9. FISH AND AQUATIC RESOURCES

9.1. Introduction

Susitna-Watana Hydroelectric Project (Project) construction and operation will affect flow, water depth, surface water elevation, and sediment regimes in the mainstem channel as well as at tributary confluences, side channels, and sloughs, both in the area of the inundation upstream from the proposed dam site and downstream in the potential zone of Project hydrologic influence. Such modifications may have an adverse effect upon the aquatic communities and fish populations residing in the river; the degree of this effect will ultimately depend on final Project design and operating characteristics.

The potential effects of the Project on fish and aquatic resources will need to be carefully evaluated as part of the licensing process. This study plan describes the Susitna-Watana Fish and Aquatic Resources Study that will be conducted to characterize and evaluate these effects. The overall objectives of this study are (1) to provide a baseline characterization of existing resources, and (2) to collect information that will support the evaluation of potential resource impacts of the proposed Project that were identified during development of the Pre-Application Document (PAD), public comment, and Federal Energy Regulatory Commission (FERC) scoping for the License Application. The impact assessments will inform development of any necessary protection, mitigation, and enhancement measures to be presented in the draft and final License Applications.

Alaska Energy Authority (AEA) is committed to conducting a thorough evaluation of the aquatic resources that could be affected by the Susitna-Watana Hydroelectric Project. AEA recognizes that the Susitna River supports a diverse assemblage of fish and aquatic biota and provided a detailed description of these resources in the PAD; however, AEA acknowledges that more information is needed to provide a better understanding of the species interaction with and dependencies on the river. To this end, AEA has initiated baseline studies on hydrology and fish resources in the Lower, Middle, and Upper Susitna River in 2012. These 2012 studies will be carried forward in the formal FERC ILP study program in 2013 and 2014. In addition, AEA is proposing to implement 15 additional fish and aquatic studies in 2013 and 2014 that will further document current conditions and provide information that will support the assessment of potential Project impacts.

The actual assessment of potential impacts will rely on information provided by the fish resources studies (see Sections 9.5 through 9.17), the instream flow study (surface water flow routing, habitat suitability criteria, and riparian floodplain vegetation surveys; see Section 8), the geomorphology study (sediment supply/transport regime and channel morphology; see Section 6), the ice processes study (surface water flow routing during the winter, ice growth and break-up; see Section 7.6), the groundwater study (surface water/groundwater interactions; see Section 7.5), and the water quality study (see Section 5). These studies will result in development of a series of flow-sensitive models (e.g., models of selected anadromous and resident fish habitats by species and life stage, models to assess connectivity and passage conditions provided into side channel and slough habitats, models to describe invertebrate habitats, temperature model, ice model, sediment transport model, turbidity model, large woody debris (LWD) recruitment model) that will be able to translate effects of alternative Project operations on the respective processes and biological resources. Because alternative Project operational scenarios will likely affect different habitats and processes differently, both spatially and temporally, the habitat and process models will be spatially discrete (e.g., by site, segment, and reach) and yet able to be integrated to allow for a holistic evaluation of each alternative operational scenario. This will allow for an Integrated Resource Analysis of separate operational scenarios that includes each resource element, the results of which can serve in a feedback capacity leading to new or modifications of existing operations scenarios.

One of the key benefits to this approach is that AEA will be able to evaluate the potential effects of Project operations under different hydrologic conditions (e.g., wet, normal, and dry year) and for varying time steps (e.g., hourly, daily, monthly etc.). This will allow for assessments of a wide range of operational characteristics including load-following, base load operations, and others. These types of analysis can be extended over variable time intervals that can be used to assess Project effects over a life cycle of a given species. For example, Project operational effects could be evaluated over 5-year (or other specified interval) increments of time as a means to estimate how Chinook salmon (or other species) habitats might vary over that period (taking into consideration all of the flow-sensitive parameters noted above). These types of analyses could be done both retrospectively as a means to consider influences of existing and historic flow conditions, as well as prospectively as a means to evaluate effects of future project operations.

The information that will be collected and the models developed will be relied upon by FERC for completing a thorough environmental impact assessment and for establishing appropriate protection, mitigation, and enhancement measures for inclusion in the Project license necessary for avoiding, reducing, or mitigating for Project effects.

AEA has carefully considered the importance of the Susitna River and its resources, and while working diligently with licensing participants and technical consultants, has identified and designed the studies presented herein the RSP. All of the studies are planned to be completed in a timely fashion to support the License Application, and AEA is confident the information generated will provide FERC with sufficient information to complete its analysis. AEA's confidence in this matter is strengthened substantially owing to the extensive amounts of data and information that were collected on the Susitna River during the 1980s that formed much of the basis for the PAD. AEA has acquired the majority of the data and information collected during those studies and in 2012 has sanctioned the technical review and compilation of the information so it will be available for use during the 2013–2014 studies and for impact analysis. The results of the 2 years of intensive study as described in this RSP, coupled with the extensive amount of pre-existing, relevant information collected during the 1980s and ongoing efforts in 2012 will provide FERC the information and analysis needed to complete a sound, scientific assessment of the baseline conditions and potential Project. A glossary of fisheries terms is included in Attachment 9-1.

9.2. Nexus Between Project Construction / Existence / Operations and Effects on Resources to be Studied

As described above, the construction and operational strategy of the Project will create a reservoir; modify the flow, thermal, gravel recruitment, and sediment regimes; and may alter connectivity of aquatic habitats in the Susitna River basin. These potential ecosystem changes will alter the composition and distribution of fish habitat and may have effects on fish and aquatic productivity. The proposed hydropower operations for the Project may influence the abundance and distribution of one or more of the resident and anadromous fish populations. The degree of impact will vary depending on the magnitude, frequency, duration, and timing of flows as well as on potential Project-related changes in temperature and turbidity. Baseline information on existing conditions will be needed to predict the likely extent and nature of potential changes that will occur due to Project construction and operations.

9.3. Agency and Alaska Native Entities Resource Management Goals and Objectives

Aquatic resources including fish and their habitats are generally protected by a variety of state and federal mandates. In addition, various land management agencies, local jurisdictions, and non-governmental interest groups have specific goals related to their land management responsibilities or special interests. These goals are expressed in various statutes, plans, and directives, as described below.

Alaska Statute 41.14.170 provides the authority for state regulations to protect the spawning, rearing, or migration of anadromous fish. Alaska Statute 41.14.840 addresses the construction of fishways and dams. State regulations relating to fish resources are generally administered by the Alaska Department of Fish and Game (ADF&G). ADF&G is responsible for the management, protection, maintenance, and improvement of Alaska's fish and game resources in the interest of the economy and general well-being of the state (AS 16.05.020). ADF&G monitors fish populations and manages subsistence, sport, and commercial uses of fish through regulations set by the Board of Fisheries (AS 16.05.221). The *Policy for Management of Sustainable Salmon Fisheries* (SSFP; 5 AAC 39.222) sets guidelines for ADF&G's management of state salmon resources. The statewide *Policy for the Management of Sustainable Wild Trout Fisheries* (PMSWTF; 5 AAC 75.222) currently guides wild rainbow trout regulatory changes. Cook Inlet Rainbow Trout/Steelhead Management Policy (CIRTMP; ADF&G 1987) provides further guidelines specific to rainbow trout in the Northern Cook Inlet Management Area (NCIMA). ADF&G's authority for protection of fish resources and habitat is further established through the Anadromous Fish Act (AS 16.05.871 – 901) and the Fishway Act (AS 16.05.841).

In addition to the state statutes, the following resource management plans and directives provide guidance and direction for protection of fish resources and aquatic habitats on lands within or adjacent to the Project area:

- Title VIII of the Alaska National Interest Lands Conservation Act (ANILCA) passed in 1980 set forth a subsistence use priority for the taking of fish and wildlife on public lands.
- The Federal Subsistence Board, which is comprised of representatives of the U.S. Fish and Wildlife Service, National Park Service, Bureau of Land Management, Bureau of Indian Affairs, and U.S. Forest Service, oversees the Federal Subsistence Management Program (57 FR 22940; 36 CFR Parts 242.1–28; 50 CFR Parts 100.1–28), with responsibility for managing subsistence resources on federal public lands for rural residents.
- The Magnuson-Stevens Fishery Conservation and Management Act (PL 104-267) provides federal protection for Essential Fish Habitat (EFH) defined as "those waters and

substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." NOAA's National Marine Fisheries Service (NMFS) is responsible for designating EFH. In the case of anadromous fish streams (principally salmon), NOAA Fisheries has designated the Anadromous Waters Catalog (AWC) prepared by ADF&G (Johnson and Klein 2009) as the definition of EFH within freshwater habitats.

- *Aquatic Resources Implementation Plan for Alaska's Comprehensive Wildlife Conservation Strategy*, September 2006. Prepared by ADF&G, Division of Sport Fish.
- *Our Wealth Maintained: A Strategy for Conserving Alaska's Diverse Wildlife and Fish Resources*. Prepared by ADF&G, Juneau, Alaska. xviii+824 pp.

Management and land use plans relevant to the Fish and Aquatic Resources Study components include the following:

- The role of state land use plans, generally administered by Alaska Department of Natural Resources (ADNR), was established by state statute (AS 38.04.005). The Susitna-Matanuska Area Plan (SMAP) and the Southeast Susitna Area Plan (SSAP) direct how the ADNR will manage general state uplands and shorelands within the planning boundaries.
- The Susitna Basin Recreation Rivers Management Plan describes how the ADNR will manage state land and water along six rivers including: the Little Susitna River, Deshka River, Talkeetna River, Lake Creek, Talachulitna River, and Alexander Creek. The plan determines how these six rivers will be managed over the long term including providing management intent for each river segment, new regulations for recreation and commercial use, and guidelines for leases and permits on state land.
- The Susitna Flats Game Refuge Management Plan provides ADF&G guidance to manage the refuge to protect fish and wildlife populations, including salmon spawning and rearing habitats.
- Chickaloon Native Village is an Ahtna Athabascan Indian Tribe and is a federally recognized Alaska Native tribe. The Chickaloon Village Traditional Council strives to increase traditional Ahtna Dene' practices for the betterment of all residents in the area. The Tribe envisions a future with functioning ecosystems, flourishing fish and wildlife populations, and a healthy, prosperous community.

9.4. Summary of Consultation with Agencies, Alaska Native Entities and Other Licensing Participants

Input regarding the issues to be addressed in the Fish and Aquatic Resources Study has been provided by licensing participants during workgroup meetings commencing in late 2011. During 2012, workgroup meetings were held in January, February, April, June, August, September, October, and November, during which resource issues were identified and discussed and objectives were defined. Various agencies (USFWS, NMFS, ADF&G, etc.) provided written comments specific to fish and aquatic studies, which have been considered and will be addressed as part of these study plans.

Summary tables of comments and responses from formal comment letters filed with FERC through November 14, 2012, are provided in Appendix 1. Copies of the formal FERC-filed comment letters are included in Appendix 2. In addition, a single comprehensive summary table of comments and responses from consultation, dated from Proposed Study Plan (PSP) filing (July 16, 2012) through release of Interim Draft RSPs, is provided in Appendix 3. Copies of meeting summaries from release of the PSP through the interim draft RSP are included in Appendix 4, organized chronologically.

9.5. Study of Fish Distribution and Abundance in the Upper Susitna River

9.5.1. General Description of the Proposed Study

This study is focused 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). Fishery resources in the upper sections of the Susitna River basin consist of a variety of salmonid and non-salmonid resident fish (Table 9.5-1). With one known exception (i.e., Chinook salmon), existing information indicates that anadromous fish are restricted to the mainstem Susitna River and tributaries downstream of Devils Canyon near RM 150 due to their apparent inability to pass several steep rapids. In addition to investigating the resident salmonid and non-salmonid fishes present in this part of the river, this study will also investigate the distribution and abundance of any anadromous fish above the proposed Watana Dam site. Chinook salmon have been observed in relatively low numbers above Devils Canyon (maximum peak count of 46 adult Chinook salmon during 1984; Thompson et al. 1986).

The physical habitat modeling efforts proposed in the Fish and Aquatics Instream Flow Study (Section 8.5) require information on the distribution and periodicity of different life stages for the fish species of interest. Not all life stages of the target fish species may be present throughout the Upper Susitna River, and seasonal differences may occur in their use of some habitats. For example, some fish that use tributary streams during the open-water period may overwinter in mainstem habitats.

This study is designed to provide baseline biological information regarding periodicity and habitat suitability for the Instream Flow Modeling Study (see Section 8.5). Results of this study will include key life history information about fish species in the Upper Susitna River, which will provide inputs for the Study of Fish Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) and the Study of Fish Passage Feasibility at Watana Dam (Section 9.11).

Study Goals and Objectives

The overarching goal of this study is to characterize the current distribution, relative abundance, run timing, and life history of resident and non-salmon anadromous species (e.g., Dolly Varden, humpback whitefish, round whitefish, Arctic grayling, northern pike, and Pacific lamprey), and freshwater rearing life stages of anadromous fish (fry and juveniles) in the Susitna River above the proposed dam site (RM 184). Specific objectives include the following:

1. Describe the seasonal distribution, relative abundance (as determined by catch per unit effort [CPUE], fish density, and counts), and fish-habitat associations of resident fishes, juvenile anadromous salmonids, and the freshwater life stages of non-salmon anadromous species.
2. Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Pacific lamprey, Arctic grayling and burbot within the hydrologic zone of influence upstream of the Project.

a. Document the timing of downstream movement and catch using out-migrant traps.

b. Describe seasonal movements using biotelemetry (passive integrated transponders [PIT] and radio-tags).

c. Describe juvenile Chinook salmon movements.

3. Characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
4. Determine whether Dolly Varden and humpback whitefish residing in the Upper River exhibit anadromous or resident life histories.
5. Determine baseline metal concentrations in fish tissues for resident fish species in the mainstem Susitna River (see Section 5.5 Water Quality and Section 5.7, Mercury Assessment and Potential for Bioaccumulation Study).
6. Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).
7. Collect tissue samples to support the Genetic Baseline Study for Selected Fish Species (Section 9.14).

9.5.2. Existing Information and Need for Additional Information

Information regarding resident species, non-salmon anadromous species, and the freshwater rearing life stages of anadromous salmon was collected during studies in connection with Alaska Power Authority's (APA's) proposed Susitna Hydroelectric Project in the 1980s. Existing information includes the spatial and temporal distribution of fish species and their relative abundance. The Pre-Application Document (PAD) (AEA 2011a) and Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) summarized this existing information and also identified data gaps for resident and rearing anadromous fish.

A total of nine anadromous and resident fish species have been documented inhabiting the Susitna River drainage upstream of Devils Canyon (Table 9.5-1). Chinook salmon use of the Upper Susitna River was first documented during the 1980s studies; this is the only anadromous fish documented to pass the rapids at Devils Canyon. Resident species that have been identified in all three segments of the Susitna River include Arctic grayling, Dolly Varden, humpback whitefish, round whitefish, burbot, longnose sucker, and sculpin (Schmidt et al. 1985; Buckwalter 2011). To varying degrees, the relative abundance and distribution of these species were determined during the early 1980s studies. For most species, the dominant age classes and sex ratios were also determined, and movements, spawning habitats, and overwintering habitats were identified for certain species.

One species that has not been documented in the Susitna River, but may occur in the upper Susitna drainage, is lake trout. Lake trout have been observed in Sally Lake and Deadman Lake of the upper Susitna watershed (Delaney et al. 1981a) but have not been observed in the mainstem Susitna or tributary streams. Pacific lamprey have been observed in the Chuit River (Nemeth et al. 2010), which also drains into Cook Inlet. Northern pike is an introduced species that has been observed in the Lower and Middle River (Rutz 1999). Although it is considered unlikely that Pacific lamprey and northern pike are present in the Upper Susitna River, this study will be helpful for evaluating these species' distributions.

In the proposed impoundment zone, Arctic grayling are believed to be the most abundant fish species (Delaney et al. 1981a; Sautner and Stratton 1983) and were documented spawning in tributary pools. In tributaries, juvenile grayling were found in side channels, side sloughs, and pool margins and in the mainstem at tributary mouths and clear water sloughs during early summer. Dolly Varden populations in the Upper Susitna River are apparently small but widely distributed. Burbot in the Upper Susitna River were documented in mainstem habitats with backwater-eddies and gravel substrate. The abundance of longnose suckers in the Upper Susitna River was less than downstream of Devils Canyon. Specific information needs relative to fish distribution and abundance in the Upper Susitna River that were identified in the ARDGA (AEA 2011b) include the following:

- Population estimates of adult Arctic grayling and Dolly Varden in select tributaries within the proposed impoundment zone.
- The migration timing of Arctic grayling spawning in the proposed impoundment zone, the relative abundance and distribution of Dolly Varden, lake trout, and juvenile Chinook salmon in the impoundment zone.
- Physical habitat characteristics used by round whitefish, longnose sucker, and burbot within the impoundment zone.

Little is known about the density and distribution of juvenile salmon in the Susitna River upstream of Devils Canyon (RM 150) and the proposed dam site at RM 184. All five species of Pacific salmon were captured in the Lower and Middle Susitna River during the 1980s licensing studies. Coho, chum, sockeye, and pink salmon have not been observed upstream of the Devils Canyon rapids. Chinook salmon are the only anadromous species known to occur in the Upper Susitna River and tributaries although the information on the extent of their distribution is limited. In 1984, Chinook spawning was documented upstream of Devils Canyon but downstream of the proposed dam site at Chinook Creek (RM 156.8), and Fog Creek (RM 176.7) (ADF&G 1985). More recent sampling has documented adults in Fog and Tsusena Creeks (RM 181.3) and upstream of the proposed dam site in Kosina Creek (RM 201). Juvenile Chinook salmon have been documented recently upstream of Devils Canyon in Fog Creek, and upstream of the proposed dam site in Kosina Creek, and in the Oshetna River (RM 225) (Buckwalter 2011). Historic data indicate that Susitna River Chinook salmon spawn exclusively in tributary streams (Thompson et al. 1986;Barrett et al.1983; Barrett 1974, 1985) and that nearly all Chinook salmon juveniles in this system out-migrate to the ocean as age-1+ fish, and very few exit the system as fry.

Existing fish and aquatic resource information appears insufficient to address the following issues that were identified in the PAD (AEA 2011a):

- **F1:** Effect of change from riverine to reservoir lacustrine habitats resulting from Project development on aquatic habitats, fish distribution, composition, and abundance, including primary and secondary productivity.
- **F2:** Potential effect of fluctuating reservoir surface elevations on fish access and movement between the reservoir and its tributaries and habitats.

- **F3:** Potential effect of Watana Dam on fish movement.

Site-specific knowledge of the distribution, timing, and abundance of fish likely to occupy the proposed Watana Reservoir primarily depends on the results of surveys conducted by the Alaska Department of Fish and Game (ADF&G) during the early 1980s using multiple sampling methods (AEA 2011a). The existing information can provide a starting point for understanding the distribution and abundance of anadromous and resident freshwater fishes in the Susitna River and the functional relationship with the habitat types present. However, any significant differences in the patterns in abundance and distribution observed during the 1980s compared to current conditions need to be determined.

In addition to providing baseline information about aquatic resources in the proposed Project area, aspects of this study are designed to complement and support other fish and aquatic studies.

9.5.3. Study Area

The study area encompasses the mainstem Susitna River from the proposed Watana Dam site (RM 184) upstream to the Oshetna River confluence (RM 233.4) (Figure 9.5-1). The Upper Susitna River is delineated by the location of the proposed Watana Dam because effects of the Project are anticipated to be different upstream and downstream of the proposed dam. The mainstem Susitna River and its tributaries upstream of the proposed dam will be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling. Tributary surveys upstream of the proposed Watana Dam are further delineated by the 3,000-foot elevation contour, which is based on the known extent of juvenile Chinook salmon distribution. Some study components, such as resident fish life-history studies and juvenile Chinook salmon distribution sampling, may extend beyond the core area.

9.5.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the distribution and abundance of fish species in the Upper Susitna River. The following sections provide brief descriptions of study site selection, sampling frequency, the approach, and suite of methods that will be used to accomplish each objective of this study. This study was initiated in 2012 and will continue over the next two years to survey as much habitat as possible.

Fish Distribution and Abundance Sampling Plan

Some details of the sampling scheme have been provided for planning purposes; however, modifications may be appropriate as the results of 2012 data collection are reviewed. A final sampling scheme will be developed as part of the detailed Fish Distribution and Abundance Implementation Plan, for Sections 9.5 and 9.6, which will be submitted to FERC no later than March 15, 2013. Implementation plan development will include (1) a summary of relevant fisheries and an overview of the life history needs for fish species known to occur in the Susitna River to guide site selection and sampling protocols, (2) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9), (3) a description of site selection and sampling protocols, (4) development of field data collection forms, and (5) 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 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. Proposed sampling methods by objective are presented below and in Table 9.5-2. Brief descriptions of each sampling technique are provided in Section 9.5.4.4.

9.5.4.1 Study Site Selection

The Upper Susitna River will represent an area where the mainstem river will be inundated and tributaries will be partially altered. As a result, the sampling effort will be tailored to collect necessary information to document fish assemblages, distribution, and abundance generally within the mainstem river and more intensely within the tributary habitat inundated up to an elevation of 2,200 feet. The number of sites may be revisited after sampling in 2013, if Chinook are located in tributaries above 2,200 feet.

A nested stratified sampling scheme will be used to select study sites to cover the range of habitat type. The habitat classification hierarchy, as described in Section 9.9.5.4.1 of the Habitat Classification Study, will be composed of five levels representing (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; (4) main channel mesohabitat; and (5) edge habitat (Table 9.9-4, Nested and tiered habitat mapping units and categories).

Level 1 will generally identify the Lower River (RM 28-98), Middle River (RM 98-184), and Upper River (RM 184-233) from each other. The mainstem Susitna River and its tributaries upstream of the proposed dam will be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling. In contrast, the mainstem downstream of the Project will be subject to the effects of flow modification from Project operations, which will diminish below the Three Rivers Confluence.

Level 2 will identify unique reaches established from the channel’s geomorphic characteristics (established from the Geomorphology Study [Section 6.0]). The Geomorphic Study Team will delineate the Lower, Middle, and Upper River segments into large-scale geomorphic river reaches with relatively homogeneous landform characteristics, including at generally decreasing scales: geology, hydrology (inflow from major tributaries), slope, channel planform, braiding or sinuosity index (where relevant), entrenchment ratio, channel width, and substrate size. Stratification of the river into relatively homogeneous segments will facilitate relatively unbiased extrapolation of sampled site data within the individual segments because sources of variability associated with large-scale features will be reduced.

Level 3 classifies the mainstem habitat into main channel, off-channel, and tributary habitat using an approach similar to the 1980s historical habitat mapping definitions (ADF&G 1983). The main channel includes five mainstem habitat types, whereas the off-channel habitat will be categorized into four types (Table 9.9-4). The 1980s classification of riverine habitats of the Susitna River included six major mainstem habitat categories consisting of main channel, side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). These mainstem habitat categories will be maintained in the 2012 classification system, but they are further categorized into main channel, off-channel, and tributary. These will be expanded to include five types of main channel (main channel, split main channel, multiple split main channel, side channel, and tributary), and four types of off-channel (slide slough, upland slough, backwater, and beaver complex) (Table 9.9-4).

Level 4 will further delineate Level 3 main channel and tributary habitats into mesohabitat types (pool, riffle, glide, and cascade) (Table 9.9-4). However, off-channel habitat will remain at Level 3 (side slough, upland slough, backwater, and beaver complex).

The presence, distribution, and frequency of these habitats vary longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. Thus, fish sampling in the Upper River will necessarily vary with habitat and will not be stratified equally among geomorphic reaches (Level 2). Stratification will occur across geomorphic reaches as much as possible but will be dictated by the distribution of habitat types present within each reach. For example, based on preliminary geomorphic reach delineation, we would expect to find multiple split main channel habitats in reaches UR1 and UR6 but not in the more confined and incised reaches UR2 through UR5. In order to ensure that representative habitats are sampled along the Upper River, six replicate sampling sites will be selected within each Level 3 habitat type for fish distribution sampling (27 sites). In addition, one replicate of each Level 4 main channel habitat nested within each Level 3 habitat will be selected for relative abundance sampling (Figure 9.5-2).

Habitat mapping in the tributaries will be completed differently than in the mainstem river due to the lack of complete aerial imagery, relatively smaller channel size, steep gradient, and limited on the ground accessibility for direct mapping. Because of this general inaccessibility, very rugged terrain, and mostly non-wadeable stream channels, near census mapping (100 percent coverage) is challenging and in some cases unsafe or impossible. For these reasons, only tributaries mapped by the Characterization and Mapping of Aquatic Habitats Study (Section 9.9; Table 9.9-2) will be selected for fish distribution and abundance sampling. Up to 18 tributary streams will be targeted for sampling during 2013 and 2014. All tributaries in which Chinook salmon juveniles or adults were observed within or at the mouth of a tributary during 2012, or during previous surveys by Buckwalter (2011) (i.e., Fog Creek, Kosina Creek, Tsusena Creek, Oshetna River), will be sampled. Of the remaining tributaries that are suitable for sampling (Table 9.9-2), efforts will be directed towards streams that are not already identified as supporting anadromous fishes in the ADF&G Anadromous Waters Catalog (AWC). Selected study sites will comprise a target of 25 percent of the mapped habitats in each tributary; this target will vary with access considerations. All known Chinook salmon-bearing tributaries will be sampled up to the 3,000-foot elevation contour, which is based on the known extent of Chinook salmon distribution.

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

9.5.4.2 Sampling Frequency

Sampling frequency will vary among sites based on specific objectives. Generally, sampling will occur seasonally during the ice-free period. Additional effort, up to bi-weekly sampling, will be required immediately following ice-out in an attempt to capture critical juvenile Chinook salmon out-migration from natal tributaries to rearing habitats.

9.5.4.3 Fish Sampling Approach

The initial task of this study will consist of a focused literature review to guide selection of appropriate sampling methods by species and habitat type, sampling event timing, and sampling event frequency. Anticipated products from the literature review include the following:

- A synthesis of existing information on life history, spatial and temporal distribution, and relative abundance by species and life stage.
- A review of sampling strategies, methods, and procedures used in the 1980s fish studies.
- Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).
- A summary of mainstem Susitna River habitat utilization for each species, by riverine habitat type (main channel, side channel, side slough, upland slough, tributary mouth, tributary).
- A summary of existing age, size, and genetics information.
- A summary of distribution of invasive species, such as northern pike.

Knowledge of behavior and life history of the target species is essential for effective survey design. Selected fish sampling techniques will vary based on habitat characteristics, season, and species/ life history of interest. Timing of surveys depends on the objectives of the study and the behavior of the target fish species. Since life stage-specific information is desirable, timing of the survey must match the use of the surveyed habitat by that life stage.

9.5.4.3.1 Objective 1: Fish Distribution, Relative Abundance, and Habitat Associations

Two general approaches to fish sampling will be used. The first is focused on gathering data on general fish distribution (presence/absence). This sampling involves a single pass with appropriate gear types. To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling event at a specific site to evaluate temporal changes in fish distribution. The second sampling approach is to gather data on relative abundance as determined by CPUE and density; complementary data on fish size, age, and condition factor will also be collected. The selected transects and fish capture methods (i.e., number of passes, amount of soak time) will be standardized such that they are repeatable on subsequent sampling occasions. This approach will also emphasize the identification of foraging and spawning habitats.

Long daylight hours during the summer may reduce the difference between day and night sampling effectiveness. The periods of twilight are important sampling periods. Sampling schedules will encompass daylight, twilight, and evening periods.

Task A: Fish Distribution Surveys

Fish distribution surveys will include seasonal sampling events during the ice-free seasons. Methods will be selected based on species, life stage, and water conditions. Snorkeling and electrofishing are preferred methods for juvenile fishes in clear water areas where velocities are safe for moving about in the creek. The use of minnow traps, beach seines, set nets, and fyke nets will be employed as alternatives in deeper waters and habitats with limited access, low visibility, and/or high velocities. For larger/adult fishes, gillnets, seines, trotlines, hoop traps, and angling will be used.

Survey methods will likely vary for the different study areas in the Upper Susitna River. Whereas snorkeling, minnow trapping, backpack electrofishing, and beach seines may be applicable to sloughs and other slow-moving waters, it is anticipated that gillnetting, boat electrofishing, hoop traps, and trot lines may be more applicable to the mainstem. The decisions about what methods to apply will be made by field crews after initial site selection in coordination with Fish Distribution and Abundance Study Lead and the Fish Program Lead and in accordance with state and federal fish sampling permit requirements.

Task B: Relative Abundance

Relative abundance surveys will include seasonal multi-pass sampling events during the ice-free seasons. As mentioned above, methods will be selected based on species, life stage, and water conditions. All methods will be conducted consistent with generating estimates of CPUE that are meaningful and facilitate comparison of counts or densities of fish over space and time. This includes calibration and quality control of methods and documentation of conditions that affect sampling efficiency—such as visibility, water temperature, and conductivity—to ensure that a consistent level of effort is applied over the sampling unit.

Task C: Fish-Habitat Associations

In conjunction with Tasks 1 and 2, data will be collected for fish distribution and abundance by habitat type. This task includes an analysis of fish presence, distribution, and density by mesohabitat type by season. The information on fish habitat use will help identify species and life stages potentially vulnerable to Project effects.

9.5.4.3.2 Objective 2: Seasonal Movements

Task A: Document the timing of downstream movement and catch for all fish species using out-migrant traps.

Understanding the timing of migration from natal tributaries to the mainstem Susitna River and from the Upper Susitna River to the proposed dam site (RM 184) is important for assessing the potential effects of the proposed Project. Out-migrant traps (rotary screw traps and inclined plane traps) are useful for determining the timing of downstream migrating juvenile salmonids and resident fish.

A maximum of two out-migrant traps will be deployed. In addition to collection of data on migratory timing, size at migration, and growth, out-migrant traps will also serve as a platform for tagging juvenile fish (Objective 2, Task C), recapturing previously tagged fish, collecting fish for stomach contents analysis in support of the River Productivity Study (Section 9.8), and collecting tissue samples (Objective 7) to support the Genetic Baseline Study for Selected Fish Species (Section 9.14).

Task B: Describe seasonal movements using biotelemetry.

Biotelemetry techniques will include radio telemetry and PIT technology. PIT tags will be surgically implanted in small fish >60 mm to monitor movement and growth; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Upper River.

PIT tag antenna arrays with automated data logging will be used at selected side channels and tributary mouths to detect movement of tagged fish into or out of the site. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

Radio-tagged fish will be tracked with monthly aerial surveys and by boat, in conjunction with the Salmon Escapement Study (Section 9.7) to describe seasonal movements of selected fish species with emphasis on identifying spawning and overwintering habitats within the hydrologic zone of influence upstream of the Project.

Up to 30 radio transmitters will be implanted in selected species including Arctic grayling, Dolly Varden, burbot, round whitefish, humpback whitefish, and northern pike if present (Objective 6). A PIT tag will be implanted into up to 1,000 fish of these species per PIT tag array that are in close proximity to an array and approximately 60 mm and larger.

Task C: Describe juvenile Chinook salmon movements.

Juvenile Chinook salmon movement within the Upper River will be described using out-migrant traps and biotelemetry methods outlined in Objective 2, Tasks A and B. This study proposes to implant PIT tags in all juvenile Chinook salmon >60 mm in length to document seasonal movement within the Upper River using antenna arrays placed in tributary mouths, sloughs, and side channels and on out-migrant traps to recapture fish. Because of the low number of adult Chinook salmon tracked to the Upper River with radio-tags in 2012, all juvenile Chinook salmon of taggable size need to be tagged to obtain a sufficient sample size. Out-migrant traps will be used to document juvenile Chinook salmon migratory timing and size at migration from natal tributaries to the Upper River and out-migration from the Upper River to below the proposed dam site (RM 184). The data on juvenile Chinook salmon movement patterns and timing will support the Study of Fish Passage Feasibility at Watana Dam (Section 9.11).

9.5.4.3.3 Objective 3: Characterize the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.

In conjunction with Objectives 1 and 2, all captured fish will be identified to species, measured to the nearest millimeter (mm) fork length, and weighed to the nearest gram. Length frequency data by species will be compared to length-at-age data in the literature to infer age classes. Recaptured PIT-tagged fish (Objective 2, Task B) will provide information on changes in length and weight (growth). Recorded parameters in each habitat unit will include number of fish by species and life stage, fork length, global positioning system (GPS) location of sampling area, time of sampling, weather conditions, water temperature, water transparency, behavior, and location and distribution of observations.

9.5.4.3.4 Objective 4: Determine whether Dolly Varden and humpback whitefish residing in the Upper River exhibit anadromous or resident life histories.

Otoliths will be collected from Dolly Varden and humpback whitefish greater than 200 mm (7.8 inches) in length to test for marine-derived elements indicative of an anadromous life history pattern. It is assumed that larger fish are more likely to have exhibited anadromy and therefore otolith collection is proposed only from fish greater than 200 mm in length. A target of 30 fish of each species during 2013 and 2014 will be collected (60 fish of each species total).

9.5.4.3.5 Objective 5: Determine baseline metal and mercury concentrations in fish tissues for resident fish species in the mainstem Susitna River.

Tissue or whole fish samples will also be collected in the mainstem Susitna River for assessment of metals (see Section 5.5.4.7, Baseline Metal Levels in Fish Tissue) and mercury (see Section 5.7.4.2.6, Mercury Assessment and Potential for Bioaccumulation Study) concentrations. Target fish species for baseline metals testing include: Dolly Varden, Arctic grayling, whitefish species, long nose sucker, lake trout, burbot, and resident rainbow trout. Target fish species for mercury sampling include: Dolly Varden, arctic grayling, stickleback, long nose sucker, whitefish species, lake trout, burbot, and resident rainbow trout.

9.5.4.3.6 Objective 6: Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).

Northern pike were likely established in the Susitna River drainage in the 1950s through a series of illegal introductions (Rutz 1999). The proliferation of this predatory species is of concern owing to its effect on salmonids and other species such as stickleback. At this time, northern pike have not been documented in the Upper River, so no targeted collection effort for pike will be made. However, the presence/absence and habitat associations of northern pike and other invasive fish species will be documented as a component of all fish capture and observation sampling events associated with Objectives 1 and 2.

9.5.4.3.7 Objective 7: Collect tissue samples from juvenile salmon and all resident and non-salmon anadromous fish.

In support of the Genetic Baseline Study for Selected Fish Species (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events. The target number of samples, species of interest, and protocols are outlined in Section 9.14. Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

9.5.4.4 Fish Sampling Techniques

A combination of gillnetting, electrofishing, angling, trot lines, minnow traps, snorkeling, out-migrant trapping, beach seines, fyke nets, hoop nets, dual-frequency identification sonar (DIDSON), and underwater video camera techniques will be used to sample or observe fish in the Upper River, and moving in and out of selected sloughs and tributaries draining to the Susitna River. Several assumptions are associated with the use of the proposed methods:

- If it can be conducted safely, snorkeling, electrofishing, and gillnetting will require nighttime sampling in clear-water areas to increase the efficacy of fish capture or observation.
- Gillnetting is likely the most effective means of capturing fish in open-water areas of the main Susitna River channel.
- All fish sampling and handling techniques described within this study will be conducted under state and federal biological collection permits. 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.
- Fish sampling techniques provide imperfect estimates of habitat use and relative fish abundance. Use and comparison of multiple sampling methods provides the opportunity

to identify potential biases, highlight strengths and weaknesses of each method, and ultimately improve estimates of fish distribution and relative abundance.

- Sampling in the reservoir inundation zone will be scaled based on elevation and Chinook salmon distribution. More intensive surveys will be conducted in tributaries to be inundated up to an elevation of 2,200 feet. Sampling from 2,200 feet to 3,000 feet elevation will be focused on Chinook salmon. If Chinook salmon are located, sub-sampling will continue upstream to the upper extent of suitable Chinook salmon habitat.

9.5.4.4.1 Gillnet Sampling

Variable mesh gillnets (7.5-foot-deep panels with 1-inch to 2.5-inch stretched mesh) will be deployed. In open water and at sites with high water velocity, gillnets will be deployed as drift nets, while in slow water sloughs, gillnets will be deployed as set (fixed) nets. The location of each gillnet set will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The length, number of panels, and mesh of the gillnets will be consistent with nets used by ADF&G to sample the river in the 1980s (ADF&G 1982, 1983, 1984). To reduce variability among sites, soak times for drift gillnets will be standardized; all nets will be retrieved a maximum of 30 minutes after the set is completed. The following formula will be used to determine drifting time:

$$T = ([(\text{set time} + \text{retrieval time})/2] + \text{soak time})$$

9.5.4.4.2 Electrofishing

Boat-mounted, barge, or backpack electrofishing surveys will be conducted using standardized transects. Boat-mounted electrofishing is the most effective means of capturing fish in shallow areas (<10 feet deep) near stream banks and within larger side channels. Barge-mounted electrofishing is effective in areas that are wadeable, but have relatively large areas to cover and are too shallow or otherwise inaccessible to a boat-mounted system. Backpack electrofishing is effective in wadeable areas that are relatively narrow. The effectiveness of barge and backpack electrofishing systems can be enhanced through the use of block nets. Electrofishing methods will follow NMFS (2000) Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act.

