	outmigrant traps, mark recapture with coded wire tags and cold branding	22	22 tributary, slough and side channel sites between Flathorn Station (RM 22.4) and Portage Creek (RM 148.8)
Roth and Stratton (1985)	Juvenile salmon outmigration and growth	Relative abundance via mark recapture	Coded wire tags May - June, cold branding July - October, 1984	mark recapture coded wire tags and cold branding	9	9 sloughs and side channels in the Middle Susitna River
		Relative abundance, outmigration time, growth	May - October 1984	stationary outmigrant traps, fyke nets, beach seine, minnow traps	4	Mainstem Deshka River, Lower (Flathorn Station) and Middle (Talkeetna Station) Susitna River and Indian River
Sundet and Pecheck (1985)	Resident fish distribution and abundance	Relative abundance	May - October 1984	boat electrofishing, mark recapture	13	Mainstem (3), slough (4) and tributary (6) locations on the Lower and Middle Susitna River below Devil Canyon.
		Population estimates	May - October 1984	radio tagging, mark-recapture	13	Mainstem (3), slough (4) and tributary (6) locations on the Lower and Middle Susitna River below Devil Canyon.
		Radio telemetry	May - October 1984	radio tags, boat electrofishing, hook and line	13	Mainstem (3), slough (4) and tributary (6) locations on the Lower and Middle Susitna River below Devil Canyon.
Wilson (1985)	River productivity	Benthic algae	March - November, 1985	Not described	2	Side channel, slough and mainstem habitats of Middle Susitna River (Skull Creek side channel, Slough 8A)
		Benthic macroinvertebrates	March - November, 1985	Not described	2	Side channel, slough and mainstem habitats of Middle Susitna River

Study	Topic	Type of data collected	Sampling Duration	Methods	Sample Sites (n)	General locations sampled
Hansen and Richards (1985)	Invertebrate food sources for Chinook salmon	Benthic macroinvertebrates	4/5 times per site between June and September, 1984	modified hess sampler	4	Three side channels and one side slough were selected for study between River Mile (RM) 129 and RM 142
		Drifting macroinvertebrates	4/5 times at each site between June and September, 1984	drift net	4	Three side channels and one side slough were selected for study between River Mile (RM) 129 and RM 142
		Juvenile Chinook diet	4/5 times at each site between June and September, 1984	backpack electrofisher	4	Three side channels and one side slough were selected for study between River Mile (RM) 129 and RM 142
		Turbidity	4/5 times at each site between June and September, 1984	Water samples collected and tested with a turbidimeter	4	Three side channels and one side slough were selected for study between River Mile (RM) 129 and RM 142
Van Nieuwenhuyse (1985)	Primary productivity	Benthic algae (chlorophyll a)	Once a month early April to late October, 1985	Scraped algae and stored in ethanol	4	Mainstem and side slough habitats and 1 side channel in Middle Susitna River
		Benthic macroinvertebrates	Once a month early April to late October, 1985	Kicknet	5	Mainstem and side slough habitats and 1 side channel in Middle Susitna River
		Turbidity	Once a month early April to late October, 1985	Turbidimeter	5	Mainstem and side slough habitats and 1 side channel in Middle Susitna River
		Photosynethetic Active Radiation (PAR)	Once a month early April to late October, 1985	LICOR	4	Mainstem and side slough habitats and 1 side channel in Middle Susitna River

Table 4.1-5. Catch per sampling event (all species combined) at mainstem Designated Fish Habitat sites sampled from June through September 1982.

Sampling Gear	Min	Mean	Median	Max	Total	Sample Events
Set Gillnet	3	13.8	4.5	43	55	4
BP Electrofishing	0	20.5	16.0	80	901	44
Beach Seine	0	38.0	11.0	1072	3302	87
Minnow Trap	0	12.7	2.0	315	1691	133
Hook and Line	0	2.4	0.0	14	33	14
Trotline	0	1.5	1.0	8	197	130
Dip Net	0	6.8	4.0	22	157	23
Boat Electrofishing	0	19.4	12.0	116	1573	81
Fish Trap	0	0.0	0.0	0	0	3
Hoop Net	0	1.2	0.0	5	6	5

Table 4.2-1. Deployment of fishwheel (F) and sonar stations (S) from 1981 to 1985. Sources: ADF&G 1982a,ADF&G 1982c, Barrett 1984, Barrett 1985, Thompson et al. 1986.

Station	Historic River Mile	1981		1982		1983		1984		1985	
		Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation	Gear	Period of Operation
Flathorn Station	22							4F	6/29 to 9/3	4F - 6F	5/26 to 9/3
Susitna Station	26.7	2F, 2S	6/27 to 9/2	2F, 2S	7/1 to 9/5						
Yentna Station	28, TRM 04	2F, 2S	6/29 to 9/7	2F, 2S	6/27 to 9/5	2F, 2S	6/30 to 9/5	2F, 2S	7/1 to 9/5		
Sunshine Station	80	4F, 2S	6/23 to 9/15	4F, 2S	6/4 to10/1	4F	6/3 to 9/11	4F	6/4 to 9/10	4F	6/3 to 9/10
Talkeetna Station	103	4F, 2S	6/22 to 9/15	4F, 2S	6/5 to 9/14	4F	6/7 to 9/12	4F	6/3 to 9/11		
Curry Station	120	2F	6/15 to 9/21	2F	6/9 to 9/18	2F	6/9 to 9/14	2F	6/9 to 9/14	2F	6/10 to 9/12

Table 4.3-1. Linear regression statistics for predicting the development of chum and sockeye eggs based upon average incubation temperature. All equations were significant at p<0.001 and r-0.99. Source: Wagaard and Burger (1983).

Species	Life Stage	Slope	Intercept
Chum	50% Hatch	1.40	3.23
	100% Yolk Absorption	0.59	2.25
Sockeye	50% Hatch	0.15	3.71
	100% Yolk Absorption	0.14	2.61

Table 4.4-1. Geomorphic feature definitions for the Lower Susitna River based on the 2012 Geomorphology Mapping Study.

Geomorphic Feature Type	Definition
Main Channel (MC)	The channels that normally convey stream flow throughout the entire year. They are visually recognizable by their turbid, glacial water and high velocities. In general, they convey more than 10 percent (approximate) of the total flow passing a given location.
Side Channel Complex (SCC)	Areas within the mainstem that contain multiple side channels separated by vegetated islands. The islands are typically several to many channel lengths long. The side channels are typically not separated by gravel bars, though gravel bars may occur within the side channels. Side channels within the side channel complexes convey turbid water.
Bar Island Complex (BIC)	These are areas where there are multiple channels in braided patterns. Both gravel bars (exposed substrate) and vegetated island may occur within these complexes. Vegetated islands form a relativity small percentage of the total area of the complex (in contrast to side channel complexes). The channel braids within the bar island complex convey turbid water.
Vegetated Island (VI)	These are single, discrete, large vegetated islands with mature trees. If a vegetated island type area is broken by numerous channels crossing it, then it should be defined as a Side Channel Complex rather than a vegetated island. Vegetated islands are delineated within the side channel complexes, bar island complex as well as the main channel by the classifications sub-bulleted below: o Main Channel (VI MC) – Vegetated islands within the main channel. o Side Channel Complex (VI SCC) - Vegetated islands within a SCC o Bar Island Complex (VI BIC) – Vegetated islands within a BIC
Bar/Attached Bar (BAB)	This is an exposed subtract feature that only appears as the channels become more defined downstream of Susitna Station (RM 28) and in the lower Talkeetna. These are bars that are attached to the banks of the mains channel(s). They are typically single discrete point bars or alternate bars and are not dissected by numerous channel threads. In some case, chute channels may dissect a BAB.
Side Channel (SC)	These are channel features that occur outside the main channel limits. They are single channels as opposed to the multiple and often interlaced/braided channels of the side channel complexes that occur within the mainstem. They are characterized by turbid, glacial water. Velocities often appear lower than in main channel. In general, they convey less than 10 percent (approximate) of the total flow passing a given location. When the upstream berms of side channels are dewatered and the channels contain clear water, they are classified as side sloughs.
Side Slough (SS)	They are single discrete channels that contain clear water. These are off-channel features that typically occur outside the main channel. Small tributaries, upwelling groundwater, and local surface runoff are the primary sources of clear water for these areas. Side sloughs do not have mature trees in their upper thalwegs and are overtopped during periods of moderate to high mainstem discharge. When these areas are overtopped, they convey turbid water and are then classified as side channels.
Upland Slough (US)	These are off-channel features that typically occur outside the mainstem channel area. They contain clear water and depend on small streams, upwelling, and local surface runoff for their water supply. Upland sloughs possess mature trees in their upstream thalwegs and are rarely overtopped by mainstem discharge.
Tributary (TR)	This is the portion of a tributary channel flowing across the floodplain. These are typically clear water except in the case of the large channels such as the Yentna, Talkeetna and Chulitna rivers, which were not included as tributaries, but delineated for several miles upstream of their confluence with the Susitna using the range of geomorphic features.
Tributary Delta (TD)	This feature is a deposit of sediment from the tributary as it meets the mainstem channel area. This would typically be a fan shaped area and the tributary may branch out into several channels across the delta/fan. Tributary fans were delineated as they enter areas from the apex (upstream end of the fan) downstream to its limits with the mainstem channel area.
Additional Open Water (AOW)	This feature represents standing water areas that are not channels, side channels or sloughs.

Table 5.1-1. Amount of clove oil solution needed for various strength and size anesthetic baths.

Bath (gallons)	Bath (Liters)	Light 30 mg/L	Expected 50 mg/L	Maximum 100 mg/L
1 gallon	3.8 liters	1 ml	2 ml	4 ml
5 gallons	18.9 liters	5.5 ml	9.5 ml	19 ml
8 gallons	30.3 liters	9 ml	15 ml	30.5 ml
10 gallons	37.9 liters	11 ml	19 ml	38 ml
15 gallons	56.8 liters	17 ml	28.5 ml	57 ml
20 gallons	75.7 liters	23 ml	38 ml	76 ml

Table 5.2-1 GRTS Based Sampling Target by Tributary.

Tributary	Susitna River Historic River Mile	Percent by length	Chinook salmon presence documented
Oshetna River	233.4	25	yes
Black River	NA	25	no
Goose Creek	231.3	25	yes
Kosina Creek	206.8	25	yes
Tsisi Creek	NA	25	no
Unnamed Tributary	203.7	15	no
Unnamed Tributary	201.8	15	no
Unnamed Tributary	194.9	15	no
Watana Creek	194.1	25	yes
Watana Creek Tributary	NA	NA	no
Unnamed Tributary	192	15	no

Table 5.1-2. Tributaries selected for fish distribution and abundance sampling upstream of Devils Canyon.

Tributary	Susitna River Mainstem HRM	Listed in AWC Catalog	Stream Access-ibility	Average Wetted Width[1] (m)	Drainage Basin Area (km²)	Average Channel Width[2] (m)	GRTS Sampling Unit Size (m)
Oshetna River	233.4	yes	yes	17	1424.5	34	800
Black River	NA	no	yes	14	NA	NA	400
Goose Creek	231.3	yes	yes	10	269.1	12	200
Jay Creek	2085	no	no	8	160.1	14	DIR
Kosina Creek	206.8	yes	partial	33	1036.5	45	800
Tsisi Creek	NA	no	yes	58	NA	NA	400
Unnamed Tributary	203.7	no	unknown	NA	<80.3	NA	200
Unnamed Tributary	201.8	no	unknown	NA	<80.3	NA	200
Unnamed Tributary	194.9	no	unknown	NA	<80.3	NA	200
Watana Creek	194.1	yes	partial	11	452.7	16	400
Watana Creek Tributary	NA	no	yes	NA	NA	13	200
Unnamed Tributary	192	no	unknown	NA	321.2	NA	400
Deadman Creek	186.7	no	no	32	453.5	27	DIR
Unnamed Tributary	184	no	no	NA	NA	NA	DIR
Tsusena Creek	181.3	no	no	10	374.3	NA	DIR
Fog Creek	176.7	yes	no	9	381.2	20	DIR
Fog Creek Tributary	NA	no	no	NA	NA	NA	DIR
Devil Creek	161	no	no	22	190.6	11	DIR
Chinook Creek	157	yes	no	9	58.3	8	DIR
Cheechako Creek	152.4	yes	no	12	94.3	8	DIR

Notes:
1 Data taken from HDR (unpublished 2012 data).
2 Data taken from Saunter and Stratton (1983).
NA = data not available or applicable, DIR = tributary selected for direct sampling

Table5.3-2. Habitat types and number of sites proposed for relative abundance sampling for Focus Area sites in Middle River Geomorphic Reach 6.

Habitat Type	Meso Habitat	Combined Focus Areas	Non-Focus Areas	
			Distribution	Abundance
Main Channel		3	3	1
Split Main Channel			3	1
Braided Main Channel		3	3	1
Side Channel		3	3	1
Upland Slough	Beaver Complex	3		
Upland Slough	No Beaver	3	3	1
Side Slough	Beaver Complex	3		
Side Slough	No Beaver	3	3	1
Backwater		1	3	1
Tributary		3	3	1
Tributary Mouth		2	3	1
Clear Water Plume		1	3	1
Subtotal		28	30	10

Table 5.5-1. Focus areas where studies directed at early life history and movements will take place.

Focus Area	Geomorphic Reach	Tributary Mouth	Side Slough	Spawning	Rearing
104-Whiskers Slough	MR-8	X	X	X	X
128- Slough 8A/Skull Creek Complex	MR-6	X	X	X	X
138-Slough 11/Gold Creek	MR-6	X	X	X	X
141- Indian River	MR-6	X	X	X	X
144- Slough 21	MR-6	X	X	X	X

Table 5.6-1. Site characteristics used to determine proposed locations for PIT-Tag interrogation systems, outmigrant traps, and stationary radio-telemetry receivers.