Sites will be selected carefully, because electrofishing may have limited success in swift, turbid, or low conductivity waters. 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. Sudden changes in turbidity can create zones of higher amperage, which can be fatal to young-of-year fish as well as larger fish. Electrofishing in swift current is problematic, with fish being swept away before they can be netted. Similarly, turbidity increases losses from samples. Electrofishing will be discontinued immediately in a sampling reach if large salmonids or resident fish are encountered.

Selection of the appropriate electrofishing system will be made as part of site selection, which will include a site reconnaissance. In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by Smith Root. The location of each electrofishing transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. To the extent possible, the selected electrofishing system and transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. Habitat measurements will be collected at each site using the characterization methods identified in Section 9.9. Any changes will be noted between sample periods. The electrofishing start and stop times and water conductivity will be recorded. Where safety concerns can be adequately addressed, electrofishing will also be conducted after sunset in clear water areas; otherwise, electrofishing surveys will be conducted during daylight hours.

9.5.4.4.3 Angling

Angling with hook and line can also be an effective way to collect fish samples depending on the target species. During field trips organized for other sampling methods, hook-and-line angling will be conducted on an opportunistic basis using artificial lures or flies with single barbless hooks. The primary objective of hook-and-line sampling will be to capture subject fish for tagging (e.g., northern pike) and to determine presence/absence; a secondary objective will be to evaluate seasonal fish distribution. 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 can also be used in conjunction with other methods, particularly if information is required on the presence and size of adult fish.

9.5.4.4.4 Trot Lines

Trot lines can be an effective method for capturing burbot, rainbow trout, Dolly Varden, grayling, and whitefish. Trotlines are typically a long line with a multitude of baited hooks and are typically anchored at both ends and set in the water for a period of time. Trot line sampling was one of the more frequently used methods during the 1980s and was the primary method for capturing burbot; however, trot lines are generally lethal. Trot lines will consist of 14 to 21 feet of seine twine with six leaders and hooks lowered to the river bottom. Trot lines 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 or whitefish are effective for burbot. Trot line construction and deployment will follow the techniques used during the 1980s studies as described by ADF&G (1982). As 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 solution prior to use.

9.5.4.4.5 Minnow Traps

Minnow traps baited with salmon eggs are an effective method for passive capture of juvenile salmonids in pools and slow-moving water (Bryant 2000). 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. During the 1980s, minnow traps were the primary method used for capturing sculpin, lamprey, and threespine stickleback. Minnow traps also captured rainbow trout and Arctic grayling. Minnow traps will be baited with salmon roe, checked, and rebaited after 90 minutes following protocols outlined by Bryant (2000). Between 5 and 10 minnow traps will be deployed, depending on the size of the sampling site. All fish captured will be identified to species, measured, and released alive near the point of capture. As 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 solution prior to use.

9.5.4.4.6 Snorkel Surveys

This survey technique is most 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. Limits occur when water is turbid or deep due to the inability to see the fish, or the water is too swift to safely survey (Dolloff et al. 1993, 1996). To get relative abundance estimates, a closed population is needed within a single habitat unit, and block nets will be used to prevent fish from leaving the unit (Hillman et al. 1992).

In stream channels with a width of less than 4 m, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 4 m, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. The counts from all snorkelers are then summed for the total count for the reach sampled. This expansion estimate assumes that counts are accurate and that snorkelers are not counting the same fish twice (Thurow 1994). Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

Snorkel surveys will also be used in combination with other techniques to estimate relative abundance. This use of snorkel surveys provides a calibration factor for the counting efficiency of snorkel surveys compared to other methods such as electrofishing and seining (Dolloff et al. 1996).

For most of the snorkel surveys in this study, two experienced biologists will snorkel along standardized transects in clear water areas during both day and night during each field survey effort. Snorkelers will visually identify and record the number of observed fish by size and species. The location of each snorkel survey transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs.

9.5.4.4.7 Fyke/Hoop Nets

Fyke or hoop nets will be deployed to collect fish in sloughs and side channels with moderate water velocity (< 3 feet per second). After a satisfactory location has been identified at each site, the same location will be used during each subsequent collection period. The nets will be operated continuously for up to two days. Each fyke net will be configured with two wings to guide the majority of water and fish to the net mouth. The fyke nets will have 1/8-inch mesh, 1-foot diameter hoops, and up to 4 hoops. 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 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 net throat to hold captured fish until they can be processed. The fyke net wings and live car will be checked daily to clear debris and to ensure that captured fish do not become injured. The location of the fyke net sets will be mapped using a hand-held GPS unit and marked on high-resolution aerial photographs.

9.5.4.4.8 Hoop Traps

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 (Evenson 1993; Stuby and Evenson 1998). Two sizes of traps have been used. Small and large hoop traps are 3.05 meters (m) and

3.66 m long, respectively. The small hoop trap has seven 6.35-mm steel hoops with diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. The large trap has inside diameters tapering from 91 to 69 centimeters (cm) with throat diameters of 36 cm. Each trap has a double throat that narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar 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 will be deployed in mainstem areas of lower velocity to capture burbot from late August through early October for radio-tagging (Objectives 1 and 2). Soak times will generally be overnight, but not more than 12 hours (M. Evenson pers comm 2012). All burbot captured will be measured and released. Up to 10 radio tags will be surgically implanted in burbot spatially distributed throughout the Upper Susitna River.

9.5.4.4.9 Beach Seine

Beach seines are an effective method to capture fish in a wide variety of habitats and are most effective in shallow water areas free of large woody debris and snags such as boulders. 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. Repetitive seining over time with standardized net sizes and standardized deployment in relatively similar habitat can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon (Hayes et al. 1996). Beach seines will be 5 feet in depth and 40 feet in length, 1/4-inch mesh (net body) with a 1/8-inch net bag; however, the actual length of seine used will depend on the site conditions. Low water conditions may be sampled using a shorter and shallower beach seine; as long as the area sampled is noted and the net is deep enough to fill the water column, then comparisons can be made. The location fished will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The area swept will be noted. Repetitive seining over time with standardized nets and soak times in relatively similar habitats can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon. To the extent possible, the same area will be fished during each sampling event; net sizes and soak times will be standardized.

9.5.4.4.10 Out-Migrant Trap

Rotary screw traps are useful for determining the timing of emigration by downstream migrating juvenile salmonids and resident fish (Objective 2). Out-migrant traps will be installed in a maximum of two sites: one site located near the proposed Watana Dam and one site near a tributary mouth. The location will occur with input from the Fish and Aquatic TWG and will be based on the physical conditions at the selected sites and logistics for deploying, retrieving, and maintaining the traps. Flow conditions permitting, traps will be fished on a cycle of 48 hours on, 72 hours off throughout the ice-free period. Each trap will be checked at least twice per day.

9.5.4.4.11 Fish Handling

Field crews will record the date, start and stop times, and level of effort for all sampling events, as well as water temperature and dissolved oxygen at sampling locations. All captured fish will be identified to species. Up to 100 individuals per species per life stage per season will be measured to the nearest mm fork length, and in Focus Areas up to 30 fish per species per site will be measured on a monthly basis. Sampling supplies will be prepared before sampling begins. For example, the date, location, habitat type, and gear type recorded in log book, beginning fish number in proper sequence, daily sample objective by gear type, and an adequate live box and clean area should be available. To increase efficiency, fish should be sampled in order in groups of 10, 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, and (4) cut all dead fish for accurate sex identification. Care will be taken to collect all data with a consistent routine and to record data neatly and legibly.

For methods in which fish are observed, but not captured (i.e., snorkeling, DIDSON, and underwater video), an attempt will be made to identify all fish to species. For snorkeling, fork length of fish observed will be estimated within 40-mm bin sizes. If present, observations of poor fish condition, lesions, external tumors, or other abnormalities will be noted. When more than 30 fish of a similar size class and species are collected at one time, the total number will be recorded and a subset of the sample will be measured to describe size classes for each species. All juvenile salmon, rainbow trout, Arctic grayling, Dolly Varden, burbot, and whitefish greater than 60 mm in length will be scanned for PIT tags using a portable tag reader. A PIT tag will be implanted into a sub-sample of fish of these species that do not have tags and are approximately 60 mm and larger. Because Chinook salmon are of particular interest and in low abundance, all captured juvenile Chinook salmon of taggable size will receive tags. For selected species, up to 1,000 fish per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot. Radio transmitters will be surgically implanted in up to 30 adult fish of sufficient body size of each species and distributed temporally and longitudinally in the Upper River.

In support of the bioenergetics modeling (Objective 5, Section 9.8.4.5.1), fish species targeted for dietary analysis will include juvenile Chinook and coho salmon, juvenile and adult rainbow trout. Of these species Chinook salmon and rainbow trout may be encountered in the Upper River. A total of five fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (described in Section 9.8.4.7). All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis. At two selected sample collection locations (one each in Upper and Middle River), punch samples of muscle tissue will be obtained from each fish for use in the stable isotope analysis (Section 9.8.4.5.2).

Otoliths will be collected from Dolly Varden and humpback whitefish greater than 200 mm (7.8 inches) in length to test for marine-derived elements indicative of an anadromous life history pattern (Objective 4). It is assumed that larger fish are more likely to have exhibited anadromy and therefore it is proposed to collect otoliths only from fish greater than 200 mm. A target of 30 fish of each species during 2013 and 2014 will be collected (60 fish of each species total). Tissue, fillets, and/or liver (burbot only) samples will also be collected in the mainstem Susitna River for assessment of metals concentrations (Objective 5) (see Section 5.5.4.7 Water Quality and Section 5.7.4.2.6, Mercury Assessment and Potential for Bioaccumulation Study). Target fish species in the vicinity of the Watana Reservoir will be Dolly Varden, Arctic grayling, stickleback, whitefish species, burbot, longnose sucker, and resident rainbow trout. If possible, fillets will be sampled from seven adult individuals from each species. Larger, older fish tend to have higher mercury concentrations; these fish will therefore be targeted with a desired sample size of seven per species. Body size targeted for collection will represent the non-anadromous phase of each species' life cycle. For stickleback, whole fish samples will need to be used. Collection times for fish samples will occur in late August and early September.

Tissue samples will be collected opportunistically in conjunction with all fish capture methods from selected resident and non-salmon fish to support the Genetic Baseline Study (Objective 7; Section 9.14). Tissue samples will include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm. The target number of samples, species of interest, and protocols are outlined in Section 9.14.

9.5.4.4.12 Remote Fish Telemetry

Remote telemetry techniques will include radio telemetry and PIT tags. Both of these methods are intended to provide detailed information from relatively few individual fish. PIT tags will be surgically implanted in small fish >60 mm; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Upper River. The target species to radio-tag include Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot. Radio-tracking provides information on fine and large spatial scales related to location, speed of movement, and habitat utilization by surveying large areas and relocating tagged individuals during aerial, boat, and foot surveys. PIT tags can be used to document relatively localized movements of fish as well as growth information from tagged individuals across seasons and years. However, the "re-sighting" of PIT-tagged fish is limited to the sites where antenna arrays are placed. To determine movement in and out of side sloughs or tributaries requires that tagged fish pass within several feet of an antenna array, thereby limiting its use to sufficiently small water bodies. To characterize growth rates, fish must be recaptured, checked for a tag, and measured.

Radio Telemetry

The primary function of the telemetry component is to track tagged fish spatially and temporally 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. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com).

The types of behavior to be characterized include the following:

- 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, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, and foot). Fixed stations will largely be those used for the Salmon Escapement Study (Section 9.7), of which, only one is slated for installation in the Upper River at the Kosina Creek confluence (RM 206.8). Up to three additional fixed stations may be established at strategic locations with input from the Fish and Aquatic TWG. These stations will be serviced in conjunction with the Salmon Escapement Study during the July through October period, but will be extended to begin on June 1 to track resident fish. 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 study area (approximately July through October). At other times of the year, the frequency of aerial surveys will be monthly and during critical species-specific time periods (e.g., burbot spawning), bi-weekly. 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. Foot and boat surveys will be conducted approximately July through October as part of the Salmon Escapement Study (Section 9.7). Spatial and temporal allocation of survey effort will be finalized based on the actual locations and number of each species of fish tagged.

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 habitats. Relocation data from the radio telemetry component of this study will be used to characterize the timing of use and degree of movements among macrohabitats 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 seven target species to be radio-tagged was estimated. Fish weights and the respective target weight of radio-tags (Table 9.5-3) were calculated using existing or derived length–weight relationships for Alaska fish (Figure 9.5-3), and length frequency distributions for Susitna River fish. This analysis illustrates that there is a relatively broad range of potential tag weights (0.5 grams [g] to 81 g) that are necessary to tag each species over the potential range in fish size. Further, it is evident that some species will require tags with a relatively short (30 to 200 days) 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 therefore precludes application to all the species at the lower portion of their most frequently occurring size range (Table 9.5-3). For example, if fish need to weigh a minimum of 200 g to be tagged, then Dolly Varden would be tagged only at its largest samples, and burbot would be tagged almost across its entire adult size range (Table 9.5-3) based on their respective length–frequency distributions.

The use of non-coded tags on the smaller adult fish would require the use of many frequencies (e.g., 50 to 150) and an entirely separate array of receivers. Overall, tagging fish weighing less than 200 g would be expensive and logistically inefficient. The only viable option to cover the entire range of fish sizes would be to use alternative vendors' radio telemetry receivers and tags that use coded technology through the entire range of tag sizes (e.g., Lotek Wireless).

Tags will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally in the Upper River. These fish will be captured during sampling events targeting adult fish and with directed effort using a variety of methods. The final spatial and temporal allocation of tags will be determined after 2012 study results are available (i.e., preliminary fish abundance and distribution). The tag's signal pulse duration and frequency, and, where appropriate, the transmit duty cycle, will be a function of the life history of the fish and configured to maximize battery life and optimize the data collection. Larger tags can accommodate the greatest battery life and therefore will be used when fish are large enough, but smaller, shorter life tags will be used across the range of adult body sizes.

PIT Tag Antenna Arrays

As described above, fish of appropriate size from target species will be implanted with a PIT tagged for mark-recapture studies. Half-duplex PIT tags either 12 mm in length or 23 mm in length will be used, depending on the size of the fish to be implanted. Each PIT tag has a unique code that allows identification of individuals. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in fish length and weight.

PIT tag antenna arrays with automated data logging will be deployed at up to six selected side channel, slough, and tributary mouths to detect movement of tagged fish into or out of the site with particular focus on juvenile Chinook salmon. With input from the Fish and Aquatic TWG, site selection for antenna arrays will be based on habitats and tributaries identified as suitable habitat for juvenile Chinook salmon. A variety of antenna types may be used including hoop antennas, swim-over antennas, single rectangle (swim-through) antennas, or multiplexed rectangle antennas to determine the directionality of movement. Antennas will be deployed shortly after ice-out in 2013. Data loggers will be downloaded every two to four weeks depending on the need to replace batteries and on reliability of logging systems. Power to the antennas will be supplemented with solar panels.

All juvenile Chinook salmon 60 mm or greater in length will be PIT-tagged. For selected species, up to 1,000 fish per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, and burbot.

9.5.4.4.13 DIDSON and Video Cameras

DIDSON and video cameras are proposed to survey selected sloughs and side channels. The 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 of less than four nephelometric turbidity units (NTU). However, Mueller et al. (2006) noted that identifying species and observing habitat conditions were more effective with video cameras than DIDSON cameras.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29-degree field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan sonar images. To obtain high-quality images of adult salmon, the maximum range will be limited to 15 meters (49 feet). Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, spawning, will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., <40 centimeters, 40 – 70 centimeters, >70 centimeters (<5 inches, 25-44 inches, >44 inches, respectively). Although this is not sufficient for definitive species identification, it will allow recognition of smaller resident fish, medium-sized adult salmon, and large Chinook salmon.

Underwater video imaging can record images in real-time over short time intervals and can provide information on fish species presence/absence 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. 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). Video is often combined with a white or infrared (IR) light source especially under ice and in low light northern latitudes; however, lighting may affect fish behavior. Since nighttime 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 that will surround 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. In addition, the video system will be equipped with a digital video recorder for reviewing and archiving footage of fish observations.

9.5.5. Consistency with Generally Accepted Scientific Practices

This study plan was developed by fisheries scientists in collaboration with the Fish and Aquatic TWG and draws upon a variety of methods including many that have been published in peer-reviewed scientific journals. As such, the methods chosen to accomplish this effort are consistent with standard techniques used throughout the fisheries scientific community. However, logistical and safety constraints inherent in fish sampling in a large river in northern latitudes also play a role in selecting appropriate methodologies. In addition, some survey methods may not be used in the mainstem river immediately upstream of Devils Canyon to avoid any risk of being swept into the canyon. During the 1980s studies, no surveys were conducted on the mainstem river from RM 150 to RM 189.0, except for spawning surveys conducted by helicopter.

9.5.6. Schedule

Initial data collection efforts for this multi-year study began in the summer/fall of 2012 and will commence after the FERC study plan determination in early 2013 and continue through October 2014. The schedule allows for two complete open water study seasons. The proposed schedule

(Table 9.5-4) for completion of the Study of Fish Distribution and Abundance in the Upper Susitna River is as follows:

- Initial collection efforts (Chinook salmon spawning surveys and fish trapping targeting juvenile Chinook salmon) in Upper River tributary streams – July to October 2012
- File a supplemental memorandum with the FERC reporting interim 2012 collection results – First quarter 2013
- Development of Implementation Plan and selection of study sites – January to March 2013
- Open water fieldwork – May to October 2013 and May to October 2014
- Reporting of interim results – September 2013 and 2014
- Quality control check of geospatially-referenced relational database – December 2013 and 2014
- Data analysis – October to December 2013 and October to December 2014
- Initial and Revised Study Reports on 2013 and 2014 activities – anticipated to be filed during the first quarter of 2014 and 2015, one and two years, respectively, after the FERC Study Plan Determination (February 2013)

9.5.7. Relationship with Other Studies

Over the study implementation phase, an iterative process of information exchange will take place between interrelated studies that depend upon one another for specimen collection or data. As studies collect and synthesize data, findings will be disseminated to interdependent studies.

In addition to providing baseline information about aquatic resources in the Project area, aspects of this study are designed to complement and support other fish and aquatic studies (Figure 9.5-4). Fish collections in the Upper River will identify species that could colonize the future reservoir site (Section 9.10) and help validate fish periodicity, habitat associations, and selection of target species for reach-specific analyses for the Fish and Aquatics Instream Flow Study (Section 8.5). Patterns of distribution and abundance from traditional sampling methods will help validate and complement information from radio telemetry, fishwheel, and sonar observations of salmon in the Salmon Escapement Study (Section 9.7). The Salmon Escapement Study will provide fixed receiver and aerial tracking of fish radio-tagged in this study. Fish movement, habitat association, and growth data will provide inputs for bioenergetics and trophic analysis modeling for the River Productivity Study (Section 9.8). Additionally, targeted species will be sampled for fish stomach contents in support of the bioenergetics modeling component.

Fish distribution and abundance will complement information about harvest rates and effort expended by commercial, sport, and subsistence fisheries to support the Fish Harvest Study (Section 9.15). Fish collections and observations in conjunction with aquatic habitat characterization will aid in the development of fish and habitat associations for the Characterization and Mapping of Aquatic Habitats Study (Section 9.9). Fish collections will provide data on fish use in sloughs and tributaries with seasonal flow-related or permanent fish barriers for the Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) and will provide information for the Study of Fish Passage

Feasibility at Watana Dam (Section 9.11). Fish tissue sample collections will support the Genetics Baseline Study for Selected Fish Species (Section 9.14) and the Mercury Assessment and Potential for Bioaccumulation Study (Section 5.7).

9.5.8. Level of Effort and Cost

Initial data collection efforts for this multi-year study began in the summer/fall 2012 and will commence after the FERC study plan determination in early 2013 and continue until March 2015. Sampling will be conducted according to a stratified scheme designed to cover a range of habitat types with a minimum of three replicates each. The level of effort at each sample site and sampling frequency will vary based on tasks and objectives. Selection of sampling sites will be influenced by the results of the Characterization and Mapping of Aquatic Habitats Study (Section 9.9) and tributary habitat mapping and fish sampling conducted by AEA during 2012, which may indicate that some tributaries are unsuitable for sampling because of safety issues or passage barriers.

The number and size of sample sites and sampling frequency require a large-scale field effort and subsequent data compilation, as well as quality assurance/quality control (QA/QC) and analysis efforts. Generally:

- Sampling will be conducted seasonally during the ice-free period in all study sites.
- Sampling will be conducted more frequently immediately following break-up to document seasonal movement patterns of juvenile Chinook salmon from natal tributaries to rearing habitats.
- Fish capture and observation methods may include snorkeling, seining, gillnetting, minnow trapping, angling, trot lines, and out-migrant traps depending on stream conditions such as depth, flow, and turbidity, target species, and life stage.
- Field crews will consist of two to four individuals, depending on sampling method used.
- Sampling in remote areas requires helicopter, fixed-wing airplane, and boat support.
- Radio-tracking of tagged fish includes 12 aerial surveys, and foot and boat surveys as necessary.

The estimated cost for implementing the Study of Fish Distribution and Abundance in the Upper Susitna River is $2,500,000.

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9.5.10. Tables

Table 9.5-1. Summary of life history, known Susitna River usage of fish species within the Upper Susitna River Segment (compiled from Delaney et al. 1981).

Common Name	Scientific Name	Life History[a]	Susitna Usage[b]	Distribution[c]
Arctic grayling	*Thymallus arcticus*	F	O, R, P	Low, Mid, Up
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up
Chinook salmon	*Oncorhynchus tshawytscha*	A	M_2, R	Low, Mid, Up
Dolly Varden	*Salvelinus malma*	A,F	O, P	Low, Mid, Up
Humpback whitefish[d]	*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
Round whitefish	*Prosopium cylindraceum*	F	O, M_2, P	Low, Mid, Up
Sculpin[e]	*Cottid*	M_1, F	P	Low, Mid, Up

[a] A = anadromous, F = freshwater, M_1 = marine

[b] O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M_2 = migration

[c] Low = Lower River, Mid = Middle River, Up = Upper River, U = unknown

[d] 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.

[e] 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*).

Table 9.5-2. Proposed methods by objective, task, species, and life stage.

Obj	Task	Species/ Life stage	Study Sites	Proposed Methods by Season
1A	Distribution	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Single pass sampling • Selection of methods will be site-specific, species-specific, and life-stage-specific. • For juvenile and small fish sampling, electrofishing, snorkeling, seining, fyke nets, angling, DIDSON and video camera where feasible and appropriate. • For adults, directed efforts with seines, gillnets, trot lines, and angling. • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Additional info from radio telemetry studies (Objective #2).
1B	Relative abundance	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Multi-pass sampling • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Snorkeling, beach seine, electrofishing, fyke nets, gillnet, minnow traps, fishwheels, out-migrant traps, etc.
1C	Fish habitat associations	Juvenile salmon, non-salmon anadromous, resident	Representative habitat types	• Analysis of data collected under Objective 1: Distribution. Combination of fish presence, distribution, and density by mesohabitat type by season.
2A	Timing of downstream movement and catch using out-migrant traps	All species; juveniles	At selected out-migrant trap & PIT tag array sites	• Out-migrant Traps: Maximum of 2. One near the proposed dam site; one near the mouth of a known Chinook salmon spawning tributary. • Combine with fyke net sampling to identify key site-specific differences. • Sampling in mainstem off-channel habitats downstream of tributaries with fyke nets, seines, and out-migrant traps
2B	Describe seasonal movements using biotelemetry (PIT and radio-tags)	All species	PIT arrays sites River-wide aerial tracking surveys	• PIT tags: tags opportunistically implanted from a variety of capture methods in Focus Areas. Antenna arrays in up to 6 sites at selected side channel, side slough, tributary mouth, and upland sloughs in the Upper River. • Radio-tags surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally & longitudinally.

Obj	Task	Species/ Life stage	Study Sites	Proposed Methods by Season
2C	Describe juvenile Chinook salmon movements	Juvenile Chinook salmon	Representative habitat types	• PIT tag arrays at tributary mouths, sloughs, and side channels (Obj 2B) • Outmigrant trap in known Chinook spawning tributary • DIDSON or underwater video to monitor movement into or out of specific habitats • Monthly measurements of fish size/ growth
5	Document age structure, growth, and condition by season	Juvenile anadromous and resident fish	All study sites for Obj 1B	• Stock biology measurements – length from captured fish up to 100 individuals per season per species per life stage . • Emphasis placed on juvenile Chinook salmon.
6	Seasonal presence/absence and habitat associations of invasive species	Northern pike	All study sites	• Same methods as #1 and #2 above. • The presence/absence of northern pike and other invasive fish species will be documented in all samples • Additional direct efforts with angling as necessary
7	Collect tissue samples to support the Genetic Baseline Study	All	All study sites in which fish are handled	• Opportunistic collections in conjunction with all capture methods listed above. • Tissue samples include axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

Table 9.5-3. Length and weight of fish species to be radio-tagged and respective target radio-tag weights.

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

Table 9.5–4. Schedule for implementation of the Fish Distribution and Abundance in the Upper Susitna River.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Initial Studies and Technical Memo			—		●								
Study Site Selection					—								
Develop and File Implementation Plan					—♦								
Fish Sampling						—	—	—		-- —	—	—	
Data Entry							—	—			—	—	
Preliminary Data Analysis							—	—					
Initial Study Report								—	—Δ				
Final Data Analysis											—	—	
Updated Study Report											—	—	—▲

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
● Technical Memorandum
♦ Implementation Plan
Δ Initial Study Report
▲ Updated Study Report

9.5.11. Figures

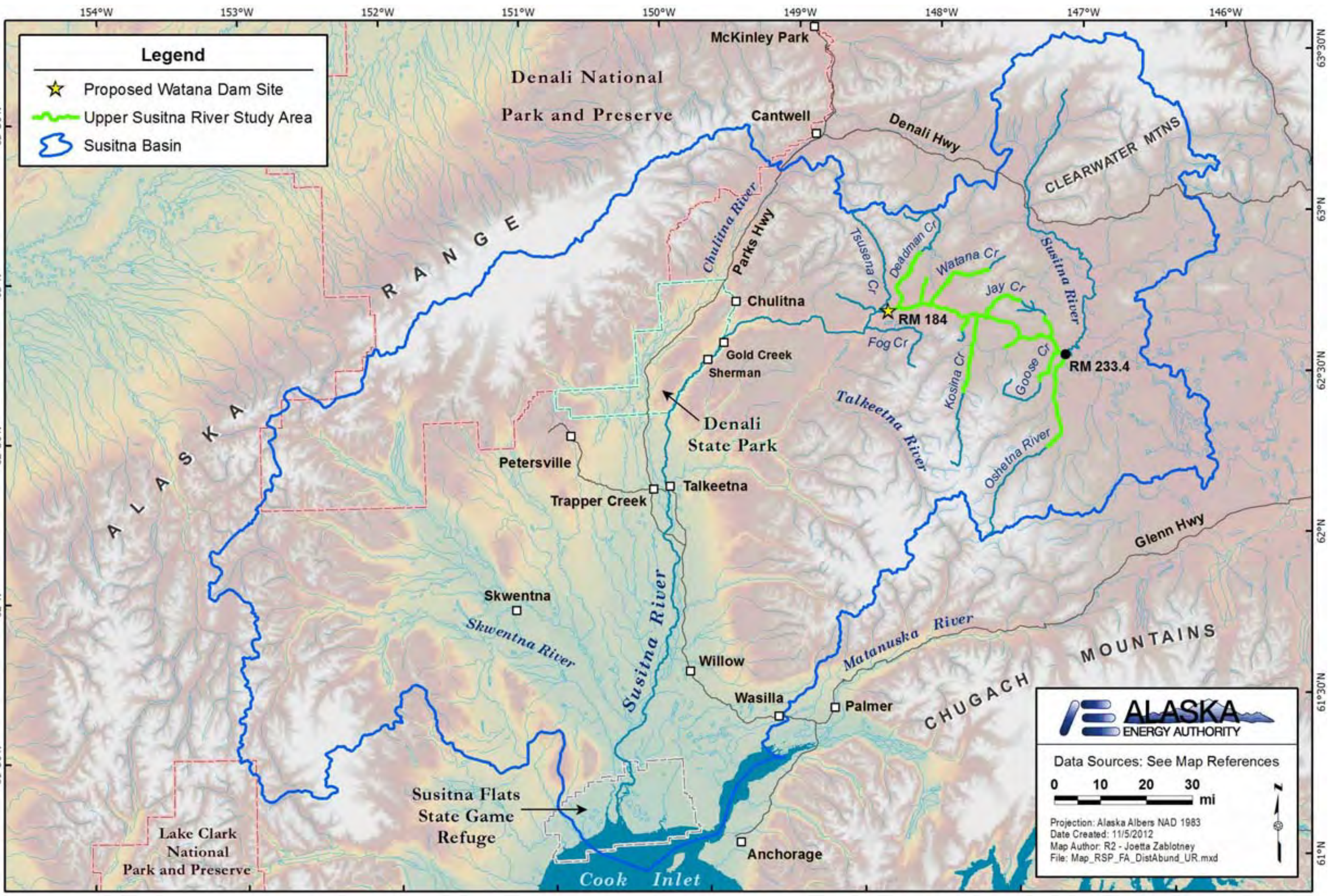

Figure 9.5-1. Fish distribution and abundance study area.

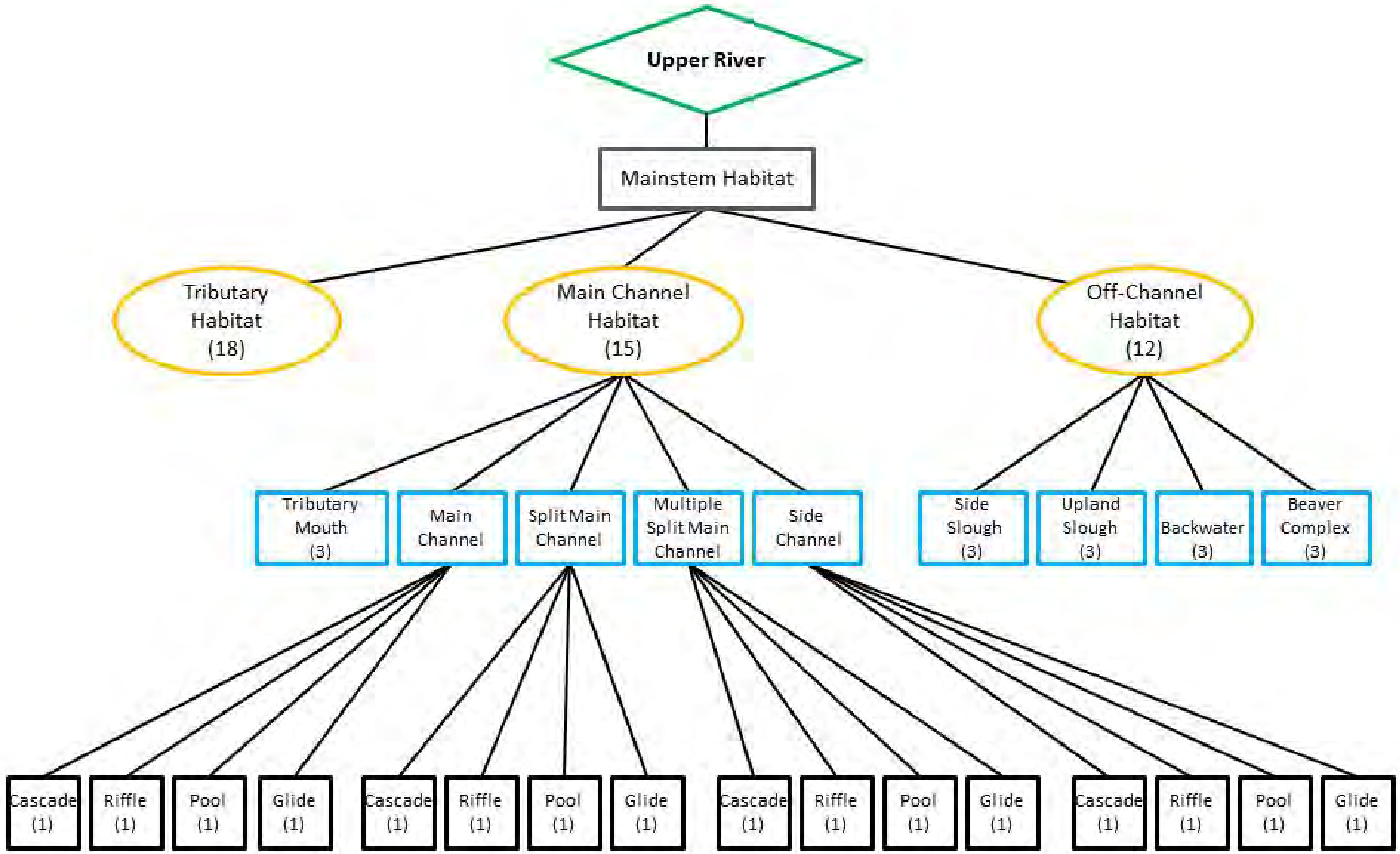

Figure 9.5-2. Schematic showing strata by habitat type for relative abundance sampling for the Upper River. Note that level two stratification within geomorphic reach, is not depicted in this figure because not all habitat types will be present within each geomorphic reach in the Upper River. The selection of habitats to sample will be distributed across geomorphic reaches as described in the Upper Susitna River Fish Distribution and Abundance Implementation Plan and in Section 9.5.4.1.

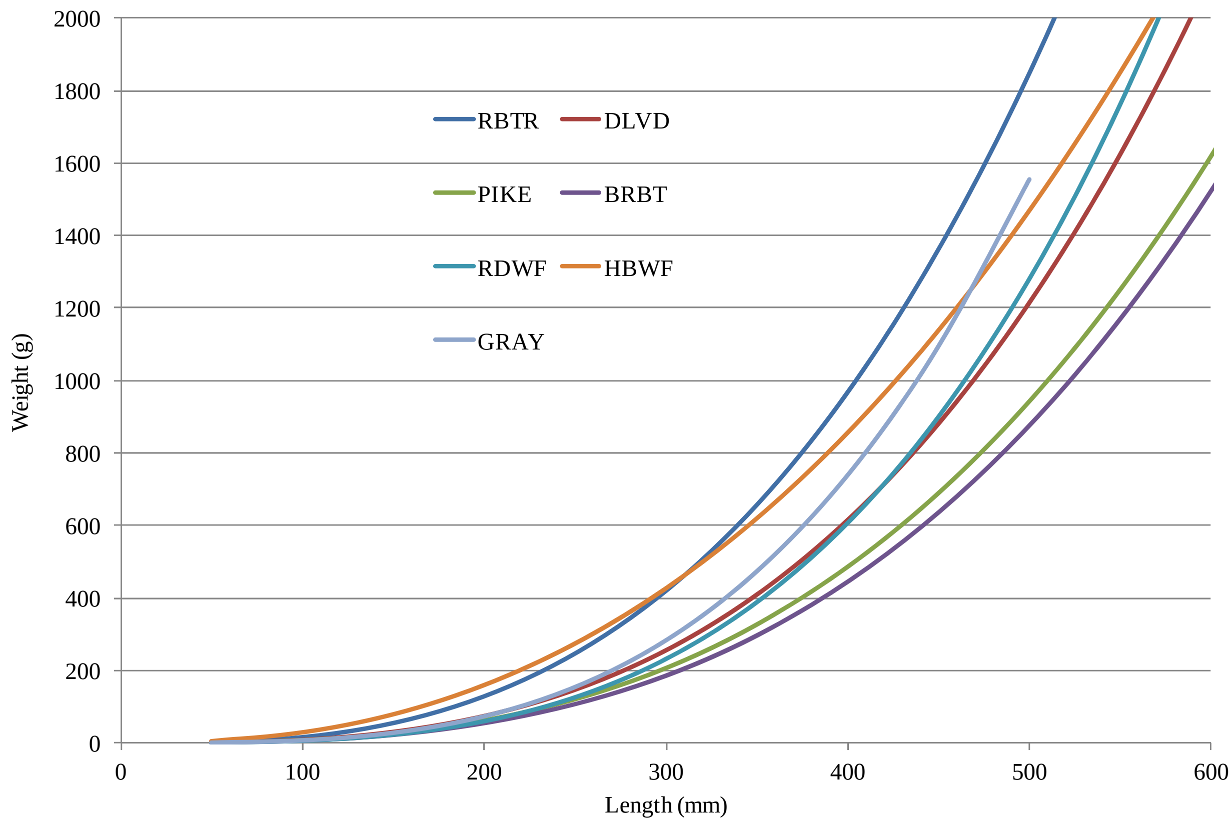

Figure 9.5–3. Existing or derived length–weight relationships for fish species to be radio-tagged.

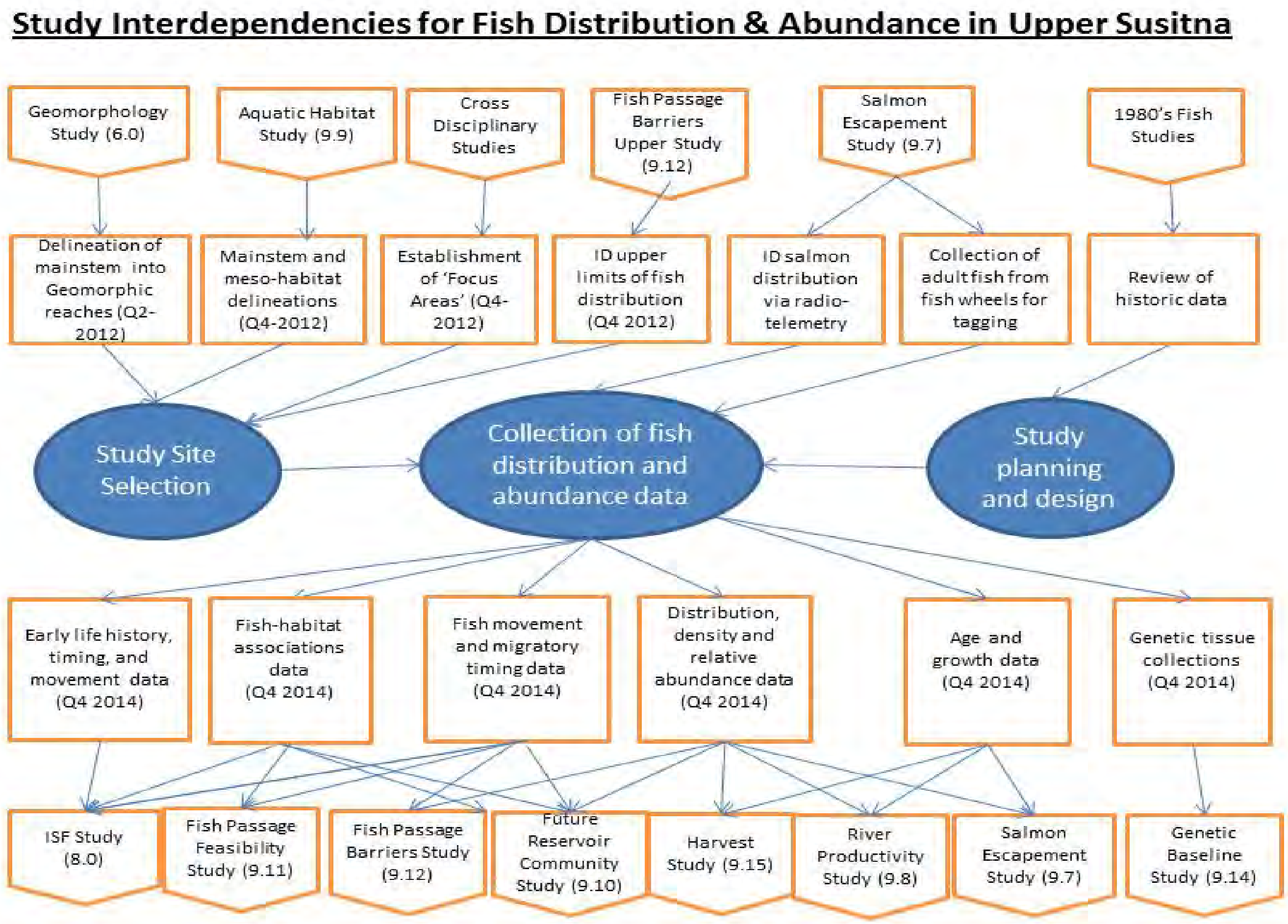

Figure 9.5-4. Flow chart showing study interdependencies for the Fish Distribution and Abundance Study in the Upper River.

9.6. Study of Fish Distribution and Abundance in the Middle and Lower Susitna River

9.6.1. General Description of the Proposed Study

This study is focused 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. Fishery resources in the Susitna River basin consist of a variety of salmonid and non-salmonid resident fish (Table 9.6-1). Adult salmon species are addressed in the Salmon Escapement Study (Section 9.7).

The physical habitat modeling efforts proposed elsewhere in this RSP require information on the distribution and periodicity of different life stages for the fish species of interest. Not all life stages of the target fish species may be present throughout the Middle and Lower Susitna River, and seasonal differences may occur in their use of some habitats. For example, some fish that use tributary streams during the open-water period may overwinter in mainstem habitats such as groundwater-fed sloughs.

This study is designed to provide baseline biological information and supporting information for the Fish and Aquatics Instream Flow Study (Section 8.5). This study will obtain key life history information about the fish in Middle and Lower Susitna River using two sampling approaches. The first sampling approach is focused on gathering data on general fish distribution (presence/absence); this approach generally involves a single pass with appropriate gear types. The second sampling approach is to gather data on relative abundance as determined by catch per unit effort (CPUE) along with complementary data on fish size, age, and condition; this generally involves multi-pass sampling with standardized transects and gear soak times. The second approach will also emphasize the identification of foraging, spawning, and overwintering habitats.

Study Goals and Objectives

Construction and operation of the Project will affect flow, water depth, surface water elevation, water temperature, and sediment dynamics, among other variables, in the mainstem channel as well as at tributary confluences, side channels, and sloughs, both in the area of inundation upstream from the Watana Dam site and downstream in the potential zone of Project hydrologic influence. These changes can have beneficial or adverse effects upon the aquatic communities residing in the river. To assess the effects of river regulation on fish populations, an understanding of existing conditions is needed. Baseline information will be used to predict the likely extent and nature of potential changes that will occur due to the Project’s effects on instream flow and water quality.

The overarching goal of this study is to characterize the current distributions, relative abundances, run timings, and life histories of all resident and non-salmon anadromous species encountered including, but not limited to Dolly Varden, eulachon, humpback whitefish, round whitefish, arctic grayling, northern pike, burbot, and Arctic lamprey, as well as freshwater rearing life stages of anadromous salmonids (fry and juveniles) in the Middle and Lower Susitna River. Specific objectives include the following:

1) Describe the seasonal distribution, relative abundance (as determined by CPUE, fish density, and counts) and fish habitat associations of juvenile anadromous salmonids, non-salmonid anadromous fishes and resident fishes.
2) Describe seasonal movements of juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot, with emphasis on identifying foraging, spawning and overwintering habitats within the mainstem of the Susitna River.
   a. Document the timing of downstream movement and catch using out-migrant traps.
   b. Describe seasonal movements using biotelemetry (passive integrated transponder [PIT] and radio-tags).
3) Describe early life history, timing, and movements of anadromous salmonids.
   a. Describe emergence timing of salmonids.
   b. Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats.
   c. Determine juvenile salmonid diurnal behavior by season.
   d. Collect baseline data to support the Stranding and Trapping Study.
4) Document winter movements and timing and location of spawning for burbot, humpback whitefish, and round whitefish.
5) Document the seasonal age class structure, growth, and condition of juvenile anadromous and resident fish by habitat type.
6) Document the seasonal distribution, relative abundance, and habitat associations of invasive species (northern pike).
7) Collect tissue samples from juvenile salmon and opportunistically from all resident and non-salmon anadromous fish to support the Fish Genetic Baseline Study (Section 9.14).

9.6.2. Existing Information and Need for Additional Information

Information regarding resident species, non-salmon anadromous species, and the freshwater rearing life stages of anadromous salmon was collected as part of the studies conducted during the early 1980s. Existing information includes the spatial and temporal distribution of fish species and their relative abundance. The Pre-Application Document (PAD) (AEA 2011a) and Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011b) summarized this existing information and also identified data gaps for resident and rearing anadromous fish.

Approximately 18 anadromous and resident fish species have been documented in the Susitna River drainage (Table 9.6-1). Three additional species are considered likely to be present, but have not been documented. To varying degrees, the relative abundances and distributions of these species were determined during the early 1980s studies. For most species, the dominant age classes and sex ratios were also determined, and movements, spawning habitats, and overwintering habitats were identified for certain species. Resident species that have been identified in all three segments of the Susitna River include Arctic grayling, Dolly Varden, humpback whitefish, round whitefish, burbot, longnose sucker, and sculpin. Other species that were observed in the Middle and Lower Susitna River Segments include Bering cisco, threespine stickleback, arctic lamprey, and rainbow trout. Eulachon have been documented only in the Lower Susitna River Segment.

Species that have not been documented, but may occur in the Susitna drainage include lake trout, Alaska blackfish, and Pacific lamprey. Lake trout have been observed in Sally Lake and Deadman Lake of the Upper Susitna watershed (Delaney et al. 1981a), but have not been observed in the mainstem Susitna or tributary streams. Pacific lamprey have been observed in the Chuit River (Nemeth et al. 2010), which also drains into Cook Inlet. Northern pike is an introduced species that has been observed in the Lower and Middle Susitna River Segments (Rutz 1999; Delaney et al. 1981b).

Non-salmon species that exhibit anadromous life histories in the Susitna River include eulachon, humpback whitefish, and Bering cisco. Dolly Varden may exhibit both anadromous and resident freshwater life history forms (Morrow 1980); however, Dolly Varden in the Susitna River were regarded primarily as a resident fish during studies conducted in the 1980s (FERC 1984). Other species that can exhibit an anadromous life history include humpback whitefish, threespine stickleback, Arctic lamprey, and Pacific lamprey (Morrow 1980). Northern pike are considered an invasive species in the Susitna drainage and have spread throughout the system from the Yenta drainage after being illegally introduced in the 1950s (Rutz 1999). Alaska blackfish would also be considered an invasive species in this basin, and while not previously captured in the Susitna River, may have been introduced.

Pacific salmon (all five species) were captured in the Lower and Middle Susitna River during the 1980s. Chinook salmon spawn exclusively in tributary streams (Thompson et al. 1986; Barrett 1985; Barrett 1984; Barrett et al. 1983); nearly all Chinook salmon juveniles out-migrate to the ocean as age 1+ fish, and very few exit the system as fry. Coho salmon typically out-migrate to sea as age 1+ or age 2+ fish. Because chum and pink salmon out-migrate to sea within a few months of emergence, little is known about their dependence on the Susitna River. Most age 0+ sockeye salmon out-migrate from the Middle River. It has not been determined whether they rear in the Lower River or if they go to sea at age 0+.

Existing fish and aquatic resource information appears insufficient to address the following issues identified in the PAD (AEA 2011a):

- F4: Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.
- F6: Potential influence of the proposed Project flow regime and the associated response of tributary mouths on fish movement between the mainstem and tributaries within the Middle Susitna River Segment.

- F7: Influence of Project-induced changes to mainstem water surface elevations July through September on adult salmon access to upland sloughs, side sloughs, and side channels.
- F8: Potential effect of Project-induced changes to stream temperatures, particularly in winter, changing the distribution of fish communities, particularly invasive northern pike.

Agency staff have also expressed concerns that over time (i.e., 50 years), historic salmon spawning areas downstream of the Watana Dam site may become less productive due to potential changes in habitat conditions, in particular those areas affected by sediment transport, gravel recruitment, bed mobilization, and embeddedness. Further, understanding the timing of migration of juvenile salmonids from natal habitats to rearing areas and from the Middle Susitna River Segment to the Lower Susitna River Segment is important for assessing the potential Project effects.

Site-specific knowledge of the distribution, timing, and abundance of fish in the Susitna River is available from the results of surveys conducted by the Alaska Department of Fish and Game (ADF&G) during the early 1980s using multiple sampling methods (AEA 2011a). The existing information can provide a starting point for understanding the distribution and abundance of anadromous and resident freshwater fishes in the Susitna River and understanding the functional relationship with the habitat types present. However, any significant differences between current abundance and distribution patterns and those observed during the 1980s need to be documented.

In addition to providing baseline information about aquatic resources in the Project area, aspects of this study are designed to complement and support other fish and aquatic studies.

9.6.3. Study Area

The proposed study area encompasses the Susitna River from RM 61 upstream to the proposed Watana Dam site (RM 184) (Figure 9.6-1). RM 61, near the confluence with the Yentna River, approximates the upper extent of tidal influence and is the lower extent of the Characterization and Mapping of Aquatic Habitats Study (Section 9.9).

9.6.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the distribution and abundance of fish species in the Middle and Lower Susitna River. The following sections provide brief descriptions of study site selection, sampling frequency, the approach, and suite of methods that will be used to accomplish each objective of this study.

Fish Distribution and Abundance Implementation Plan

Some details of the sampling scheme have been provided for planning purposes; however, modifications may be appropriate as the results of 2012 data collection are reviewed. 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 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. Proposed sampling methods by objective are presented below and in Table 9.6-2. Brief descriptions of each sampling technique are provided in Section 9.6.4.4.

9.6.4.1 Study Site Selection

A nested stratified sampling scheme will be used to select study sites to cover the range of habitat types. The habitat classification hierarchy, as described in Section 9.9.5.4.1 of the Habitat Classification Study, will be composed of five levels representing the following: (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; (4) main channel mesohabitat; and (5) edge habitat (Table 9.9-4, Nested and tiered habitat mapping units and categories).

Level 1 separates the Susitna River into three major hydrologic segments: Lower River (RM 61–98), Middle River (RM 98–RM 184), and Upper River (RM 184–233). The Upper River Hydrologic Segment consists of the mainstem Susitna River and its tributaries upstream of the proposed dam (RM 184) and will partially be within the impoundment zone and subject to Project operations that affect daily, seasonal, and annual changes in pool elevation plus the effects of initial reservoir filling (Section 9.5). In contrast, the Middle and Lower Hydrologic Segments include the mainstem downstream of the proposed dam will be subject to the effects of flow modification and water quality from Project operations, which will diminish in the Lower Segment below the Three Rivers Confluence (98.5).

Level 2 identifies unique reaches based on the channel’s geomorphic characteristics (established from the Geomorphology Mapping Study). The Geomorphic Study Team will delineate the Lower, Middle, and Upper Susitna River reaches into large-scale geomorphic river segments with relatively homogeneous landform characteristics, including at generally decreasing scales: geology, hydrology (inflow from major tributaries), slope, channel planform, braiding or sinuosity index (where relevant), entrenchment ratio, channel width, and substrate size. Stratification of the river into relatively homogeneous segments will facilitate relatively unbiased extrapolation of sampled site data within the individual segments because sources of variability associated with large-scale features will be reduced. Stratification will occur across geomorphic reaches as much as possible but will be dictated by the distribution of habitat types present within each reach. For example, based on preliminary geomorphic reach delineation, we would expect to find multiple split main channel habitats in reaches MR 2, 6, and 8 but not in the more confined and incised reaches that include Devils Canyon MR 3, 4, 5, and 7.

Level 3 classifies the mainstem habitat into main channel, off-channel, and tributary habitat using a similar approach to the 1980s historical habitat mapping definitions (ADF&G 1983). The main channel includes five mainstem habitat types, whereas the off-channel habitat will be categorized into four types (Table 9.9-4). The 1980s classification of riverine habitats of the Susitna River included six major mainstem habitat categories consisting of main channel, side channel, side slough, upland slough, tributaries, and tributary mouths (ADF&G 1984). These mainstem habitat categories will be maintained in the 2012 classification system, but they are further categorized into main channel, off-channel, and tributary. These will be expanded to include five types of main channel (main channel, split main channel, multiple split main channel, side channel, and tributary), and four types of off-channel (side slough, upland slough, backwater, and beaver complex) (Table 9.9-4).

Level 4 will further delineate Level 3 main channel and tributary habitats into mesohabitat types (pool, riffle, glide, and cascade) (Table 9.9-4). However, off-channel habitat will remain at Level 3 (side slough, upland slough, backwater, and beaver complex).

The presence, distribution and frequency of these habitats vary longitudinally within the river depending in large part on its confinement by adjoining floodplain areas, size, and gradient. Thus, the fish sampling scheme also varies between the Middle and Lower River. Sampling in the Lower River Segment will focus on relative abundance in Lower River Geomorphic Reach LR1 (RM 61-98.5). This sampling will occur at 27 total sites (Figure 9.6-2) comprising three replicates in each of the four categories of mainstem off-channel habitats (12), three replicates within each of the four mainstem channel categories (12), and three replicates for tributary mouths. Sampling within Lower River Geomorphic Reaches LR2-4 (RM 28-61) and tributaries is not proposed at this time. It is assumed that the flow-related effects of Project operations on mainstem and tributary habitats will be attenuated with increased distance from the dam an increased flow inputs from tributaries and accretion. If results of the 2013 hydrology and geomorphology studies indicate potential effects in Lower River Geomorphic Reaches 2-4 and tributaries, this decision will be revisited during the Fish and Aquatic Technical Working Group (TWG) process early winter of 2013-2014.

In the Middle River, fish distribution sampling will occur at 96 sites (Figure 9.6-3). The number of replicates per habitat unit varies from three for mesohabitats within main channel, split channel, and multiple split main channel to six for most other mainstem habitats (side sloughs, upland sloughs, backwater habitats, beaver complexes, and tributary mouths). Due to the number and varied nature of tributaries, sampling in 18 of the 62 Middle River tributaries is proposed, and the team will select tributaries across the eight geomorphic reaches that represent multiple stream orders; tributaries that have not been previously identified as supporting anadromous fishes in the AWC will be prioritized. For relative abundance sampling, sampling of 54 sites in the Middle River (Figure 9.6-4) is proposed. Sampling will occur throughout the Middle River with the exception of Devils Canyon, where safety concerns prevent access.

Additionally, all “Focus Areas” will be sampled for relative abundance (Figure 9.6–5). Focus Areas are sites in which a full complement of cross-disciplinary intensive studies will occur to enhance the richness of the data. Focus Area sites are being selected based on a combination of recent and historic data along with the professional judgment of the various technical teams. The first selection criterion is to select one or more sites that are considered representative of the stratum or larger river and that contain all habitat types of importance. A suite of criteria includes, but is not limited to geomorphological, riparian/floodplain, fish presence, and habitat characteristics; groundwater, ice, and water quality; and constraints such as safety considerations, raptor nests, land ownership and access. Geospatial data for these individual attributes will be overlain in the Geographic Information System (GIS) to assist in site selection. Approximately 8 Focus Areas are anticipated for the Middle River as well as at least one study site below the Three Rivers Confluence in the Lower River.

Site selection includes completing the geomorphic reach delineation and habitat mapping tasks first. One sampling site representative of each mesohabitat type (side slough, upland slough, side channel, beaver pond, and tributary mouth) present will then be selected for sampling using techniques to determine relative abundance. It is anticipated that 50 Focus Area sites will be sampled (Figure 9.6-5; 10 Focus Areas x 5 habitat types); however it is likely that not all Focus Areas will contain each habitat type, therefore stratification will be finalized after results of habitat mapping have been completed in spring 2013.. In addition to technical considerations, access and safety will be key non-technical attributes for site selection for all studies. This, too, influenced site selection in the 1980s studies, and will certainly influence site selection in the present studies.

Finally, winter sites will be selected based on information gathered from winter 2012–2013 pilot studies at Whiskers Slough and Slough 8A (Section 9.6.4.5). At a minimum, attempts will be made to sample at all Focus Areas. The farthest upstream sites will need to be accessed by air travel; sites closer to Talkeetna may be accessed by snow machine. Safety and access are important considerations for the selection of these sites. Sampling methodologies including, but not limited to, under ice use of Dual Frequency Identification Sonar (DIDSON) and video cameras, minnow traps, seines, trot lines, pit tags, and radio tags will be tested in 2012–2013.

9.6.4.2 Sampling Frequency

Sampling frequency will vary among seasons and sites based on specific objectives. Generally, sampling will occur monthly at all sites for fish distribution and relative abundance surveys during the ice-free season. At Focus Areas, sampling will occur monthly year-round and biweekly after break-up through July 1 to characterize the movements of juvenile salmonids during critical transition periods from spawning to rearing habitats. More information on sampling frequency specific to each objective is presented in Table 9.6-2.

9.6.4.3 Fish Sampling Approach

The initial task of this study will consist of a focused literature review to guide selection of appropriate methods by species and habitat type, sampling event timing, and sampling event frequency. Anticipated products from the literature review include the following:

- A synthesis of existing information on life history, spatial and temporal distribution, and relative abundance by species and life stage.
- A review of sampling strategies, methods, and procedures used in the 1980s fish studies.
- Preparation of periodicity charts for each species within the study area (timing of adult migration, holding, and spawning; timing of incubation, rearing, and out-migration).
- A summary of mainstem Susitna River habitat utilization for each species, by riverine habitat type (main channel, side channel, side slough, upland slough, tributary mouth, tributary).
- A summary of existing age, size, and genetics information.
- A summary of distribution of invasive species, such as northern pike.

Knowledge of behavior and life history of the target species is essential for effective survey design. Selected fish sampling methods will vary based on habitat characteristics, season, and species/ life history of interest. Timing of surveys depends on the objectives of the study and the behavior of the target fish species. Since life stage-specific information is desirable, timing of the survey must match the use of the surveyed habitat by that life stage.

9.6.4.3.1 Objective 1: Fish Distribution, Relative Abundance, and Habitat Associations

Two general approaches to fish sampling will be used. The first is focused on gathering data on general fish distribution (presence/absence). This sampling involves a single pass with appropriate gear types. To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling event at a specific site to evaluate temporal changes in fish distribution. The second sampling approach is to gather data on relative abundance as determined by catch per unit effort (CPUE) density; complementary data on fish size, age, and condition factor will also be collected. The selected transects and fish capture methods (i.e., number of passes, amount of soak time) will be standardized such that it is repeatable on subsequent sampling occasions. This approach will also emphasize the identification of foraging, spawning, and overwintering habitats.

Task A: Fish Distribution Surveys

Fish distribution surveys will include monthly 1-pass sampling events during the ice-free seasons with year-round monthly sampling in Focus Areas. Methods will be selected based on species, life stage, and water conditions. Snorkeling and electrofishing are preferred methods for juvenile fishes in clear water areas where velocities are safe for moving about in the creek. The use of minnow traps, beach seines, set nets, and fyke nets will be employed as alternatives in deeper waters and habitats with limited access, low visibility, and/or high velocities. For larger/adult fishes, gillnets, seines, trotlines, hoop traps, and angling will be used along with the opportunistic use of fishwheels in conjunction with the Salmon Escapement Study (Section 9.7).

Survey methods will likely vary for the different study areas in the Middle and Lower Susitna River Segments. Whereas snorkeling, minnow trapping, backpack electrofishing, and beach seines may be applicable to sloughs and other slow-moving waters, it is anticipated that gillnetting, boat electrofishing, hoop traps, and trot lines may be more applicable to the mainstem. The decisions as to what methods to apply will be made by field crews after initial site selection in coordination with Fish Distribution and Abundance Study Lead and the Fish Program Lead and in accordance with state and federal fish sampling permit requirements. Access may also influence survey methods and will be determined after a reconnaissance visit to the site early in the 2013 field season.

Lastly, methods will vary seasonally with the extent of ice cover. Methods for winter sampling will be based on winter 2012–2013 pilot studies. Selected methods will potentially include DIDSON, underwater video, minnow traps, e-fishing, seines, and trot lines.

Task B: Relative Abundance

Relative abundance surveys will include monthly multi-pass sampling events during the ice-free seasons with year-round monthly sampling in Focus Areas. As mentioned above, methods will be selected based on species, life stage, and water conditions. All methods will be conducted consistent with generating estimates of CPUE that are meaningful and facilitate comparison of counts or densities of fish over space and time. This includes calibration and quality control of methods and documentation of conditions that affect sampling efficiency—such as visibility, water temperature, and conductivity—to ensure that a consistent level of effort is applied over the sampling unit.

Task C: Fish Habitat Associations

In conjunction with Tasks 1 and 2, data will be collected for fish distribution and abundance by habitat type. This task includes an analysis of fish presence, distribution, and density by mesohabitat type by season. The information on fish habitat use will help identify species and life stages potentially vulnerable to Project effects.

9.6.4.3.2 Objective 2: Seasonal Movements

Task A: Document the timing of downstream movement and catch for all fish species using out-migrant traps.

Understanding the timing of migration from natal tributaries to the mainstem Susitna River and from the Middle Susitna River Segment to the Lower Susitna River Segment is important for assessing the potential effects of the proposed Project. Out-migrant traps (rotary screw traps, inclined plane traps) are useful for determining the timing of downstream-migrating juvenile salmonids and resident fish.

Historically, out-migrant traps were fished at Talkeetna Station (historical RM 103) during open water periods from 1982 to 1985 (Schmidt et al. 1983; Roth et al. 1984; Roth and Stratton 1985; Roth et al. 1986) and at Flathorn Station (historical RM 22.4) during 1984 and 1985 (Roth and Stratton 1985; Roth et al. 1986). Data from the 1980s suggests that the majority of Chinook salmon fry out-migrate from natal creeks by mid-August and redistribute into sloughs and side channels of the Middle River or migrate to the Lower River (Roth and Stratton 1985; Roth et al. 1986).

A maximum of six out-migrant traps will be deployed. Up to three traps will be stationed in the mainstem Susitna River to characterize downstream migratory timing. Specific locations will be determined with input from the Fish and Aquatic TWG. Because Chinook salmon are predominantly tributary spawners, out-migrant traps will also be deployed in tributary mouths such as Portage Creek, Indian River, and Whiskers Creek. In addition to collection of data on migratory timing, size at migration, and growth, out-migrant traps will also serve as a platform for tagging juvenile fish (Objective 2, Task B), recapturing previously tagged fish, and collecting tissue samples (Objective 7) to support the Genetic Baseline Study (Section 9.14).

Task B: Describe seasonal movements using biotelemetry.

Biotelemetry techniques will include radio telemetry and PIT technology. PIT tags will be surgically implanted in small fish >60 mm to monitor movement and growth; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally in the Middle and Lower River.

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. Additionally, swim-over antennas will be deployed on an experimental basis at five sites prior to ice-over and maintained throughout the winter months. All juvenile Chinook salmon of appropriate size will be PIT-tagged; other target species will be tagged based on proximity to PIT antenna arrays with a goal of 1,000 tags per species per PIT tag array. Target species are juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot. Recaptured fish will provide information on the distance and time travelled since the fish was last handled and changes in length (growth).

Radio-tagged fish will be tracked with monthly aerial surveys, by boat, and by snow machine in conjunction with the Salmon Escapement Study. The goal is to implant 30 radio transmitters per target species including Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, burbot, and rainbow trout.

9.6.4.3.3 Objective 3: Early Life History

Task A: Describe emergence timing of salmonids.

In conjunction with the Intergravel Monitoring component of the Fish and Aquatics Instream Flow Study (Section 8.5.4), salmon redds in selected side channels and sloughs will be monitored on a monthly basis throughout the winter in Focus Areas. Because chum salmon and sockeye salmon are the principal salmon species using side channels and side sloughs for spawning in the Susitna River (Sautner et al. 1984), 1980s egg development and incubation studies were conducted on these two species and focused on chum salmon. Studies included monitoring of surface and intergravel water temperatures, egg development, spawning substrate composition, and trapping of emergent fry.

Sample sites will be selected in known chum and/or sockeye salmon spawning locations within Focus Areas. Because water temperature is the most important determinant of egg development and the timing of emergence (Quinn 2005), a component of the Fish and Aquatics Instream Flow Study (Section 8.5.4) will include continuous monitoring stations for collection of temperature data. Following methods used in the 1980s, fyke nets will be used to capture emerging fry on a biweekly basis beginning in mid-April in each of the monitored side channels.

Task B: Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats.

Bi-weekly sampling of fish distribution (Objective 1, Task A) from ice-out through July 1 will occur in Focus Areas to identify changes in fish distribution by habitat type. Sampling methods will include snorkeling, seining, electrofishing, minnow traps, fyke nets, and out-migrant traps (Objective 2, Task A). Biotelemetry cannot be used for this task because juvenile salmonids will be too small to tag at this life stage.

Task C: Determine juvenile salmonid diurnal behavior by season.

Selected sloughs in Focus Area sites will be sampled based on results from the Winter 2012–2013 Pilot Study comparing the efficacy of underwater video and DIDSON for fish observation. A stratified random sampling program over a 24-hour period will be developed to observe underwater activity and ultimately to identify juvenile overwintering behavior to support stranding and trapping analyses. Holes will be drilled in the ice where no open leads exist in a few select sloughs; fish observation apparatus will also be deployed in open leads with low velocity at pre-determined observation points. This task will be implemented in conjunction with the Intergravel Monitoring component of the Fish and Aquatics Instream Flow Study (Section 8.5.4). Depending on the efficacy of underwater imaging techniques, they may be adopted for use during the ice-free season at selected Focus Area sites. Alternatively, sampling stratified by time of day using various techniques including but not limited to downstream migrant traps, seining, fyke nets, minor traps and possibly electrofishing will be used to characterize the diurnal distribution of juvenile salmonids.

Task D: Collect baseline data to support the Fish Stranding and Trapping Study.

Susceptibility to stranding can vary with fish size and species. Based on a review of available literature, the Washington Department of Fish and Wildlife (Hunter 1992) concluded that salmonid fry smaller than 50 mm in length are most susceptible to stranding whereas larger life stages (i.e., fingerlings, smolts, and adults), while also vulnerable, can be protected by less restrictive ramping criteria. Related to this, size (or life stage) periodicity will dictate the seasonal timing during which vulnerable size classes may be present in the varial zone. Stranding and trapping susceptibility may also vary by species based on differences in periodicity, as well as species-specific habitat preferences and behavior. The focus of this task is to support the stranding and trapping component of the Fish and Aquatics Instream Flow Study (Section 8.5.4). Fish distribution sampling will occur at Focus Areas and at representative habitat units to identify seasonal timing, size, and distribution among habitat types for fish (particularly < 50 mm). Electrofishing, seining, fyke nets, and minnow traps will be the primary methods for collecting salmon fry. Additional fish size data from downstream migrant traps (Objective 2, Task A) will help identify when fish exceed the 50-mm length threshold.

9.6.4.3.4 Objective 4: Document Winter Movements and Timing and Location of Spawning for Burbot, Humpback Whitefish, and Round Whitefish

Radio-tags will be surgically implanted in up to 30 burbot, humpback whitefish, and round whitefish. Fish capture methods include fishwheels, gillnets, hoop traps, and angling. Radio-tagged fish will be tracked by air, boat, and snow machine (Section 9.6.4.4.12). Following methods outlined by Sundet (1986), radio-tag locations will be pin-pointed in winter with snow machines, and trot lines will be set in the area of the radio-tag to identify winter spawning aggregations and capture additional fish. The gonadal development of each captured fish will be examined to determine spawning status; the gonads for all sampling mortalities will be preserved for laboratory examination. The timing and location of all captured fish will be documented.

9.6.4.3.5 Objective 5: Document the Seasonal Age Class Structure, Growth, and Condition of Juvenile Anadromous and Resident Fish by Habitat Type

In conjunction with Objectives 1 and 3, all captured fish will be identified to species. Up to 100 per season per species per life stage will be measured to the nearest millimeter (mm) fork length, and in Focus Areas up to 30 fish per species per site will be measured on a monthly basis. Length frequency data by species will be compared to length-at-age data in the literature to infer age classes. Recaptured PIT-tagged fish (Objective 2 Task B) will provide information on changes in length and weight (growth). Recorded parameters in each habitat unit will include number of fish by species and life stage; fork length; global positioning system (GPS) location of sampling area, time of sampling, weather conditions, water temperature, water transparency, behavior, and location and distribution of observations. In concert with Objective 3 Task D, seasonal timing, size, and distribution of fishes among habitat types, particularly fish <50 mm, will be used to support the Fish Stranding and Trapping Study.

9.6.4.3.6 Objective 6: Document the Seasonal Distribution, Relative Abundance, and Habitat Associations of Invasive Species (Northern Pike)

Northern pike were likely established in the Susitna River drainage in the 1950s through a series of illegal introductions (Rutz 1999). The proliferation of this predatory species is of concern owing to their effect on salmonids and other species such as stickleback. Rutz (1999) investigated movements of northern pike in the Susitna River using radio telemetry and investigated northern pike predation on salmonids by analyzing stomach contents of juveniles captured with minnow traps. Both of these fish capture methods used by Rutz (1999) will be used in the current study, as well as angling, to capture northern pike. The presence/absence and habitat associations of northern pike and other invasive fish species will be documented in all fish capture and observation sampling events associated with Objectives 1 and 2.

9.6.4.3.7 Objective 7: Collect Tissue Samples from Juvenile Salmon and All Resident and Non-Salmon Anadromous Fish

In support of the Fish Genetic Baseline Study (Section 9.14), fish tissues will be collected opportunistically in conjunction with all fish capture events. The target species and number of samples are given in Section 9.14. Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

9.6.4.4 Fish Sampling Techniques

A combination of gillnet, electrofishing, angling, trot lines, minnow traps, snorkeling, fishwheels, out-migrant trapping, beach seines, fyke nets, DIDSON, and video camera techniques will be used to sample or observe fish in the Lower River and Middle River, and moving in and out of selected sloughs and tributaries draining into the Susitna River. Selected methods will vary based on habitat characteristics, season, and species/life history of interest. All fish sampling and handling techniques described within this study will be selected in consultation with state and federal regulatory agencies and sampling will be conducted under state and federal biological collection permits. 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.

9.6.4.4.1 Gillnets

Variable mesh gillnets (7.5-foot deep panels with 1-inch to 2.5-inch stretched mesh) will be deployed. In open water and at sites with high water velocity, gillnets will be deployed as drift nets, while in slow water sloughs, gillnets will be deployed as set (fixed) nets. Depending on conditions, gillnets may be deployed in ice-free areas, and under the ice during winter months. The location of each gillnet set will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The length, number of panels, and mesh of the gillnets will be consistent with nets used by ADF&G to sample the river in the 1980s (ADF&G 1982, 1983, 1984). To reduce variability among sites, soak times for drift gillnets will be standardized; all nets will be retrieved a maximum of 30 minutes after the set is completed. The following formula will be used to determine drifting time:

$$T = ([(\text{set time} + \text{retrieval time})/2] + \text{soak time})$$

9.6.4.4.2 Electrofishing

Boat-mounted, barge, or backpack electrofishing surveys will be conducted using standardized transects. Boat-mounted electrofishing is the most effective means of capturing fish in shallow areas (<10 feet deep) near stream banks and within larger side channels. Barge-mounted electrofishing is effective in areas that are wadeable, but have relatively large areas to cover and are too shallow or inaccessible to a boat-mounted system. Backpack electrofishing is effective in wadeable areas that are relatively narrow. The effectiveness of barge and backpack electrofishing systems can be enhanced through the use of block nets. Electrofishing methods will follow NMFS (2000) *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act*.

Sites will be selected carefully, because electrofishing may have limited success in swift, turbid, or low conductivity waters. 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. Sudden changes in turbidity can create zones of higher amperage, which can be fatal to young-of-year fish as well as larger fish. Electrofishing in swift current is problematic, with fish being swept away before they can be netted. Similarly, turbidity increases losses from samples. Electrofishing will be discontinued immediately in a sampling reach if large salmonids or resident fish are encountered.

Selection of the appropriate electrofishing system will be made as part of site selection, which will include a site reconnaissance. In all cases, the electrofishing unit will be operated and configured with settings consistent with guidelines established by Smith Root. The location of each electrofishing transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. To the extent possible, the selected electrofishing system and transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. Habitat measurements will be collected at each site using the characterization methods identified in Section 9.9. Any changes will be noted between sample periods. The electrofishing start and stop times and water conductivity will be recorded. Where safety concerns can be adequately addressed, electrofishing will also be conducted after sunset in clear water areas; otherwise, electrofishing surveys will be conducted during daylight hours.

9.6.4.4.3 Angling

Angling with hook and line can also be an effective way to collect fish samples depending on the target species. During field trips organized for other sampling methods, hook-and-line angling will be conducted on an opportunistic basis using artificial lures or flies with single barbless hooks. The primary objective of hook-and-line sampling will be to capture subject fish for tagging (i.e., northern pike) and to determine presence/absence; a secondary objective will be to evaluate seasonal fish distribution. 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 can also be used in conjunction with other methods, particularly if information is required on the presence and size of adult fish.