Location	RM; Geo Reach	Focus Area	Habitat Types Present	Spawning	Rearing	RT Station	PIT Array	Trapping	Rational for Selection/Exclusion
Upper River (RM 184-233)									
Oshetna River at confluence	RM 233.4; UR-2		Tributary mouth	Unknown		X-proposed	X	X	Juvenile Chinook salmon documented (Buckwalter 2011); Agencies have expressed interest in Oshetna. Co-locating RT, PIT & Trapping in Upper River aids logistics. Variety of resident species in the drainage (Buckwalter 2011).
Kosina Creek (Upper) at Tsisi Creek confluence			Tributary	Chinook			X	X	Adult and juvenile Chinook salmon documented (ADF&G 1984a; Buckwalter 2011; HDR 2012); Upper Kosina has Chinook production, and the lower Kosina is likely not feasible to fish Co-locating PIT & Trapping efforts in Upper River aids logistics.
Kosina Creek at confluence	RM 206.8; UR-4		Tributary mouth	Chinook		X-existing			Adult and juvenile Chinook salmon documented (ADF&G 1984a;Buckwalter 2011; HDR 2012)
Watana Creek at confluence	RM 194.1; UR-6		Tributary mouth	Unknown		X-proposed			Upstream of proposed dam site (10 miles) potential for project impact/inundation. Adult salmon migration check point RT. Watana as a good resident fish stream and also a good interim point on the Su for adult salmon. Will be covered by adult escapement aerial surveys. Prone to mudslides. Upstream "bracket" for potential dam site.
Middle River (RM 98.5-184)									
Susitna River at Watana Dam Site	RM 184; MR-1	X-184	Main, split main, side channel			X-proposed			To document fish movements past the proposed dam site. Focus Area-184 length comprises 50% of MR-1 reach length (2 miles long) and contains split main channel and side channel habitat present in this reach. Adult salmon migration check point for RT.
Fog Creek at confluence	RM 176.7; MR-2		Tributary mouth	Chinook		X-proposed			Adult and juvenile Chinook salmon documented (ADF&G 1984a;Buckwalter 2011; HDR 2012); Resident rainbow trout present; good location to monitoring fish moving between Upper and Middle River. Downstream detection site for the proposed dam site. Adult salmon migration check point for RT.
Devils Creek Station	RM 161; MR-4		Tributary			X-existing			Adult Chinook salmon documented (ADF&G 1984a; HDR 2012)
Chinook Creek Station	RM 157; MR-4		Tributary mouth	Chinook		X-existing			Adult Chinook salmon documented (ADF&G 1984a; HDR 2012)

Location	RM; Geo Reach	Focus Area	Habitat Types Present	Spawning	Rearing	RT Station	PIT Array	Trapping	Rational for Selection/Exclusion
Cheechako Creek Station	RM 152.4; MR-4		Tributary	Chinook		X-existing			Adult and juvenile Chinook salmon documented (ADF&G 1984a; HDR 2012)
Portage Creek at RM 1			Tributary	Chinook		X-proposed			Chinook spawning tributary (ADF&G 1984a); good resident fish stream
Portage Creek at confluence	RM 148.8; MR-5	X-151	Main channel, trib mouth	Chinook	X	X-existing			Mouth of Chinook spawning tributary (ADF&G 1984a), Focus Area-151 is a single main channel and thus representative of the confined Reach MR-5. Portage Creek is a primary tributary of the Middle Segment and the confluence supports high fish use.
Susitna River at Slough 21	RM 141.1; MR-6	X-144	Main, split main, side channel, trib mouth, side slough, beaver complex	Chum, Pink Sockeye	X	X-existing			Major spawning area for Middle River (ADF&G 1984b), Focus Area-144 contains a wide range of main channel and off-channel habitats, which are common features of Reach MR-6. Side Channel 21 is a primary salmon spawning area. Reach MR-6 is 26 miles long (30% of Middle Segment length) and is characterized by a wide floodplain and complex channel morphology with frequent channel splits and side channels
Indian River at RM 1			Tributary	Chinook		X-proposed	X	X	Chinook, coho, and chum spawning tributary (ADF&G 1984a). Chinook spawning tributary (HDR 2012); good resident fish stream; PIT array near two FAs allows for more fish tagging effort. Co-locating efforts aids logistics.
Indian River at confluence	RM 138.6; MR-6	X-141	Main, split main, side channel, trib mouth, upland slough, beaver complex	Chinook	X	X-existing			Mouth of Chinook spawning tributary (HDR 2012). Focus Area-141 includes the Indian River confluence, which is a primary Middle Susitna River tributary, and a range of main channel and off-channel habitats. Channel and habitat types present in Focus Area-141 are typical of complex Reach MR-6. High fish use of the Indian River mouth has been documented and DIHAB modeling was performed in main channel areas.

Location	RM; Geo Reach	Focus Area	Habitat Types Present	Spawning	Rearing	RT Station	PIT Array	Trapping	Rational for Selection/Exclusion
Susitna River at Slough 11/Gold Creek	RM 135.3; MR-6	X-138	Main, split main, side channel, trib mouth, side slough, upland slough, beaver complex	Sockeye, Chum, Pink	X				PIT array within FA allows for more fish tagging effort. Perhaps we should consider a location for an array elsewhere in this FA rather than the lower end of the slough. Possibilities could include Upper Side Channel 11, and a side channel adjacent to the downstream end of Side Slough 11. According to Quane et al 1984, the upper berm at Upper Side Channel 11 breaches at about 13,000 cfs and a backwater on the order of 400 ft long is present at the downstream end of the channel at a discharge of 11,400 cfs. Focus Area-138 primary feature is a complex of side channel, side slough and upland slough habitats, each of which support high adult and juvenile fish use. Complex channel structure of Focus Area-138 is characteristic of Reach MR-6. IFG modeling was performed in side channel habitats.
Fourth of July Creek at confluence	RM 131.1; MR-6		Tributary mouth	Yes		X-proposed			Abundance of rainbow trout observed in 2012 (LGL field observations). In the 1982 sampling substantially more rainbows were captured near the mouth of 4th of July Creek than Slough 11
Susitna River at Slough 8A/Skull Creek	RM 125.1; MR-6	X-128	Main, split main, side channel, trib mouth, side slough	Chum, Sockeye, Pink	X		X		Focus Area-128 consists of side channel, side slough and tributary confluence habitat features that are characteristic of the braided MR-6 reach. Side channel and side slough habitats support high juvenile and adult fish use and habitat modeling was completed in side channel and side slough habitats. No RT station as it is easily surveyed by aerial flights.
Susitna River at Gateway	RM 123.7; MR-6		Main channel Middle River			X-existing			
Susitna River at Curry	RM 120; MR-6		Main channel Middle River					X	Mainstem site. Good hydraulic conditions for trap operation. Site of escapement fishwheel and logistically feasible.

Location	RM; Geo Reach	Focus Area	Habitat Types Present	Spawning	Rearing	RT Station	PIT Array	Trapping	Rational for Selection/Exclusion
Susitna River at Lane Creek/Slough 6A	RM 113; MR-7	X-115	Main, split main, side channel, trib mouth, upland slough, beaver complex		X	X-existing			Focus Area-115 contains side channel and upland slough habitats that are representative of MR- 7. Reach MR-7 is a narrow reach with few braided channel habitats. Upland Slough 6A is a primary habitat for juvenile fish and habitat modeling was done in side channel and upland slough areas.
Susitna River at Talkeetna Station	RM 103; MR-8		Main channel Middle River					X	Sampled using fixed incline plane traps and fishwheels in 1980s. Check on trap location with Christopher Estes or Dana Schmidt. Roth et al. 1986 did a comparison of the two traps at Talkeetna Station. They concluded that Trap 2, on the west bank of the river, had significantly higher catch rates than Trap 1 for the majority of fishing days for all species by age class except age 0+ coho. They also correlated catch rates with water velocity at the traps and found the traps were not selective for 0+ age outmigrants, but concluded that some older fish could avoid the traps. Close to Whiskers focus area.
Susitna River at Whiskers Creek/Slough	RM 101; MR-8	X-104	Main, split main, side channel, trib mouth, side slough, upland slough	Pink	X	X-proposed	X		PIT array within FA allows for more fish tagging effort. 2012-13 Winter Studies Area, Chum spawning tributary (ADF&G 1984b), Focus Area-104 contains diverse range of habitat, which is characteristic of the braided, unconfined Reach MR-8. Focus Area-104 habitats support juvenile and adult fish use and a range of habitat modeling methods were used in side channel and side slough areas.
Lower River (RM 61-98.5)									
Montana Creek at confluence	RM 77; LR-2		Tributary mouth	Yes		X-resident	X	X	Best salmon and resident fish producing stream in Lower River within study area. Co-locating efforts aids logistics.
Totals		**10**				**18**	**6**	**6**	

Table 5.6-2. Target species and minimum sizes for PIT tagging.

Target Species	Minimum Taggable Size (g/FL or TL) with 12mm/0.1g Tag	Minimum Taggable Size (g/FL or TL) with 23mm/0.6g Tag	Potential Interrogation Sites where species may be found[a]
Juvenile Chinook salmon	4g/60mm FL	24g/100mm FL	1-6
Juvenile coho salmon	4g/60mm FL	24g/100mm FL	1,2,3,4
Juvenile sockeye salmon	4g/60mm FL	24g/100mm FL	1,2,3,4
Juvenile chum salmon	n/a	n/a	Taggable size not likely in study area
Juvenile pink salmon	n/a	n/a	Taggable size not likely in study area
Rainbow trout	4g/70mm FL	24g/ 120 mm FL	1,2,3,4
Humpback whitefish	4g/70mm FL	24g/120 FL	1-6
Round whitefish	4g/70mm FL	24g/120mm FL	1-6
Burbot	4g/ 100mm TL	24g/165mmTL	1-6
Northern Pike	4g/70mm	24g/120mm	1,2,3,4
Artic grayling	4g/ 70mm FL	24g/120mm FL	1-6
Dolly Varden	4g/70mm FL	24g/120mm FL	1-6
Artic lamprey	5g/150 mm TL	24g/	1,2,3

Notes:

[a]: 1=Montana Creek at confluence, 2=Whiskers Creek/Slough, 3=Slough 8A, 4=Indian River at RM1, 5=Kosina Creek at Tsisi Creek confluence, 6=Oshetna River at confluence

Table 5.8-1. Length and weight of fish species to be radio-tagged and respective target radio-tag weights.

Species	Known Distribution [a]	Target number for tagging	All sizes		Most likely to be caught			Tag Weight of Min (3%)	Tag Weight of Max (3%)	Fish length (mm) @ 200 g weight
			Length (mm)	Weight (g)	Fish Length (mm)	Est. Weight Min (g)	Est. Weight Max (g)			
Arctic grayling	Low, Mid, Up	30 Mid/Low + 30 Up	36–444	<1–830	120–420	18	705	0.5	21.2	270
Dolly Varden	Low, Mid, Up	30 Mid/Low + 30 Up	30–470	<1–1,007	130–300	20	256	0.6	7.7	277
Round whitefish	Low, Mid, Up	30 Mid/Low + 30 Up	23–469	<1–1,035	150–390	23	553	0.7	16.6	287
Rainbow trout	Low, Mid,	30 Mid/Low	27–612	<1–3,327	180–480	96	1635	2.9	49.1	232
Humpback whitefish	Low, Mid, Up	30 Mid/Low + 30 Up	30–510	<1–1,544	210–450	180	1141	5.4	34.2	219
Burbot	Low, Mid, Up	30 Mid/Low + 30 Up	26–791	<1–3,532	300–510	186	931	5.6	27.9	307
Northern pike	Low, Mid	30 Mid/Low	83–713	5–2707	200-700	62	2700	1.9	81.0	296
Lake Trout	Up	30 Up	NA	NA	NA	NA	NA	TBD	TBD	TDB
Longnose Sucker	Low, Mid, Up	30 Mid/Low + 30 Up	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

a Low = Lower River, Mid = Middle River, Up = Upper River, U = Unknown: NA indicates data not available at time of draft plan.

Table 5.8-2. ATS radio tag specifications and minimum tagging weight.

Tag Model	Weight (g)	Diameter (mm)	Length (mm)	Tag Life (days)		Minimum Tagging Weight (grams)
				Slow Pulse	Fast Pulse	
1810C	6	12	30	180	79	200
1815C	7	12	36	450	199	233
1820C	8	12	43	652	288	267
1830C	11	12	54	901	387	367

Table 5.8-3. Expected antenna orientation for each fixed radiotelemetry station.

Station	Status	Antenna Orientation			Rational
		Antenna 1	Antenna 2	Antenna 3	
Oshetna River	Proposed	Down Susitna River	Up Susitna River	Up Oshetna River	Large accessible tributary within impoundment zone
Kosina Creek	Proposed	Down Susitna River	Up Susitna River	Up Kosina Creek	Salmon spawning stream
Watana Creek	Proposed	Down Susitna River	Up Susitna River	Up Watana Creek	Large accessible tributary within impoundment zone
Dam Site	Proposed	Down Susitna River	Up Susitna River		Monitor fish moving past the proposed dam site
Fog Creek	Proposed	Down Susitna River	Up Susitna River	Up Fog Creek	Large accessible salmon spawning tributary with lake access
Devil	Proposed	Down Susitna River	Up Susitna River		Monitor site for fish passing above Impediment 3
Chinook Creek	Proposed	Down Susitna River	Up Susitna River		Monitor site for fish passing above Impediment 2
Cheechako Creek	Proposed	Down Susitna River	Up Susitna River		Monitor site for fish passing above Impediment 1
Portage Creek	Proposed	Down Susitna River	Up Susitna River		Salmon spawning stream
Upper Portage Creek	Proposed	Down Portage Creek	Up Portage Creek		Salmon spawning stream; Accurate records of fish moving into tributary
Slough 21	Proposed	Down Slough 21	Up Slough 21		Salmon spawning area
Indian River	Proposed	Down Susitna River	Up Susitna River		Salmon spawning stream
Upper Indian River	Proposed	Down Indian River	Up Indian River		Salmon spawning stream; Accurate records of fish moving into tributary
4th of July Creek	Proposed	Down Susitna River	Up Susitna River	Up 4th of July Creek	Between Gateway and Indian. Rainbow trout stream.
Gateway	Proposed	Down Susitna River	Up Susitna River		Monitor for Curry tagged fish moving upstream
Lane Creek	Proposed	Down Susitna River	Up Susitna River		Monitor for Curry tagged fish moving downstream; Monitor for Lower River tagged fish moving into Middle River
Whiskers Creek	Proposed	Down Susitna River	Up Susitna River	Up Whiskers Creek	Salmon spawning stream; Possible burbot holding area
Montana Creek	Proposed	Down Montana Creek	Up Montana Creek		Salmon spawning stream

Table 5.9-1. Susitna-Watana studies and objectives related to fish tissue sample collection in association with the 2013 and 2014 Upper, Middle, and Lower Susitna River fish distribution and abundance surveys

Study	Objective(s)
Baseline Water Quality Study (RSP Section 5.5)	4. Measure baseline metals concentrations in sediment and fish tissue for comparison to state criteria.
Mercury Assessment and Potential for Bioaccumulation Study (RSP Section 5.7)	2. Characterize the baseline mercury concentrations of the Susitna River and tributaries. This will include collection and analyses of vegetation, soil, water, sediment pore water, sediment, piscivorous birds and mammals, and fish tissue samples for mercury.
Study of Fish Distribution and Abundance in the Upper Susitna River (RSP Section 9.5)	5. Determine baseline metal concentrations in fish tissues for resident fish species in the mainstem Susitna River. 7. Collect tissue samples to support the Genetic Baseline Study for Selected Fish Species.
Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (RSP Section 9.6)	7. Collect tissue samples to support the Genetic Baseline Study for Selected Fish Species.
River Productivity Study (RSP Section 9.8)	5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Upper Susitna River.
Genetic Baseline Study for Selected Fish Species (RSP Section 9.14)	1. Develop a repository of genetic samples for fish species captured within the entire Susitna River drainage, with an emphasis on those species found in the Middle and Upper Susitna River. 2. Contribute to the development of genetic baselines for each of the five species of Pacific salmon spawning in the Susitna River drainage. 3. Characterize the genetic structure of Chinook salmon in the Susitna River watershed, including determining the effective population size of fish spawning above Devils Canyon. 4. For 2013 and 2014, quantify the genetic variation among Upper and Middle River Chinook salmon for use in mixed-stock analyses, including analyses of Lower River samples of the entire Susitna Chinook salmon population. 5. If sufficient genetic uniqueness is found, estimate the annual percent of juvenile Chinook salmon in selected Lower River habitats that originated in the Middle and Upper Susitna River in 2013 and 2014.