9.6.4.4.4 Trot Lines

Trot lines can be an effective method for capturing burbot, rainbow trout, Dolly Varden, grayling, and whitefish. Trot lines are typically long lines with a multitude of baited hooks and are typically anchored at both ends and set in the water for a period of time. Trot lines can also be used during periods of winter ice cover. Trot line sampling was one of the more frequently used methods during the 1980s and was the primary method for capturing burbot; however, trot lines are generally lethal. Trot lines will consist of 14 to 21 feet of seine twine with six leaders and hooks lowered to the river bottom. Trot lines 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 the herring or whitefish are effective for Trot line construction and deployment will follow the techniques used during the 1980s studies as described in ADF&G (1982). As 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 solution prior to use.

9.6.4.4.5 Minnow Traps

Minnow traps baited with salmon eggs are an effective method for passive capture of juvenile salmonids in pools and slow-moving water (Bryant 2000). 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. During the 1980s, minnow traps were also the primary method used for capturing sculpin, lamprey, and threespine stickleback. Minnow traps also captured rainbow trout and Arctic grayling. Minnow traps will be baited with salmon roe, then checked and rebaited after 90 minutes following protocols outlined by Bryant (2000). Between 5 and 10 minnow traps will be deployed, depending upon the size of the sampling site. All fish captured will be identified to species, measured, and released alive near the point of capture. As 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 solution prior to use.

9.6.4.4.6 Snorkel Surveys

This survey technique is most 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. Limits occur when water is or deep due to the inability to see the fish, or the water is too swift to safely survey (Dolloff et al. 1993, 1996). To get relative abundance estimates, a closed population is needed within a single habitat unit, and block nets will be used to prevent fish from leaving the unit (Hillman et al. 1992).

In stream channels with a width of less than 4 m, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 4 m, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. The counts from all snorkelers are then summed for the total count for the reach sampled. This expansion estimate assumes that counts are accurate and that snorkelers are not counting the same fish twice (Thurow 1994). Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

Snorkel surveys will also be used in combination with other techniques to estimate relative abundance. This use of snorkel surveys provides a calibration factor for the counting efficiency of snorkel surveys compared to other methods such as electrofishing and seining (Dolloff et al. 1996).

For most of the snorkel surveys in this study, two experienced biologists will snorkel along standardized transects in clear water areas during both day and night during each field survey effort. Snorkelers will visually identify and record the number of observed fish by size and species. The location of each snorkel survey transect will be mapped using hand-held GPS units and marked on high-resolution aerial photographs.

9.6.4.4.7 Fyke/Hoop Nets

Fyke or hoop nets will be deployed to collect fish in sloughs and side channels with moderate water velocity (< 3 feet per second). After a satisfactory location has been identified at each site, the same location will be used during each subsequent collection period. The nets will be operated continuously for up to two days. Each fyke net will be configured with two wings to guide the majority of water and fish to the net mouth. The fyke nets will have 1/8-inch mesh, 1-foot diameter hoops, and up to 4 hoops. 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 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 net throat to hold captured fish until they can be processed. The fyke net wings and live car will be checked daily to clear debris and to ensure that captured fish do not become injured. The location of the fyke net sets will be mapped using a hand-held GPS unit and marked on high-resolution aerial photographs.

9.6.4.4.8 Hoop Traps

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 (Evenson 1993; Stuby and Evenson 1998). Two sizes of traps have been used. Small and large hoop traps are 3.05 m and 3.66 m long, respectively. The small hoop trap has seven 6.35-mm steel hoops with diameters tapered from 0.61 m at the entrance to 0.46 m at the cod end. The large trap has inside diameters tapering from 91 to 69 cm with throat diameters of 36 cm. Each trap has a double throat that narrows to an opening 10 cm in diameter. All netting is knotted nylon woven into 25-mm bar 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 will be deployed in mainstem areas of lower velocity to capture burbot from late August through early October for radio-tagging (Objectives 1, 2, and 4). Soak times will generally be overnight, but not more than 12 hours (M. Evenson pers comm 2012). All burbot captured will be weighed, measured, and released. Up to 30 radio-tags will be surgically implanted in burbot spatially distributed throughout the Susitna River.

9.6.4.4.9 Beach Seines

Beach seines are an effective method to capture fish in a wide variety of habitats and are most effective in shallow water areas free of large woody debris and snags such as boulders. 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. Repetitive seining over time with standardized net sizes and standardized deployment in relatively similar habitat can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon (Hayes et al. 1996). Beach seines will be 4 feet in depth and 40 feet in length, ¼-inch mesh (net body) with a 1/8-inch net bag; however, the actual length of seine used will depend on the site conditions. Low water conditions may be sampled using a shorter and shallower beach seine; as long as the area sampled is noted and the net is deep enough to fill the water column, then comparisons can be made. The location fished will be mapped using hand-held GPS units and marked on high-resolution aerial photographs. The area swept will be noted. Repetitive seining over time with standardized nets and soak times in relatively similar habitats can be an effective way to quantify the relative abundance of certain species over time and space, especially for small juvenile migrating salmon. To the extent possible, the same area will be fished during each sampling event; net sizes and soak times will be standardized.

9.6.4.4.10 Out-Migrant Traps

Rotary screw traps are useful for determining the timing of emigration by downstream-migrating juvenile salmonids and resident fish (Objective 2). In the 1980s, out-migrant trapping occurred at Talkeetna Station (RM 103) during open water periods from 1982 to 1985 to determine migratory timing and size at migration to the Lower Susitna River throughout the time traps were operating (Schmidt et al. 1983; Roth et al. 1984; Roth and Stratton 1985; Roth et al. 1986). Peak catch often occurred during periods of high flows. Out-migrant traps were also fished at Flathorn Station (RM 22.4) during 1984 and 1985.

Selection of rotary screw trap locations will occur with input from the Fish and Aquatic TWG and will be based on specific species, the physical conditions at the selected sites, and logistics for deploying, retrieving, and maintaining the traps. Up to six out-migrant traps will be deployed. Three to four traps will be located in mouths of important tributary streams or spawning areas such as Fog Creek, Kosina Creek, Portage Creek, Indian Creek, and possibly Gold Creek and Whiskers Slough. The remaining two or three traps will be situated in the main channel to describe the broad timing of out-migrants from all upstream sources. Flow conditions permitting, traps will be fished on a cycle of 48 hours on, 72 hours off throughout the ice-free period. Each trap will be checked at least twice per day.

9.6.4.4.11 Fishwheels

Fishwheels will primarily be deployed to capture anadromous salmon as part of the Adult Salmon Escapement Study (Section 9.7). However, non-salmon species are occasionally captured by fishwheel. Non-salmon species collected by fishwheel will provide additional data to support the objectives of this study and will be used opportunistically as a source of fish for tagging studies and tissue sampling.

9.6.4.4.12 Remote Fish Telemetry

Remote telemetry techniques will include radio telemetry and PIT technology. Both of these methods are intended to provide detailed information from relatively few individual fish. Radio-tracking provides information on fine and large spatial scales related to the location, speed of movement, and habitat utilization by surveying large areas and relocating tagged individuals during aerial, boat, and foot surveys. The target species to radio-tag include Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic grayling, burbot, and rainbow trout. PIT tags will be surgically implanted in small fish >60 mm; radio transmitters will be surgically implanted in adult fish of sufficient body size of selected species distributed temporally and longitudinally throughout the Susitna River. The target species to PIT-tag include juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot. PIT tags can be used to document relatively localized movements of fish as well as growth information from tagged individuals across seasons and years. However, the “re-sighting” of PIT-tagged fish is limited to the sites where antenna arrays are placed. To determine movement in and out of side sloughs or tributaries requires that tagged fish pass within several feet of an antenna array, thereby limiting its use to sufficiently small water bodies. To characterize growth rates, fish must be recaptured, checked for a tag, and measured.

Radio Telemetry

The primary function of the telemetry component is to track these tagged fish spatially and temporally 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. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com).

The types of behavior to be characterized include the following:

- 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, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

Locating radio-tagged fish will be achieved by fixed receiver stations and mobile surveys (aerial, boat, snow machine, and foot). Fixed stations will largely be those used for the Salmon Escapement Study. In addition, up to five additional fixed stations will be established at strategic locations with input from the TWG. 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 study area (approximately July through October). At other times of the year, the frequency and location of aerial surveys will be at least monthly and bi-weekly during critical species-specific time periods (e.g., burbot spawning). Telemetry surveys will also be conducted by boat, snow machine, and on foot to obtain the most accurate and highest resolution positions of spawning 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 will be visited to obtain individual fish positions. Foot and boat surveys will be conducted approximately July through October as part of the spawning ground and habitat sampling in the Salmon Escapement Study. Spatial and temporal allocation of survey effort will be finalized based on the actual locations and number of each species of fish tagged.

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 habitats. Relocation data from the radio telemetry component of this study will be used to characterize the timing of use and degree of movements 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 seven target species to be radio-tagged has been estimated. Fish weights and the respective target weight of radio-tags (Table 9.6-3) were calculated using existing or derived length–weight relationships for Alaska fish (Figure 9.6-6), and length frequency distributions for Susitna River fish. 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. Further, it is evident that some life stages will require tags with a relatively short (30- to 200-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 therefore precludes application to all of the species at the lower portion of their most frequently occurring size range (Table 9.6–3). For example, if fish need to weigh a minimum of 200 g to be tagged, then Dolly Varden would be tagged only at its largest samples, and burbot would be tagged almost across its entire range (Table 9.6–3) based on its respective length–frequency distributions.

The use of non-coded tags on the smaller fish would require the use of many frequencies (e.g., 50–150) and an entirely separate array of receivers. Overall, tagging fish weighing less than 200 g would be expensive and logistically inefficient. The only viable option to cover the entire range of fish sizes would be to use alternate vendors' radio telemetry receivers and tags that use coded technology through the entire range of tag sizes (e.g., Lotek Wireless).

Tags will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally throughout the Middle and Lower River. These fish will be captured opportunistically during sampling events targeting adult fish and with directed effort using a variety of methods. Preference will be given fish caught with more benign techniques that cause minimal harm and stress to fish. The final spatial and temporal allocation of tags will be determined after 2012 study results are available (i.e., preliminary fish abundance and distribution). The tag's signal pulse duration and frequency, and, where appropriate, the transmit duty cycle, will be a function of the life history of the fish and configured to maximize battery life and optimize the data collection. Larger tags can accommodate the greatest battery life and therefore will be used when fish are large enough, but smaller, shorter-life tags will be used across the range of body sizes.

PIT Tag Antenna Arrays

Half-duplex PIT tags either 12 mm in length or 23 mm in length will be used, depending upon the size of the fish. 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).

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 variety of antenna types may be used including hoop antennas, swim-over antennas, single rectangle (swim-through) antennas, or multiplexed rectangle antennas to determine the directionality of movement.

Up to 10 sites will be selected with input from the Fish and Aquatic TWG for deploying PIT tag antenna arrays. Antennas will be tested in the Winter 2012–2013 Pilot Study and deployed shortly after ice-out in 2013 (See Section 9.6.4.5). Data loggers will be downloaded every two to four weeks, depending on the need to replace batteries and the reliability of logging systems. Power to the antennas will be supplemented with solar panels.

PIT tag arrays will be tested in a 2012 pilot study. Assuming the pilot testing is successful, swim-over antennas will be deployed at five sites prior to ice-over and will be maintained throughout the winter months. Downloading of data and battery replacement every three to four weeks, weather permitting, will be the objective during winter months. Depending on the detectability of tags during the winter of 2012–2013 Winter Pilot Study, winter deployment of antennas may be expanded during the two subsequent winter field seasons. Data on fish growth and movements into and out of habitats will inform bioenergetics and trophic analysis modeling in the River Productivity Study.

All juvenile Chinook salmon of appropriate size will be PIT-tagged. For other target species, up to 1,000 tags per species per PIT tag array will be tagged based on proximity to PIT arrays. Target species are juvenile salmonids and selected fish species such as rainbow trout, Dolly Varden, humpback whitefish, round whitefish, northern pike, Arctic lamprey, Arctic grayling, and burbot.

9.6.4.4.13 DIDSON and Video Cameras

Pending results of the 2012–2013 winter pilot study, the use of DIDSON and video cameras is proposed to survey selected sloughs and side channels. The sloughs will be the same as those selected for the wintertime deployment of PIT tag antennas. The 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 (NTU). In addition to fish observations, video cameras may also be used to characterize micro-habitat attributes such as the presence of anchor ice, hanging dams, macrophytes, structure, and substrate type. Depending on the efficacy of underwater imaging techniques, they may be adopted for use during the ice-free season at selected Focus Area sites.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29-degree field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan images. To obtain high-quality images of adult salmon, the maximum range will be limited to 15 meters (49 feet). Within this field of view, evidence of spawning behavior, e.g., redd digging, chasing, and spawning, will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., <40 centimeters, 40–70 centimeters, >70 centimeters (<25 inches, 25–44 inches, >44 inches, respectively). Although this is not sufficient for definitive species identification, it will allow recognition of smaller resident fish, medium-sized adult salmon, and large Chinook salmon.

Underwater video imaging can record images in real-time over short time intervals and can provide information on fish species presence/absence 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. 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). Video is often combined with a white or infrared (IR) light source especially under ice and in low light northern latitudes; however, lighting may affect fish behavior. Since nighttime 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 that will surround 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. In addition, the video system will be equipped with a digital video recorder for reviewing and archiving footage of fish observations.

9.6.4.4.14 Fish Handling

Field crews will record the date, start and stop times, and level of effort for all sampling events, as well as water temperature and dissolved oxygen at sampling locations. All captured fish will be identified to species. Up to 30 individuals per species per life stage per site will be measured to the nearest millimeter (mm) fork length. Sampling supplies will be prepared before sampling begins. For example, the date, location, habitat type, and gear type recorded in log book, beginning fish number in proper sequence, daily sample objective by gear type, and an adequate live box and clean area should be available. To increase efficiency, fish should be sampled in order 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, and (4) cut all dead fish for accurate sex identification. Care will be taken to collect all data with a consistent routine and to record data neatly and legibly.

For methods in which fish are observed, but not captured (i.e., snorkeling, DIDSON, and underwater video), an attempt will be made to identify all fish to species. For snorkeling, fork length of fish observed will be estimated within 40-mm bin sizes. When fish are captured observations of poor fish condition, lesions, external tumors, or other abnormalities will be noted if present. When more than 30 fish of a similar size class and species are collected at one time, the total number will be recorded and a subset of the sample will be measured to describe size classes for each species. All juvenile salmon, rainbow trout, Arctic grayling, Dolly Varden, burbot, longnose sucker, and whitefish greater than 60 mm in length will be scanned for PIT tags using a portable tag reader. A PIT tag will be implanted into up to 1,000 fish of these species per PIT tag array that do not have tags and are in close proximity to an array and approximately 60 mm and larger. Radio transmitters will be surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally and longitudinally throughout the Susitna River.

In support of the bioenergetics modeling component of the River Productivity Study (Section 9.8), targeted fish species will be collected for dietary analysis. These species include juvenile coho salmon, juvenile and adult rainbow trout, and juvenile and adult northern pike, as identified in consultation with agencies and other licensing participants. A total of five fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods. All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis.

Tissue samples will be collected opportunistically in conjunction with all fish capture methods from selected resident and non-salmon fish to support the Genetic Baseline Study (Objective 7; Section 9.14). Tissue samples include an axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm. The target number of samples, species of interest, and protocols are outlined in Section 9.14.

The number of fish per species or species assemblage and the handling protocols will be determined with input from the Fish and Aquatics TWG and the Subsistence Group for species consumed by humans, and the Wildlife TWG for piscivorous furbearers and birds.

9.6.4.5 Winter Sampling Approach

Over the 2012/2013 winter, pilot studies will be conducted at the Whiskers Slough (RM 101-102) and Slough 8A (RM 125-126) Middle Segment Focus Area sites of the Susitna River. These sites were selected based on their accessibility from Talkeetna, because they contain a diversity of habitat types, and because sampling in the 1980s and 2012 revealed that these sites were used for spawning as well as rearing by salmonids. Three winter pilot studies will be initiated in 2012–2013 focusing on (a) intergravel temperature, D.O., and water level monitoring; (b) winter fish observations using DIDSON and underwater video; and (c) winter fish sampling techniques.

Overall study objectives for the winter pilot study include:

1. Evaluate the effectiveness and feasibility of winter sampling methods for each study including: intergravel temperature, D.O. and water level monitoring, underwater fish observations via DIDSON sonar and underwater video, and fish populations using minnow traps, seines, electrofishing, trotlines, PIT tags, and radio tags.
2. Assess winter sampling logistics. This includes safety, sampling methods in different habitat types under varying degrees of ice cover, transportation and access to and from sample sites, travel time, and winter-specific gear needs.
3. Evaluate the feasibility of sampling during spring break up.

Develop recommendations for 2013–2014 study plans.

Intergravel Temperature Monitoring

For the intergravel temperature component (Section 8.5.4.5.1.2.1), a detailed sampling design will subsequently be developed that will be based on a stratified random sampling approach. Both Whiskers Slough and Slough 8A will be stratified into specific habitat types (Beaver complex, backwater, side slough, upland slough, tributary mouth, mainchannel) within which 10-12 candidate monitoring sites will be randomly selected. Special emphasis will be giving to including areas with known fish spawning. Dissolved oxygen will be measured in conjunction with intergravel temperature at one location at each of the two Focus Areas. To the extent possible, locations with groundwater upwelling will be distinguished from seepage locations that may represent lateral intergravel flow from mainstem Susitna River surface flow. Sites will include areas of recent spawning activity as well as areas with no spawning activity. Depending on individual site characteristics, temperature monitoring devices will be installed at locations of 1) groundwater upwelling, 2) bank seepage and lateral flow from mainstem, 3) mixing between upwelling and bank seepage, 4) no apparent intergravel discharge, fish spawning, and 5) main channel Susitna River flow.

At each intergravel temperature monitoring location, Hobo TidBit temperature probes will be deployed at three separate gravel depths (5 cm, 20 cm, and 35 cm) corresponding to observed burial depth ranges of chum and sockeye eggs (Bigler and Levesque 1985, DeVries 1997). Intergravel temperature probes will be attached to stainless steel cable and inserted into the gravel using a scour chain installation device (Nawa and Frissell 1993). Additional above gravel temperature recorders will be co-located at a subset of the intergravel sampling sites. These latter devices allow for the downloading of temperature data without removing the recorders from the gravel and allow for the detection of differences between surface and groundwater temperature. The D.O. sensors (HOBO D.O. logger with optical sensor) will likewise be inserted into the gravel to a depth of approximately 20 centimeters using a stainless steel cable. In addition, a series of pressure transducers (Solinst level loggers) will be deployed at the upper and lower ends of select side channel and slough habitats and in adjoining areas of the main channel Susitna River to monitor water surface elevations and stage response with changes in main channel stage. The final number and location of monitoring sites will vary depending on site conditions and safety concerns.

The temperature, D.O., and pressure transducers will be deployed in January 2012 following the chum and sockeye salmon spawning period and will be retrieved in April 2013 prior to ice break-up. Data from the above gravel recorders will be downloaded on a monthly basis and will occur concurrently with times specified as part of the under ice fish observation study.

Underwater Fish Observations

Under-ice fish observations will be made using DIDSON sonar and underwater video cameras. The two systems will be run concurrently in tannic water to determine which method is more effective for underwater fish observations in varying water clarity. Underwater video and DIDSON sonar observations will be made during the January–April 2013 sampling. Video sampling will occur in both slough and side channel habitats in the same general study sites as the intergravel temperature recorders. Observation will take place in 5 locations in Whiskers Slough and 6 locations in Slough 8A. A stratified random sampling program over a 24-hour period will be developed to observe underwater activity during day and nighttime conditions and ultimately to identify juvenile overwintering behavior to support stranding and trapping analyses. In addition to fish observations, Habitat Suitability Criteria (HSC) sampling methods will be used to characterize local habitat characteristics (velocity, water depth, substrate, cover, etc.) throughout the winter at all observed fish locations. Water velocity and depth measurements will be made either through the ice (ice holes) or in open water leads using a topset wading rod and Price AA meter. Channel substrate composition will be visually characterized using a modified Wentworth size scale. HSC measurements will only be collected at those fish observations points where positive fish species identification and estimates of total length can be made.

Winter Fish Sampling Techniques

Winter fish sampling will employ multiple methods to determine which are most effective for each fish species, life stage, and habitat type. Because sampling efforts will occur in both open water 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 water sites, the fish capture methods will be 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 detectability of tags fish under ice cover.

All fish sampling will occur once a month from January through March 2013 and will be coordinated with the intergravel temperature monitoring and the underwater fish observation components.

Trot Lines

Trot lines will be used to capture resident fish species including burbot, whitefish, Arctic grayling and possibly rainbow trout and Dolly Varden. This was the primary method for sampling resident fish (mostly burbot and whitefish) used by ADF&G during the 1980s winter studies (Sundet 1986). Following methods outlined by ADF&G, trotlines will be 15 to 20 feet in length with 6 hooks and leaders weighted to the bottom of the river. Holes will be drilled in the ice with a two-man ice auger. Trot lines will be baited with salmon roe or herring and set for 24 hours at a time once a month from January through March. Trot lines will be set in main channel sites at Whiskers Slough and at Slough 8A within slough (Figures 9.6-7 and 9.6-8). Sites will be marked with a hand-held GPS to ensure that sites can be relocated and resampled during future sampling events. All captured fish will be identified to species, measured for length, and. gonads examined to determine spawning status. The gonads for all sampling mortalities will be preserved for laboratory examination. Tissue samples will be collected from all captured fish and sent to the ADF&G Conservation Genetics Lab for genetic analysis.

Minnow Traps

Minnow traps will be deployed in attempt to capture juvenile salmonids and other juvenile resident fish species overwintering in mainstem and slough habitats. Minnow traps were a common winter method utilized by ADF&G in 1980s and were found to be effective for anadromous and resident juvenile fish species (Stratton 1986) but also were able to catch non-target species such as stickleback, sculpin and lamprey. Minnow traps will be deployed in the same holes drilled for trotlines, baited with salmon roe and set for 24 hours. Minnow traps will be deployed at 8 sites at Whiskers Slough and 3 sites at Slough 8A monthly from January – March 2013. Minnow trapping locations will be marked with hand-held GPS units in order to resample the same habitats each month. All captured fish will be identified to species, measured, and released to the stream unharmed.

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. Beach seines will be used in shallow, open-water reaches free of woody debris and boulders and will be swept through the water walking upstream. Seines will be 15 and 25 feet wide by 5 feet depth with ¼ inch mesh. Locations of the habitats seined will be marked with hand-held GPS units such that transects are standardized and repeatable. Single passes with beach seines will occur at multiple locations between sites on a monthly basis. All fish captured by beach seining will be identified to species, measured for length, and returned to the stream unharmed.

Electrofishing

Single-pass backpack electrofishing surveys will be conducted in open-water leads (i.e., sloughs and side channels) in 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. The electrofishing start and stop times and water conductivity will be recorded. To the extent possible, the selected electrofishing sites and transects will be standardized and the methods will be repeated during each sampling period at each specific site to evaluate temporal changes in fish distribution. All captured fish will be identified to species, measured for length, and returned to the stream unharmed.

PIT Tag Arrays

Using 12 and 23 mm PIT tags and a mobile antenna array, we will test PIT tag detection in varying ice thickness. This pilot effort will help determine the maximum depth of ice that 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 down stream 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 PIT tags can be detected.

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). 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 down stream under the ice. Mobile antenna arrays will be used to determine the maximum ice thickness and distance radio tags can be detected.

9.6.5. Consistency with Generally Accepted Scientific Practices

This study plan was developed by fisheries scientists in collaboration with the Fish and Aquatic TWG and draws upon a variety of methods including many that have been published in peer review scientific journals. As such, the methods chosen to accomplish this effort are consistent with standard techniques used throughout the fisheries scientific community. However, logistical and safety constraints inherent in fish sampling in a large river in northern latitudes also play a role in selecting appropriate methodologies. To describe the seasonal distribution, relative abundance, and habitat associations of the various fish species in winter, alternative methods involving snorkel and dive surveys were considered. These alternative methods were dismissed based on safety concerns owing to potentially extreme cold temperatures and remoteness of the sampling locations, and because sampling would most appropriately be conducted at night.

9.6.6. Schedule

Initial data collection efforts for this multi-year study will begin with the Winter Pilot Study (January-April 2013) and will continue through March 2015. The schedule allows for two open water and three ice-over study seasons. The proposed schedule for the completion of the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River Segments is given below and in Table 9.6-4:

- Conduct Winter Pilot Studies to inform 2013/14 and 2014/15 efforts – January through April 2013
- Development of Implementation Plan and selection of study sites – January through March 2013
- Continuation of Field studies after FERC Study Plan Determination – May 2013 through March 2015

- Refined methods for winter sampling methods based on results of Winter 2012-2013 Pilot Study – June 2013
- Reporting of interim results – September 2013 and September 2014
- Quality control check of geospatially-referenced relational database – December 2013 and December 2014
- Data analysis – October to December 2013 and October to December 2014
- Initial and Revised Study Reports on 2013 and 2014 activities – anticipated to be filed during the first quarter of 2014 and 2015, one and two years, respectively, after the FERC Study Plan Determination (February 2013)
- Supplemental technical memorandum on winter 2014–2015 effort – May 2015

9.6.7. Relationship with Other Studies

Over the two-year study implementation phase, an iterative process of information exchange will take place between interrelated studies that depend upon one another for specimen collection or data (Figure 9.6-9). Planning milestones include: segment delineation (Q2 2012) from the Geomorphology Study (Section 6.0), mesohabitat delineation (Q4 2012) from the Aquatic Habitat Study (Section 9.9), and Focus Area selection (Q4 2012) by the interdisciplinary study (Section 8.5) will aid in site selection and development of the detailed Fish Distribution and Abundance in the Middle and Lower Susitna River Implementation Plan (Q1 2013). In addition to review of historic studies, the intergravel temperature component of the ISF Study (Q1 2013; Section 8.5) and the Winter Pilot Study (Q1 2013; Section 8.5 and 9.6.4.5) will aid with the estimation of fry emergence timing and planning and development of the Fish Distribution and Abundance in the Middle and Lower Susitna River Implementation Plan (Q1 2013). Delivery of information on spawning site locations and fishwheel collections from the Salmon Escapement Study (9.7) will occur in an iterative fashion during the migration and spawning seasons.

Data checked for quality on fish distribution from this study will be provided to many studies including the Instream Flow Study (Section 8.5) in the fourth quarter of 2014 to validate fish periodicity, habitat associations, and selection of target species for reach-specific analyses. Additionally, data collected on movement patterns and growth will be delivered to the Fish and Aquatics Instream Flow Study (Section 8.5) in the fourth quarter of 2014 to aid in the identification of seasonal timing, size and distribution among habitat types for fish (particularly < 50 mm) in support of the stranding and trapping component. Distribution and abundance data will be delivered to the Salmon Escapement Study (Section 9.7) in the fourth quarter of 2014 help validate and complement information from radio telemetry, fishwheel, and sonar observations of adult salmon. Fish movement, habitat association, and growth data will provide inputs for bioenergetics and trophic analysis modeling in the fourth quarter of 2014, a component of the River Productivity Study (Section 9.8). Further, target species will be sampled iteratively throughout the course of the study for fish stomach contents in support of bioenergetics modeling (Section 9.8). The opportunistic collection of tissue samples will occur iteratively throughout the course of the study and be coordinated with the Fish Genetics Study (Section 9.14). Information gathered on fish distribution and abundance will be delivered to the Fish Harvest Study (Section 9.15) in the fourth quarter of 2014 to complement information about harvest rates and to better understand commercial, sport, and subsistence fisheries. Fish collections and observations in conjunction with aquatic habitat characterization (Aquatic Habitat Study, Section 9.9) will occur iteratively throughout the course of the study and aid in the development of fish and habitat associations. In fourth quarter of 2014, fish collections will provide data on fish use in sloughs and tributaries with seasonal flow-related or permanent fish barriers to better classify barrier or corroborate the Fish Passage Barriers Study (Section 9.12).

9.6.8. Level of Effort and Cost

This is a multi-year study that will begin in early 2013 and end in March 2015. The study will include two winter periods and two ice-free periods. Sampling will be conducted according to a stratified sampling scheme designed to cover the range of habitat types with a minimum of six replicates each. The level of effort at each sample site and sampling frequency will vary based on tasks and objectives. The number and size of sample sites and sampling frequency require a large-scale field effort and subsequent data compilation, quality assurance/quality control (QA/QC), and analysis efforts. Generally:

- Sampling will be conducted monthly during the ice-free seasons in all study sites and year-round in Focus Area sites.
- Sampling will be conducted bi-weekly from ice-out through July 1 in selected Focus Areas to document seasonal movement patterns of juvenile salmonids from spawning to rearing habitats.
- Fish capture and observation methods may include snorkeling, seining, gillnetting, minnow trapping, angling, trot lines, out-migrant traps, DIDSON, and underwater video depending on stream conditions such as depth, flow, turbidity, target species, and life stage.
- Field crews will consist of two to four individuals, depending on the sampling method used.
- Sampling in remote areas requires helicopter, fixed-wing airplane, snow machine, and boat support.
- Radio-tracking of tagged fish includes 12 aerial surveys, and foot, boat, and snow machine surveys as necessary.

Total study costs are estimated at $4,500,000.

9.6.9. Literature Cited

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9.6.10. Tables

Table 9.6-1. Summary of life history, known Susitna River usage, and known extent of distribution of fish species within the Lower, Middle, and Upper Susitna River Segments (from ADF&G 1981 a, b, c, etc.).

Common Name	Scientific Name	Life History[a]	Susitna Usage[b]	Distribution[c]
Alaska blackfish	*Dallia pectoralis*	F	U	U
Arctic grayling	*Thymallus arcticus*	F	O, R, P	Low, Mid, Up
Arctic lamprey	*Lethenteron japonicum*	A,F	O, M_2, R, P	Low, Mid
Bering cisco	*Coregonus laurettae*	A	M_2, S	Low, Mid
Burbot	*Lota lota*	F	O, R, P	Low, Mid, Up
Chinook salmon	*Oncorhynchus tshawytscha*	A	M_2, R	Low, Mid, Up
Chum salmon	*Oncorhynchus keta*	A	M_2, S	Low, Mid
Coho salmon	*Oncorhynchus kisutch*	A	M_2, S, R	Low, Mid
Dolly Varden	*Salvelinus malma*	A,F	O, P	Low, Mid, Up
Eulachon	*Thaleichthys pacificus*	A	M_2, S	Low
Humpback whitefish[d]	*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	M_2, R	Low, Mid
Rainbow trout	*Oncorhynchus mykiss*	F	O, M_2, P	Low, Mid
Round whitefish	*Prosopium cylindraceum*	F	O, M_2, P	Low, Mid, Up
Sculpin[e]	*Cottid*	M_1[f], F	P	Low, Mid, Up
Sockeye salmon	*Oncorhynchus nerka*	A	M_2, S	Low, Mid
Threespine stickleback	*Gasterosteus aculeatus*	A,F	M_2, S, R, P	Low, Mid

[a] A = anadromous, F = freshwater, M_1 = marine

[b] O = overwintering, P = present, R = rearing, S = spawning, U = unknown, M_2 = migration

[c] Low = Lower River, Mid = Middle River, Up = Upper River, U = Unknown

[d] 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.

[e] 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*).

[f] Pacific staghorn sculpin were found in freshwater habitat within the Lower Susitna River Segment.

Table 9.6-2. Proposed methods by objective, task, species, and life stage.

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
1A	Distribution	Juvenile salmon, non-salmon anadromous, resident	Focus Areas + representative habitat types Select Focus Areas (accessible)	Ice Free Season: • Single pass sampling • Selection of methods will be site-specific, species-specific, and life-stage-specific. • For juvenile and small fish sampling, electrofishing, snorkeling, seining, fyke nets, angling, DIDSON and video camera where feasible and appropriate. • For adults, directed efforts with seines, gillnets, trot lines, and angling. • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Additional info from radio telemetry studies (Objective #2). Winter: • Based on winter 2012-2013 pilot studies • Potentially DIDSON, video camera, minnow traps, e-fishing, seines, and trot lines.
1B	Relative abundance	Juvenile salmon, non-salmon anadromous, resident	Focus Area study sites + representative habitat types	• Multi-pass sampling • To the extent possible, the selected transects will be standardized and the methods will be repeated during each sampling period at a specific site to evaluate temporal changes in fish distribution. • Snorkeling, beach seine, electrofishing, fyke nets, gillnet, minnow traps, fishwheels, out-migrant traps, etc.
1C	Fish habitat associations	Juvenile salmon, non-salmon anadromous, resident	Focus Area study sites+ representative habitat types	• Analysis of data collected under Objective 1: Distribution. Combination of fish presence, distribution, and density by mesohabitat type by season.

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
2A	Timing of downstream movement and catch using out-migrant traps	All species; juveniles	At selected out-migrant trap & PIT tag array sites	• Out-migrant Traps: Maximum of 6. 2-3 Main channel to indicate broad timing of out-migrants from all upstream sources. 3-4 in tributary mouths and sloughs, such as Fog Creek, Kosina Creek, Portage Creek, Indian Creek and possibly Gold Creek and Whiskers Slough. Combine with fyke net sampling to identify key site-specific differences. • Sampling in mainstem off-channel habitats downstream of tributaries with fyke nets, seines, and out-migrant traps • Fishwheels (adults only) opportunistically in conjunction with the Salmon Escapement Study
2B	Describe seasonal movements using biotelemetry (PIT and radio-tags)	All species		<u>Ice-Free Season:</u> • PIT tags: tags opportunistically implanted in target species from a variety of capture methods in Focus Areas. Antenna arrays in up to 10 sites at selected side channel, side slough, tributary mouth, and upland sloughs in the Middle River and Lower River. • Radio-tags surgically implanted in up to 30 individuals of sufficient body size of each target species distributed temporally and longitudinally. . <u>Winter</u>: • Based on winter 2012-2013 pilot studies. • Potentially DIDSON, video camera, minnow traps, electrofishing, seines and trot lines. • Aerial tracking of radio-tags (adults).
3A	Describe emergence timing of salmonids;	Juvenile salmonids	Select Focus Areas	• Bi-weekly sampling using fyke nets, seines, electrofishing and minnow traps in salmon spawning areas within Focus Areas.
3B	Determine movement patterns and timing of juvenile salmonids from spawning to rearing habitats;	Juvenile salmonids	Focus Areas	• Focus on timing of emergence and movement of newly emergent fish from spawning to rearing areas or movement of juvenile fish <50 mm in winter (i.e., the post-emergent life stages most vulnerable to load-following operations) • DIDSON or underwater video to monitor movement into or out of specific habitats
3C	Determine juvenile salmonid diurnal behavior by season	Juvenile salmonids	Focus Areas	• Stratified time of day sampling to determine whether fish are more active day/night • DIDSON and/or video camera methods to observe fish activity • Potentially electrofishing and seining

Obj	Task	Species/ Life Stage	Study Sites	Proposed Methods by Season
3D	Collect baseline data to support the Stranding and Trapping Study		Focus Areas + supplement with additional representative habitat types as necessary.	• Opportunistic support to ID seasonal timing, size and distribution among habitat types for fish <50 mm in length. • Estimate presence/absence, relative abundance, and density using similar methods as Objectives 1A, 1B, 1C, and 2 for fish <50 mm • Focus on slough and other mainstem off-channel habitats • DIDSON, video camera, electrofishing, seines, out-migrant traps and fyke nets. • Monthly measurements of fish size/ growth
4	Winter movements, timing, and location of spawning	burbot, humpback whitefish, and round whitefish	Mainstem habitats	• Radio-tags surgically implanted in up to 30 fish of sufficient body size of each species distributed temporally & longitudinally. • To capture burbot for radio-tagging, use hoop traps late Aug-early Oct following methods by Evenson (1993). • To capture whitefish for radio-tagging, use fishwheels opportunistically and directed efforts including angling, seines & gillnets. • Use aerial & snow machine tracking of radio-tags to pinpoint winter aggregations of fish; sample these areas with trot lines (similar to 1980s). Trot lines are lethal sampling. • Collect, examine, and preserve gonads to determine spawning status.
5	Document age structure, growth, and condition by season	juvenile anadromous and resident fish	All study sites for Obj 1B and Focus Areas	• Stock biology measurements- length from captured fish up to 100 individuals per season per species per life stage and up to 30 fish per month per species per habitat type in Focus Areas. • Emphasis placed on juvenile salmonids <50mm. • Opportunistically support Stranding and Trapping Study
6	Seasonal presence/absence and habitat associations of invasive species	northern pike	All study sites	• Same methods as #1 and #2 above. • The presence/absence of northern pike and other invasive fish species will be documented in all samples • Additional direct efforts with angling as necessary
7	Collect tissue samples to support the Genetic Baseline Study	All	All study sites in which fish are handled	• Opportunistic collections in conjunction with all capture methods listed above. • Tissue samples include axillary process from all adult salmon, caudal fin clips from fish >60 mm, and whole fish <60 mm.

Table 9.6-3. Length and weight of fish species to be radio-tagged and respective target radio-tag weights.

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

Table 9.6–4. Schedule for implementation of the Fish Distribution and Abundance in the Middle and Lower Susitna River Study.

Activity	2012				2013				2014				2015	
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2Q
Winter Pilot Study					——									
Study Site Selection					——									
Develop and File Implementation Plan					——♦									
Open Water and Winter Fish Sampling						——	——	——	——	—— -----	——	——	——	
Data Entry							——	——			——	——		
Preliminary Data Analysis							——	——						
Initial Study Report								——	Δ					
Final Data Analysis											——	——		
Updated Study Report												——	▲	
Winter 2014-15 Technical Memo														●

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
♦ Implementation Plan
Δ Initial Study Report
▲ Updated Study Report
● Winter 2014-15 Technical Memorandum

9.6.11. Figures

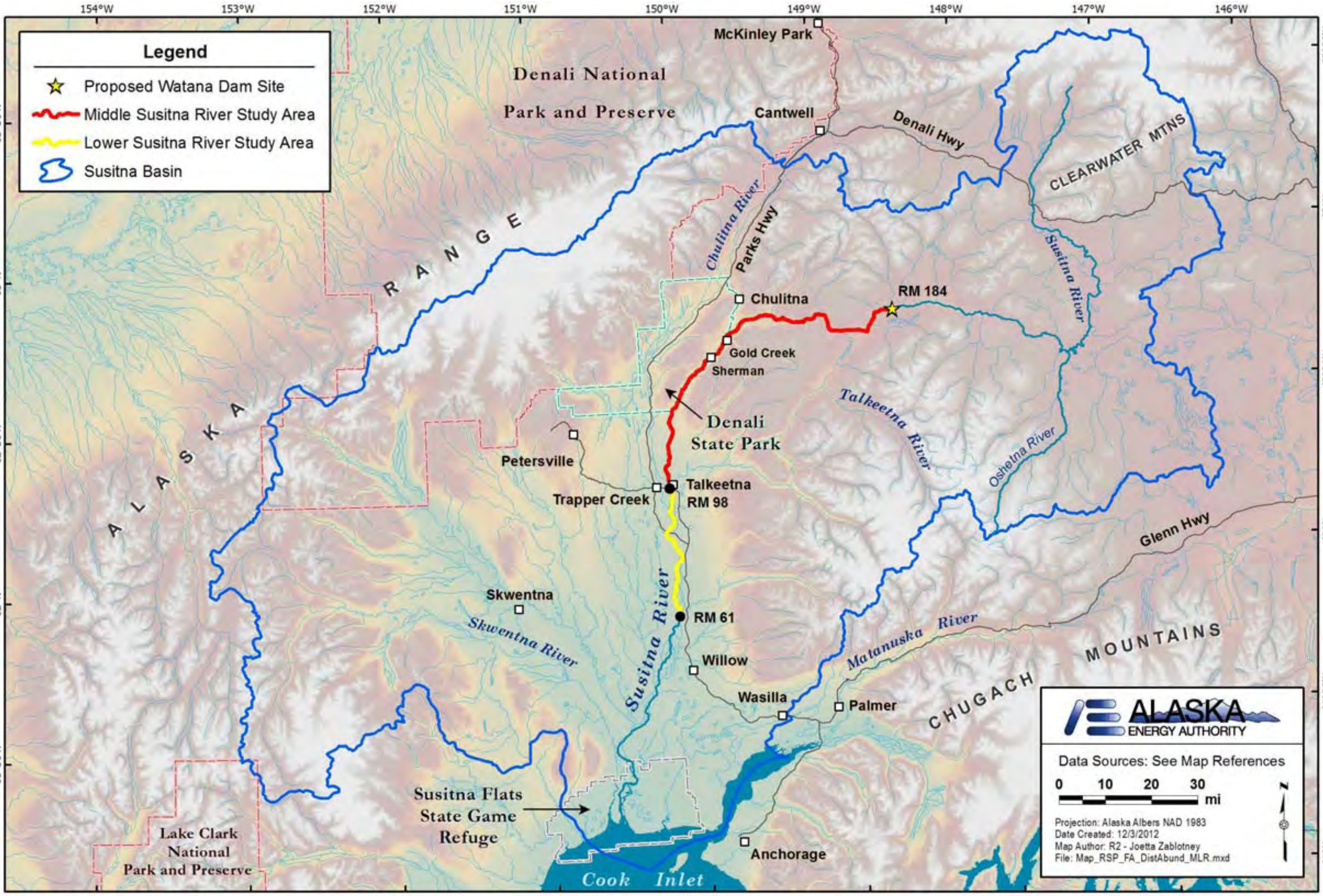

Figure 9.6-1. Map for Fish Distribution and Abundance in the Middle and Lower Susitna River Study Plan. Note that fish sampling in the Lower River is proposed in geomorphic reach LR1 from RM 61 to 98.

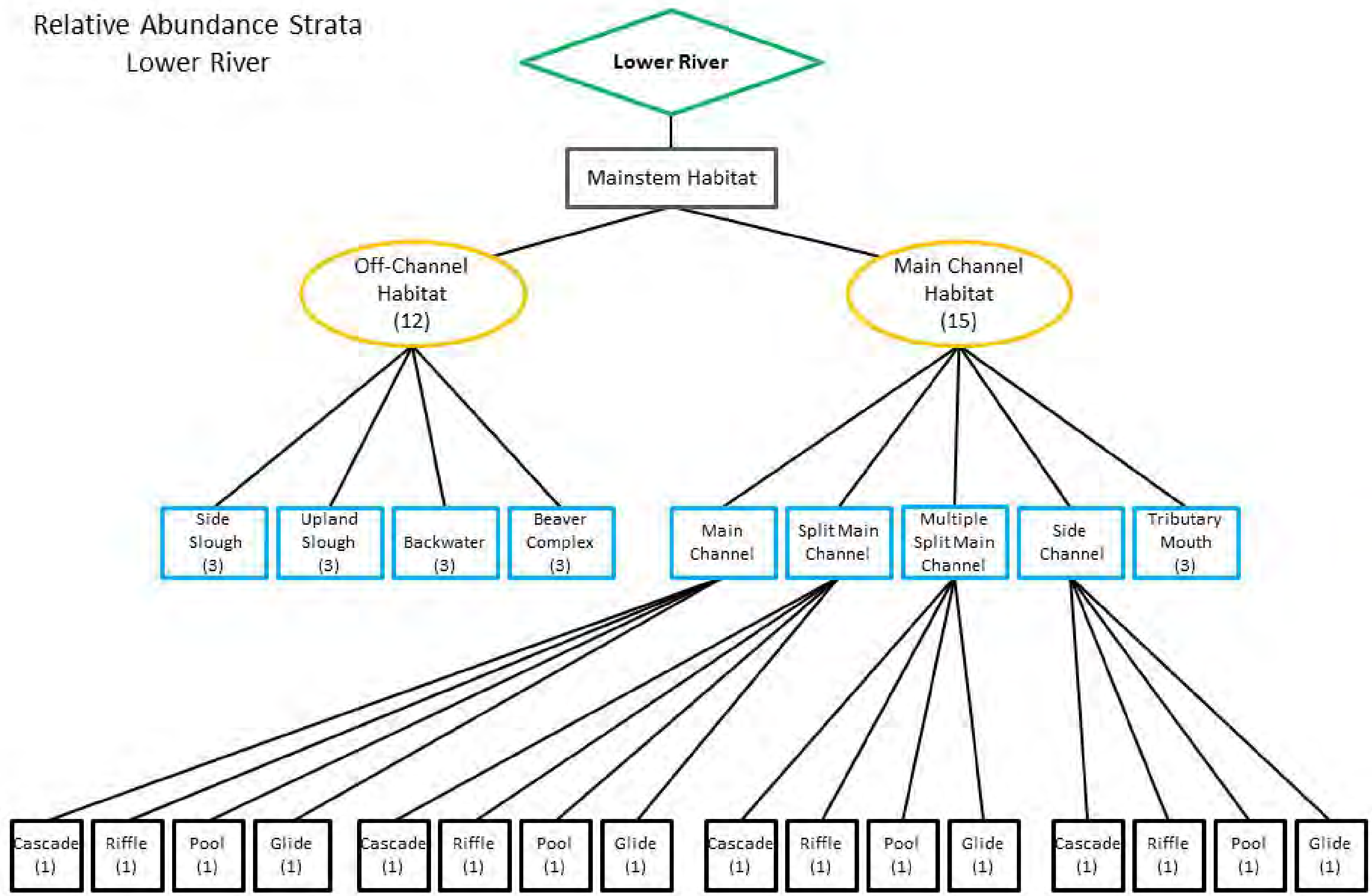

Figure 9.6-2. Schematic showing strata by habitat type for relative abundance sampling for the Lower River. Note that level two stratification within geomorphic segment, is not depicted in this figure because not all habitat types will be present within each geomorphic segment in the Upper River. The selection of habitats to sample will be distributed across geomorphic segments as described in the Fish Distribution and Abundance in the Lower and Middle Susitna River Implementation Plan and in Section 9.6.4.1.

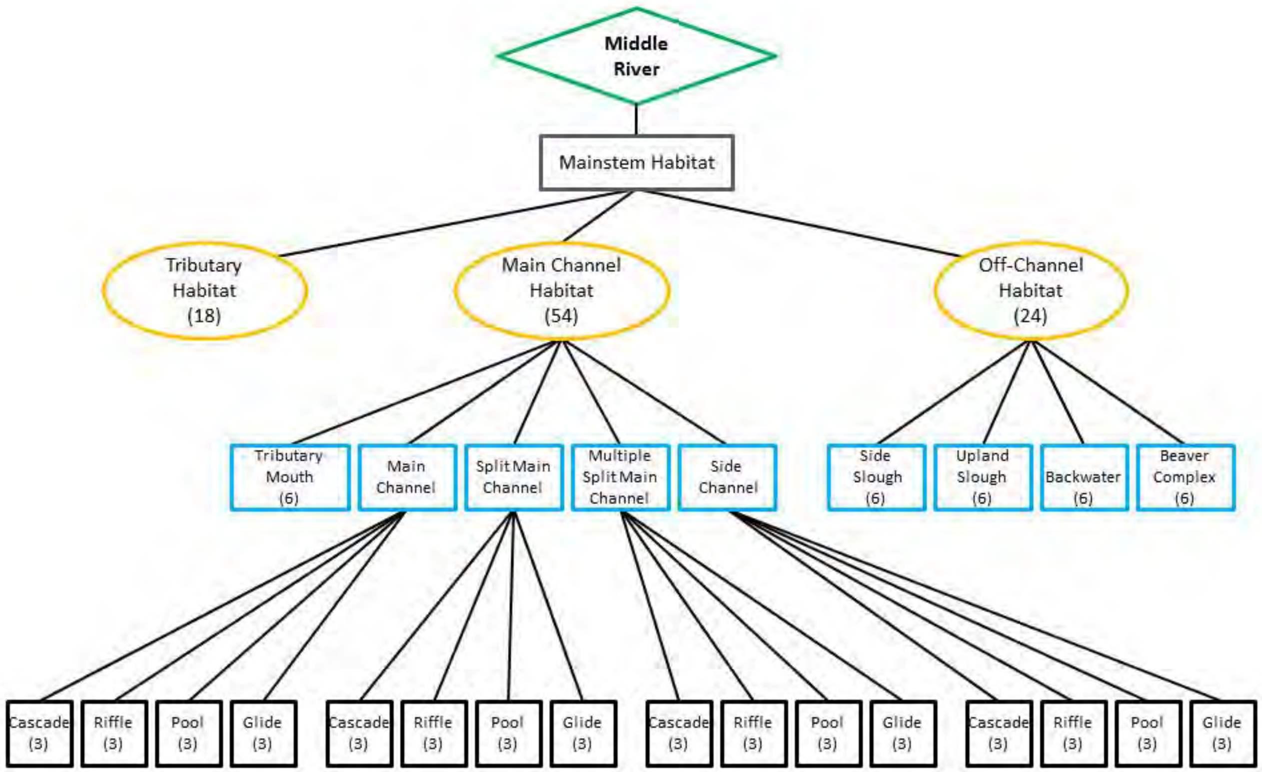

Figure 9.6-3. Schematic showing strata by habitat type for fish distribution sampling for the Middle River. Note that level two stratification within geomorphic segment, is not depicted in this figure because not all habitat types will be present within each geomorphic segment in the Upper River. The selection of habitats to sample will be distributed across geomorphic segments as described in the Fish Distribution and Abundance in the Lower and Middle Susitna River Implementation Plan and in Section 9.6.4.1.

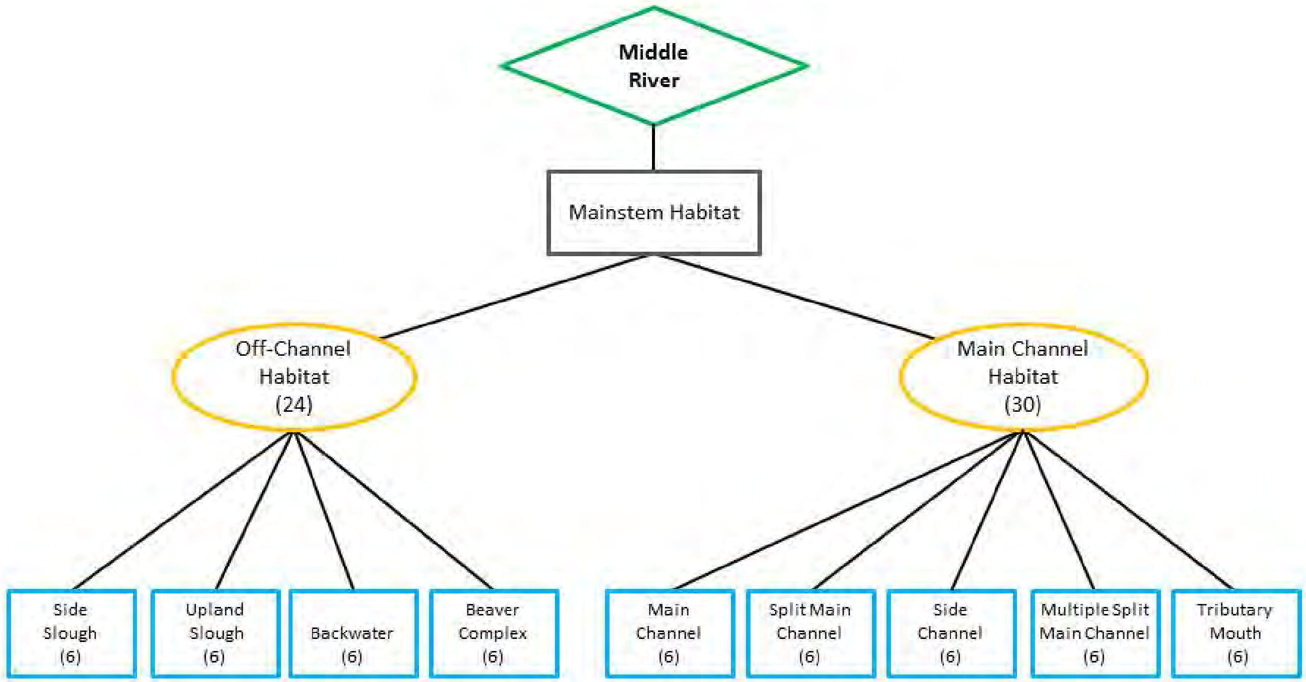

Figure 9.6-4. Schematic showing strata by habitat type for relative abundance sampling for the Middle River.

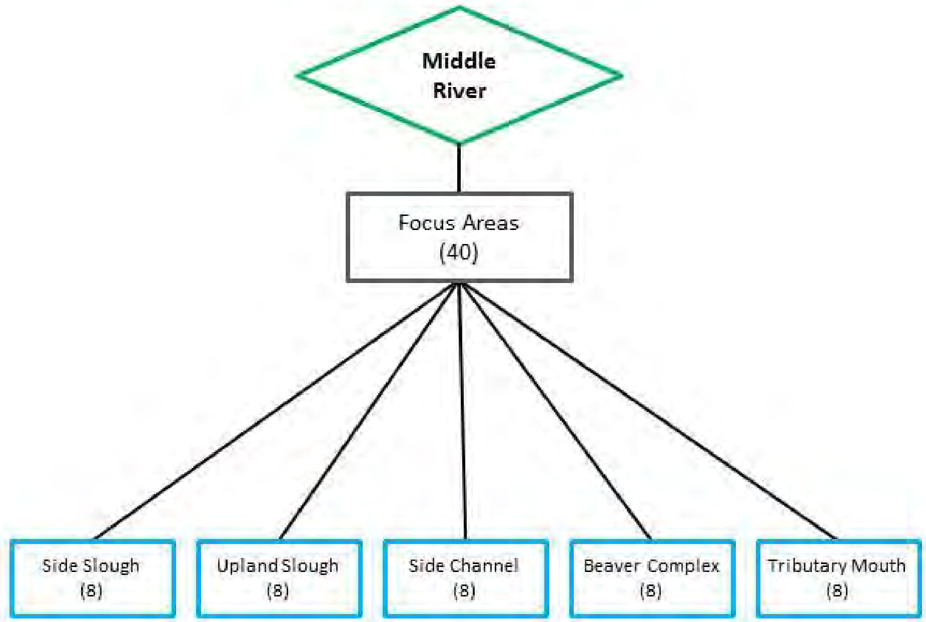

Figure 9.6-5. Schematic showing strata by habitat type for relative abundance sampling in Focus Areas.

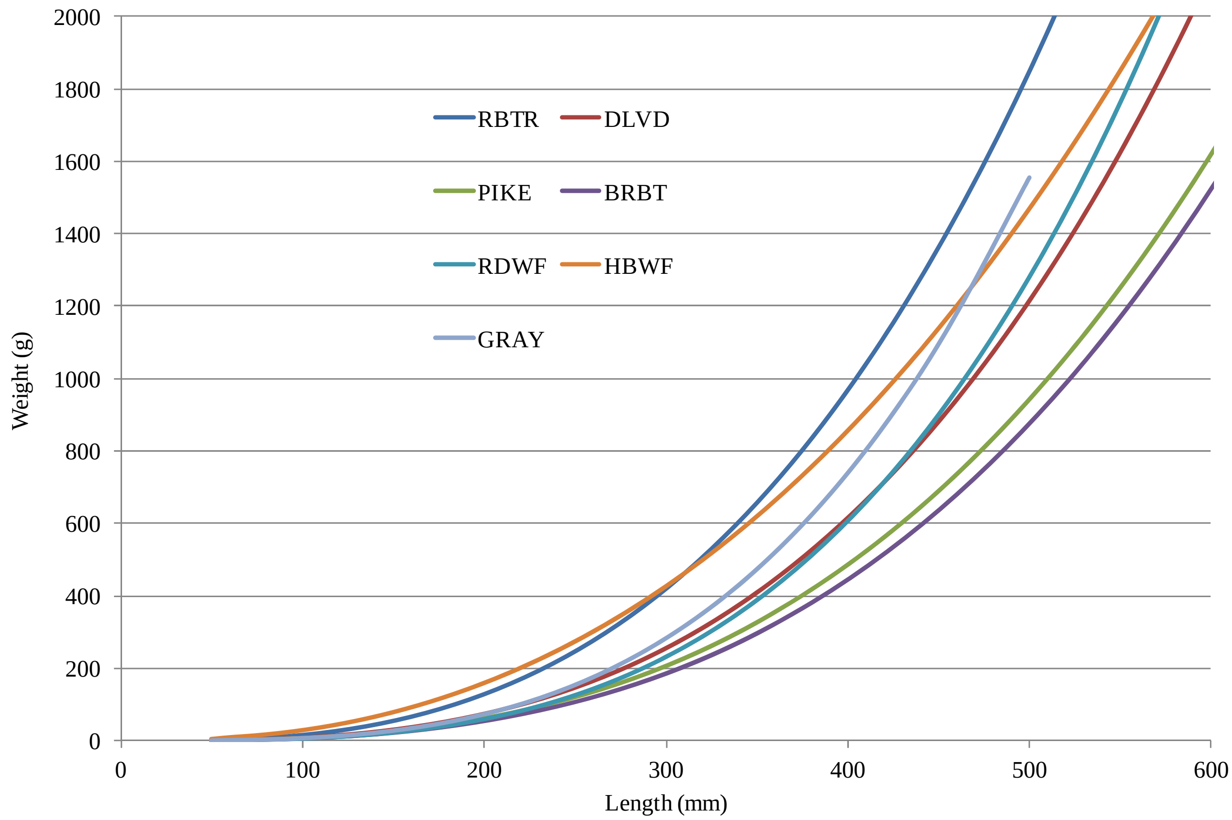

Figure 9.6-6. Existing or derived length-weight relationships for fish species to be radio-tagged.

Figure 9.6.-7. Distribution of winter sampling sites in Slough 8A, Susitna River.

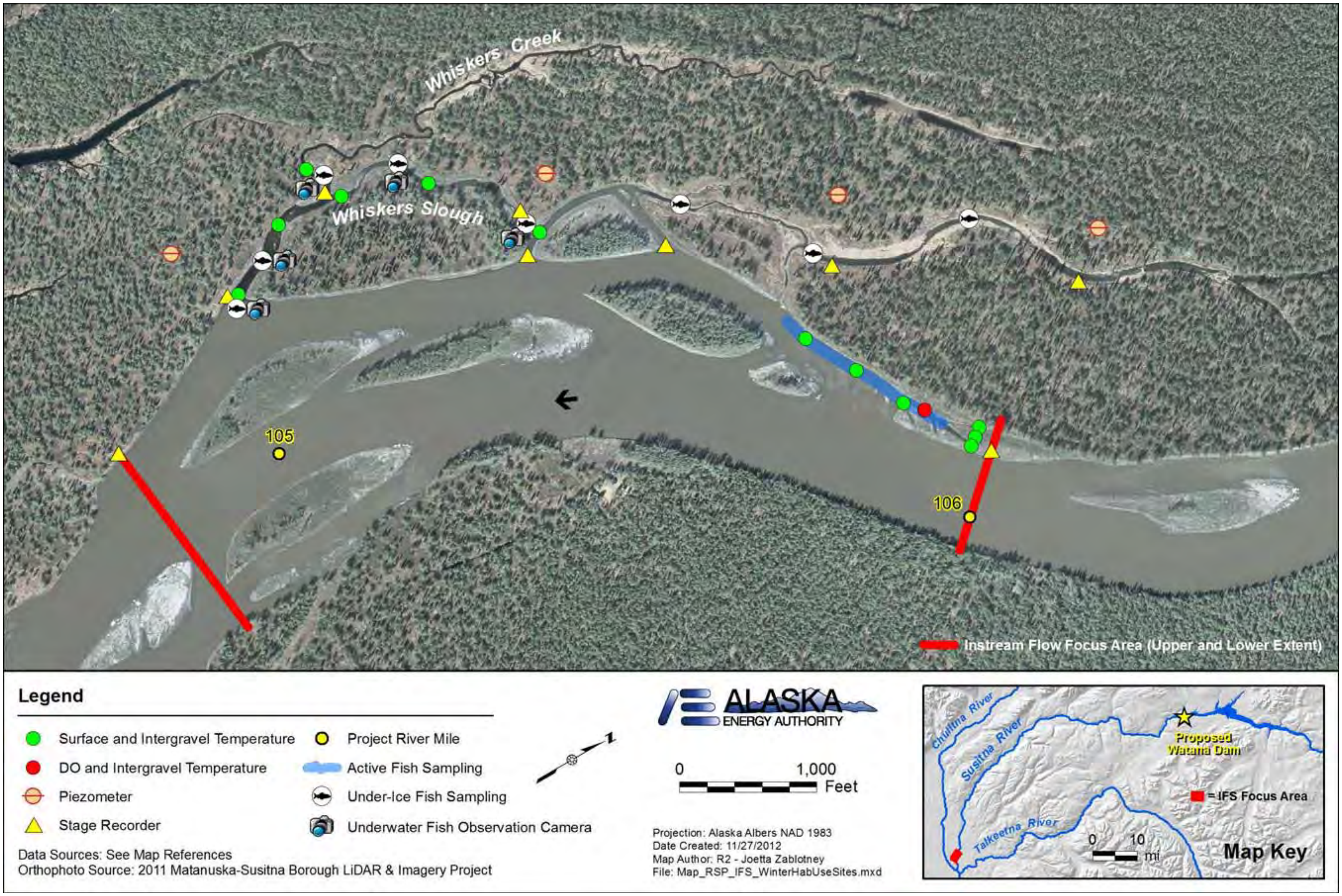

Figure 9.6-8. Distribution of winter sampling sites in Whiskers Slough, Susitna River.

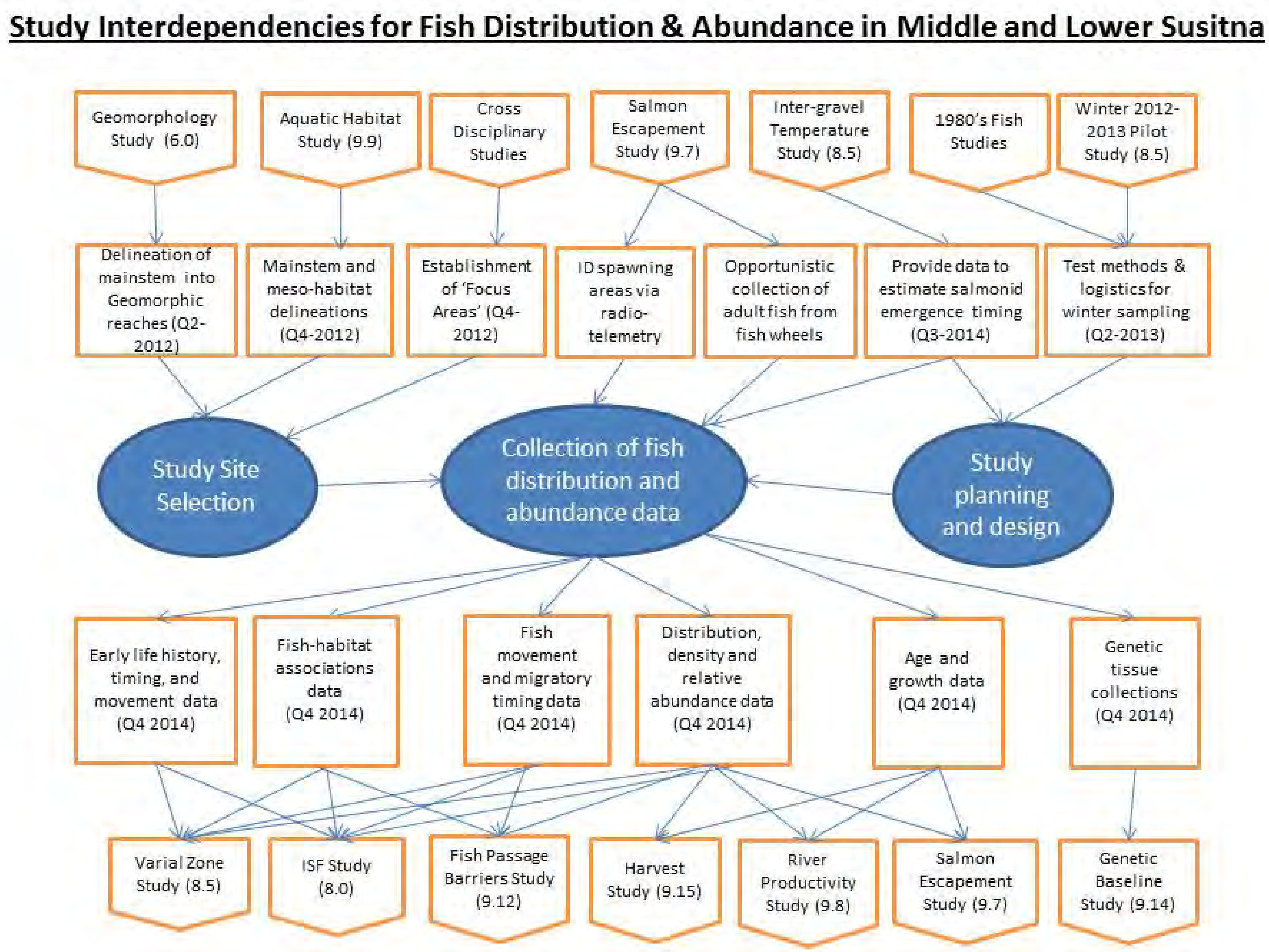

Figure 9.6-9. Flow chart of study interdependencies for Fish Distribution and Abundance in the Middle and Lower Susitna River Study Plan.

9.7. Salmon Escapement Study

9.7.1. General Description of the Proposed Study

Information from this Salmon Escapement Study will be used in combination with other studies to assess potential effects of the proposed Project on fisheries resources. Construction and operation of the Project will modify the flow, thermal, and sediment regimes of the Susitna River, which may alter the composition and distribution of fish. This study will provide information on the distribution and abundance of adult salmon in the Lower, Middle, and Upper Susitna River. This work will be conducted through collaboration among the Alaska Energy Authority (AEA), the Alaska Department of Fish and Game (ADF&G), and other licensing participants. Information developed in this study may also be used to develop any necessary protection, mitigation, or enhancement measures to address Project impacts to salmonid resources.

9.7.1.1 Study Goals

The primary goal of the study is to characterize the current distribution, abundance, habitat use, and migratory behavior of all species of adult anadromous salmon across mainstem river habitats and select tributaries above the Three Rivers Confluence (i.e., confluence of the Susitna, Chulitna, and Talkeetna rivers). Sufficient information of this nature has been collected for several species elsewhere in the Susitna watershed. However, for Chinook and coho salmon, additional information would aid in assessing the potential impacts of the Project. Therefore, a second goal of this study is to estimate the distribution, abundance, and migratory behavior of adult Chinook throughout the *entire* Susitna River drainage, and the coho salmon distribution and abundance in the Susitna River above the confluence of the Yentna River.

9.7.1.2 Study Objectives

1. Capture, radio-tag, and track adults of five species of Pacific salmon in the Middle and Upper Susitna River in proportion to their abundance. Capture and tag Chinook, coho and pink salmon in the Lower Susitna River.
2. Characterize the migration behavior and spawning locations of radio-tagged fish in the Lower, Middle, and Upper Susitna River.
3. Characterize adult salmon migration behavior and timing within and above Devils Canyon.
4. If shown to be an effective sampling method, and where feasible, use sonar to aid in documenting salmon spawning locations in turbid water in 2013 and 2014.
5. Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon.
6. Generate counts of adult Chinook salmon spawning in the Susitna River and its tributaries to estimate the proportions of fish with tags for populations in the watershed.
7. Collect tissue samples to support the Fish Genetic Baseline Study (Section 9.14).

8. Estimate the system-wide Chinook salmon escapement to the entire Susitna River, the coho salmon escapement to the Susitna River above the its confluence with the Yentna River, and the distribution of Chinook, coho, and pink salmon among tributaries of the Susitna River (upstream of Yentna River confluence) in 2013 and 2014.

9.7.2 Existing Information and Need for Additional Information

Existing information includes fish spatial and temporal distribution and relative abundance information from recent and early 1980s studies. The Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011a) and PAD (AEA 2011b) summarized existing information and identified data gaps for adult and rearing salmon. The licensing effort of the 1980s APA Susitna Hydroelectric Project generated a substantial body of literature, some of which will be summarized and used to support the 2013–2014 data collection efforts. The adult salmon habitat use studies conducted by ADF&G during the 1980s are summarized by Woodward-Clyde Consultants and Entrix, Inc. (1985). In recent years, ADF&G has conducted adult salmon (sockeye, coho, and chum) spawning distribution and abundance studies in the Susitna River (e.g., Merizon et al. 2010; Yanusz et al. 2011). In 2012, ADF&G expanded its scope to include Chinook and pink salmon. Existing fish and aquatic resource information appears insufficient to address the issues below that were identified in the PAD (AEA 2011b).

- **F2:** Potential effect of fluctuating reservoir surface elevations on fish access and movement between the reservoir and its tributaries and habitats.
- **F3:** Potential effect of Watana Dam on fish movement.
- **F4:** Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.
- **F5:** Potential effect of Project flow regime on anadromous fish migration above Devils Canyon. Devils Canyon is a velocity barrier to most fish movement and changes in flows can result in changes in the potential fish movement through this area (approximately river mile [RM] 150).
- **F6:** Potential influence of the proposed Project flow regime and the associated response of tributary mouths on fish movement between the mainstem and tributaries within the Middle River reach.
- **F7:** Influence of Project-induced changes to mainstem water surface elevations July through September on adult salmon access to upland sloughs, side sloughs, and side channels.
- **F8:** Potential effect of Project-induced changes to stream temperatures, particularly in winter, changing the distribution of fish communities, particularly invasive northern pike.

Susitna River Chinook and coho salmon stocks support important commercial, sport, and subsistence fisheries in Northern Cook Inlet (NCI). The Susitna River currently supports the fourth largest run of Chinook salmon in Alaska (Ivey et al. 2009). Chinook salmon escapements in the Susitna drainage are monitored annually by ADF&G with single aerial (helicopter) or foot surveys. These surveys provide an index of escapement rather than a complete census of the escapement. These measurements provide a ranking of escapement magnitudes across years, but alone these measurements provide little information on the total number of fish in the escapement (Fair et al. 2010).

In 1985, ADF&G operated fishwheels at RM 22 and RM 82 in the Susitna River to estimate the escapement of Chinook salmon to the Susitna River drainage. The Chinook salmon escapement at Flathorn was estimated to be 113,931 fish (length greater than 400 millimeters [15.75 inches]) with a standard deviation of 77,931 (Thompson et al. 1986). This is the only drainage-wide Chinook salmon escapement estimate for the Susitna River. A drainage-wide abundance estimate of returning adult Chinook salmon using capture-recapture methods is most likely to yield the most accurate and precise estimate of the abundance of spawning Chinook salmon.

During the 1985 adult salmon investigation study, spawning ground surveys were conducted for Chinook salmon in the Middle and Lower Susitna River. These observational surveys were conducted by surveyors wearing polarized sunglasses looking for visual verification of mating pairs, distinct redds, or the confirmed presence of eggs by intergravel sampling (Thompson et al. 1986). No spawning areas were observed in the sloughs or Middle River mainstem channel in 1985. The 1985 report does not mention if spawning areas were found in the Lower River mainstem channel. This radio telemetry study would attempt to characterize any Chinook salmon spawning in the mainstem Susitna River. ADF&G has successfully used this approach to identify likely spawning areas for sockeye, coho, and chum salmon within the Susitna River drainage (Yanusz et al. 2011; Merizon et al. 2010; Yanusz et al. 2007).

9.7.3 Study Area

The study area encompasses the Susitna River from Cook Inlet upstream to the Oshetna River, or as far upstream as Chinook salmon are detected (Figure 9.7-1), with an emphasis on wherever salmon spawn in mainstem habitats of the Susitna River. The mainstem Susitna River is divided into three generalized reaches for the purposes of this study plan: the Lower River (RM ~30-98), Middle River (RM 98–150), and Upper River (RM 150–234). Devils Canyon extends from approximately RM 150 to RM 164.

9.7.4 Study Methods

Descriptions of the study methods are organized below by objective. This is a multi-year study initiated in 2012. The methods below refer to research to be conducted in 2013 and 2014.

9.7.4.1 Objective 1: Capture, radio-tag, and track adults of five species of Pacific salmon in the Middle and Upper Susitna River in proportion to their abundance. Capture and tag Chinook, coho, and pink salmon in the Lower Susitna and Yentna rivers.

Tasks to address Objective 1 include the following:

- Install and operate two fishwheels at approximately RM 30 of the Susitna and two fishwheels on the lower Yentna River from late May through August 2013 and 2014.
- Supplement the fishwheel effort in the Lower River with gillnet/tangle nets to address potential size selectivity of capture and augment catch totals.
- Install and operate two fishwheels at Curry (RM 120) from early June to early September in 2013 and 2014 (Figure 9.7-1). Supplement fishing effort for Chinook salmon in the Middle River by operating a fishwheel in Devils Canyon below the impediments from late June through late July in 2013 and 2014.
- Radio-tag a total of 1,400 Chinook salmon (700 in the Yentna River and 700 in the Susitna River at RM 30) and 600 coho and 200 pink salmon in the Susitna River at RM 30 in 2013 and 2014.
- Radio-tag 400 Chinook salmon and 200 each of chum, sockeye, pink, and coho salmon in the Middle River at Curry (RM 120). Apply as many of the 400 radio tags for Chinook salmon in Devils Canyon.
- Assess the degree to which radio-tagged fish are representative of all salmon passing each of the tagging sites (e.g., test for size selectivity, compare mark rates among spawning areas).
- Evaluate the potential for handling-induced changes in fish behavior based on the post-release survival and migration rates of radio-tagged fish.