Table 5.9-2. 2013 and 2014 annual sampling targets for the Genetic Baseline Study for Selected Fish Species[a]

Species	Life Stage	Sample Location	Target Sample Size
Chinook salmon	adult (spawning)	any Susitna River tributary with evidence of Chinook salmon spawning	≥100[b]
		flanking region of the Susitna River (e.g., Knik Arm and northwestern Cook Inlet) with evidence of Chinook salmon spawning	≥100 [b]
chum salmon	adult (spawning)	Susitna River upstream of the Three Rivers Confluence	100
coho salmon	adult (spawning)	Susitna River upstream of the Three Rivers Confluence	100
pink salmon	adult (spawning)	Susitna River upstream of the Three Rivers Confluence	100
sockeye salmon	adult (spawning)	Susitna River upstream of the Three Rivers Confluence	100
Chinook salmon	juvenile	Lower Susitna River[c]	1,600
		Susitna River upstream of the Three Rivers Confluence	200
		Chinook Creek	200
		Oshetna River	200
		Indian River	200
		Portage Creek	200
		Talkeetna River	200
		Chulitna River	200
Alaska blackfish	any	Upper and Middle Susitna River[d]	50
Alaska whitefish	any	Upper and Middle Susitna River[d]	50
Arctic grayling	any	Upper and Middle Susitna River[d]	50
Bering cisco	any	Upper and Middle Susitna River[d]	50
Burbot	any	Upper and Middle Susitna River[d]	50
Coast range sculpin	any	Upper and Middle Susitna River[d]	50
Dolly Varden	any	Upper and Middle Susitna River[d]	50
Eulachon	any	Upper and Middle Susitna River[d]	50
Humpback whitefish	any	Upper and Middle Susitna River[d]	50
Lake trout	any	Upper and Middle Susitna River[d]	50
Lake whitefish	any	Upper and Middle Susitna River[d]	50
Longnose sucker	any	Upper and Middle Susitna River[d]	50

Species	Life Stage	Sample Location	Target Sample Size
Ninespine stickleback	any	Upper and Middle Susitna River[d]	50
Northern pike	any	Upper and Middle Susitna River[d]	50
Pacific lamprey	any	Upper and Middle Susitna River[d]	50
Pacific staghorn sculpin	any	Upper and Middle Susitna River[d]	50
Prickly sculpin	any	Upper and Middle Susitna River[d]	50
Rainbow trout	any	Upper and Middle Susitna River[d]	50
Round whitefish	any	Upper and Middle Susitna River[d]	50
Slimy sculpin	any	Upper and Middle Susitna River[d]	50
Threespine stickleback	any	Upper and Middle Susitna River[d]	50

Notes:
a Adapted from RSP Section 9.14.
b Includes total archived and new samples.
c Includes 16 sample sites representing 5 different main channel habitat types.
d Includes tributaries.

11. FIGURES

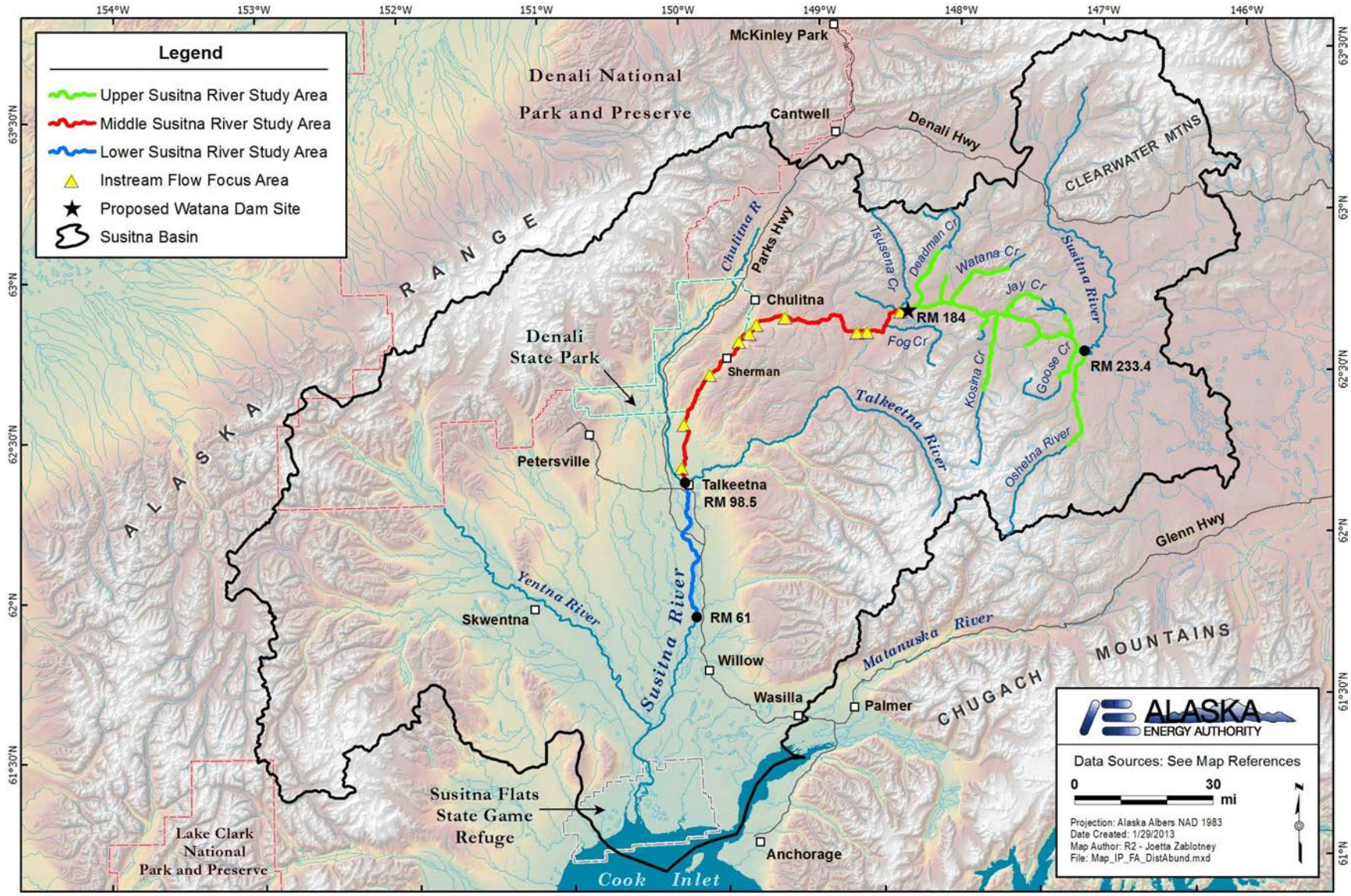

Figure 3-1. Study area for the Fish Distribution and Abundance in the Upper and Middle/Lower Susitna River studies.

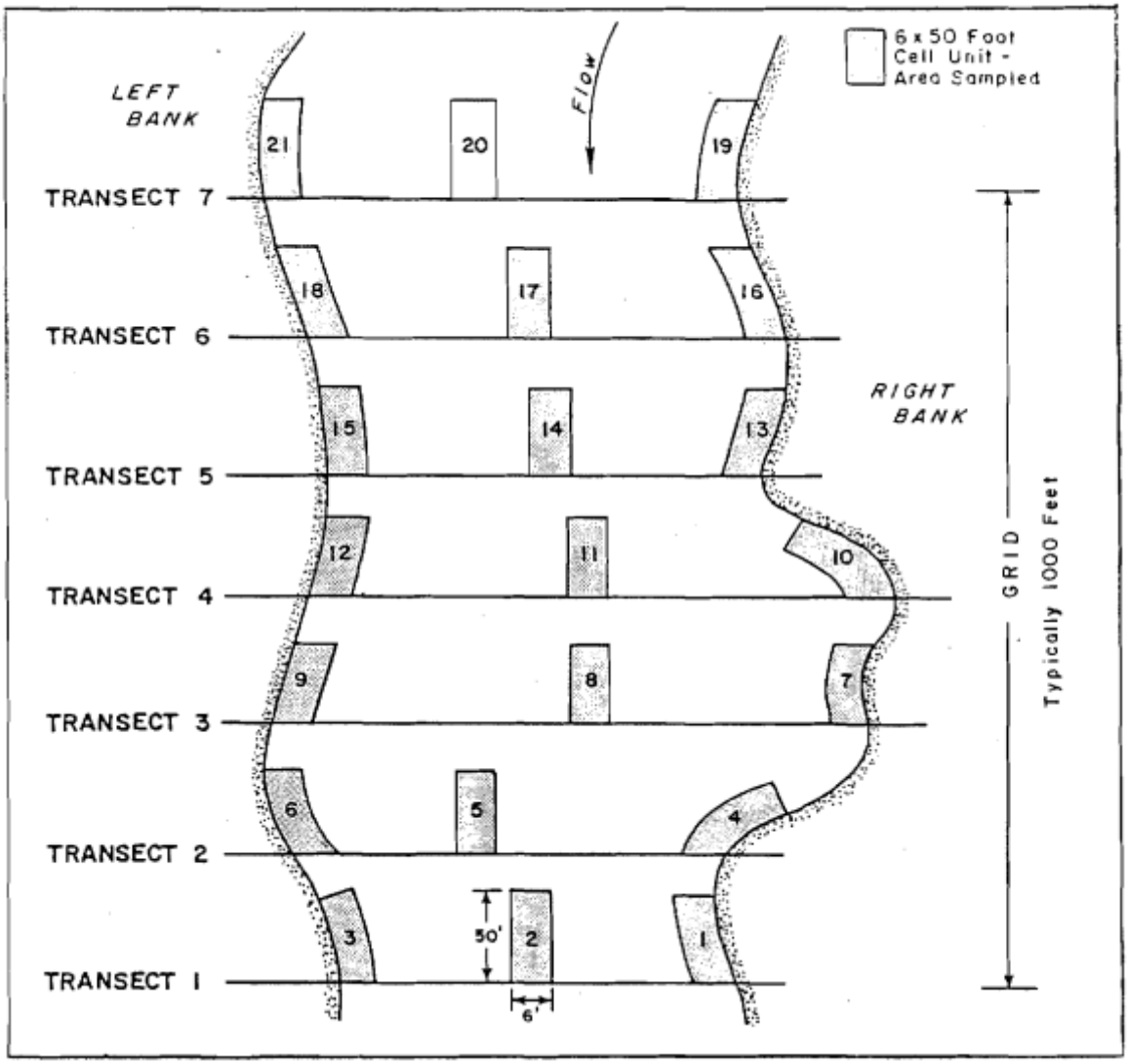

Figure 4.1-1. Arrangement of transects, grids, and cells at a JAHS site. Source: Dugan et al. (1984).

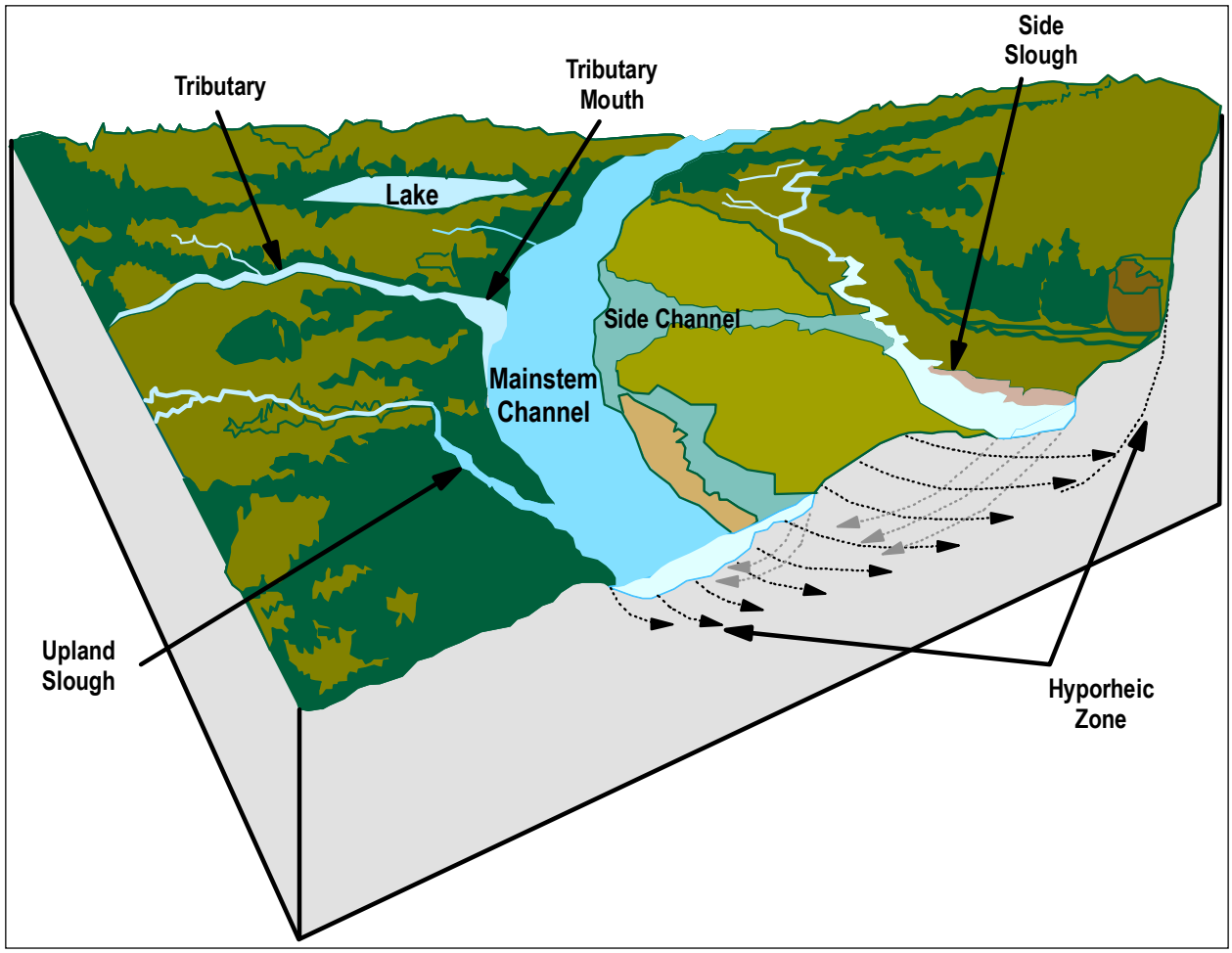

Figure 4.1-2. Habitat types identified in the Middle Susitna River during the 1980s studies (adapted from ADF&G 1983; Trihey 1982).