Meeting the goals of this study will be aided by radio-tagging fish of each species in a manner as representative of each species' "population" in the Lower and Middle River as possible. Tagging particular stocks and/or sizes of fish at different rates than others can often be accommodated during data analysis (Seber 1982; Schwartz and Seber 1999) but could weaken inferences about relative distribution among tributaries and habitat uses of the Middle River such as the relative distribution of spawning fish, migratory behaviors, any fish passage above Devils Canyon, and the river-wide abundance of Chinook and coho salmon. There are multiple ways to assess whether fish passing the tagging sites are equally vulnerable to being radio-tagged. Of greatest importance is to survey spawning areas to determine the size composition of tagged and untagged fish (size distributions) and determine the proportion of fish in different areas that contain a tag (i.e., the mark rate). Statistically significant differences in mark rates among areas would suggest unequal vulnerability; differences in the size distributions of the marked and unmarked fractions of the fish would suggest size-selective capture and tagging.

9.7.4.1.1 Fish Capture

Fishwheels will be used to capture adult salmon for tagging. Two fishwheels will be operated at approximately RM 30 in locations that were fished in 2010–2012. Two fishwheels will be operated on the lower Yentna River during a similar period, and in the same locations as have been operated for three decades. Two fishwheels will also be operated in 2013 and 2014 near Curry (RM 120) from the first week of June through the first week of September at the same two locations in 1981–1985 and in 2012. In addition, at least one fishwheel will be operated in the Middle River in lower Devils Canyon at approximately RM 150-151 and below the first of three impediments in Devils Canyon. The Middle River fishwheels consist of aluminum pontoons, three baskets, and two partially submerged live tanks for holding fish in river water. A tower and winch assembly will be used to adjust the height of the baskets and ensure that the baskets are fishing within 20 centimeters (cm) of the river bottom. Net leads will be installed between fishwheels and the adjacent riverbank to direct fish away from the bank and into the path of the fishwheel baskets. Fishwheels will be operated 8–12 hours per day. A two-person crew will staff the fishwheels during operations; when the crew is to be absent from the fishwheel for more than 1 hour, the fishwheel baskets will be raised from the water and stopped. Fishwheels operated in the Lower River will be of similar construction, operated in a similar manner, and will be staffed at all times during operation (Yanusz et al. 2011).

Fishwheel effectiveness, expressed as a fraction of the passing salmon run it captures, often varies within and among seasons. Also known as the catchability coefficient, effectiveness changes with water depth under the fishwheel and water velocity around the fishwheel. The overall abundance of fish in the river at any one time may also affect effectiveness. Variable effectiveness within a season is most problematic for a study of this nature if it varies across the period of the annual run of a particular species and less problematic if it varies across species. Fish later or earlier within a run of a particular species can represent fish of different sizes, ages, and ultimately, fish bound for different habitats. Therefore, stable effectiveness across time, body size, and spawning destination is ideal, and assumptions will need to be tested by appropriate data collection at the fishwheels and surveys of spawning areas. If sufficiently large numbers of fish can be tagged and later examined, any changes in effectiveness can be compensated for by stratification of results.

9.7.4.1.2 Radio-tagging

ATS pulse-coded, extended-range tags will be applied to a subset of salmon captured in the Lower and Middle river fishwheels. There are 100 unique codes on each available frequency. Model F1835B transmitters will be used for pink salmon (16 grams, 30-centimeter-long antenna, 96-day battery life); Model F1840B tags for sockeye, coho, and chum salmon (22 grams, 30-centimeter antenna, 127-day battery life); and Model F1845B tags for Chinook salmon (26 grams, 41-centimeter antenna, 162-day battery life). All transmitters will be equipped with a mortality sensor that changes the signal pattern to an “inactive” mode for the remainder of the season once the tag becomes stationary for 24 hours. All of the radio tags will be labeled with return contact information. Each tag will be tested immediately prior to deployment to ensure it is functioning properly upon release.

Only uninjured fish that meet or exceed a specific length threshold will be radio-tagged; i.e., Chinook salmon with a mid-eye to fork length (METF) of ≥ 500 millimeters; coho, sockeye, and chum salmon ≥ 400 millimeters; and pink salmon ≥ 325 millimeters. All fish to be tagged will be placed in a water-filled, foam-lined, V-shaped trough. To minimize handling time (i.e., achieve < 1 minute per fish) and tagging-related effects on fish behavior, anesthetic will not be used. Radio tags will be inserted orally into the stomach of the fish using a piece of PVC tubing (1/3-inch diameter and 18 inches long) with the tag antenna left to protrude from the mouth. All radio-tagged salmon will be measured to determine mid-eye-to-fork length (to the nearest centimeter), and sexed based on external morphological characteristics (coloration, body and fin shape, jaw morphology). Radio-tagged fish at Curry will be tagged with a spaghetti tag to assess tag loss, evaluate the effects of spaghetti-tagging on post-handling behavior and final spawning destination, and to provide an external mark for anglers to recognize a fish that has a radio tag. Radio-tagged fish will be sampled for scales (to age) and tissue for genetic baselines (see Section 9.14, Genetic Baseline Study for Selected Fish Species).

To minimize any effects from fish holding, salmon will typically be tagged immediately upon capture. All fish will be released immediately after tagging. All fish captured will be inspected for radio and spaghetti tags.

9.7.4.1.3 Spaghetti-Tagging

Spaghetti-tagging will also augment the ability to test assumptions about the representativeness of fish captured in the fishwheels. The fishwheels may capture more fish of some species than will be needed for radio-tagging alone, and additional marking of fish will provide more information to test assumptions about how representative the captured fish are of the population of fish passing fishwheel sites than the radio tags alone. A portion of these additional fish captured will be spaghetti-tagged, and this portion will vary among species according to availability of fish above radio-tagging goals and the opportunities available for examining fish subsequent to the tagging event.

If similar catches are obtained as in 2012, all of the Chinook salmon captured at Curry that are above the daily radio-tagging goals will be spaghetti-tagged. Tagged Chinook salmon can be subsequently examined in several upstream tributaries to test study assumptions and determine the fraction marked in the different stocks. Based on the 2012 results, we expect few or no coho salmon caught at Curry above the radio-tagging goal of 200 fish.

Sockeye and chum salmon that spawn above Curry will be available for counting and examining for marks in clear-water side channels and sloughs, and the Portage Creek and Indian River tributaries. Given the number of radio tags deployed (200/species), some additional marking of sockeye and chum with spaghetti tags may enable a test for the assumption that capture and marking of fish will be in proportion to stock-specific abundance passing Curry. It is expected that insufficient numbers of pink salmon could be spaghetti-tagged (and later examined) to develop defensible mark-rate estimates in 2013 (an “off-peak” year). In 2014, although a “peak-year”, experience in the area in 2012 suggests there are few places to examine significant numbers of pink salmon on the spawning grounds. However, should it become clear during the 2013 field effort that spawning ground surveys could be more successful, spaghetti tags may be applied to pink salmon in 2014.

9.7.4.1.4 Daily Tagging Goals

Recent (2012) and historical (1981–1985) fishwheel catches, effectiveness, and salmon run timing will guide tag application rates over the season. In 2012, Chinook salmon were captured at RM 30 from the last week of May through the first week of July.

Across the five years from 1981 to 1985, Chinook salmon were caught at Curry from as early as June 9 (range June 9–20) to as late as August 20 (range July 29–August 20), with midpoints of the annual runs ranging from June 9–25. During those studies, catches ranged from 201–379 (average 301) for sockeye salmon, 93–350 (average 215) for coho salmon, 861–4,228 (average 2,131) for chum salmon, and 17,394 for the 1984 even-year pink salmon run. Midpoints of the annual migrations at Curry ranged from approximately August 4–5 for sockeye, August 12–13 for coho, August 3–15 for chum, and July 31–August 7 for pink salmon. In 2012, the run timing in the Middle River was within the historical ranges described above. The runs at Curry in 2012 were most similar to those in 1985.

As was done in 2012, the early season tagging rates of fish captured in the fishwheels will be developed prior to the season and will be based on average historical run timing and expected daily fishwheel catches at Curry. These initial radio-tagging rates will be adjusted in-season using run timing information from the fishwheels in the Lower Susitna River (RM 30) and the ratio of current year's daily catch at Curry to the expected daily fishwheel catch based on historical data.

9.7.4.1.5 Numbers and Size of Marked and Unmarked Fish at Selected Locations

To test if Chinook, sockeye, and chum salmon passing fishwheels are equally vulnerable to being captured and radio-tagged, fish will be examined on selected spawning grounds to develop two primary metrics: estimates of the proportion of fish tagged (mark rate) and the size distributions of tagged and untagged fish.

Weirs on tributary streams and aerial and foot surveys will be used to count live and dead fish. Combined with fixed-station and aerial relocating data, these will provide counts of marked and unmarked fish. Lengths of dead fish will be measured to the nearest centimeter and sex and spawning success noted.

9.7.4.1.6 Examining Handling-Induced Changes in Behavior

An assumption of this study is that the behavior of radio-tagged fish is not materially affected by the capture and handling process. By materially affected, we mean that the capture and tagging does not affect the final spawning destination of a fish and/or its migration behavior once it has recovered from the tagging event and resumed its migration. If (and when) sufficient genetic structure can be found among stocks of various species in the Susitna River, genetics could offer a reasonably good test of whether handling may have influenced the final destination of tagged fish. Until then, this assumption cannot be tested directly, but there are several indirect ways to assess its potential magnitude.

The post-release survival and travel time (days) to first detection at upstream fixed-station receivers will provide an indication of the level of handling-induced changes in behavior. Long delays to resume upstream migration and high mortality rates would be indicative of significant changes in behavior; little delay and low mortality rates would be indicative of little effect. Second, we will compare the upstream movement (delays and rates of travel) of tagged fish that were subjected to different holding densities and holding times in the fishwheels. Third, although potentially confounded with different stock-specific vulnerabilities to capture, tag mark rates at spawning locations based on visual observations and telemetry detections (number of tags) can provide an indication of possible handling-induced changes in behavior. Stratification of results by spawning destination based on mark rates can help mitigate any effects of differences that this source of post-release changes in spawning destination might have on our conclusions. Finally, we expect that the fishwheels will recapture some of our radio-tagged fish and the post-release migratory behavior of these already tagged fish will provide additional data on the effects of the fish capture process, including any potential cumulative handling effects.

Note that this is not an issue if the effect is binomial in nature or simply a significant “on” or “off” with any individual fish. The radio-tag study design allows the fish that drop back and do not resume their upstream migration to be censored (removed) from the experiment and subsequent analyses. The issue is more with subtle effects that could go undetected but materially affect conclusions.

9.7.4.1.7 Assessing Any Stock- and Size-selective Capture

Fish will be randomly selected from the fishwheels for tagging. To assess whether these fish are representative of all fish in the in the river, several assumptions need to be tested.

An assumption of equal probability of capture across fish from all spawning destinations can be tested indirectly by examining several sources of information. If there are unequal probabilities of capture among spawning stocks, it will be caused by, and manifest itself, in multiple ways.

Fishwheel effectiveness across time: The main assumption of this study component is that the radio tags are deployed at the fishwheels in proportion to abundance for each species. To help evaluate this assumption at Curry, we will compare the relative effectiveness of each fishwheel, as determined from the ratio of fish caught by a fishwheel and the number of fish observed with DIDSON sonar system operated in close proximity to the fishwheel across multiple time periods, and river discharge. The DIDSON will also be used to qualitatively assess fish approach behavior at the fishwheel relative to discharge and fish abundance. We will also compare the catch per unit effort (CPUE; fish per fishwheel hour) over time and across a range of discharges.

Differences among stocks: To assess whether fish from a particular spawning area were right or left bank-oriented with respect to the capture site, we will compare the proportion of fish migrating into specific areas with the collection bank. Assuming data are suited to statistical analysis, we will also use contingency table analysis to compare mark rates over time and areas at upstream locations (i.e., at weirs and from ground surveys). If tags are deployed in proportion to abundance, then we would expect mark rates to be constant across both temporal and spatial strata in these spawning ground areas. One concern is that mainstem fish could be more vulnerable to the fishwheels because they linger or mill upstream and downstream of capture sites. Recaptures of radio-tagged fish at the tagging site fishwheels will provide a good test of whether milling fish are exposed to greater capture rates. In addition to quantitative and qualitative assessment of subsequent behavior of these recaptured fish, we will compare the final destinations (mainstem/tributary) of recaptured fish to other tagged fish to determine whether fish that spawn in the mainstem are recaptured at a higher rate.

Size-related (and age-related) selectivity will be tested using Kolmogorov-Smirnov (K-S) two-sample tests. For each species, we will compare the cumulative length-frequency distributions of (1) radio-tagged and spaghetti-tagged fish and those fish randomly sampled on the spawning grounds; (2) radio-tagged and spaghetti-tagged fish and all other fish sampled for length at the Curry fishwheels; and (3) radio-tagged and spaghetti-tagged fish captured in individual fishwheels. Using data from similar sources, contingency table analyses and Chi-square tests will be used to compare the sex and age composition of fish radio-tagged by species. Size-related bias can usually be eliminated by size stratification of results.

9.7.4.2 Objective 2: Determine the migration behavior and spawning locations of radio-tagged fish in the Lower, Middle, and Upper Susitna River.

This is a continuation of the multi-year study initiated in 2012. Tasks to meet Objective 2 include the following:

- Track the locations and behavior of radio-tagged fish using an array of fixed-station receivers and mobile-tracking surveys. Aerial surveys will begin in July and end in early October each year.
- Conduct boat- and ground-based surveys to locate holding and spawning salmon to the level of microhabitat use.

Three groups of radio-tagged fish will be tracked: (1) adult Chinook, coho, chum, pink, and sockeye salmon will be radio-tagged and released in the Middle River at Curry (RM 120); (2) Chinook, coho, and pink salmon tagged in the Lower Susitna River (RM 30); and (3) Chinook salmon tagged in the lower Yentna River (Figure 9.7-1). The three study components and data analyses will be tightly coordinated. All mobile (aerial, boat, and foot) and fixed-station receiver data will be analyzed together, and analysis products will be characterized in a consistent manner.

The primary function of the telemetry component is to track these tagged fish spatially and temporally with a combination of fixed and mobile receivers. Time/date stamped, coded radio signals from tags implanted in fish will be recorded by fixed station or mobile positioning. All telemetry gear (tags and receivers) across both studies will be provided by ATS, Inc. (Advanced Telemetry Systems, www.atstrack.com).

The types of behavior to be characterized include the following:

- 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, holding, and spawning time and locations/positions
- Movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

These data, in conjunction with habitat descriptions, will allow characterization of migratory behavior and final destinations for salmon in mainstem habitats (main channel, slough, side channel) and tributaries. In addition, observed spawning locations will be characterized at a microhabitat level (e.g., depth, velocity, substrate). Spawning or final locations of tagged fish will be used to determine the number and proportion of the tagged fish of each species using mainstem habitats.

9.7.4.2.1 Fixed-Station Monitoring

Stand-alone operating telemetry arrays will be deployed at strategic locations on the Lower, Middle, and Upper River to provide migration checkpoints and develop spawning ground inventories and the fates of individual tagged fish. Each station will include a radio receiver, power supply, antenna switcher, and two or three aerial antennas. Antennas may be mounted in trees or on tripod-mounted poles and orientated to distinguish between upstream and downstream movements of fish (i.e., direction of travel). Receivers will be programmed to scan all frequencies and record coded tags. Initial station installation will include range testing to define the expected detection range (approximately 900 linear feet at 10 feet water depth, configuration dependent) of each antenna. Standard reference or "beacon" tags will be deployed at most fixed stations to provide a continuous record of known signal detections. Fixed stations will be manually downloaded (i.e., by the field crew) on a weekly basis unless a remote communication protocol is established. 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.

Figure 9.7-1 shows the locations of the radio telemetry fixed stations in the Lower, Middle, and Upper Rivers. Proposed locations for radio telemetry fixed stations in the Middle and Upper River are also shown in greater spatial resolution in Figure 9.7-2 and are listed below.

1. Lane Creek area (~ RM 113.0)
2. Middle River Gateway - (RM 123.7)
3. Slough 11 (~ RM 135.3)
4. Indian River confluence (RM 138.6)
5. Slough 21 (~ RM 141.1)
6. Portage Creek confluence (RM 148.8)
7. Cheechako Creek confluence (RM 152.4)
8. Chinook Creek confluence (RM 157.0)
9. Devil Creek area (RM 164.0)
10. Kosina Creek confluence (RM 206.8)

The Lower River stations were chosen to represent all significant tributaries that are known to contain or may contain Chinook salmon (Figure 9.7-1). The Middle and Upper River sites were chosen based on the following: (1) the need to provide geographic separation of the Middle River area to describe migration and spawning behaviors, and (2) monitoring at the appropriate resolution through the Upper River area to quantify passage through Devils Canyon. See below for additional details about the telemetric monitoring in Devils Canyon (Objective 3).

9.7.4.2.2 Telemetry Aerial Surveys

Aerial surveys of the mainstem Susitna from RM 22 to Kosina Creek will be conducted by helicopter to allow relatively accurate positioning of tagged fish, to locate spawning areas, and to make visual counts of fish in clear water areas, all with respect to mainstem habitat types. Aerial surveys will begin in July and end in late October (≈16 weeks). Survey timing may be adjusted depending on the observed fishwheel catches in the Lower and Middle River. Surveys will be scheduled at five-day intervals with the intent to ensure a maximum of seven days between surveys with weather contingencies. In the event that fixed stations indicate that no tagged fish have migrated upstream of Devils Canyon, aerial surveys to at least Kosina Creek will be conducted at least three times to confirm these results. If radio-tagged fish are detected moving upstream in the mainstem at the Kosina Creek telemetry station, aerial surveys will be extended to locate those radio-tagged fish and visually survey for untagged fish.

Surveys via helicopter can be conducted at lower elevations and at slower speeds than can be achieved using fixed-wing aircraft, and therefore will allow more time for signal acquisition, higher spatial resolution, and fish/habitat observations. Fixed-wing surveys are most appropriate when the study goal is a spatial resolution of tagged fish locations to be within approximately 800 meters (i.e., to the nearest 0.5 river mile), and some fixed-wing surveys will be conducted about every 10 days. The goal for helicopter-based surveys is to be within approximately 300 meters (1,000 feet), as well as to determine whether the fish is in off-channel or mainstem habitat. Higher precision will be achievable in reaches where conditions are most favorable. 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 that position of the aircraft at the time of the highest signal power. Range testing of the mobile aerial setup will be conducted in the Lower 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 highest spatial resolution.

The mainstem aerial surveys will need to cover over 200 river miles (RM 22 to RM 230), and multiples of that total when side channels and braids of the Lower River are included. 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 (~1,500 feet) of river will generally be sufficient. The proposed frequent 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 mainstem fish “at large” (i.e., tagged and not tracked in a tributary). During the survey, the “river km” 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.

As well, when aggregations of two or more tagged fish are found "stationary" (i.e., within 2 kilometers [1.25 miles] on one or more surveys) and/or when visual observations of spawning fish are made from the helicopter, ground- and boat-based surveys will pinpoint spawning locations to within 5–10 meters (16–32 feet). This protocol will be particularly important for ensuring coverage of any suspected Lower River habitats with the appropriate level of spatial resolution.

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 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 sampling team and Instream Flow Study to inform their field sampling efforts.

Fixed-wing aerial surveys of tributary systems of the Susitna and Yenta rivers will be conducted from RM 20 to Devils Canyon and the upper Chulitna River at 7- to 10-day intervals from late June through September. These surveys will provide fish locations to the nearest river mile (1.6 km) and will help to fully characterize the fates of fish tagged in the Lower and Middle rivers. Although these will provide less precise spatial resolution of fish locations (and habitat use) than from helicopter surveys, fixed-wing surveys will more effectively cover the very large lineal distances of the Susitna River tributaries than possible by helicopter (and in areas where high spatial resolution is not required).

9.7.4.2.3 Lower River Surveys

Helicopter surveys of the Lower River will cover mainstem areas from RM 22 to the confluence of the Chulitna River (RM 98). This reach is highly braided with side channels and sloughs, so complete coverage will require considerable effort and in-flight route tracking. With the survey protocol outlined above and the number of tags anticipated to be at-large on any one survey, this area will require up to two survey days to complete.

9.7.4.2.4 Middle River Surveys

Helicopter surveys of the Middle River will cover mainstem areas from the confluence of the Chulitna River (RM 98) through Devils Canyon (≈ RM 164). This reach (66 miles) will require approximately one day to complete, and as much as two days late in the season when all tags are deployed.

9.7.4.2.5 Upper River Surveys

Helicopter surveys of the Upper River will generally be triggered by detection of fish moving above fixed-stations at the Portage and Devils Canyon stations. Once fish are detected above Devils Canyon, aerial surveys will cover the mainstem areas from Devils Canyon (≈ RM164) to the confluence of the Kosina Creek (RM 206.8). This reach will include approximately 53 relatively confined river miles. This survey will require approximately one survey day; less when done in conjunction with Middle River surveys (i.e., when less conveyance time is involved). Radio-tagged fish above Devils Canyon will be located at a spatial resolution in habitat types similar to the Middle and Lower River surveys.

9.7.4.2.6 Boat and Ground Surveys

Telemetry surveys will also be conducted by boat and on foot to obtain the most accurate and highest resolution positions of spawning 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 will be visited to obtain individual fish positions. It is expected that resolution will be within 5–10 meters (16–32 feet) in turbid water and within 2–3 meters (6.5–10 feet) in clear water (dependent on density and highest resolution at low densities). Underwater stripped-coax antennas and judicious use of signal gain control will allow locating tagged fish and recording their geographic position with a GPS. These data will be collected in concert with the field activities and provided to the habitat suitability sampling team to inform their sampling efforts. These surveys will be conducted approximately weekly during the July through September mobile tracking period.

9.7.4.3 Objective 3: Characterize adult salmon migration behavior and timing within and above Devils Canyon.

The tasks to achieve Objective 3 include the following:

- Establish an array of fixed-station receivers at and above Devils Canyon to monitor the behavior of radio-tagged fish from early June to October each year (Figures 9.7-1 and 9.7-2).
- Conduct aerial surveys of the Upper River to locate tagged and other salmon.
- Locate spawning and holding salmon upstream of Devils Canyon.

A combination of fixed-station receivers below (at the Portage Creek confluence, RM 148.8), within (RM 150 and RM 164), and above Devils Canyon will be used to determine the migration timing and behavior of any radio-tagged salmon that pass into the Upper River area (Figure 9.7-2). Fixed-station receivers will be deployed at locations where they will have the highest probability of detecting radio-tagged salmon. The fixed station deployed at the confluence with Kosina Creek will provide additional information that can be used to assess the detection efficiencies for all mainstem fixed-station receivers downstream from this site. The data from these receivers will also be used to identify the broad reaches of the Upper River to guide the aerial and ground-based survey efforts needed to identify spawning areas.

The mobile survey data will aid in confirming the presence of radio-tagged fish, and locating any fish not detected at downstream fixed-station receiver sites. These additional detections will be combined with the aerial survey data to estimate detection efficiencies for each fixed-station receiver. The timing and proportion of all tagged salmon that pass Devils Canyon will be calculated and compared to the remaining tagged population, and their final spawning locations will be identified.

9.7.4.4 Objective 4: Use available technology to document salmon spawning locations in turbid water in 2013 and 2014.

This objective involves using side-scan and/or Dual Frequency Identification Sonar (DIDSON) to characterize any suspected salmon spawning in turbid water of the mainstem habitats of the Susitna River.

Previous studies in the mainstem Susitna River have relied on late-season visual surveys of redds to identify and characterize salmon spawning that occurs in turbid water after temperatures have fallen and the river water has cleared. The efficacy of this technique in the Susitna River mainstem habitats has not been evaluated and it may underestimate the extent of spawning activity in turbid water. Late-season visual surveys of redds may fall below 100 percent detection because detection may vary with discharge, suspended sediment levels, etc.

An AEA-sponsored study in August 2012 set out to examine the feasibility of using sonar to find and characterize spawning activity in turbid water. Technical difficulties in August and flow conditions and fish behavior in September 2012 precluded a rigorous test of this method. The method will be used again in 2013 to examine the feasibility of sampling turbid water to quantify spawning activity. Sonar has the potential to detect redds in turbid water and confirm spawning activity by directly monitoring fish behavior. Radio telemetry provides a powerful tool to identify suspected spawning activity, but subsequent sampling of fish with sonar and/or other methods may be needed to help determine whether spawning has actually occurred. Net sampling may help to determine the degree of sexual maturation and reduce confusion between holding and spawning areas in some instances. If spawning behavior such as the digging of redds is not obvious from the DIDSON imagery, and redds are not clearly visible from the side-scan imagery, additional sampling of the gravel by attempting to pump eggs would be required to confirm spawning. Initial emphasis in 2013 will be placed on any suspected Chinook salmon spawning areas in turbid water identified in the 2012 radio telemetry study.

9.7.4.4.1 Sonar Equipment and Methods

The EdgeTech 4125 600/1600 kHz side-scan sonar can generate high-resolution images with an across-track resolution of 0.6 centimeters (~0.25 inch), independent of the range sampled. The system is well suited for collecting data over large areas. Depending on the water depth, the high frequency side-scan sonar can sample a swath of up to 50 meters (164 feet). As a rule of thumb, if the transducer is 1 meter (3.28 feet) above the bottom, one can “see” an approximately 10-meter (32.8-foot) wide swath on each side of the survey boat (port and starboard). The minimum water depth required for the deployment of the transducer is approximately 0.5 meter (1.64 feet). The survey will be conducted at a boat speed of approximately 1 meter per second (3.28 feet per second), slower in shallow water if there is a danger of hitting obstacles. Where the side-scan sonar encounters aggregations of redds, the survey will periodically be paused to supplement the data with stationary spot checks with a DIDSON.

DIDSON is a high-resolution imaging sonar that provides video-type images over a 29-degree field of view and can thus be used to observe fish behavior associated with spawning, i.e., dynamic behavior that cannot be identified on the static side-scan images. To obtain high-quality images of adult salmon the maximum range will be limited to 15 meters (49 feet). Within this field of view, evidence of spawning behavior (e.g., redd digging, chasing, spawning) will be clearly identifiable. Furthermore, on DIDSON images fish can be classified by size category, e.g., <40 centimeters, 40–70 centimeters, >70 centimeters (<25 inches, 25–44 inches, >44 inches, respectively). Although this is not sufficient for definitive species identification, it will allow recognition of smaller resident fish, medium-sized adult salmon, and large Chinook salmon. DIDSON has successfully been used to survey salmon redds in the Columbia River.

If deemed feasible based on results from 2012, acoustic surveys will be made from early August through September to coincide with the times when sockeye, chum, Chinook, and pink salmon are actively spawning.

9.7.4.4.2 Sonar Data Analysis and Reporting

All sonar data will be collected along with a differential GPS with 10 Hertz (Hz) positioning rate. The GPS coordinates together with heading, pitch, and roll information will allow matching of side-scan and DIDSON data with any visual and telemetry-based ground-truthed data. The side-scan analysis will provide locations of individual redds or redd fields. The DIDSON data analysis will provide the coordinates, coverage, and duration of each station surveyed, together with the mean number of fish observed in the field of view, their size categories (<40 centimeters, 40– 0 centimeters, >70 centimeters [<25 inches, 25–44 inches, >44 inches, respectively]), and a qualitative description of their behavior.

9.7.4.5 Objective 5: Compare historical and current data on run timing, distribution, relative abundance, and specific locations of spawning and holding salmon.

A comparison will be made of this study's results from 2012–2014 to the historical results that characterized the relative abundance, locations of spawning and holding salmon, and use of mainstem, side channel, slough, and tributary habitat types by adult salmon.

Research conducted in the early 1980s provided information relevant to this study. Annual abundance estimates relevant to at least four fishwheel sites along the Susitna River mainstem were developed in each of three years (1983–1985). These abundance estimates were apportioned to mainstem, sloughs, and tributaries, and the results will be useful for assessing the potential impacts of the Project. One weakness of these studies was that they relied heavily on visual observations of fish (and abandoned late-season redds). These methods and results may underestimate the use and relative importance of mainstem habitats, many of which occur in turbid water during a substantial portion of the spawning period. Another concern is that data collected approximately 30 years ago may not characterize the current habitat use in the mainstem Susitna River.

This study will address both of these concerns by deploying a similarly scaled study of the spawning runs to the Susitna River in 2012–2014 and by using radio telemetry and sonar technology not available in the 1980s. We expect both methods to provide a more rigorous characterization of the use of mainstem habitats than methods used in the 1980s. To the extent spawning distribution and habitat use in the current study are similar to earlier studies, it will greatly increase the sample size and confidence in the conclusions from studies in both periods. Therefore, it will be important to explicitly compare and contrast the distribution and habitat use of salmon in the Lower, Middle, and Upper River habitats of the Susitna River.

9.7.4.6 Objective 6: Generate counts of adult Chinook salmon spawning in the Susitna River and its tributaries.

This objective will be addressed by conducting adult salmon spawning surveys (see Objective 1, Section 9.7.4.1.5) and operating weirs on tributaries (see Objective 8) in 2013 and 2014. The purpose of this work will be to attempt to establish survey-area mark rates (proportion of fish tagged in different streams or mainstem habitats) so that inferences can be made about the representativeness of tagging across stocks. In addition, mark rates from these areas can be used to estimate the abundance passing the tagging sites (but not the abundance at the recovery site). If sufficient sampling can be obtained and some assumptions met, some inference can be made about relative abundance among recovery locations using the estimates of mark rates and the number of radio-tagged fish present.

Assumptions will be made and tested regarding the representativeness of tagging and proportion of the run detected visually and by telemetry. A combination of ground-, aerial-, and weir-based counts will be used. Ground-based surveys will be made where high observer efficiency can be achieved (e.g., Portage and Indian Creeks). Weirs will be placed on selected tributaries (see Objective 8). Aerial surveys by helicopter were conducted in July and August 2012. Protocols will be developed based on experience in 2012 and these will be used again in 2013 and 2014 to survey the Portage and Indian tributaries of the Middle River.

Aerial survey data will be used to establish estimates of minimum and likely numbers of fish based on a range of observer efficiencies. These can then be used to establish ranges of possible species-specific mark rates in 2013 and 2014. Multiple aerial surveys will be flown bracketing the peak timing of spawning. Survey aircraft will be equipped with telemetry receivers and GPS to identify positions of tagged and not-tagged Chinook salmon and any other Pacific salmon that may be observed. The aerial surveys will *not* provide a direct estimate of the total salmon abundance in tributaries. Instead, these will provide a minimum count and then help to establish minimum and likely tributary-specific mark rates, as was done for Portage and Indian tributaries in 2012.

9.7.4.7 Objective 7: Collect tissue samples to support the Fish Genetics Study.

The task for this objective is to collect genetic samples from adult anadromous salmon in conjunction with addressing Objectives 1 and 2. Tissue samples will be taken from all radio-tagged salmon and from all untagged spawning fish that are sampled during spawning ground surveys. Sample collections will be coordinated with the Genetic Baseline Study team (see Section 9.14). Similar to 2012, this study will identify the locations of spawning fish and whenever feasible, collect tissue for use with genetics studies by ADF&G and other researchers.

9.7.4.8 Objective 8: Estimate the system-wide Chinook and coho salmon escapement to the Susitna River above Yentna River and the distribution of those fish among tributaries of the Susitna River in 2013 and 2014.

A commonly applied two-event, capture-recapture experiment will be used to estimate the annual abundance of Chinook salmon in the entire Susitna River drainage and the coho salmon abundance in the Susitna River above the Yentna River confluence. Such methods to estimate salmon escapement are ubiquitous in Alaska and along the West Coast of North America. In the Susitna River, the capture event will be provided by fishwheels operating throughout the seasonal salmon migration. Radio tags will be applied to fish as close to proportional of the migrating salmon as possible. Later in the salmon migration, a series of recapture sites on tributaries and mainstem sites will examine salmon to establish the proportion of each species that has a tag (also known as the species-specific and stock-specific mark rate). Using relatively simple algebra and making some testable assumptions, an estimate of the total species-specific abundance that passed the *tagging site* can be estimated; in this case, the abundance and in-river escapement at the fishwheels sites on the Susitna (Chinook and coho salmon) and the Yentna (Chinook salmon) rivers. Length, sex, and genetics information from the tagged and untagged fish can be used to assess the validity of most assumptions. Behavior of radio-tagged fish following tagging also provides information for evaluating two critical assumptions: that you know how many tagged fish have "entered" the experiment, and whether their behavior compromises the experiment.

Fishwheels on the Yentna and Lower Susitna rivers will be used to capture fish for marking. Weirs on tributaries of the Susitna River will be used to recapture fish for estimating the proportion of each species that has a tag. At the weir recapture sites, Chinook salmon will be counted and inspected for tags. Weirs will be operated on the Deshka River (which has been operated by ADF&G for many years), and on Willow Creek and the Middle Chulitna River, as well as Talachulitna River and Lake Creek in the Yentna drainage. These weir sites were chosen based on the numbers of fish using the systems based on a long time series of annual aerial survey data and the ability to weir the sites. Finally, the fishwheels at Curry will also examine a relatively large number of fish of each species and the mark rates (of lower river tags) in the Curry fishwheels. The size characteristics of the tagged and untagged fish at Curry can be used along with weir-based information in estimating escapement and testing assumptions of the mark-recapture experiment each year.

A two-event, capture-recapture experiment will also be used to estimate the abundance of coho salmon in the Susitna River upstream of the confluence with the Yentna River. Coho salmon will be counted and inspected for tags at the weirs on the Deshka River and Willow Creek. In addition, the middle Chulitna River will be evaluated as a possible site once the 2012 coho salmon telemetry analyses provide an indication the relative size of the coho salmon return to the river.

At Willow Creek, a DIDSON unit will likely be used in conjunction with the weir to estimate Chinook and coho salmon abundance. Past studies at Willow Creek found that, early in the season during spring runoff, Chinook salmon migrated past the likely weir site when high, occluded water precluded installation and operation of a weir. The weir will be installed once the water recedes to levels where the weir can be safely installed. In August and September when coho salmon migrate into the creek, the weir may be compromised by high water resulting from rain. During these times, coho salmon abundance will be estimated using DIDSON.

9.7.5 Consistency with Generally Accepted Scientific Practice

The fishwheel capture methods for supplying salmon for biotelemetry studies have been used around Alaska and elsewhere in North America since the early 1980s, including on the Susitna River at the locations proposed here (Cannon 1986). Similarly, radio-tracking of tagged adult salmon by fixed and mobile (aerial and boat) receivers has been established elsewhere, and used extensively in the Lower Susitna River over the last six years (Yanusz et al. 2007; Yanusz et al. 2011; Merizon et al. 2010) and during the AEA-sponsored salmon tagging at Curry in 2012

(Link et al. *in prep*). Two-event, capture-recapture experiments are ubiquitous in North America for assessing salmon abundance.

9.7.6 Schedule

Initial data collection efforts for this multi-year study began in the summer/fall of 2012 and will continue through the 2013 and 2014 adult salmon migration and spawning seasons. The schedule allows for one initial and two complete study seasons. The proposed schedule (Table 9.7-1) for completion of the Salmon Escapement Study is as follows:

- Initial data collection in 2012 will consist of: (1) operation of fishweels in the Susitna near Curry from June through August, (2) radio tagging and tracking of adult salmon (3) steam counts and carcass surveys in Indian River and Portage Creek (4) HSC surveys of mainstem spawning habitat for spawning salmon (5) evaluation of side-scan sonar to identify redds.
- File a supplemental memorandum with the FERC reporting interim 2012 Salmon Escapement results – First quarter 2013
- Install fishwheels and fixed telemetry stations – May and June 2013 and 2014
- Operate fishwheels in the Lower Susitna and Yentna Rivers – May through August, 2013 and 2014.
- Operate fishwheels in the Susitna River near Curry – June through early September, 2013 and 2014.
- Conduct aerial surveys in 2013 and 2104 to relocate radio-tagged salmon – mid-June through September in the Lower River and from mid-July through early October in the Middle and Upper River.
- Quality Controlled (QC) Data – December 2013 and 2014.
- QC'd geospatially-referenced relational database – December 2013 and 2014.
- Data analysis – October to December 2013 and October to December 2014
- Initial and Revised Study Reports on 2013 and 2014 activities – anticipated to be filed during the first quarter of 2014 and 2015, one and two years, respectively, after the FERC Study Plan Determination (February 2013)

9.7.7 Relationship with Other Studies

The salmon escapement study is interrelated to several other studies (Figure 9.7-3). Four Project studies will interrelate by providing predecessor information useful to the salmon escapement study. The Upper River Fish Distribution and Abundance Study (Section 9.5) and Middle and Lower River Fish Distribution and Abundance Study (Section 9.6) will each provide salmon distribution information useful for determining travel time, distance and spawning locations (Objective 1); characterizing migration behavior (Objective 2); characterizing movement in and above Devils Canyon (Objective 3); and estimating Chinook and coho escapement and relative distribution among tributaries (Objective 8). The Characterization and Mapping of Aquatic Habitats Study (Section 9.9) will provide habitat characterization information useful for the characterization of migration behavior and spawning locations (Objective 2). The Fish Genetic

Baseline Study (Section 9.14) will provide information on Chinook salmon genetic structure useful for estimation of the relative distribution among tributaries and mainstem spawning habitats (Objective 8). The Salmon Escapement, along with the Upper River Fish Distribution Study (Section 9.5) and Middle and Lower River Fish Distribution Study (Section 9.6), will also interrelate by opportunistically providing genetic tissue samples of Chinook salmon for the Genetic Baseline Study (Section 9.14).

The Salmon Escapement Study will also interrelate with five other Project studies by providing useful output information (Figure 9.7-3). Characterization of travel time and distance, spawning locations (Objective 1), and migration behavior (Objective 2) will provide general information on salmon distribution and access to habitat, which will be used by the Fish Passage Barriers Study (Section 9.12) and the Aquatic Resources Access Study (Section 9.13). Characterization of migration behavior and spawning locations (Objective 2), and fish movement in and above Devils Canyon (Objective 3) will each provide information on salmon presence above the proposed dam site, which will be useful to the Future Reservoir Fish Community (Section 9.10) and the Fish Passage Feasibility Study (Section 9.11). Estimates of Chinook and coho salmon escapement and relative distribution among tributaries (Objective 8) will provide information on distribution and relative abundance of Chinook salmon by major tributary, which can be used in the Analysis of Fish Harvest Study (Section 9.15).

9.7.8 Level of Effort and Cost

The schedule, staffing, and costs will be detailed as the 2013–2014 Study Plan develops. Total study costs are estimated at $10,000,000. Objectives 1 through 7 would be approximately $2,400,000 per year and the estimated costs for work associated with Objective 8 would be $2,600,000 per year.

9.7.9 Literature Cited

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9.7.10 Tables

Table 9.7-1. Schedule for implementation of the Salmon Escapement Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Initial studies and Technical Memorandum		—	—	—	•								
Deploy fishwheels and fixed telemetry stations						—				—			
Operate fishwheels and radio tag fish						—	—			—	—		
Conduct aerial telemetry surveys							—	—			—	—	
Aerial and ground escapement visual counts							—				—		
Data entry and geospatial database							—	—			—	—	
In-season progress reporting							—	—			—	—	
Preliminary data Analysis							—	—					
Initial Study Report								—	—Δ				
Final data analysis											—	—	
Updated Study Report												—	—▲

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
• Technical Memorandum
Δ Initial Study Report
▲ Updated Study Report

9.7.11 Figures

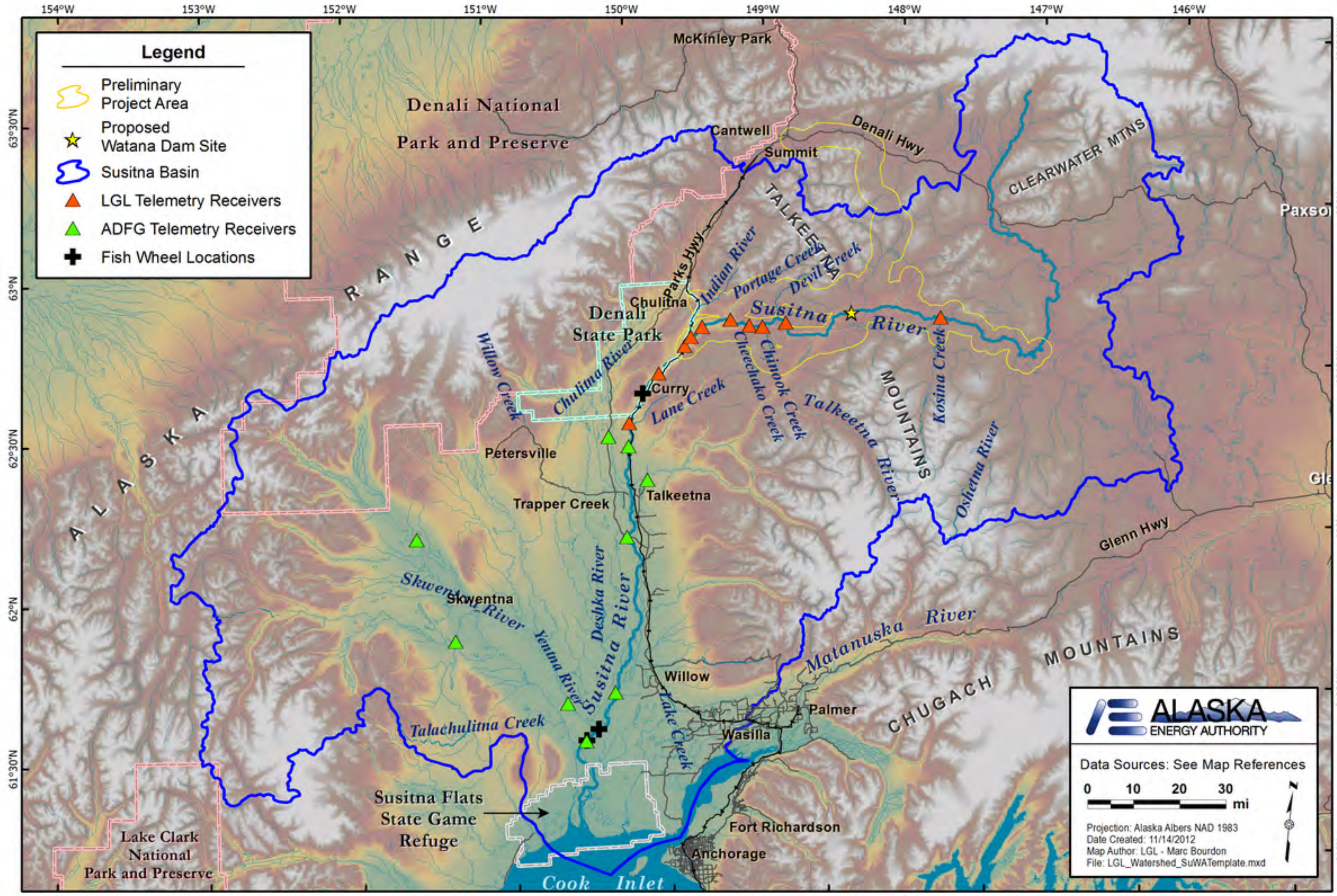

Figure 9.7-1. Susitna watershed showing fish capture sites (fishwheels) and the locations of fixed-station telemetry receivers in the Susitna River.

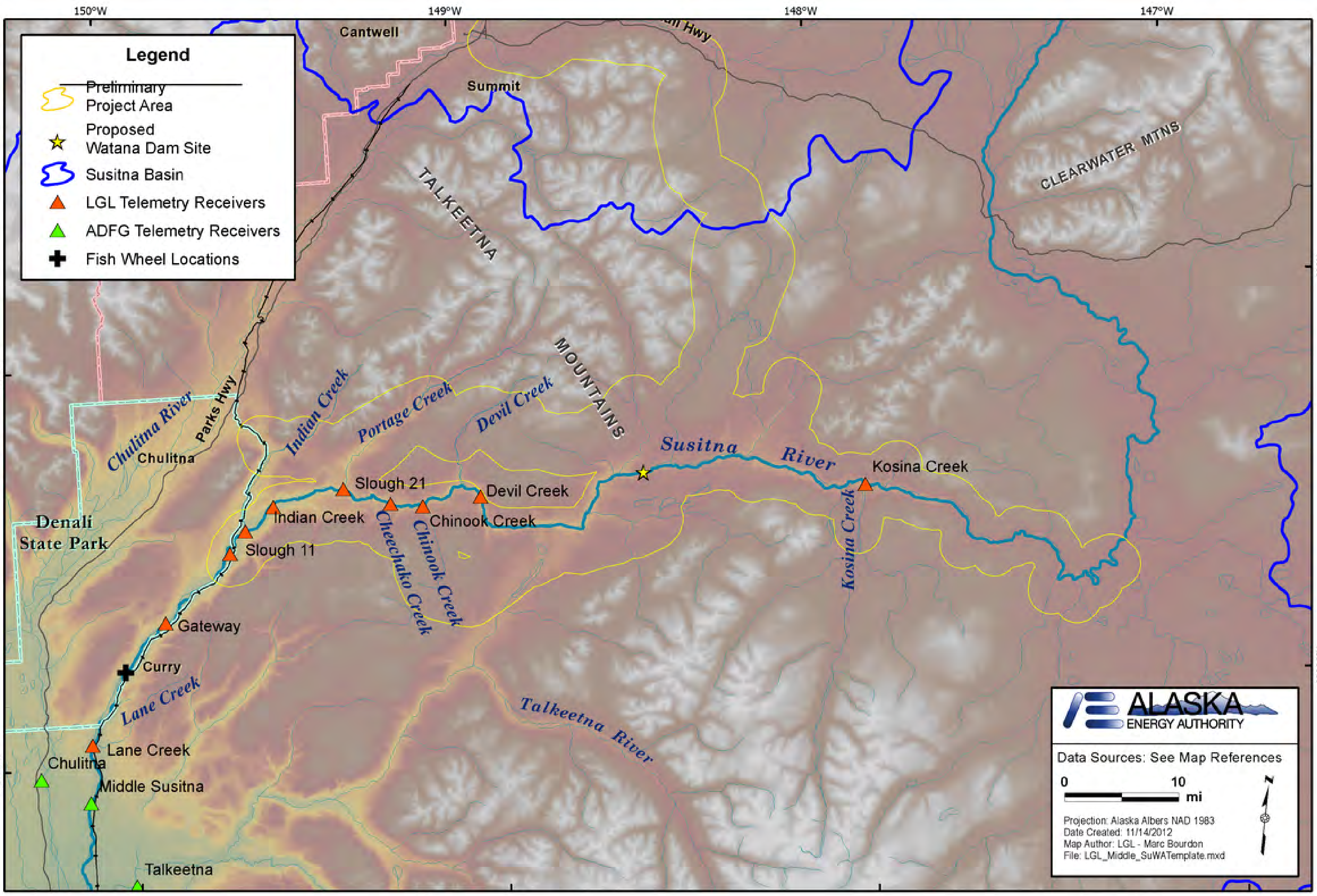

Figure 9.7-2. Fixed-station telemetry receivers in the Middle and Upper Susitna River, 2012–2014.

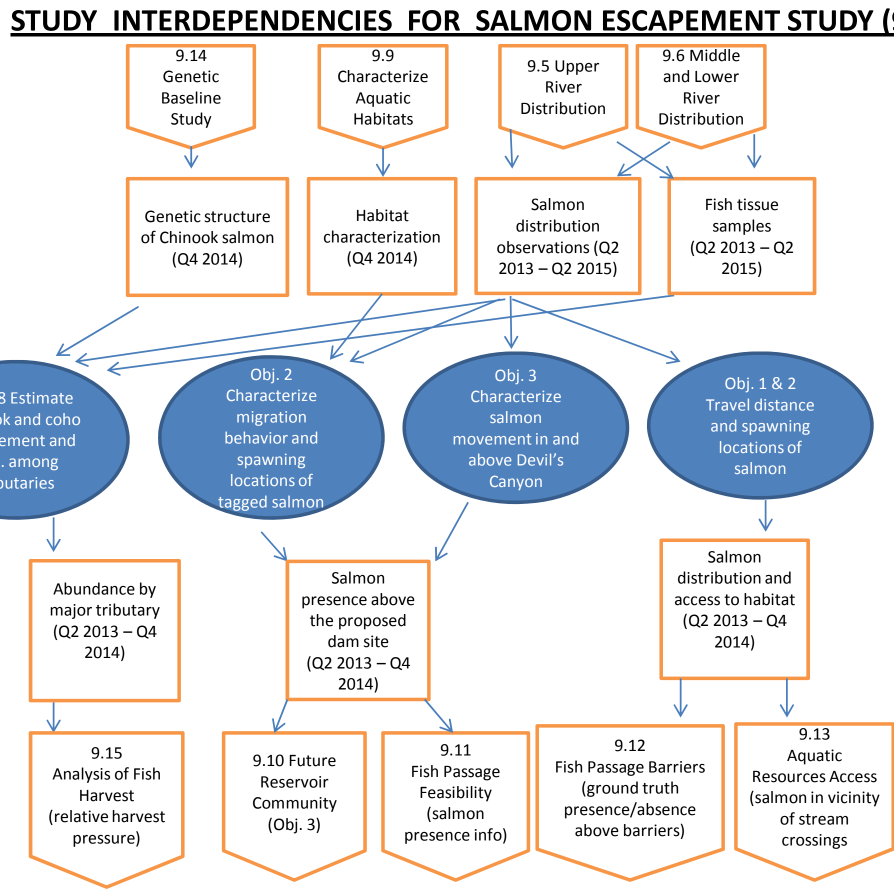

Figure 9.7-3. Study interdependencies for Salmon Escapement Study.

9.8. River Productivity Study

9.8.1. General Description of the Proposed Study

The production of freshwater fishes in a given habitat is constrained both by the suitability of the abiotic environment and by the availability of food resources (Wipfli and Baxter 2010). Algae are an important base component in the lotic food web, being responsible for the majority of photosynthesis in a river or stream and serving as an important food source to many benthic macroinvertebrates. In turn, benthic macroinvertebrates are an essential component in the processes of an aquatic ecosystem, due to their position as consumers at the intermediate trophic level of lotic food webs (Hynes 1970; Wallace and Webster 1996; Hershey and Lamberti 2001). Macroinvertebrates are involved in the recycling of nutrients and the decomposition of terrestrial organic materials in the aquatic environment, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, namely fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). In turn, nutrients and energy provided by spawning salmon have the potential to increase freshwater and terrestrial ecosystem productivity (Wipfli et al. 1998; Cederholm et al. 1999; Chaloner and Wipfli 2002; Bilby et al. 2003; Hicks et al. 2005), and may subsidize otherwise nutrient-poor ecosystems (Cederholm et al. 1999).

The significant functional roles that macroinvertebrates and algae play in food webs and energy flow in the freshwater ecosystem make these communities important elements in the study of a stream's ecology. The operations of the proposed Project would likely affect one or more of the factors that can affect the abundance and distribution of benthic algae and benthic macroinvertebrate populations, which could ultimately affect fish growth and productivity in the system. The degree of impact on the benthic communities and fish resulting from hydropower operations will necessarily vary depending on the magnitude, frequency, duration, and timing of flows, as well as potential Project-related changes in geomorphology, ice processes, temperature, and turbidity. By investigating the current populations of algae, benthic macroinvertebrates, and fish in the Susitna River and the trophic relationships between them, this study will generate information about the current health and status of these populations throughout the varied habitats in the Susitna River, and provide a better understanding on the availability and utilization of food resources in the system. In addition, by applying what is known about the effects of river regulation and hydropower operation on these populations in riverine ecoysystems, AEA can begin to assess the potential impacts of Project operations on river productivity in the Susitna River, as well as provide information to inform development of any necessary protection, mitigation, and enhancement (PM&E) measures.

Study Goals and Objectives

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

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

2. Characterize the pre-Project benthic macroinvertebrate and algal communities with regard to species composition and abundance in the Middle and Upper Susitna River.
3. Estimate drift of benthic macroinvertebrates in selected habitats within the Middle and Upper Susitna River to assess food availability to juvenile and resident fishes.
4. Conduct a feasibility study in 2013 to evaluate the suitability of using reference sites on the Talkeetna River to monitor long-term Project-related change in benthic productivity.
5. Conduct a trophic analysis to describe the food web relationships within the current riverine community within the Middle and Upper Susitna River.
6. Develop habitat suitability criteria for Susitna benthic macroinvertebrate and algal habitats to predict potential change in these habitats downstream of the proposed dam site.
7. Characterize the invertebrate compositions in the diets of representative fish species in relationship to their source (benthic or drift component).
8. Characterize organic matter resources (e.g., available for macroinvertebrate consumers) including coarse particulate organic matter, fine particulate organic matter, and suspended organic matter in the Middle and Upper Susitna River.
9. Estimate benthic macroinvertebrate colonization rates in the Middle Susitna Segment under pre-Project baseline conditions to assist in evaluating future post-Project changes to productivity in the Middle Susitna River.

9.8.2. Existing Information and Need for Additional Information

A number of evaluations of the benthic macroinvertebrate community were conducted on the Susitna River in the 1970s and in the 1980s for the original Alaska Power Authority (APA) Susitna Hydroelectric Project (Friese 1975; Riis 1975, 1977; ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuyse 1985; Trihey and Associates 1986). ADF&G studies in the 1970s included sampling of macroinvertebrates using artificial substrates (rock baskets) deployed for a set period of time to allow for colonization. Friese (1975) and Riis (1975) set a total of eight rock baskets in Waterfall Creek, Indian River, and the mainstem Middle Susitna River for 30 days during summer (July – September). Riis (1977) also deployed rock baskets in the Susitna River near the mouth of Gold Creek for a colonization period of 75 days; however, only two of seven baskets were retrieved. Results were limited to low numbers of invertebrates per basket, identified to taxonomic family.

Studies conducted in the 1980s for the original APA Susitna Hydroelectric Project focused on benthic macroinvertebrate communities in the sloughs, side channels, and tributaries of the Middle Segment of the Susitna River from river mile (RM) 125 to RM 142 during the period from May through October. Efforts included direct benthic sampling with a Hess bottom sampler and drift sampling. Alaska Department of Fish and Game (ADF&G) efforts in 1982 and 1984 also involved collection of juvenile salmon in these side channels and sloughs, and an analysis was conducted to compare gut contents with the drift and benthic sampling results (ADF&G 1983; Hansen and Richards 1985). In addition, Hansen and Richards (1985) collected water velocity, depth, and substrate-type data to develop habitat suitability criteria (HSC), which were used to estimate weighted usable areas for different invertebrate community guilds, based on their behavioral type (swimmers, burrowers, clingers) in slough and side channel habitats. Efforts in 1985 (Trihey and Associates 1986) expanded to include sampling at nine sites in the Middle Susitna River Segment: three side channels, two sloughs, two tributaries, and two mainstem sites.

Algal communities were periodically sampled and analyzed for chlorophyll-a at Susitna Station from 1978 to 1980. In the 1980s, algae samples were collected as part of the APA Susitna Hydroelectric Project water quality studies, with sampling conducted at Denali, Cantwell (Vee Canyon), Gold Creek, Sunshine, and Susitna Station on the Susitna River, as well as on the Chulitna and Talkeetna rivers (Harza-Ebasco 1985 as cited in AEA 2011). Analysis showed low productivity (less than 1.25 mg/m^3 chlorophyll-a) and indicated algal abundance was most likely limited by high concentrations of turbidity (AEA 2011).

Baseline field data for benthic primary and secondary production was also collected in 1985, as part of the Primary Production Monitoring Effort (Van Nieuwenhuyse 1985). Chlorophyll-a (*chl-a*), and macroinvertebrates were collected from early April to late October 1985 from a variety of off-channel and mainstem habitat sites. Early April sampling took place in an open-water lead in Slough 8A, and revealed high macroinvertebrate densities (average 17,600 individuals/m^2) comprised almost entirely of chironomid larvae, and chlorophyll-a densities averaging 34.4 mg/m^2. Sampling in early May in Slough 8A revealed macroinvertebrate densities averaging 2,950 individuals/m^2, again almost entirely chironomids, and *chl-a* densities averaging 37mg/m^2. Results from five mainstem habitat sites showed similar macroinvertebrate numbers, with densities ranging from 393 to 8,820 individuals/m^2 in May 1985, but with considerably more diversity; chironomids accounted for an average of 53 percent of the density, and only 8 percent of the macroinvertebrate biomass. Algae samples beyond May 1985 had not been analyzed; therefore, no data were available for summer or fall. No sampling results were given for summer macroinvertebrate sampling (June and July). August and September 1985 sampling showed low average densities at mainstem sites (44 – 164 individuals/m^2), with large increases occurring in October 1985 (1,729 – 7,109 individuals/m^2). Average densities in Slough 8A in August 1985 remained similar to spring levels, at 2,851 individuals/m^2, with a surge in September 1985 (13,964 individuals/m^2); again, chironomids represented over 80 percent of the numbers. No further information or reports were available concerning the Primary Production Monitoring Effort task.

Benthic macroinvertebrate information from the 1980s is focused on a limited number of mainstem, side channel, and slough habitats located within a 17-mile reach of the Middle Susitna River. Additional information is needed on mainstem benthic communities, as well as those in side channel and slough habitats, within both the Middle and Upper Susitna River segments. Benthic algae information needs to be collected in conjunction with the macroinvertebrates to define their relationship in the river's trophic system. To assess the impact of future hydropower operations on the benthic communities within the Susitna River, additional information must be collected through an increased sampling effort, including more sampling sites along the river in relation to the distance both downstream from the proposed dam site and upstream from the proposed Project reservoir area.

9.8.3. Study Area

The River Productivity Study will entail field sampling throughout the Upper Segment and Middle Segment on the Susitna River (Table 9.8-1; Figures 9.8-1 through 9.8-2). The Upper

Susitna River Segment is defined as the section of river above the proposed Watana Dam site at RM 184 (Figure 9.8-1). Sampling in the upper portions of this segment above the proposed reservoir (RM 233 – 260) will investigate the benthic communities that will be unaffected by the Project. The Middle Susitna River Segment encompasses the 86-mile section of river between the proposed Watana Dam site and the Chulitna River confluence, located at RM 98 (Figure 9.8-2). Sampling activities within this segment will investigate the benthic communities that may be affected by the Project and its regulated flows. Sampling will be conducted at various distances from the proposed dam site to document longitudinal variability, and estimate the effects that the proposed Project will have on benthos in the river system downstream. The Lower Susitna River Segment, defined as the approximate 98-mile section of river between the Chulitna and Talkeetna rivers confluence and Cook Inlet, will not be sampled in this study because the larger influences of the Chulitna and Talkeetna rivers will attenuate Project operation effects, if any, that would affect benthic communities on the mainstem Susitna River below the Three Rivers Confluence.

AEA will reevaluate how far downstream Project operational significant effects extend based in part upon the results of the Open-water Flow Routing Model (see Section 8.5.4.3), which is scheduled to be completed in Q1 2013. Thus, an initial assessment of the downstream extent of Project effects will be developed in Q2 2013 with input of the TWG. This assessment will include a review of information developed during the 1980s studies and study efforts initiated in 2012, such as sediment transport (Section 6.5), habitat mapping (Sections 6.5 and 9.9), operations modeling (Section 8.5.4.2.2), and the Mainstem Open-water Flow Routing Model (Section 8.5.4.3). The assessment will guide the need to extend studies into the Lower River Segment and if needed, will identify which geomorphic reaches will be subject to detailed instream flow analysis in 2013. Results of the 2013 studies would then be used to determine the extent to which the study should be modified to include sampling in the Lower River Segment in 2014.

9.8.4. Study Methods

This study will employ a variety of field methods to build upon the existing information related to the benthic macroinvertebrate and algal communities in the Upper and Middle Susitna River. The following sections provide brief descriptions of study site selection, sampling timing, the approach, and methods that will be used to accomplish each objective of this study.

River Productivity Implementation Plan

This study includes a description of the sampling scheme. However, specific details regarding site locations, timing, sampling devices, processing, and analyses will be dependent upon the results of 2012 data collection efforts.

The final sampling scheme will be included in the River Productivity Implementation Plan, which will be filed with FERC prior to March 15, 2013.

The Implementation Plan development will include: (1) a summary of relevant macroinvertebrate and algal studies in the Susitna River, (2) an overview of the life-histories of the target fish species in the Susitna River that are selected for the trophic analysis (Section 9.8.4.5.1), (3) a review of the preliminary results of habitat characterization and mapping efforts (Section 9.9) and "Focus Areas" (Section 8.5.4.2.1.2), (4) a description of site selection protocols, (5) a description of sampling protocols, (6) a description of sample processing protocols, (7) a discussion of data analysis methods, (8) development field data collection forms, and (9) 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 sampling locations, details about the choice and use of sampling techniques and apparatuses, and a list of field equipment needed. The implementation plan will also help ensure that field collection efforts occur in a consistent and repeatable fashion across field crews and river segments. Proposed sampling methods by objective are presented below.

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

Several reviews have been written on the effects that modified flows have on the benthic communities residing below dams (Ward 1976; Ward and Stanford 1979; Armitage 1984; Petts 1984; Cushman 1985; Saltveit et al. 1987; Brittain and Saltveit 1989). A majority of these reviews indicate that temperature and flow regimes are often the most important factors affecting benthic macroinvertebrates below dams. The type of dam and its mode of operation will have a large influence over the type and magnitude of effects on the receiving stream below. General information on the effects of hydropower on riverine habitats, especially glacially-fed river systems, as well as Project-specific information, will be reviewed and synthesized in a written report. Specifically, AEA will prepare a written report that provides a literature review summarizing relevant literature on macroinvertebrate and algal community information in Alaska, including 1980s Susitna River data; review and summarize literature on general influences of changes in flow, temperature, substrates, nutrients, organic matter, turbidity, light penetration, and riparian habitat on benthic communities; and review and summarize the potential effects of dams and hydropower operations, including flushing flows and load-following, on benthic communities and their habitats. To the extent consistent with copyright laws, electronic copies of all cited publications will be provided through the ARLIS library.

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

9.8.4.3. Benthic macroinvertebrate sampling

Macroinvertebrate sampling will be stratified by reach and mainstem habitat type defined in the Project-specific habitat classification scheme (mainstem, tributary confluences, side channels, and sloughs). To accomplish this objective, sampling will occur at six stations, each with three sites (one mainstem site and two off-channel sites associated with the mainstem site), for a total of 18 sites. Two stations will be located in the Upper Segment, above the proposed dam and reservoir area (upstream of RM 223) (Table 9.8-1; Figure 9.8-1). In the Middle Segment, two stations will be located between the dam site and the upper end of Devils Canyon, and two stations will be located below Devils Canyon, within the Geomorphic Reach MR-6 (Table 9.8-1; Figure 9.8-2). All stations established within the Middle Segment will be located at Focus Areas established by the Instream Flow Study (Section 8.5.4.2.1.2), in an attempt to correlate macroinvertebrate data with additional environmental data (flow, substrates, temperature, water quality, riparian habitat, etc.) for statistical analyses, and HSC/HSI development. Station and site locations will be determined during the first quarter of 2013, and detailed in the River Productivity Implementation Plan.

Three sampling periods will occur from April through October in both study years (2013–2014) to capture seasonal variation in community structure and productivity. Seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn. Specific details on timing will be provided in the River Productivity Implementation Plan. Timing of life history events for coho, Chinook salmon, and rainbow trout (target species for Objective 5, Section 9.8.4.5.1) will be consulted when scheduling sampling efforts.

Sampling will be conducted in riffle/run mesohabitats within mainstem and off-channel macrohabitat types (i.e., tributary confluences, side channels, and sloughs). Higher flows may inundate new shoreline substrates, which poses the risk of sampling in areas that are not fully colonized. The shoreline bathymetry for each site will be evaluated such that changes in water level due to increasing or decreasing flows must remain constant enough that the substrates accessible for sampling will be continually inundated for a period of at least one month, to facilitate colonization of those substrates.

Benthic macroinvertebrate sampling will be conducted using a stream-type sampler (Hess, Surber, Slack) commonly used for other Alaskan benthic macroinvertebrate studies to allow for comparable results; state and federal protocols (Hansen and Richards 1985; Barbour et al. 1999; Klemm et al. 1990; Klemm et al. 2000; Carter and Resh 2001; Moulton et al. 2002; Peck et al. 2006), as well as methods used in the Susitna River studies in the 1980s, will be considered when designing the sampling approach, which will be detailed in the River Productivity Implementation Plan. Replicate samples (n=5) will be collected to allow for statistical testing of results for short- and long-term monitoring. Measurements of depth, mean water column velocity, mean boundary layer velocity (near bed), and substrate composition will be taken concurrently with benthic macroinvertebrate sampling at the sample location for use in HSC/HSI development in the instream flow studies. Water temperatures will be monitored hourly at sites with submerged temperature loggers deployed at all sampling sites throughout the ice-free season. Fine-scale (1 meter vertical and horizontal resolution) measurements of flow will be recorded within a 5-m radius of selected sampling sites. Temperature and flow monitoring will be coordinated with the Baseline Water Quality Study (Section 5.5) and the Instream Flow Study (Section 8.5), and supplemental temperature loggers will be deployed if necessary to cover all River Productivity Study sites.

In addition, floating emergence traps will be deployed at each site to determine both the timing and the amount of adult insect emergence from the Susitna River (Cushman 1983). Adult aquatic insect emergence mass is a product of aquatic insect production from the stream, and is therefore a good surrogate for actual production (minus predation), and will be especially useful for relative comparisons between river sections and years (personal communication, M. Wipfli, University of Alaska-Fairbanks). Emergence traps will be checked and reset every month. Trapped adults will be identified, enumerated, and weighed. Exact trap design will be determined according to methods compatible with those used for other studies in comparable streams/basins in Alaska, and will be detailed in the River Productivity Implementation Plan.

Due to the prevalence of large woody debris in the Susitna River, woody snags, if present at a sampling site, also will be sampled as a substrate strata for benthic macroinvertebrates, as requested by the U.S. Fish and Wildlife Service (USFWS) (USFWS River Productivity Study Request; May 31, 2012). Sampling methods for woody snags will be semi-quantitative, based upon protocols established by the USGS (Moulton et al. 2002). Suitable woody snags will have been submerged for an extended period of time so as to be clearly colonized. Woody snags to be sampled will be removed from the water by using a saw and placed over a plastic bin or in a bucket, and all benthic macroinvertebrates will be removed by handpicking, brushing, and rinsing. The snags will be allowed to dry for a period of time so that missed organisms will crawl out of the crevices and can then be collected. Snag sections sampled will be measured for length and average diameter to determine surface area sampled. Each snag section will originate from a separate snag, and therefore count as a separate, replicate sample.

In order to address the effects of changing flow patterns on benthic macroinvertebrates, algae (Section 9.8.4.2.2), and benthic organic matter (BOM) (Section 9.8.4.8), baseline data will be collected to assess the benthic community responses to storm events within side slough habitats. Additional sampling will be conducted both before and after storm events that meet or exceed a 1.5-year flood event at two side slough sites, located in two separate Focus Areas in the Middle River Segment between Portage Creek and Talkeetna (Section 8.5.4.2.1.2). Replicate samples (n=5) will be collected at both the upstream and downstream ends of each slough, and will include benthic macroinvertebrates, algae, and BOM. Sampling will be conducted for two storm events per year. Specific details on locations and targeted flows will be based on information from the Instream Flow (Section 8.5) and Geomorphology (Section 6.5) studies available in early 2013, and will be provided in the River Productivity Implementation Plan.

Benthic macroinvertebrate replicate samples collected will be stored in individual containers and immediately preserved in the field with 95 percent ethanol (non-denatured). Samples will be processed in a laboratory using methods compatible with those used for other studies in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols and the taxonomic resolution of specimen identifications. Sampling and processing methodology will be detailed in the River Productivity Implementation Plan.

Results generated from the collections will include several descriptive metrics commonly used in aquatic ecological studies, such as density (individuals per unit of area), taxa richness (both mean and total), EPT taxa (i.e., *Ephemeroptera*, *Plecoptera*, *Trichoptera*) richness, diversity (H’), evenness (J’), percent dominant taxa, the relative abundance of major taxonomic groups, and the relative abundance of the functional feeding groups. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for benthic and emergence sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven dried at 60˚C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial (adult) life-stages of each primary invertebrate taxon. For two selected stations, benthic macroinvertebrates and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Data collected during this study will be compared to the results of 1980s studies (ADF&G 1983; Hansen and Richards 1985; Van Nieuwenhuyse 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current community structure. In addition, any invasive benthic macroinvertebrates identified in the sample collections will be identified and their collection locations will be recorded using the Geographic Information System (GIS) (NAD 83).

9.8.4.4. Benthic algae sampling

Benthic algae sampling will be collected concurrently with benthic macroinvertebrate sampling at all six stations (18 sites total) to allow for correlation between the two collections (Table 9.8-1), plus the additional baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs, as discussed in Section 9.8.4.2.1. Benthic algae sampling will be conducted using methods compatible with other Alaska benthic algal studies, to allow for comparison of results. Algal sampling methods will be based on the EPA's field operations procedures for periphyton single or targeted habitat sampling when designing the sampling approach (Eaton et al. 1998; Barbour et al. 1999; Peck et al. 2006). Measurements of depth, mean water column velocity, mean boundary layer velocity, turbidity, and substrate composition will be taken concurrently with algae sampling at the sample location for use in HSC development in the instream flow studies. Light availability will be measured at each sample location with an underwater light sensor, to measure the photosynthetically active radiation (PAR) available to the algal community. Turbidity measurements will also be taken at the site to determine water clarity. Benthic algae samples will be processed in a laboratory, using methods compatible with those used for other studies in comparable streams/basins in Alaska, considering state and federal protocols (Eaton et al. 1998; Barbour et al. 1999; Moulton et al. 2002; Peck et al. 2006) to determine sample processing protocols, including sub-sampling protocols. Algal sampling and processing methods will be detailed in the River Productivity Implementation Plan.

Results generated from the collections would include both dry weight and chlorophyll-a, and several descriptive metrics to describe the algal community; full details will be provided in the River Productivity Implementation Plan. For two selected stations, portions of algal material will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2). In addition, any invasive algae taxa identified in the sample collections will be identified and their locations will be recorded using GIS (NAD 83).

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

Invertebrate drift sampling will be conducted concurrently with benthic macroinvertebrate sampling at all sites within the six established sampling stations to allow for comparisons between the drift component and the benthic macroinvertebrate community, as well as revealing the availability of terrestrial invertebrates to fish predation. Sampling will be conducted in riffle/run habitats within the mainstem sites, and their associated off-channel habitat sites (Table 9.8-1).

Invertebrate drift sampling will be conducted using a drift net similar to those used for other drift studies in Alaska to allow for comparison of results; state and federal protocols will be considered (Keup 1988; Klemm et al. 2000). Drift sampling will be conducted during pre-dawn hours, as a measure of drift that is available to feeding fish (Waters 1972; Brittain and Eikeland

1988; Keup 1988). Sampling methods will involve collecting duplicate samples to allow for statistical testing of results for short- and long-term monitoring (Klemm et al 1990; Klemm et al. 2000). Water velocity will be recorded with an in-net flow meter. Invertebrate drift samples will be processed in a laboratory, using methods compatible with other studies conducted in comparable streams/basins in Alaska. State and federal protocols (Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered when making decisions about the sample processing protocols, including sub-sampling protocols, taxonomic resolution of specimen identifications, and length measurements for individual specimens. Samples at two selected stations (one each in Upper and Middle segments) will be tested for the stable isotope analysis task (Section 9.8.4.5.2). Organic matter (OM) content will be retained and analyzed by size (coarse and fine particulate OM) as discussed in Section 9.8.4.8.

Results generated from these collections will include drift density, drift rate, and drift composition. In conjunction with the bioenergetics modeling (Section 9.8.4.5.1), biomass estimates will be taken for primary invertebrate taxa collected for drift sampling. The fresh blotted wet mass of invertebrate taxa in samples will be recorded, the samples will be oven-dried at 60˚C until reaching constant mass, and the dry mass will be recorded. For a select sub-sample of the collection, energy density (J / g wet weight) will be estimated from the percent dry mass (dry mass / wet mass) of each sample (Ciancio et al. 2007; James et al. 2012). Energy density will be determined separately for the aquatic and terrestrial life stages of each primary invertebrate taxon. For two selected stations, portions of terrestrial invertebrate composition and organic matter in samples will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2).

Data collected as part of this study will be compared to data from the benthic macroinvertebrate collections (Section 9.8.4.2.1) and the fish dietary analysis (Section 9.8.4.7). In addition, drift results will be compared to the results of 1980s drift studies (ADF&G 1983; Hansen and Richards 1985; Trihey and Associates 1986) to evaluate any differences between the historic and current drift components of the macroinvertebrate communities.