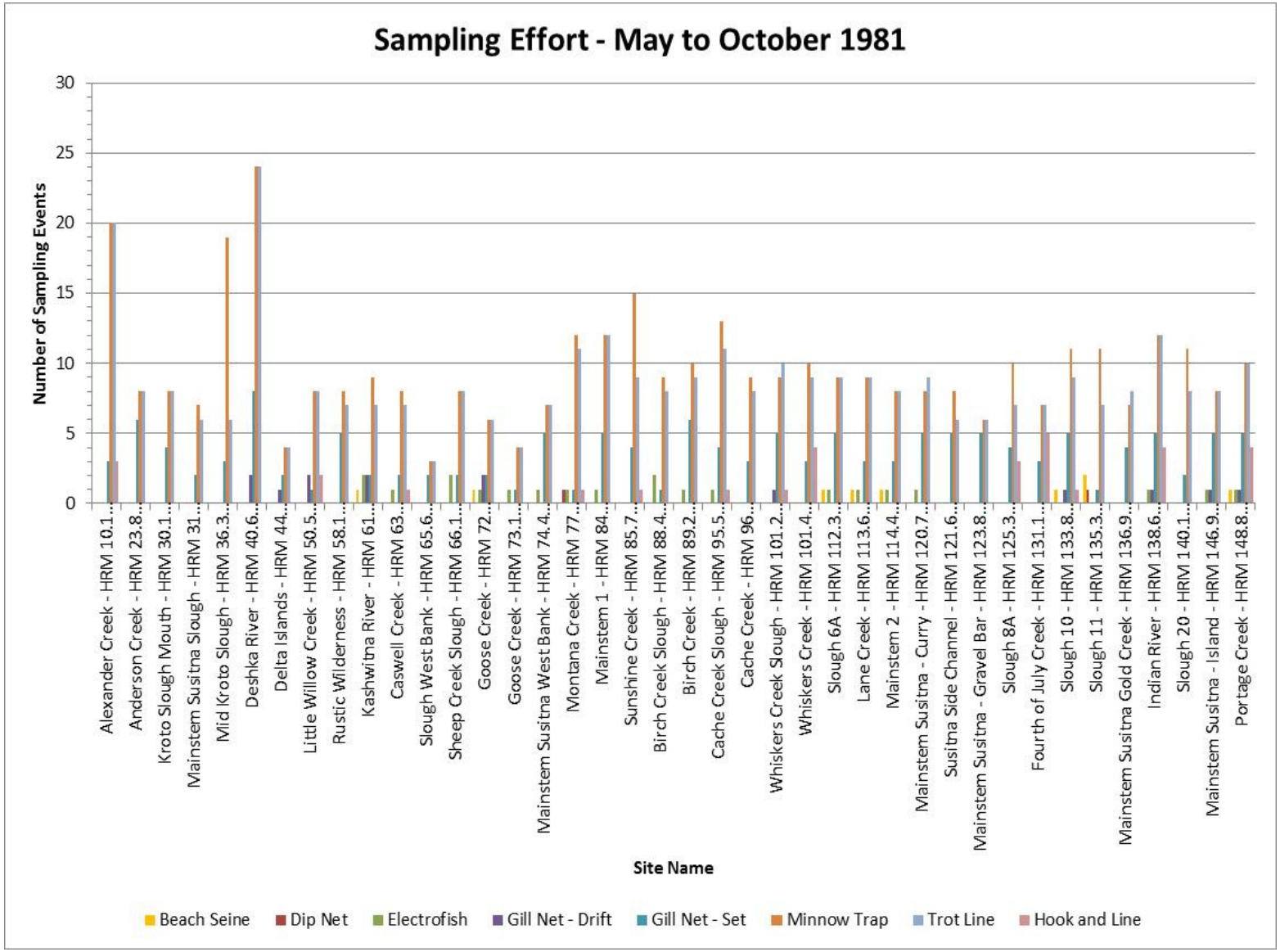

Figure 4.1-3. Sampling effort at 39 habitat location sites (including mainstem, slough, side channel, tributary, and tributary mouth sites) from May to mid-October 1981. Source: Delaney et al. (1981).

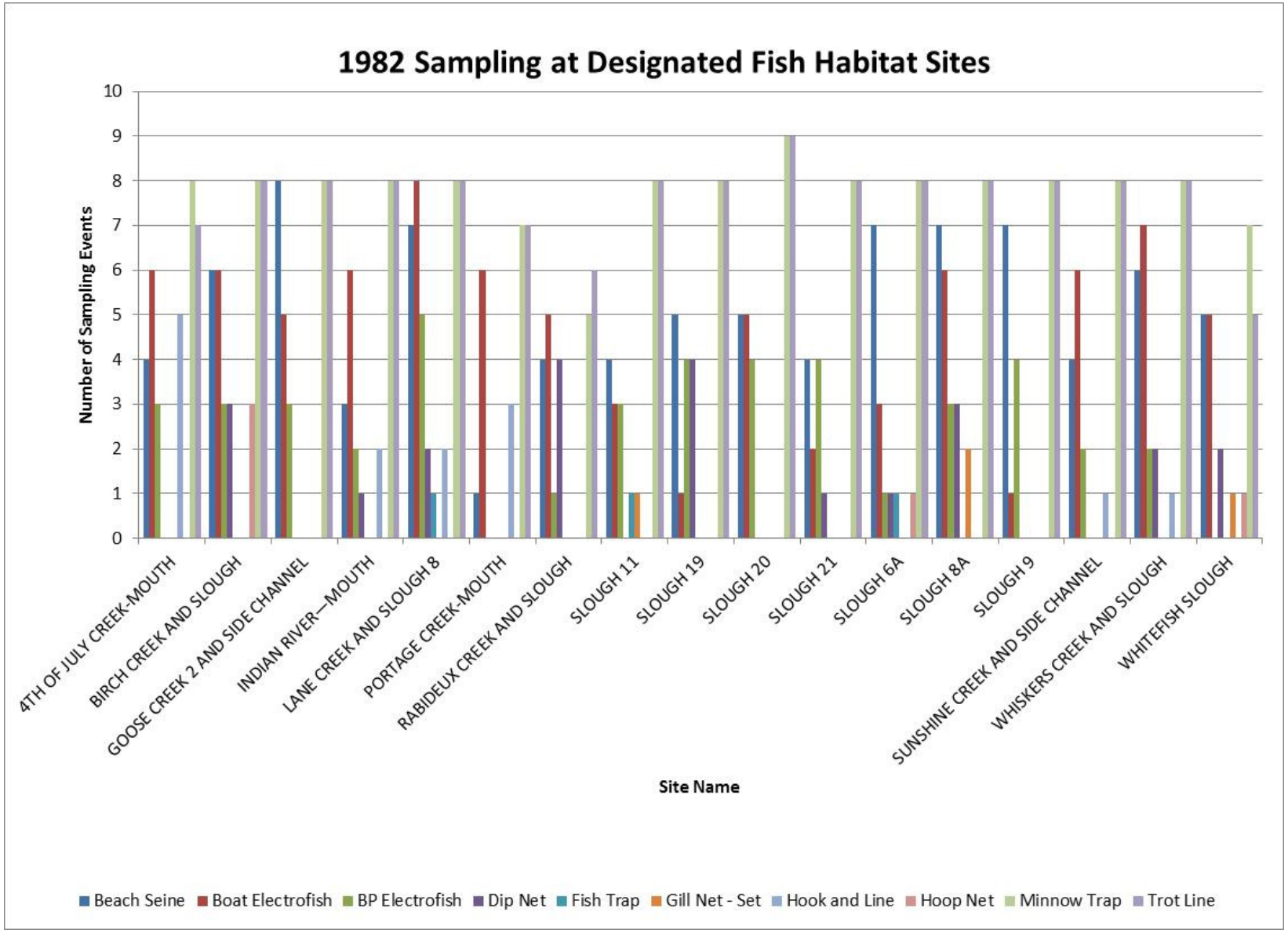

Figure 4.1-4. Sampling effort at 17 DFH sites during the 1982 open water season. Source: Schmidt et al. (1983).

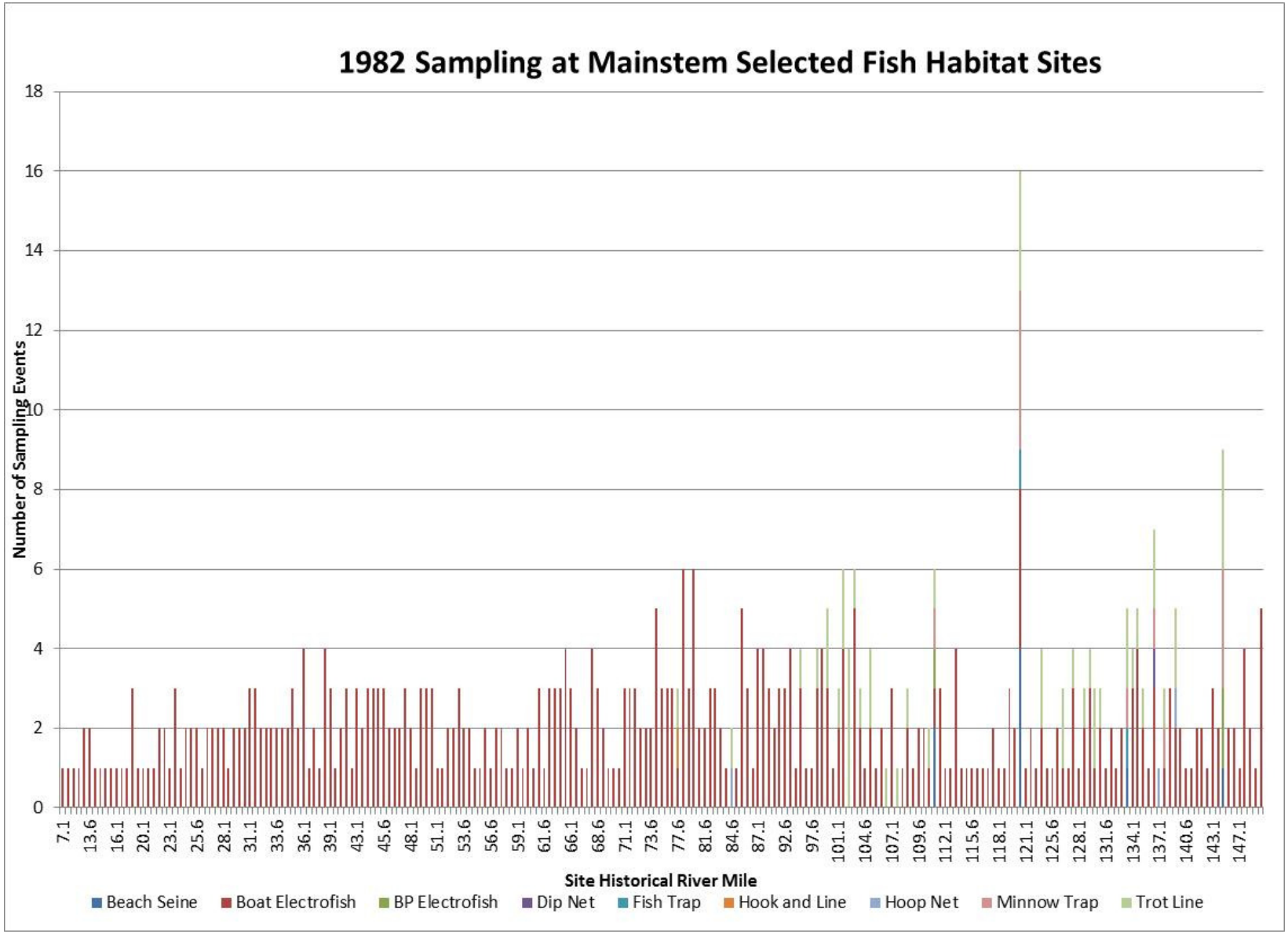

Figure 4.1-5. Sampling effort at 225 mainstem Selected Fish Habitat sites during 1982.

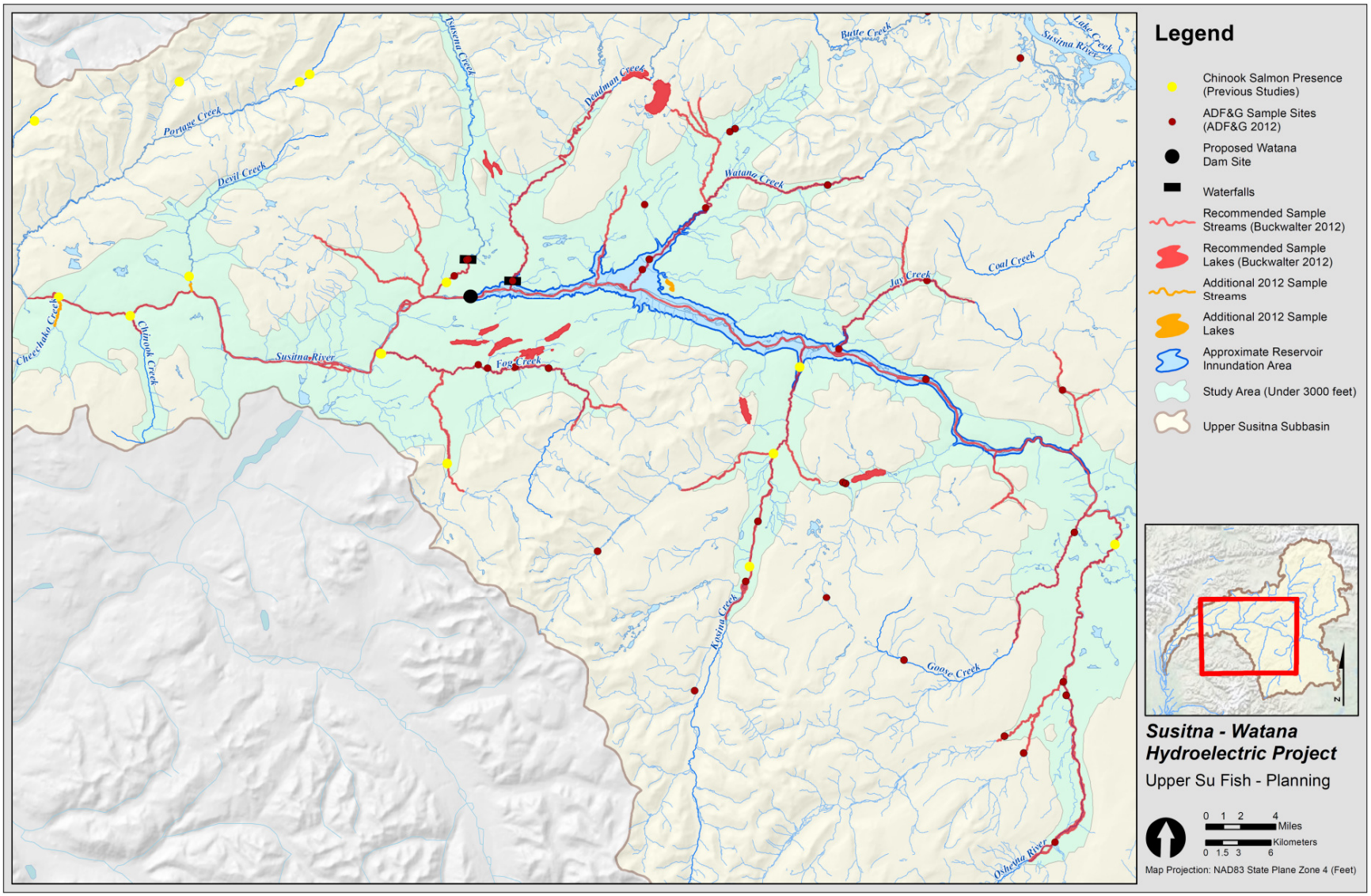

Figure 4.1-6. Study area for the 2012 Upper Susitna River Fish Distribution and Habitat Study.

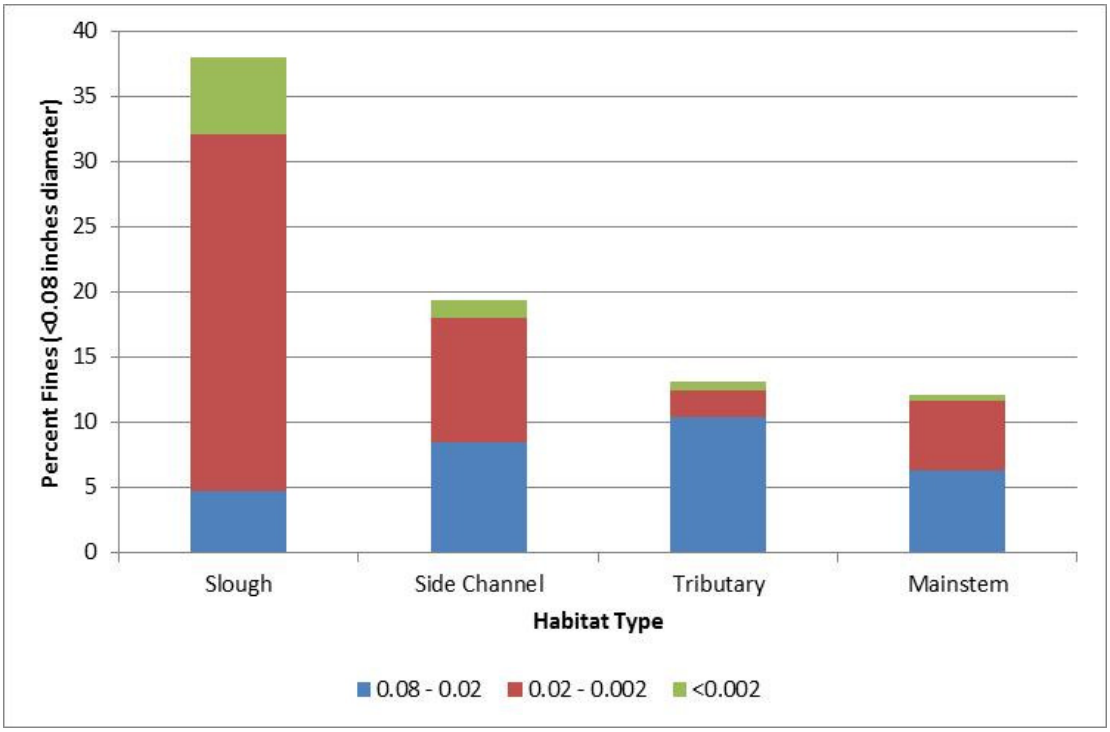

Figure 4.3-1. Percent size composition of fine substrate (<0.08 in. diameter) of McNeil samples collected in various habitat types in the middle Susitna River, Alaska. Source: Vining et al. (1985).

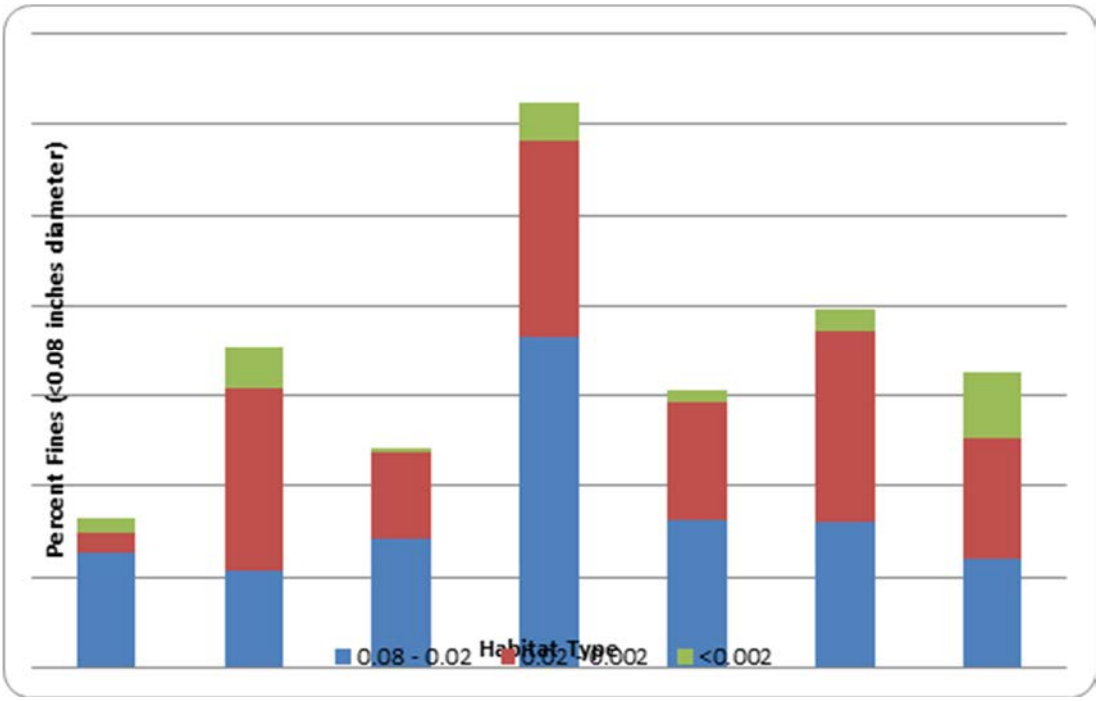

Figure 4.3-2. Percent size composition of fine substrate (<0.08 in. diameter) in McNeil samples collected at chum salmon redds during May 1984 in study sites of middle Susitna River, Alaska. Source Vining et al. (1985).

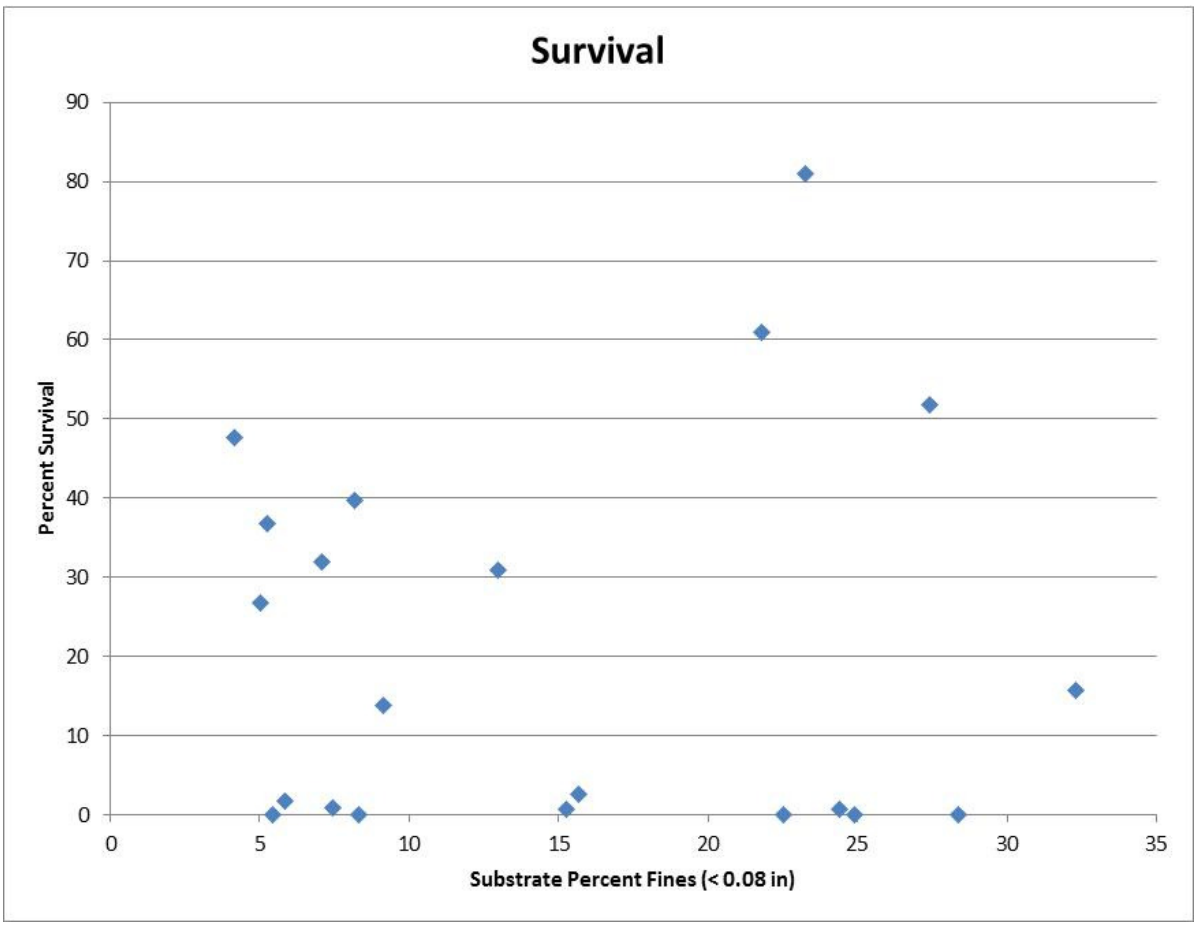

Figure 4.3-3. Relationship between percent survival of salmon embryos and the percent of fine substrate (<0.08 in. diameter) within Whitlock-Vibert Boxes removed from artificial redds within selected habitats of the middle Susitna River, Alaska. Source: Vining et al. (1985).

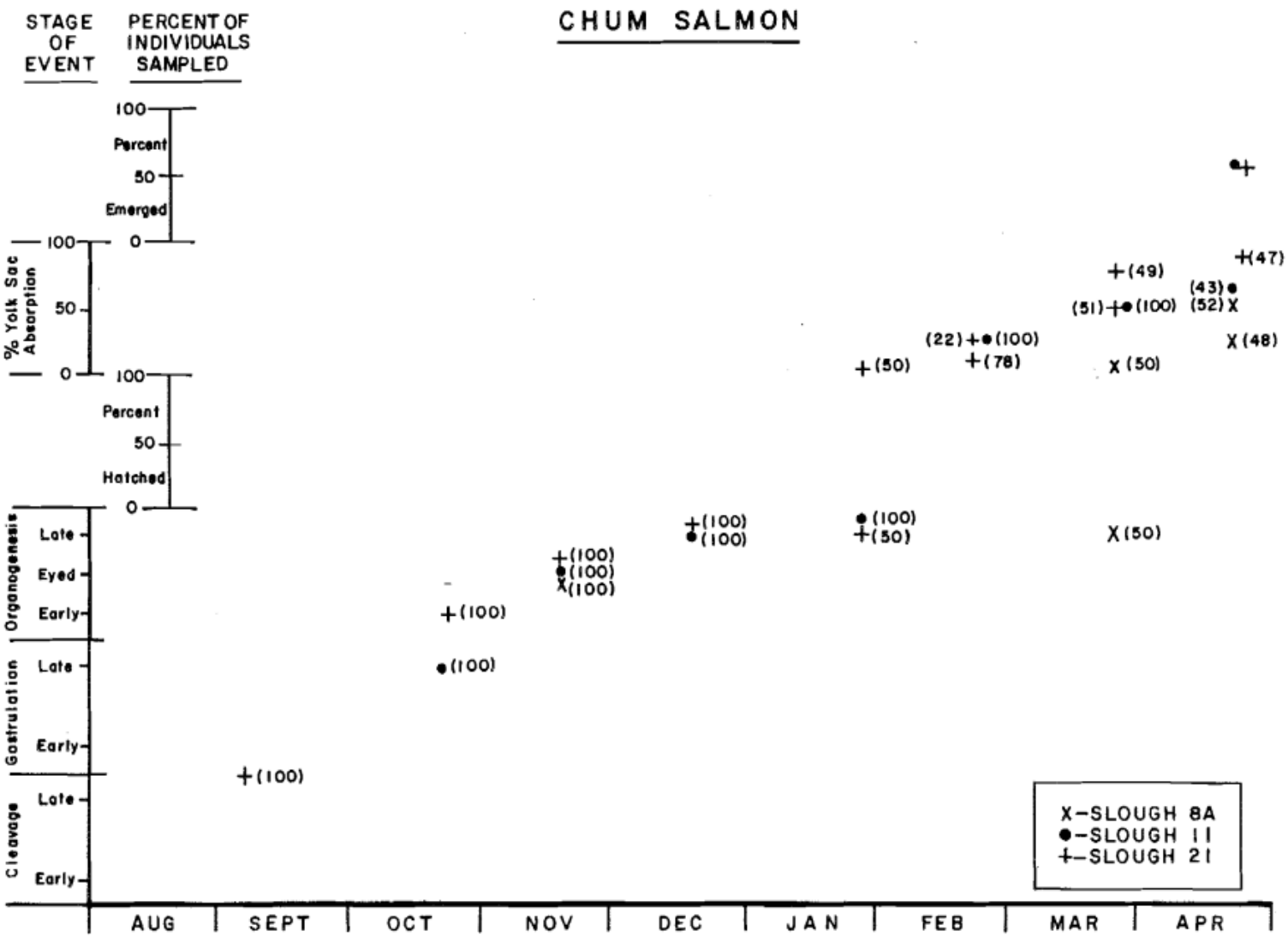

Figure 4.3-4. Embryonic development, hatching, yolk sac absorption, and emergence data for chum salmon at three sloughs, winter, 1982-1983. Numbers in parentheses are the percentages of individuals sampled which were at the indicated stage. Source: Hoffman et al. (1983).

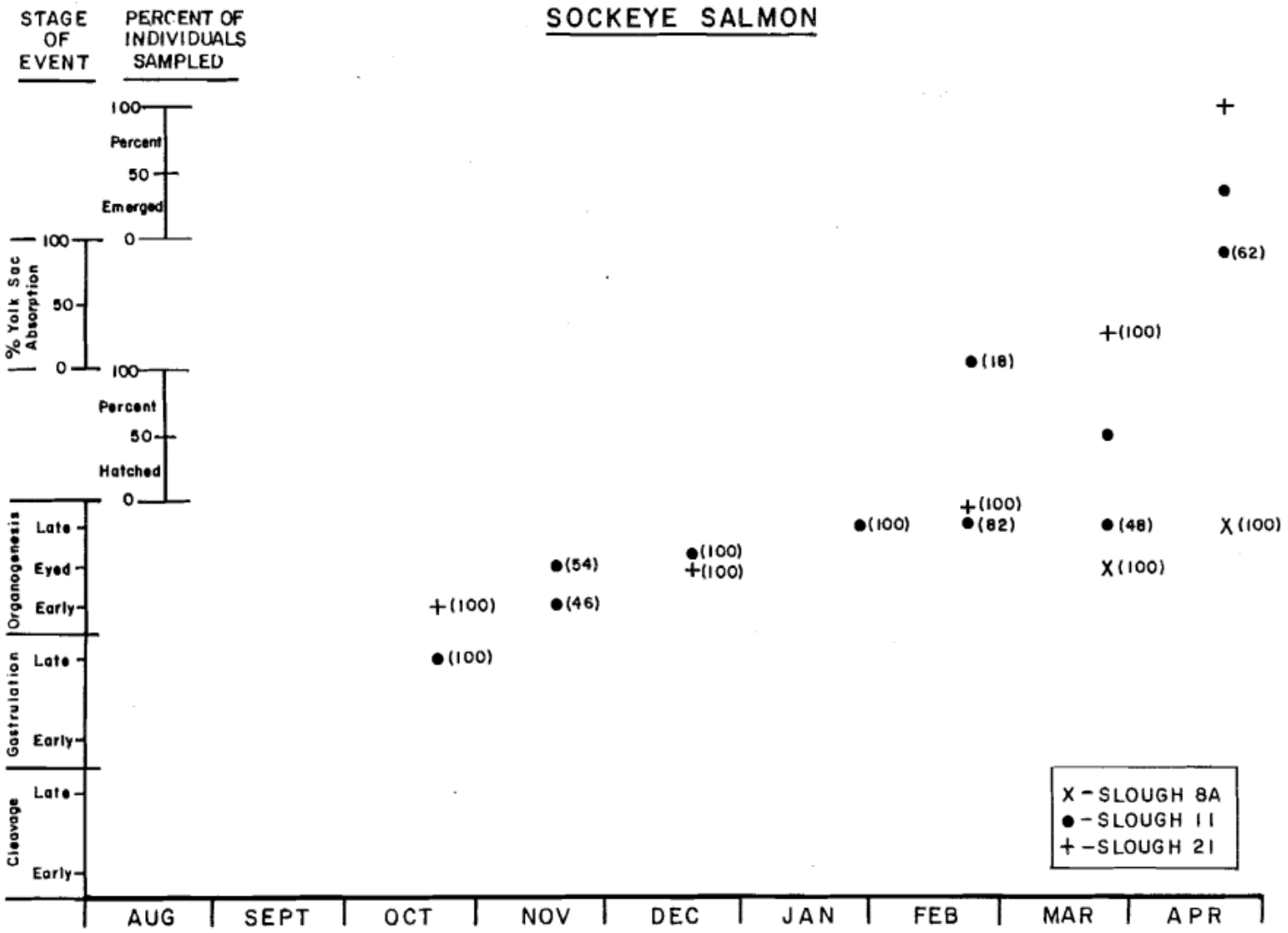

Figure 4.3-5. Embryonic development, hatching, yolk sac absorption, and emergence data for sockeye salmon at three sloughs, winter, 1982-1983. Numbers in parentheses are the percentages of individuals sampled which were at the indicated stage. Source: Hoffman et al. (1983).

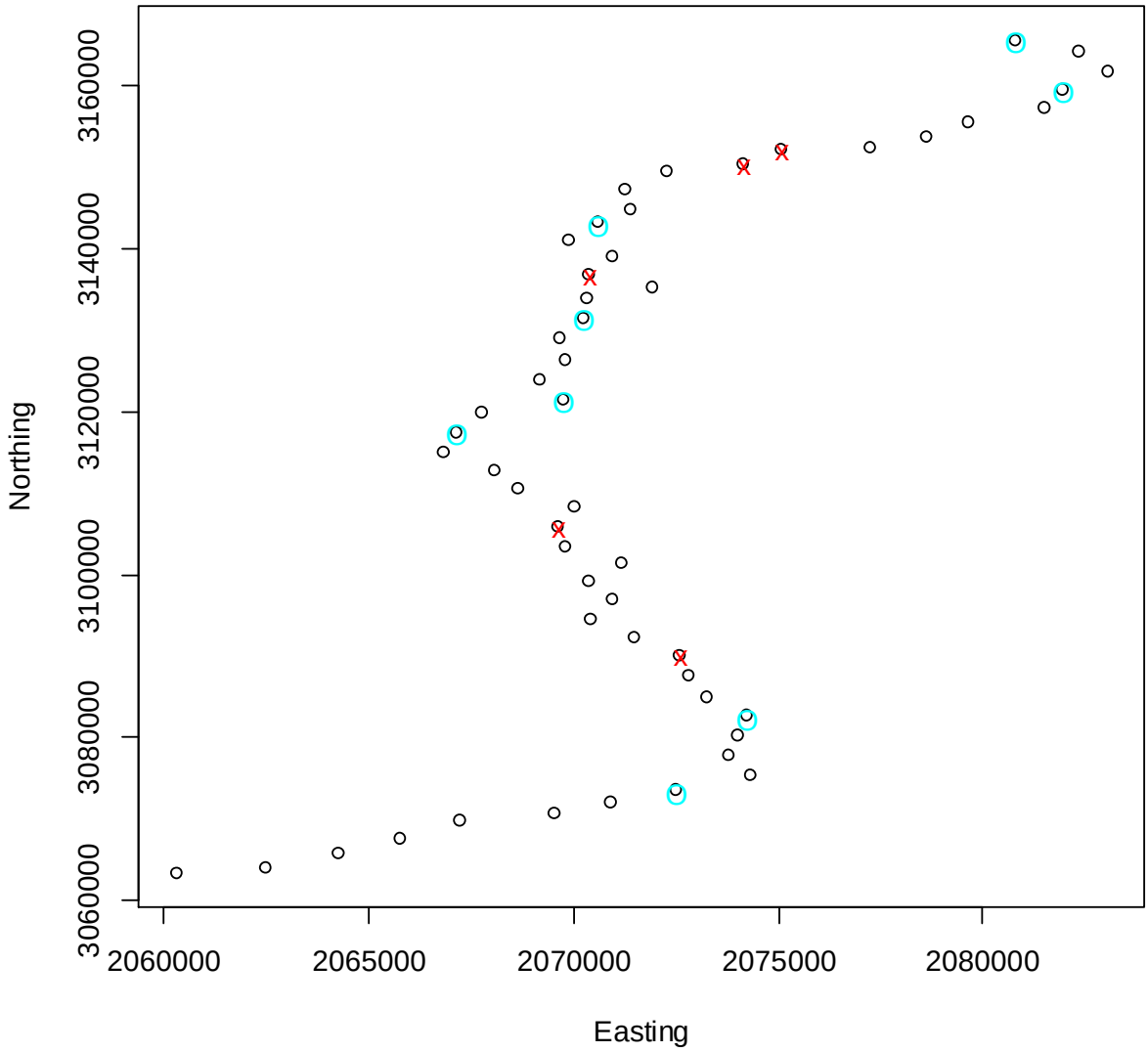

Figure 5.2-1. GRTS sample locations selected for the Oshetna River. Each black circle represents the downstream edge of an 800m sample unit. The red "x" marks indicate a sample unit will be sampled for abundance and distribution. The larger blue circles indicate a sample unit will be sampled for distribution only.

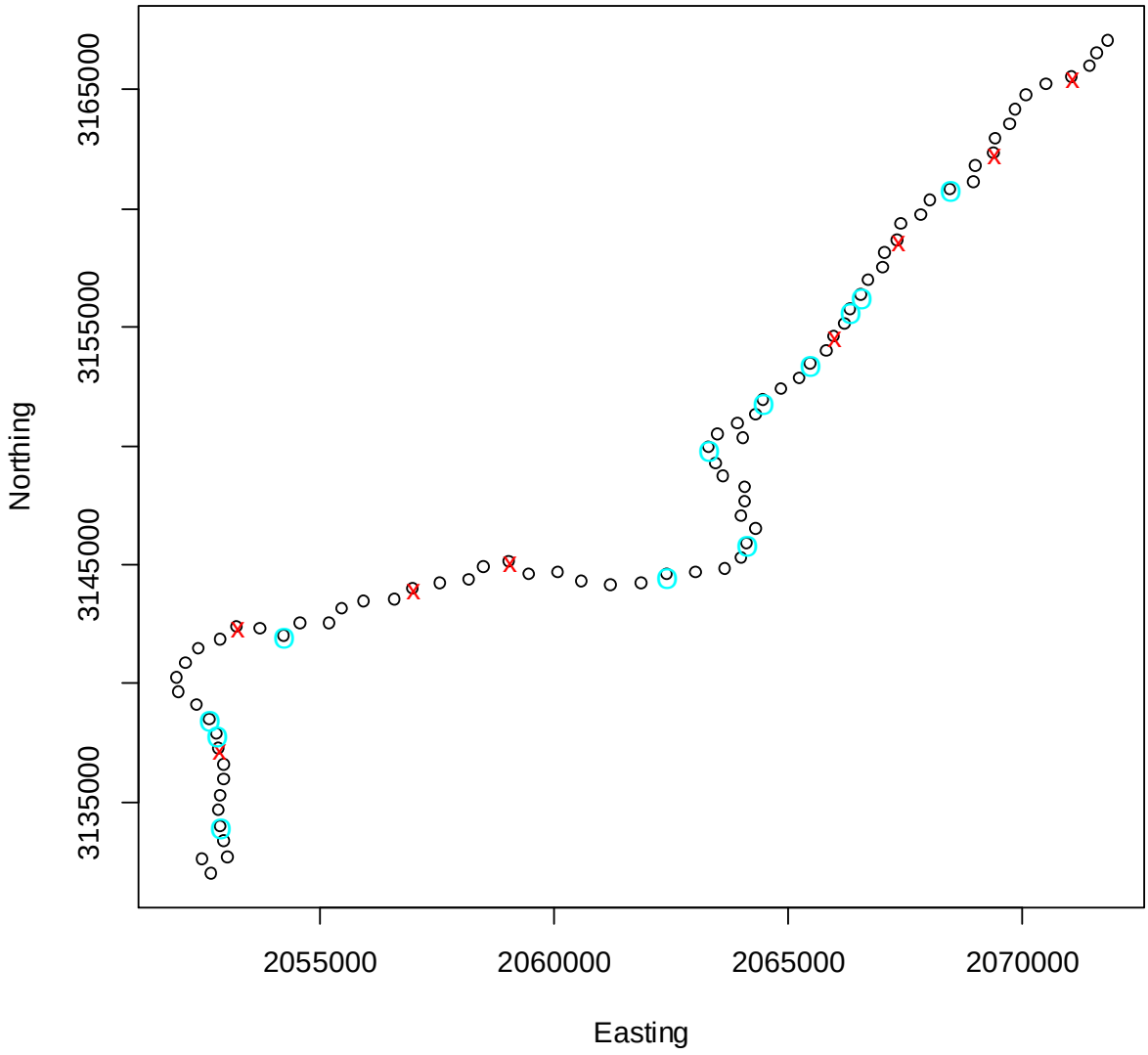

Figure 5.2-2. GRTS sample locations selected for Goose Creek. Each black circle represents the downstream edge of a 200m sample unit. The red "x" marks indicate a sample unit will be sampled for abundance and distribution. The larger blue circles indicate a sample unit will be sampled for distribution only.

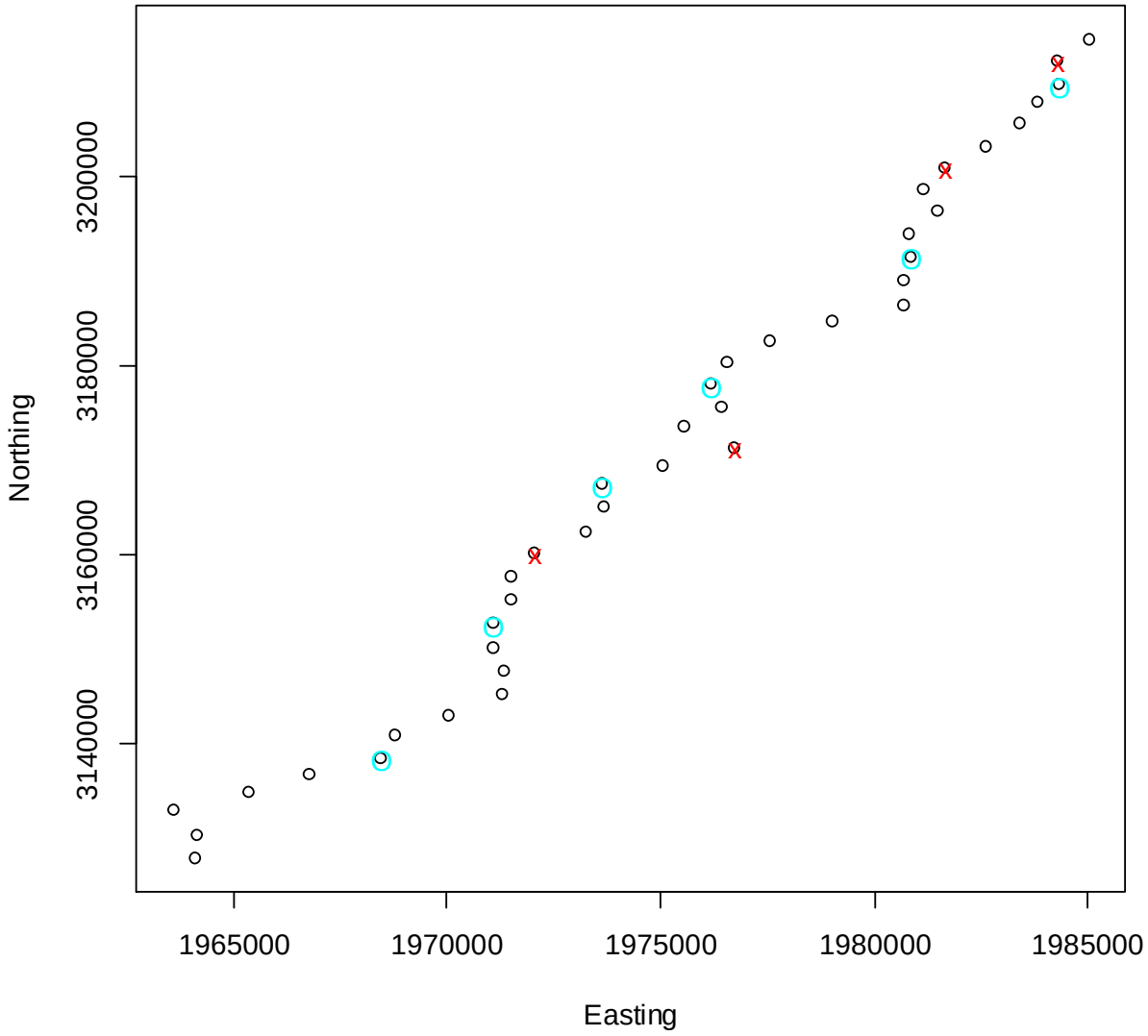

Figure 5.2-3. GRTS sample locations selected for the Kosina River. Each black circle represents the downstream edge of an 800m sample unit. The red "x" marks indicate a sample unit will be sampled for abundance and distribution. The larger blue circles indicate a sample unit will be sampled for distribution only.

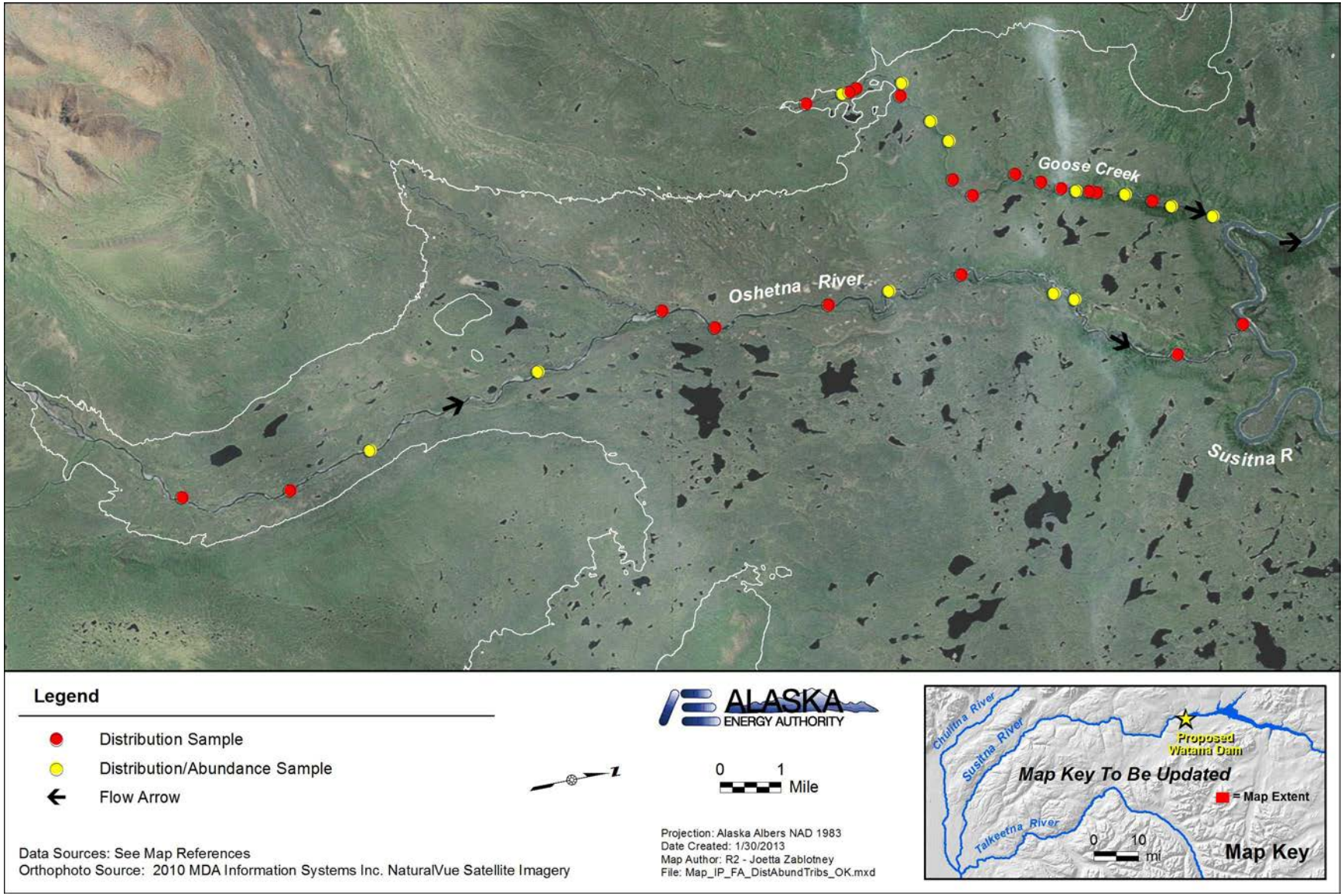

Figure 5.2-4. Map showing sample locations in the Oshetna River and Goose Creek.

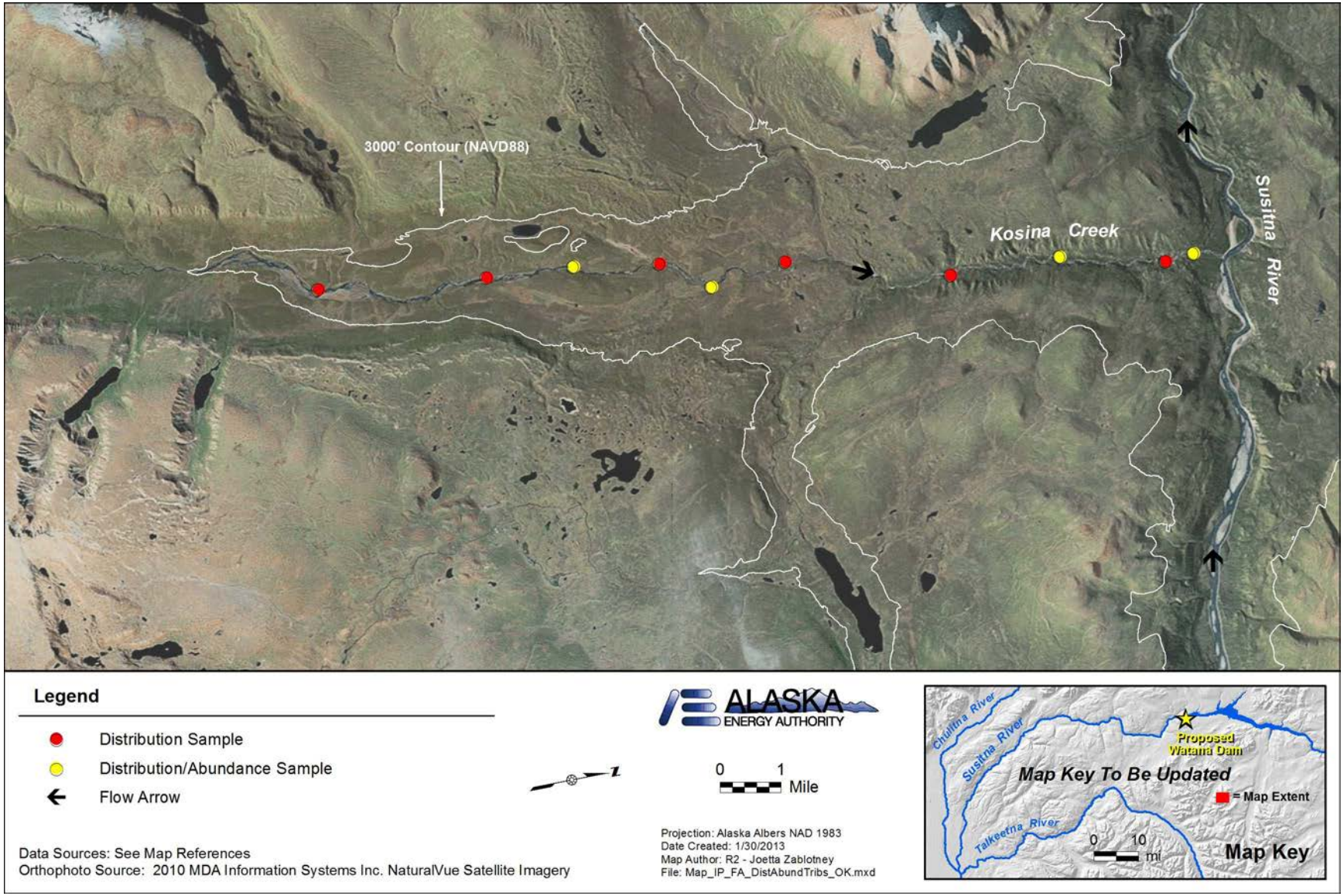

Figure 5.2-5. Map showing sample locations in Kosina Creek.

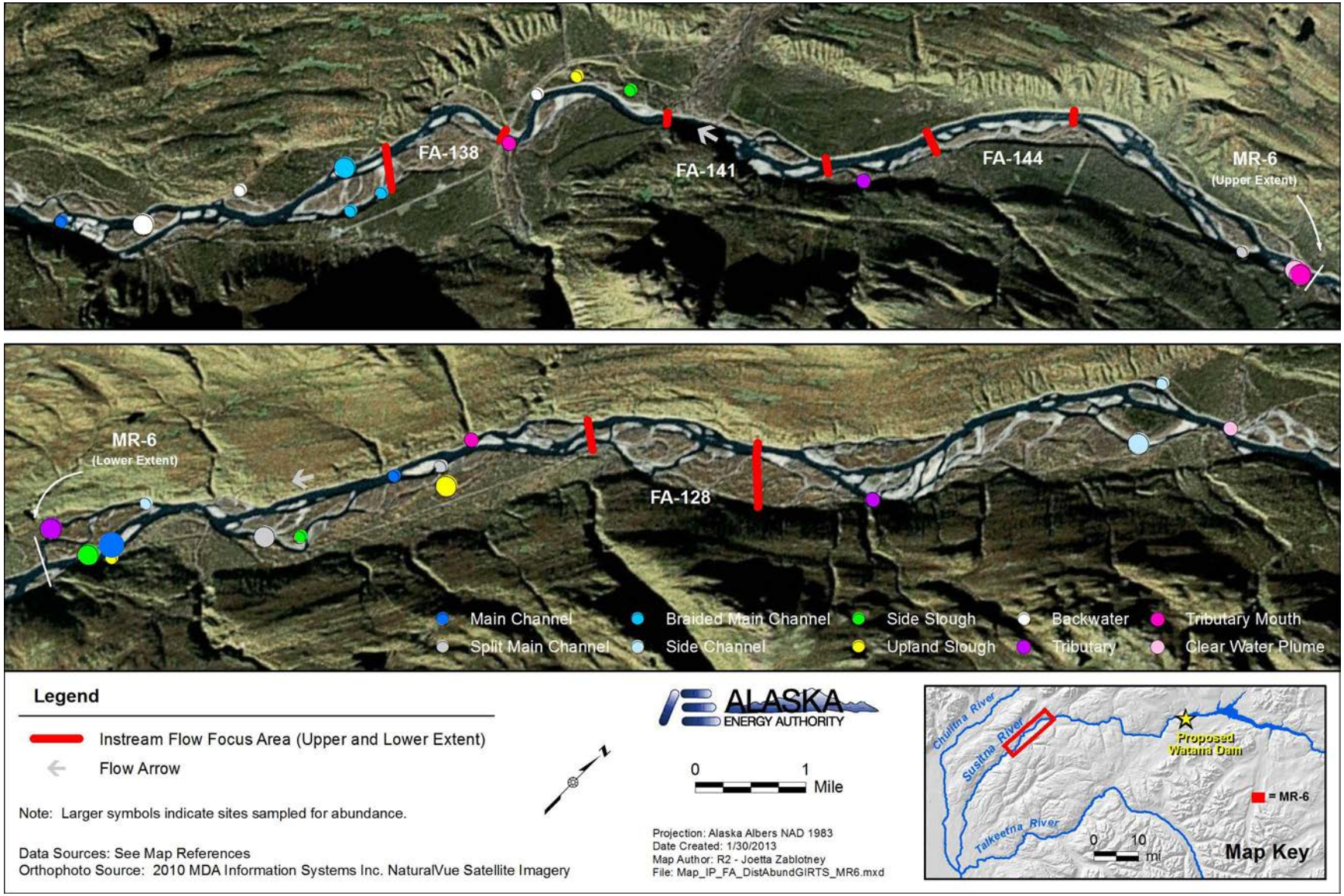

Figure 5.3-1. GRTS site selection by habitat type for non-Focus Areas in Geomorphic Reach 6.

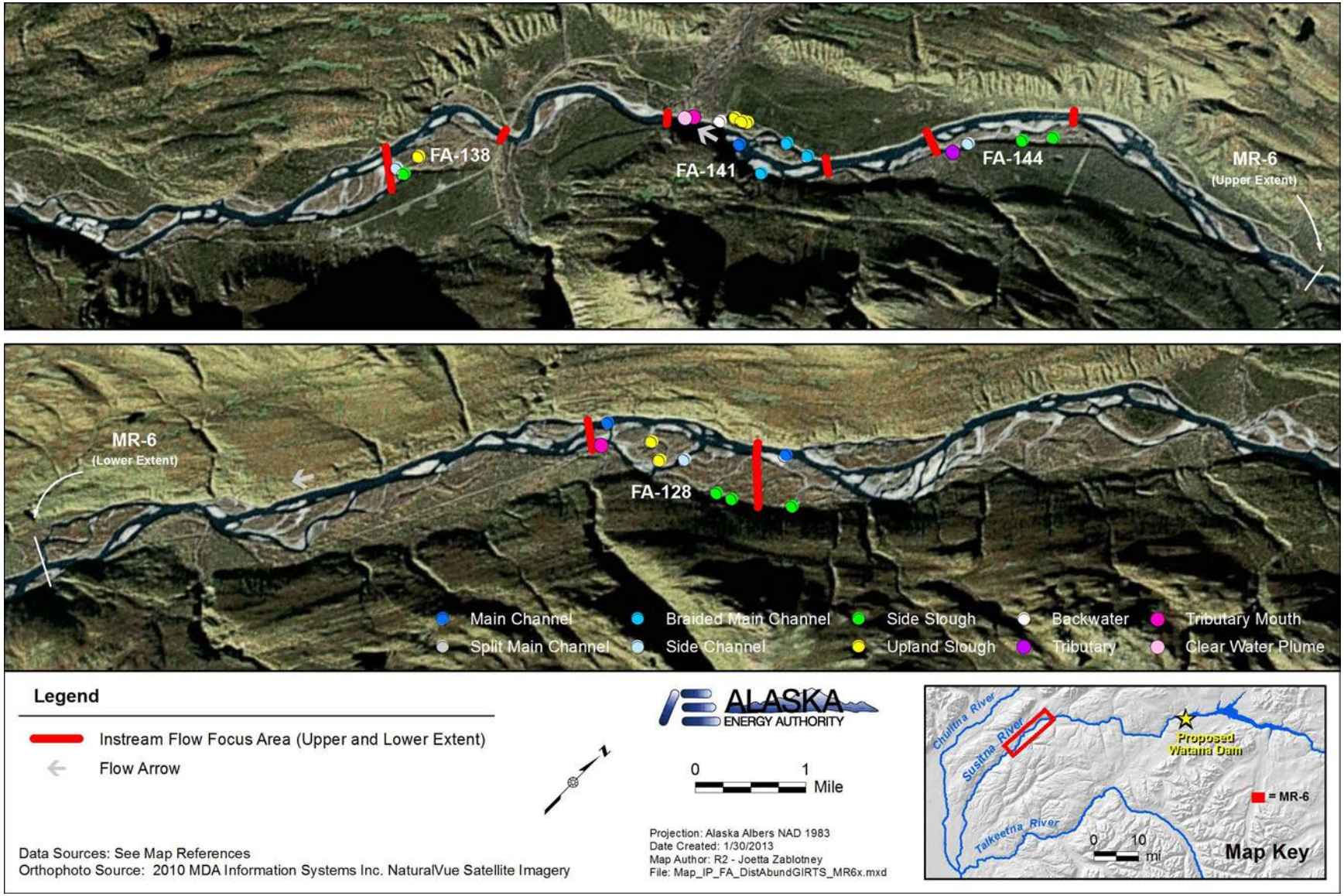

Figure 5.3-2. GRTS site selection by habitat type for Focus Areas. All sites are sampled for distribution and abundance.

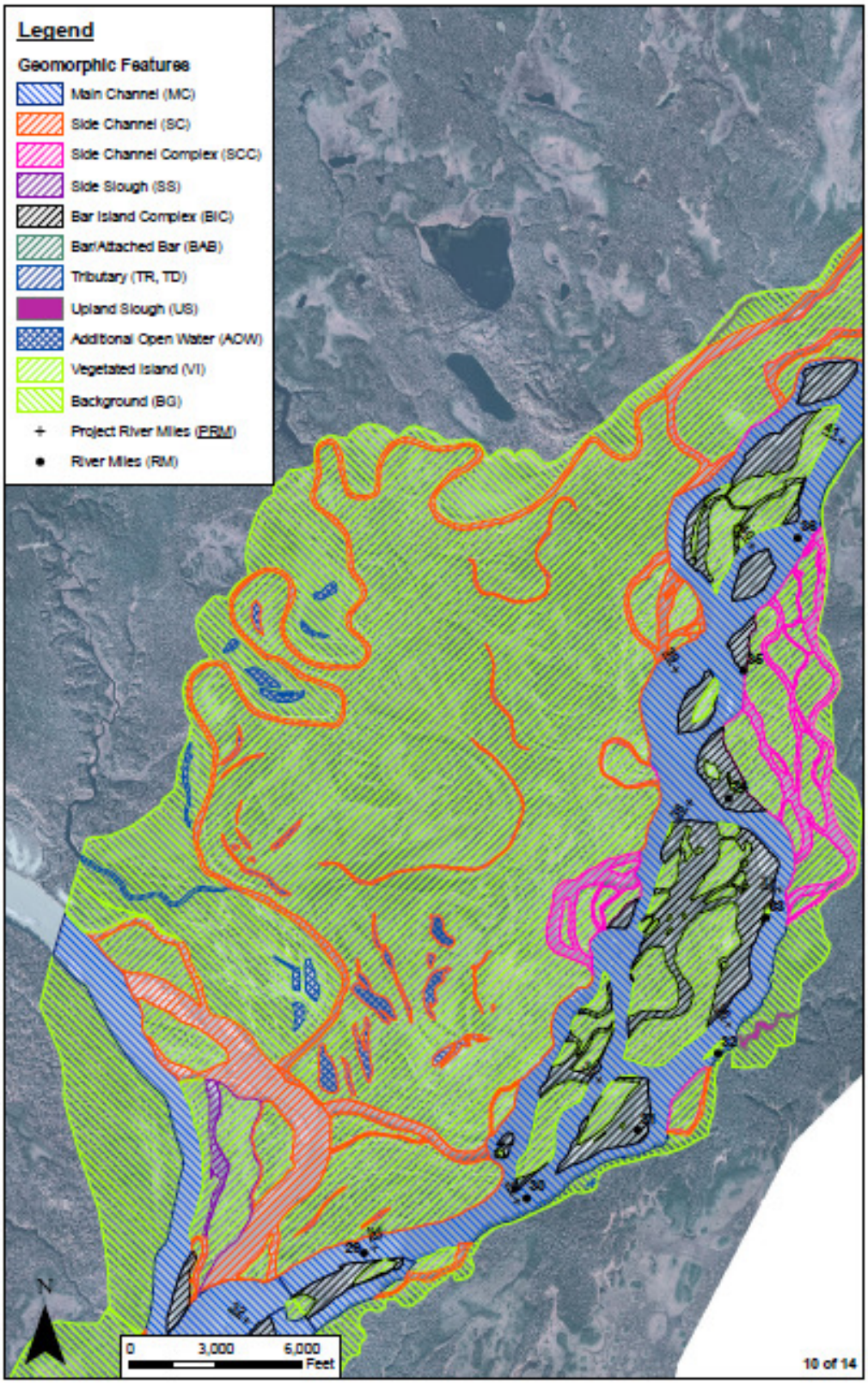

Figure 5.4-1. Example of a fish distribution and abundance sampling transect and randomized study site selection by mainstem habitat type in the Lower Susitna River.

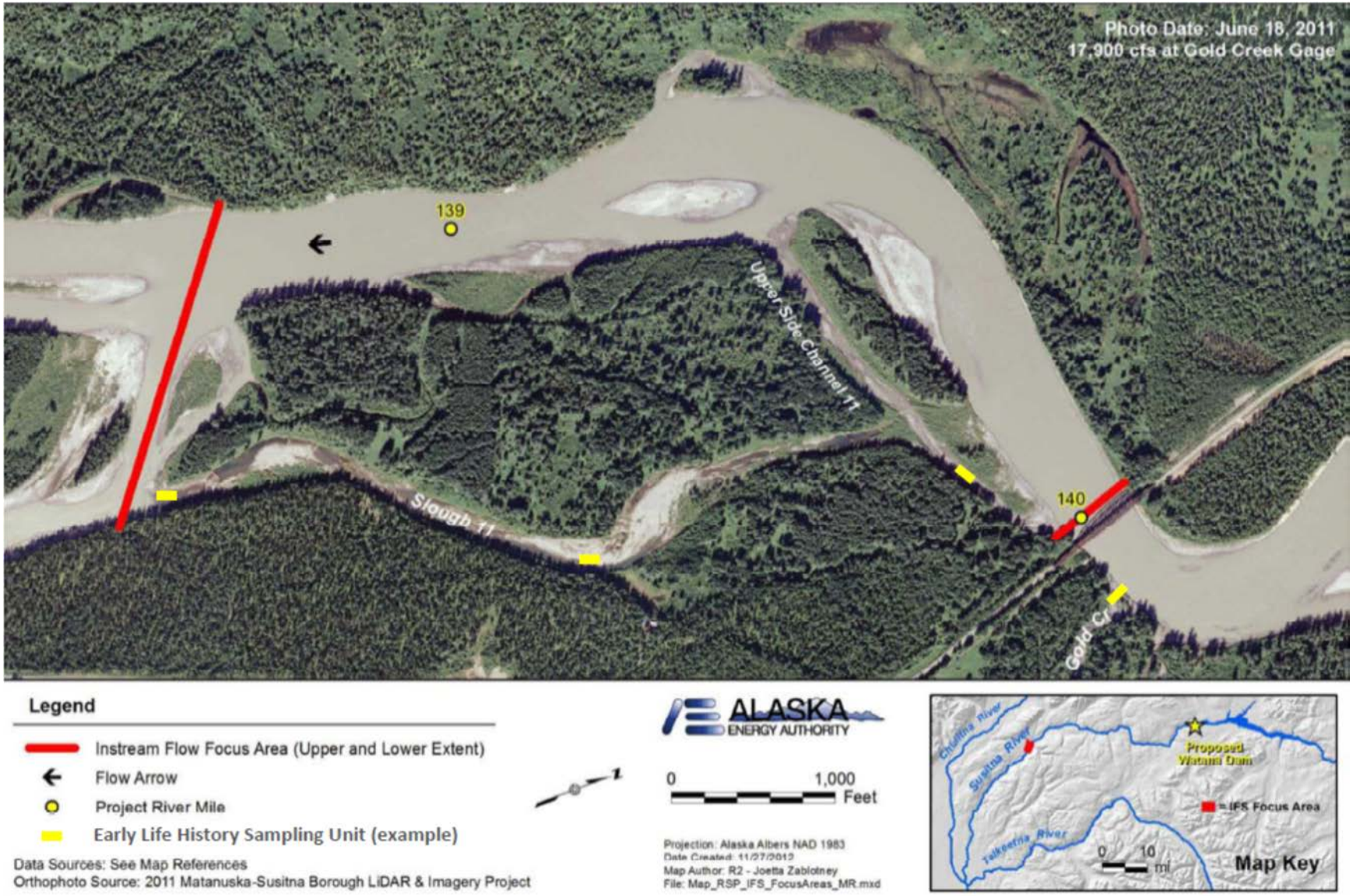

Figure 5.5-1. An example of early-life history sampling units located at (1) mouth of spawning tributary, (2) upper side slough, (3) middle side slough, and (4) side slough mouth. Note: sampling units are 40-meters long and not to scale on figure.

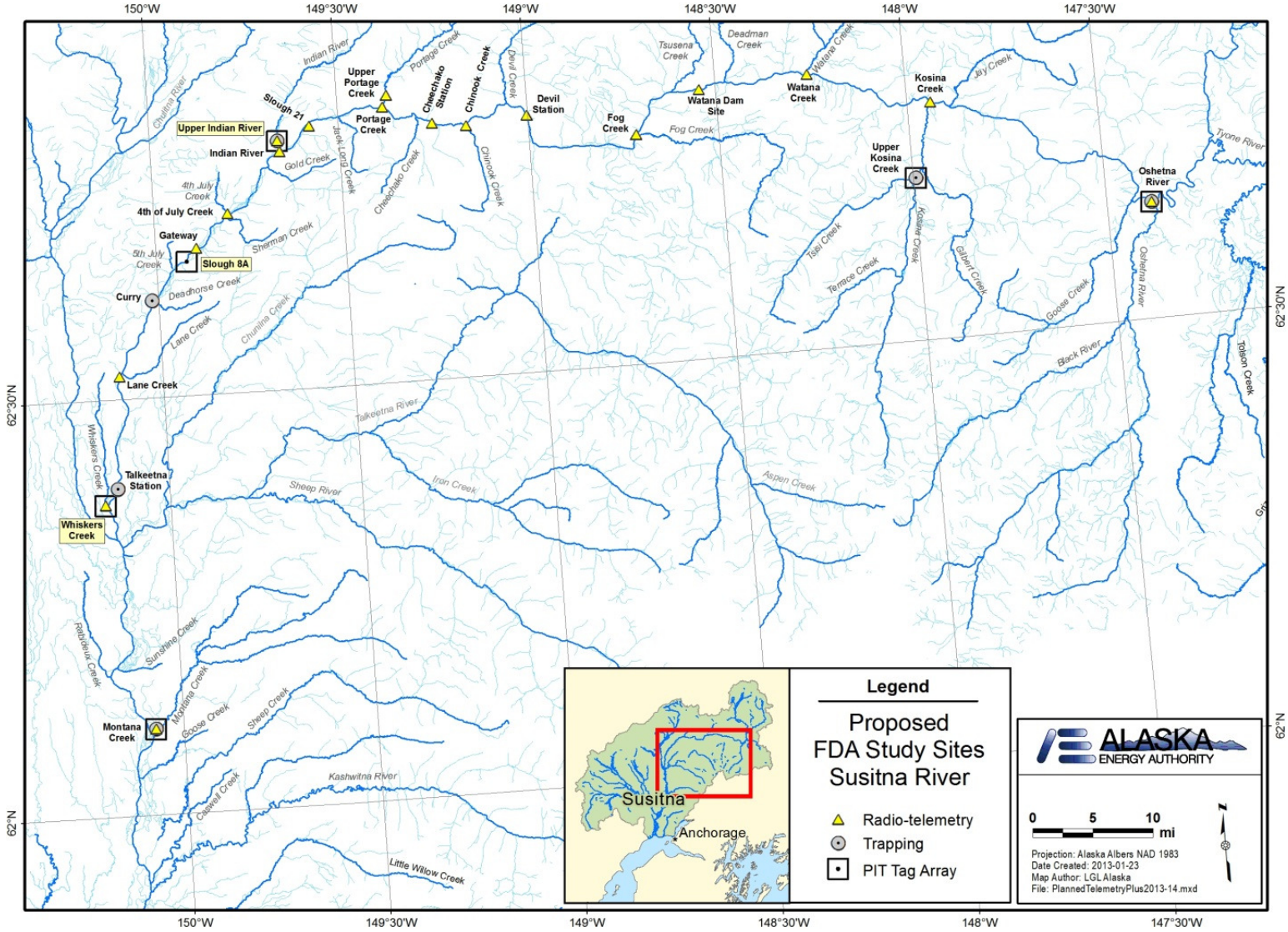

Figure 5.6-1. Proposed locations for PIT-Tag interrogation systems, outmigrant traps, and stationary radio-telemetry receivers in the Lower, Middle, and Upper Susitna River.

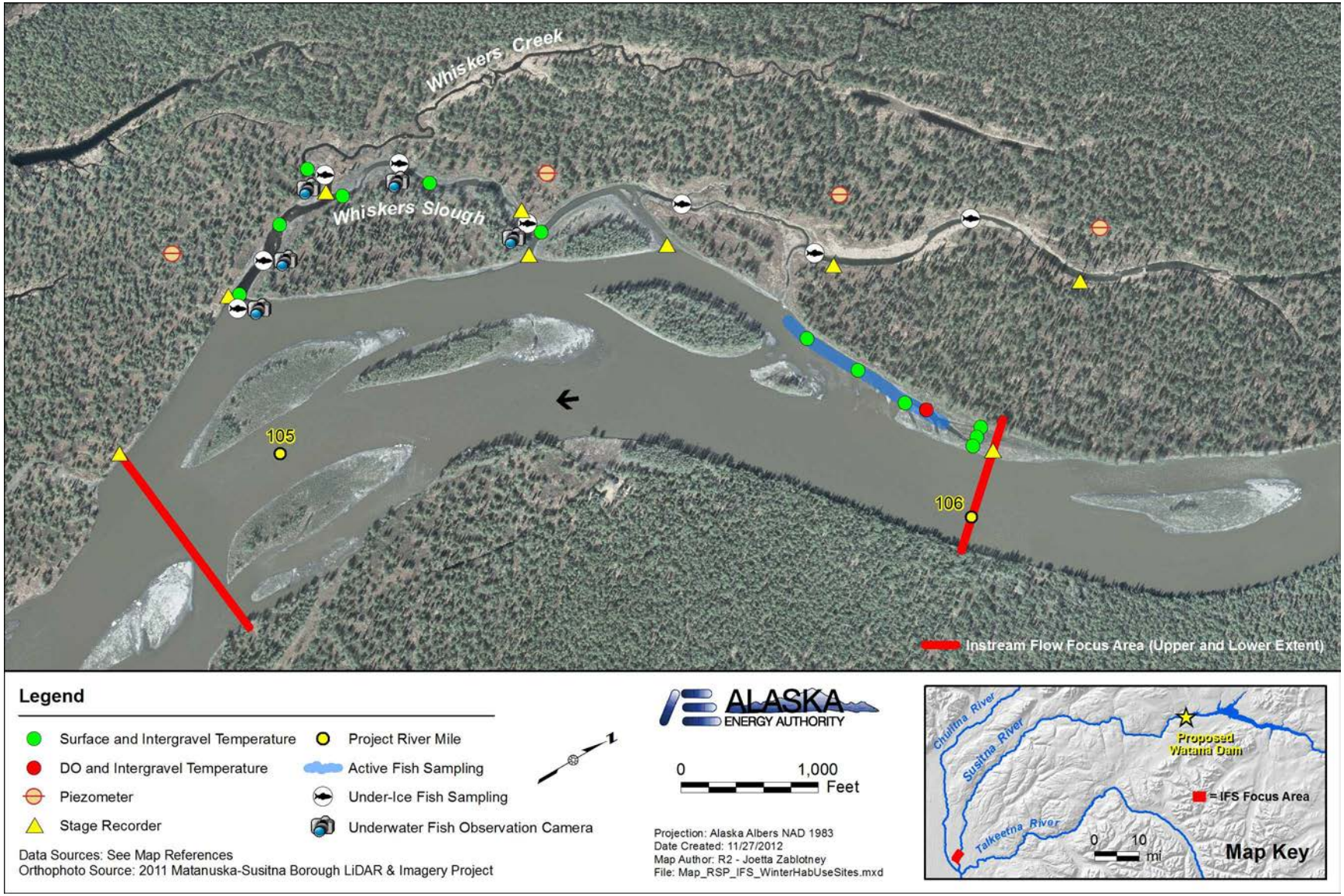

Figure 5.11-1. Distribution of winter sampling sites in Whiskers Slough, Susitna River.

Figure 5.11-2. Photograph showing the DIDSON sonar head mounted on a bracket and fastened to an aluminum pole. The DIDSON was lowered down under the ice and used to sample fish at multiple mesohabitats in the Athabasca River in February, 2012.

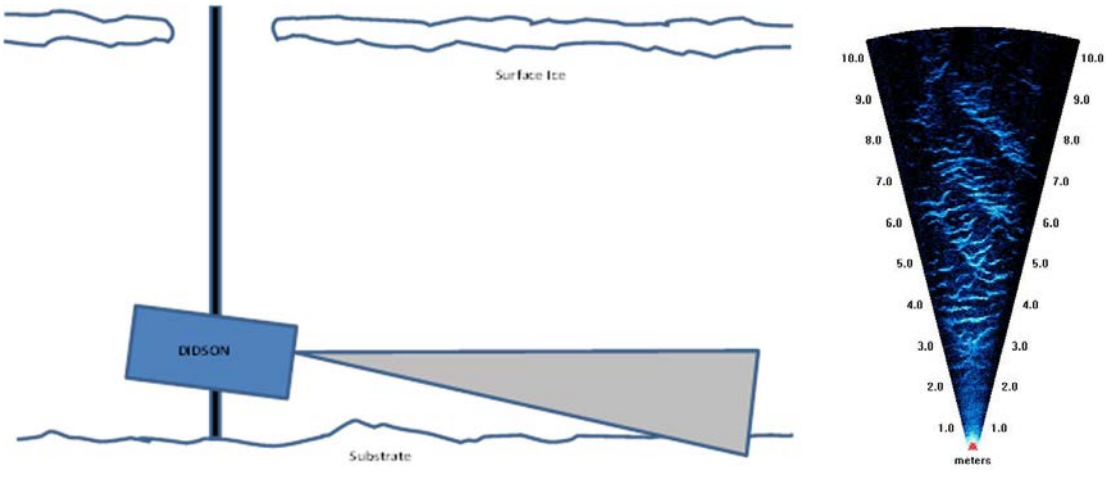

Figure 5.11-3. Conceptualized depiction of DIDSON deployed under the ice for sampling fish in off-channel habitats of the Susitna River (left) and still image from DIDSON data (right) collected from the Athabasca River showing the ridges and furrows of the sandy substrate (from Johnson et al. 2012).