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

Sampling sites will be established in the Talkeetna River in areas that are physically similar to those sampled in the Middle Susitna River Segment, to ensure comparability. Sampling will be conducted in riffle habitats within the mainstem, side channels, and sloughs. One station will be established, with a mainstem site and two off-channel habitat sites associated with the mainstem site. Benthic and drift sampling will occur during approximately the same periods as sampling in the Middle Susitna River Segment (Objectives 2 and 3, Sections 9.8.4.2 and 9.8.4.3), with seasonal sampling during 2013. Benthic macroinvertebrate, benthic algal, and drift sampling methods and processing protocols will be identical to those used in sampling the Middle Susitna River Segment (Objective 2, Section 9.8.4.2). In the first quarter of 2014, sampling results from Talkeetna sites will be compared to results from similar sites in the Middle Susitna River Segment to determine whether the Talkeetna River would serve as a suitable reference site. Statistical analyses will test for similarities and significant differences between Talkeetna sites and Middle Susitna Segment sites by comparing community compositions and a collection of calculated metrics. Methods will be detailed in the River Productivity Implementation Plan, and may include ANOVA, MANOVA, cluster analysis using Non-Metric Multi-Dimensional Scaling (NMDS) ordinatation with the Bray-Curtis Dissimilarity Coefficient, and/or other multivariate ordination techniques (Principal Components Analysis, Canonical Correspondence Analysis). Results indicating close similarities, or no significant differences, between sites on the two rivers would indicate suitability as a reference. If suitable, sites on the Talkeetna River can be used in a long-term monitoring program with Susitna River sites to help differentiate potential long-term changes that are Project-related versus those occurring for other reasons outside Project influence. Such a monitoring program would ideally collect multiple years of both pre-Project and post-Project data.

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

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

To complement the fish habitat suitability analysis (Section 9.8.4.6), which focuses on physical habitat features, trophic models will be developed to incorporate the density and quality of prey into an estimate of habitat quality. Growth rate potential models integrate knowledge of the foraging capabilities and bioenergetic physiology of a consumer with field data on its physical environment and prey base to quantify the values of different habitats (Brandt et al. 1992; Nislow et al. 2000; Jensen et al. 2006; Farley and Trudel 2009). The currency of these models, growth rate potential (GRP), is the expected growth rate of a consumer occupying a given habitat. For salmon, juvenile growth is strongly correlated with early marine survival and overall stock dynamics (Pearcy 1992; Beamish and Mahnken 2001; Moss et al. 2005; Duffy and Beauchamp 2011), making GRP a particularly valuable metric of freshwater habitat quality.

One drawback of typical GRP models is that modeled fish are often assumed to occupy a single uniform habitat (e.g., Brandt and Kirsch 1993). However, real fish may be able to exceed the growth rate predicted by these models by moving among nearby habitats to feed, rest, and digest. For example, by regularly moving between habitats of differing temperatures, some sculpin can increase their growth rates by as much as three-fold, relative to a strategy of using a single habitat (Wurtsbaugh and Neverman 1988; Neverman and Wurtsbaugh 1994). The growth of juvenile coho and Chinook salmon is relatively insensitive to the range of temperatures typically found in Alaskan streams, suggesting that small temperature differences among habitats may not substantially affect growth (Beauchamp 2009). However, thermal heterogeneity has a strong influence on the growth of juvenile coho salmon in the Bristol Bay region, due to the short growing season and the potential for faster-growing individuals to consume energy-rich salmon eggs (Armstrong et al. 2010). Further, resident fishes such as rainbow trout can exploit thermal variation patterns by moving from colder to warmer streams to prolong their access to salmon eggs and carcasses during the summer (Ruff et al. 2011). Thus, the local movement patterns of both juvenile salmon and non-anadromous resident fishes among habitat types within the Susitna River study area could potentially have important consequences for their growth rates.

Growth rate potential models will be developed to quantify the effects of environmental conditions and food availability on fish growth at each sampling location, while allowing for local movement among habitats. Due to the relatively data-intensive nature of GRP models, this analysis will focus on two species: coho salmon and rainbow trout. Coho salmon will be included due to their high ecological and economic value in the Susitna Basin and Cook Inlet. Rainbow trout will be included as a representative resident species and a potentially important competitor and predator of juvenile salmon. Importantly, detailed foraging parameters are available for both species (e.g., Dunbrack and Dill 1984; Berg and Northcote 1985; Piccolo et al. 2007; Piccolo et al. 2008a, 2008b), enabling the development of well-supported foraging models. The necessary bioenergetics model parameters are also available for both species (Stewart and Ibarra 1991; Rand et al. 1993).

Species-specific GRP models for coho salmon and rainbow trout will couple a foraging model (Fausch 1984; Hughes and Grand 2000; Hayes et al. 2007) with a Wisconsin bioenergetics model (Kitchell et al. 1977; Hanson et al. 1997). The foraging models will take inputs of flow, turbidity, and prey density and predict a consumption rate. The bioenergetics models will take inputs of consumption, body size, water temperature, diet composition, and the energy density of prey and predict a growth rate. Each GRP model will allow for the potential of local movement among habitats within a sampling location to enhance growth rates. Optimal simulated movement patterns will be estimated and compared with the observed movements documented by the radio telemetry and PIT tagging components of the Fish Distribution and Abundance Study (Section 9.6).

Preliminary growth models for each species will be developed using data from the 2013 field season as well as from prior Susitna Basin studies. Initial model predictions of the growth potential of particular sites will be tested by comparison with the observed growth and distribution of fish captured in those sites. A sensitivity analysis will be conducted to identify the most important parameters for further refinement (Beaudreau and Essington 2009). Field sampling during 2014 will focus on improving estimates for these parameters.

In addition, a separate trophic analysis will determine how water temperature, food availability, and food quality influence the growth performance of juvenile Chinook salmon in different habitats. Mechanistic drift foraging models for Chinook salmon are not yet available to allow the estimation of growth rate potential under changing conditions. However, field data and bioenergetics analysis will allow useful comparisons of growth rates, consumption rates, and growth efficiency (the growth achieved per gram of food consumed) among different habitats under current conditions. To make these comparisons, a Wisconsin bioenergetics model parameterized for Chinook salmon (Stewart and Ibarra 1991; Madenjian et al. 2004) will take field inputs of body size, growth rate, water temperature, diet composition, and the energy density of prey. The model will estimate the consumption rate and growth efficiency. These metrics will be compared among habitats to determine whether growth is currently limited primarily by water temperature, food consumption, or food quality in the study area, and whether these limiting factors differ among habitats (McCarthy et al. 2009).

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

Stable isotope analysis is a method which examines the naturally-occurring stable isotopes of elements (typically carbon and nitrogen) stored in organic materials. The analysis is frequently used to answer questions related to trophic structure and energy pathways within freshwater ecosystems and the interfaces with marine and terrestrial ecosystems (Chaloner et al. 2002;

Finlay and Kendall 2007). Carbon isotope ratios ($\delta^{13}C$) are indicators of an organism's diet because consumers tend to reflect the carbon isotope values of the food they consume, whereas nitrogen isotopes ($\delta^{15}N$) indicate an organism's trophic level because the heavier nitrogen isotope accumulates in the consumer with each successive trophic transfer (approximately 3– 4 parts per thousand, according to DeNiro and Epstein 1981) (Chaloner et al. 2002). If food resources move in a predictable manner through the food chains, these stable isotopes can be used to trace the sources of productivity within aquatic food webs and the trophic position of consumers, which can be essential information for understanding the food web dynamics or for detecting responses to environmental and human-driven change (Chaloner et al. 2002; Finlay and Kendall 2007).

Several recent studies have used stable isotopes to investigate the contribution of marine-derived nutrients (MDN) from spawning salmon to freshwater ecosystems, and have estimated that salmon can contribute 17–30 percent (Bilby et al. 1996) to > 50 percent (Kline et al. 1990) of the nitrogen, and 23–40 percent (Bilby et al. 1996) of the carbon present in freshwater organisms. Adult salmon incorporate rich marine nutrients during their time in the ocean and are thereby enriched with the heavier isotopes of nitrogen and carbon, which they retain after entering fresh water to spawn, as they do not feed in fresh waters, and therefore remain isotopically distinct from terrestrially-derived organic material (Kline et al. 1990). Stable isotope analysis can be used to trace MDN through freshwater ecosystems, and ultimately can be used to quantify the contribution of marine-derived nitrogen or carbon to freshwater food webs (Kline et al. 1990; Hicks et al. 2005).

To better understand the trophic relationships in the Upper and Middle Susitna River, a stable isotope analysis will be conducted at two selected stations (with three sampling sites each), with one in the Upper River Segment, and one in the Middle River Segment. Selection of these two stations will be made in the initial sampling efforts in the second quarter, based on how representative the site is in respect to the reach, and its suitability to provide ample materials for testing. Tissue samples from multiple study components (benthic macroinvertebrates, benthic algae, benthic organic matter, terrestrial invertebrates and organic matter in drift samples, salmon carcasses, and fin clip samples from the fish diet analysis collections) at the sites within these two stations will be collected for stable isotope analysis. Results will be used in conjunction with the bioenergetics model (Section 9.8.4.5.1) to further explain the energy source pathways and trophic relationships in the Susitna River food web.

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

Habitat Suitability Index (HSI) models provide a quantitative relationship between numerous environmental variables and habitat suitability. An HSI model describes how well each habitat variable individually and collectively meets the habitat requirements of the target species and life stage under the structure of Habitat Evaluation Procedures (USFWS 1980). Alternatively, Habitat Suitability Criteria (HSC) curves are designed for use in the Instream Flow Incremental Methodology to quantify changes in habitat under various flow regimes (Bovee et al. 1998). HSC describes the instream suitability of habitat variables related only to stream hydraulics and channel structure. Both models and habitat index curves are hypotheses of species–habitat relationships and are intended to provide indicators of habitat change, not to directly quantify or predict the abundance of target organisms. For the Susitna-Watana Hydroelectric Project aquatic habitat studies, HSC (i.e., depth, velocity, and substrate/cover) and HSI (i.e., turbidity, duration of inundation, and dewatering) models will be integrated to analyze the effects of alternate operational scenarios.

Literature-based draft HSC/HSI curves will be developed for benthic macroinvertebrate and algae communities. Potential sources of information include the Internet, university libraries, peer-reviewed periodicals, and government and industry technical reports. Special emphasis will be given to the existing 1980s study (Hansen and Richards 1985) for applicable information and methodology. Because benthic macroinvertebrate (BMI) and periphyton communities are comprised of numerous taxa, the HSC/HSI curves will be developed for commonly used benthic metrics (e.g., biomass, chlorophyll-a [algae], density, diversity, or dominant taxa) selected to summarize and describe the communities. The selection of individual species of interest will consider the dietary preferences of the target fish species selected for the trophic analysis (Objective 5, Section 9.8.4.5.1). The review will also examine macroinvertebrate life histories, behavior, and functional feeding groups to assist in grouping taxa into guilds as possible metrics. Habitat suitability information will address BMI and algal responses to changes in depth, velocity, substrate, turbidity, and frequency of inundation and dewatering.

Next, a histogram (i.e., bar chart) will be developed for each of the habitat parameters (e.g., depth, velocity, substrate, frequency of dewatering) using site-specific field observations (from Objectives 2, Section 9.8.4.2, and Objective 9, Section 9.8.4.9). The histogram developed using field observations from 2013 will then be compared to the literature-based HSI curve to validate applicability of the literature-based HSI curve for aquatic habitat modeling. This stage will be conducted by the third quarter of 2014.

As a final step TWG will confirm HSC/HSI curves for each benthic metric. Using a roundtable discussion format, the TWG will review literature-based benthic community information and site-specific data to develop a final set of HSC/HSI curves. These curves will be used in the Instream Flow Study (Section 8.5) to define the relationship between habitat quantity and quality for each of the selected benthic metrics under various operational scenarios. Analysis and modeling efforts will be coordinated with the Instream Flow Study Team.

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

In order to investigate and understand the trophic relationships within a river system and how they ultimately relate to fish, it is critical to examine not only the food source (Objective 2, Section 9.8.4.2) and its availability to fish via drift (Objective 3, Section 9.8.4.3), but also the consumption by fish predators. Because both benthic macroinvertebrates and terrestrial invertebrates are a primary food source for fish and other organisms (Wipfli 1997; Hershey and Lamberti 2001; Allan et al. 2003), any significant disturbance to the benthic community and the shoreline riparian vegetation has the possibility of affecting their predators. Therefore, it is important to investigate the trophic relationship between fish and these food sources by conducting a fish gut analysis and comparing results to drift and benthic macroinvertebrate data. In support of the bioenergetics modeling (Objective 5, Section 9.8.4.5.1), fish species targeted for dietary analysis will include juvenile coho salmon, juvenile Chinook salmon, and juvenile and adult rainbow trout, as identified in consultation with the TWG. Fish collection sites will correspond to all sites within the six sampling stations identified for the study (Table 9.8-1), benthic macroinvertebrate collection sites (both benthic, , and drift sampling, to allow for comparison with the benthic macroinvertebrate community (Section 9.8.4.2.1) and drift compositions (Section 9.8.4).

A total of eight fish per species/age class per sampling site collection will be sampled for fish stomach contents, using non-lethal methods (Meehan and Miller 1978; Hyslop 1980; Bowen 1996; Kamler and Pope 2001). All fish will have fork length and weight recorded with the stomach sample. In addition, scales will be collected from the preferred area of the fish, below and posterior to the dorsal fin, for age and growth analysis (DeVries and Frie 1996). At two selected sampling stations (one each in Upper Segment and Middle Segment), fin clips will be obtained from five fish at each site for use in the stable isotope analysis (Section 9.8.4.5.2). The fish collection methods and scheduled sampling efforts will be coordinated with the appropriate fish study team (Fish Distribution and Abundance in the Middle and Lower Susitna River Study, Section 9.6; Fish Distribution and Abundance in the Upper Susitna River Study, Section 9.5). Methods for collecting fish specimens are included in Sections 9.5.4.3, and 9.5.4.3.

Fish gut content samples will be processed in a laboratory using methods compatible with studies conducted in other comparable streams/basins in Alaska. State and federal protocols (Hyslop 1980; Bowen 1996; Barbour et al. 1999; Major and Barbour 2001; Moulton et al. 2002) will be considered in determining the sample processing protocols, the taxonomic resolution of specimen identifications, and data analysis approach. Data collected during this study will be compared to the results of 1980s fish diet studies (ADF&G 1983; Hansen and Richards 1985) to evaluate any differences between the historic and current fish diets. Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

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

Organic matter materials serve as an important food resource to benthic macroinvertebrates, serving as a conduit for the energy flow from organic matter resources to vertebrate populations, such as fish (Hershey and Lamberti 2001; Hauer and Resh 1996; Reice and Wohlenberg 1993; Klemm et al. 1990). Given the dominant characteristics of the Susitna River system (large, cold, and turbid during the growing season), secondary productivity is not likely to be driven by primary production or from the algal community within the system, but rather by allocthanous inputs of organic material from the terrestrial environment. Benthic organic material is one of the most important “interrelated environmental factors” influencing the macroinvertebrate community, and damming the river will have significant consequences for the transport of organic matter from the upper watershed. Therefore, to address the importance of organic matter to productivity in this type of system, quantifying benthic organic matter as part of this study is essential.

This organic matter exists as both fine particulate organic matter (FPOM) and coarse particulate organic matter (CPOM). FPOM includes particles ranging from 0.45 to 1000 µm in size, and can occur in the water column as seston, or deposited in lotic habitats as fine benthic organic matter (FBOM) (Wallace and Grubaugh 1996). CPOM is defined as any organic particle larger than 1 mm in size (Cummins 1974). In order to quantify the amounts of organic matter available in the Susitna River for river productivity, CPOM and FPOM (specifically FBOM) will be collected concurrently with all benthic macroinvertebrate sampling, including the baseline sampling effort addressing the effects of changing flow patterns on benthic communities in sloughs (Objective 2, Section 9.8.4.2.1). Organic debris collected within each sample will be retained after processing for organisms. In order to streamline the collection efforts, a net mesh size of 250 µm for sampling devices will retain FPOM in the 250–1,000 µm size range for analysis, as well as CPOM particles. Suspended FPOM (seston) will be collected from material in invertebrate drift samples, utilizing the 250-µm mesh size for drift nets, as well (Objective 3, Section 9.8.4.3). Organic matter retained after organism sorting and processing will be separated from inorganic material, rinsed through sieves to separate particles into size classes, oven-dried (60°C), and weighed. Results will be calculated as amounts of CPOM and FPOM per unit area (g/m^2 and g/m^3, respectively). For the two selected stations, portions of the material will then be utilized for stable isotope analysis (Objective 5, Section 9.8.4.5.2). Additional details on sampling and processing methodology and analysis will be described in the River Productivity Implementation Plan.

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

Colonization is a process in which organisms move into and become established in new areas or habitats (Smock 1996). In disturbed habitats, this process is more accurately called recolonization. Numerous studies have shown that macroinvertebrates can rapidly colonize new or disturbed substrates (Shaw and Minshall 1980; Ciborowski and Clifford 1984; Williams and Hynes 1977; Townsend and Hildrew 1976; Miyake et al. 2003). The rate of recolonization is dependent on several factors, including time of the year, substratum particle size, the structure of the macroinvertebrate assemblages available to colonize at the time, and the distance of the colonist assemblages from the new or disturbed area (Robinson et al. 1990; Smock 1996; Mackay 1992).

Two additional factors, predicted as major post-Project effects, that may affect colonization rates are changes in turbidity and temperature. In order to assess the influences of turbidity and temperature on the benthic community colonization rates, a field study will be conducted for both study years (2013 and 2014) to estimate potential benthic macroinvertebrate colonization rates for four different habitat types that reflect these conditions in the Susitna River. Due to the difficulty of isolating each of these conditions under natural conditions, colonization will be examined under turbid/warm, clear/warm, turbid/cold, clear/cold conditions. Sampling locations and scheduling will be determined after a review of 2012 study results, from both AEA studies, as well as from data collected outside of AEA, and site reconnaissance to assess candidate sites.

Sets of three preconditioned artificial substrates will be deployed incrementally for set periods of colonization time (e.g., 8, 6, 4, 2, and 1 week[s]) and then pulled simultaneously at the conclusion of the colonization period. Artificial substrates will be deployed at two depths at fixed sites along the channel bed. Benthic macroinvertebrate processing protocols will be identical to those used in Objective 2 (Section 9.8.4.2.1). Specific details on site locations, the choice of artificial substrates, and timing of colonization tests will be provided in the River Productivity Implementation Plan.

Colonization information will be compared with colonization results from similar river systems and with post-Project colonization results. In addition, results will be utilized in HSC/HSI development (Objective 6, Section 9.8.4.6), and in the varial zone modeling task in the Instream Flow Study (Section 8.5.4.6.1.6) to assist in determining the potential Project effect of short-term flow fluctuations, most commonly the result of hydroelectric power generation, on benthic macroinvertebrates.

9.8.5. Consistency with Generally Accepted Scientific Practices

The methods described above have been developed in consultation with agency and Technical Workgroup (TWG) participants. All data collection and processing efforts will follow state (ADF&G) or federal (EPA, USGS) guidelines referenced throughout the study methods discussion (Agradi 2006; Barbour et al. 1999; Bovee et al. 1998; Eaton et al. 1998; Keup 1988; Klemm et al. 1990, 2000; Major and Barbour 2001; Moulton et al. 2002; Peck et al. 2006; USFWS 1980). In addition, any laboratory analysis will be conducted by a state- or federally-certified facility.

9.8.6. Schedule

The preliminary schedule for the river productivity study elements is presented in Table 9.8-2. During 2013, the literature review summarizing the impacts of hydropower development and operations on benthic macroinvertebrate and algal communities will be prepared and presented to the TWG. Research, field sampling, and sample processing and analysis will begin in the latter half of the first quarter of 2013, following FERC's approval of the study plan. Field sampling at the Susitna River sites and the Talkeetna River test reference sites for benthic macroinvertebrates, algae, organic matter, drift, fish diet analysis, and stable isotopes will be conducted for three seasonal sampling periods from April through October in both study years (20132014). These seasonal periods are tentatively scheduled for April through early June for Spring, late June through August for Summer, and September through October for Autumn (Table 9.8-2), due to annual variability in the timing of seasons. Specific details on timing will be provided in the River Productivity Implementation Plan. Two additional sampling events for benthic macroinvertebrates, algae, and organic matter to capture responses to storm events will occur during April through October. Exact timing is subject to storm event occurrences. Sample processing of organisms and materials collected in the 2013 field efforts will require extensive laboratory efforts, and will continue throughout the remainder of 2013 and into the first quarter of 2014. Trophic analysis efforts will also begin in the latter half of the first quarter of 2013 and continue throughout 2013 and 2014. The Initial Study Report summarizing these 2013 activities will be issued within one year of FERC's Study Plan Determination (i.e., February 1, 2013).

Results from the 2013 effort will be utilized in the effort to generate habitat suitability criteria, which begin early in the first quarter of 2014. Second-year field sampling efforts, adhering to the same tentative scheduling as in 2013, will resume in the latter half of the first quarter of 2014, with sample processing, data analysis, trophic analysis research continuing through the fourth quarter. The Updated Study Report will be produced within two years of FERC's Study Plan Determination.

9.8.7. Relationship with Other Studies

The flow of information into and out of the River Productivity Study is anticipated to occur over the two year study period through an iterative process. The River Productivity Study is interrelated to several AEA studies (Figure 9.8-3). The Instream Flow Study (Section 8.5), Characterization and Mapping of Aquatic Habitat Study (Section 9.9), and the Geomorphology studies (Sections 6.5 and 6.6) will provide useful information, expected by Q1 2013, to assist in the site selection process. The Baseline Water Quality Study (Section 5.5) will provide useful input information for analysis of river productivity for use in the trophic analysis (Section 9.8.4.5). The Upper (Section 9.5) and Middle and Lower River (Section 9.6) Fish Distribution and Abundance studies will provide information on target fish species for the trophic analysis, including life history event timing to assist in sampling scheduling and seasonal locations in Q1 2013 and Q1 2014, as well as throughout the 2013 and 2014 field seasons. The Fish Distribution and Abundance studies will also coordinate with the collection of samples for gut content analysis (Section 9.8.4.7) and stable isotope analysis (Section 9.8.4.5.2) throughout the field seasons. Output information from the multiple objectives of the River Productivity Study will provide additional input information to the trophic analysis, Objective 5, Section 9.8.4.5, of the River Productivity Study as well as any water quality field measurements (e.g., temperature, turbidity, and PAR data) collected to the Baseline Water Quality Study (Section 5.5) and site-specific field observations from Objective 2 and Objective 9 for use in the Instream Flow Study's IFIM and varial zone models (Section 8.5.4.6). Information flowing out from the River Productivity Study will be communicated with other Fish Progam Study Lead. Additional formal data sharing also will occur among study after completion of QA/QC procedures and with delivery of the Initial Study Report (Q1 2014) and Updated Study Report (Q1 2015).

9.8.8. Level of Effort and Cost

The initial cost estimate for completion of the nine study objectives described above is $1,200,000. Efforts such as the literature review, trophic analysis (bioenergetics model and stable isotope analysis), and HSC criteria development will be office-based studies. Collection of benthic macroinvertebrates, algae, and organic matter, drift samples, and the analysis of fish diets will require three extensive field efforts per year for the two study years. Adult emergence sampling will require monthly to bi-weekly site visits from April through October to collect samples and reset the traps. The colonization study will require frequent site visits each month to deploy additional sets of samplers over the course of the study. A majority of the work effort will take place in the laboratory to sub-sample, sort, and identify the macroinvertebrate and algae samples, as well as to conduct the stable isotope analyses on the numerous sample components. After sample processing, the remainder of the study effort will be office-based, consisting of data entry, analysis, and synthesis and report writing.

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9.8.10. Tables

Table 9.8-1. Preliminary macroinvertebrate and algae sampling sites, stratified by reach and habitats. Refer to Figures 9.8-1 – 9.8-2 for locations of the preliminary sampling reaches and stations.

Sampling Reach	Reach Description	Number of Mainstem Sites	Number of Associated Off-channel Sites[1]
Upper Segment			
UR-1, -2, -3	Reference upstream of reservoir	2	4
Middle Segment			
MR-1	Immediately below dam site	1	2
MR-2	Upstream of Devils Canyon	1	2
MR-6	Downstream of Devils Canyon	2	4
Susitna River Totals		6	12

Notes: 1 Side-channels, sloughs, tributary confluences associated with a mainstem sampling site.

Table 9.8-2. Preliminary schedule for River Productivity Study.

Activity	2013				2014				2015
	1Q	2Q	3Q	4Q	1Q	2Q	3Q	4Q	1Q
Literature Review on Hydropower Impacts		—	—	—					
Sampling benthic macroinvertebrate communities, algal communities, and organic matter.		⊙ —	⊙ —	⊙ —	—	⊙ —	⊙ —	⊙ —	
Invertebrate drift sampling		⊙ —	⊙ —	⊙ —	—	⊙ —	⊙ —	⊙ —	
Sampling Talkeetna for Reference Site Feasibility Study		⊙ —	⊙ —	⊙ —	—				
Trophic analysis with bioenergetics and stable isotope analysis		⊙ —	⊙ —	⊙ —	—	⊙ —	⊙ —	⊙ —	
Generate habitat suitability criteria					—	—	—	—	
Conduct a fish gut analysis		⊙ —	⊙ —	⊙ —	—	⊙ —	⊙ —	⊙ —	
Establish baseline colonization rates		—	— ⊙	— ⊙	—	—	— ⊙	— ⊙	
Data Analysis and Reporting			—	—	—	—	—	—	—
Initial Study Report				—	— Δ				
Updated Study Report								—	— ▲

Legend:
— Planned Activity
⊙ Tentatively scheduled sampling event
Δ Initial Study Report
▲ Updated Study Report

9.8.11. Figures

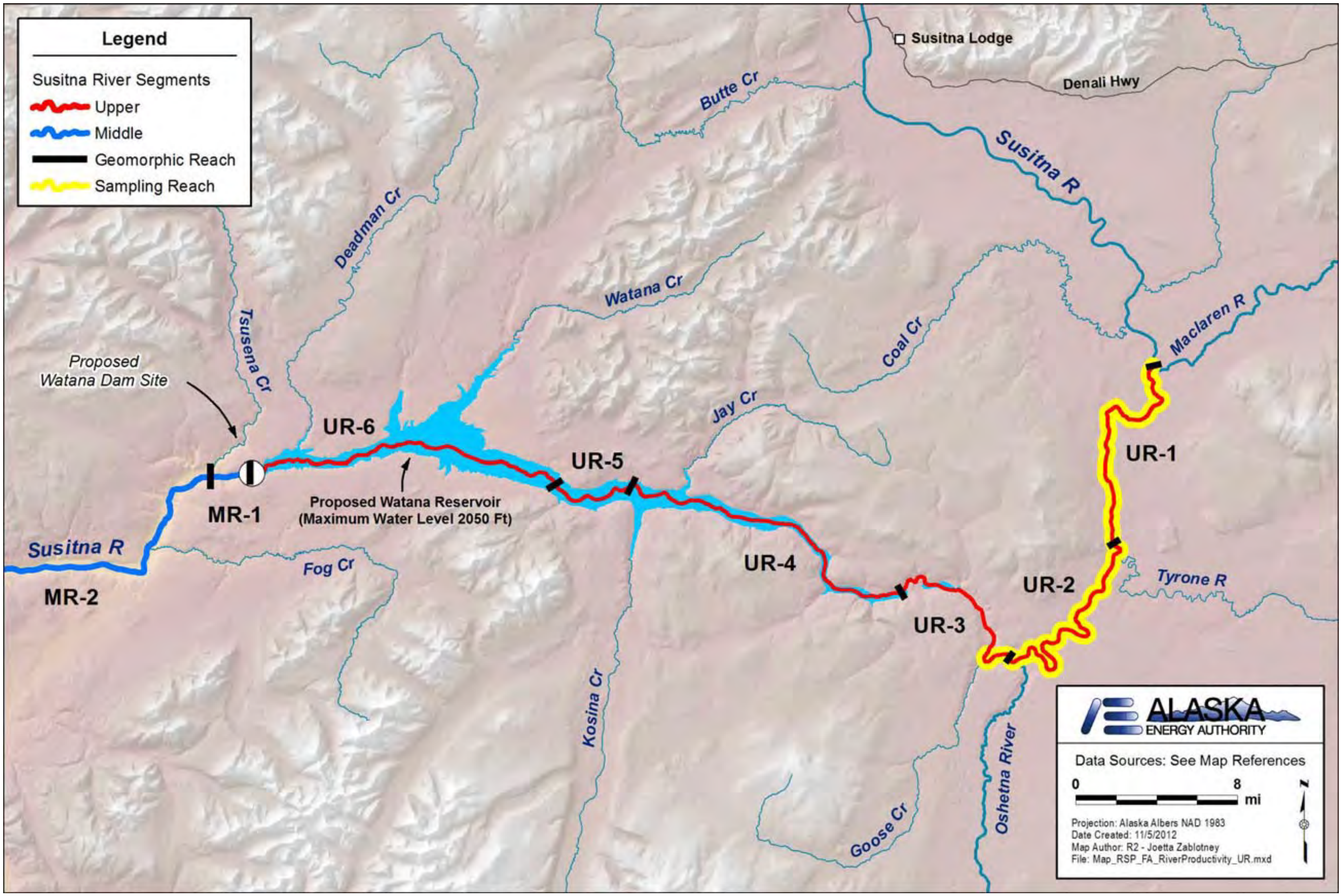

Figure 9.8-1. Upper Susitna River Segment, preliminary sampling reaches for the River Productivity Study.

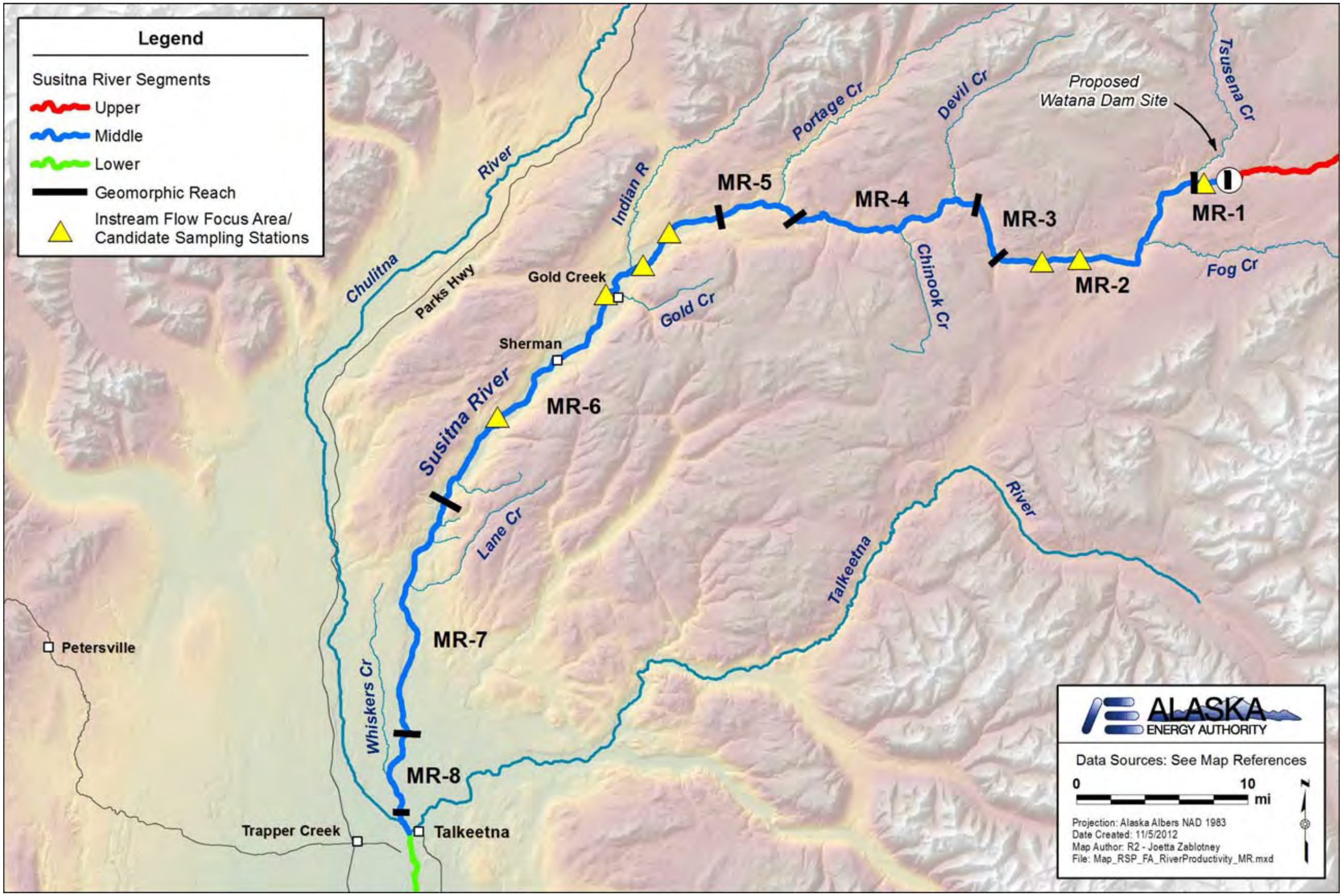

Figure 9.8-2. Middle Susitna River Segment, with the Instream Flow Focus Areas under consideration for the four sampling locations proposed within Geomorphic Reach MR-6 for the River Productivity Study.

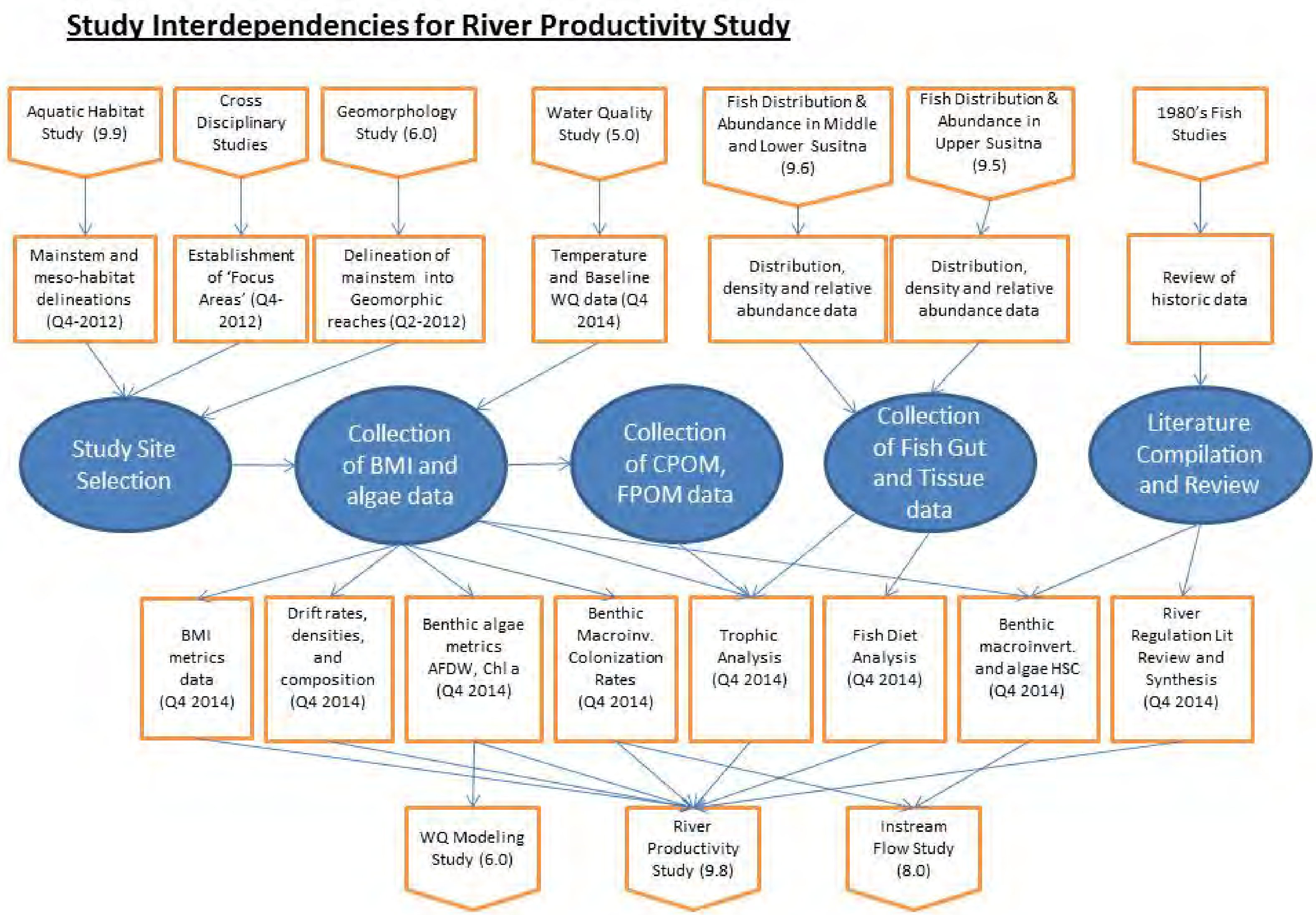

Figure 9.8-3. Study interdependencies for River Productivity Study.

9.9. Characterization and Mapping of Aquatic Habitats

9.9.1. General Description of the Proposed Study

This study plan describes a Susitna River-specific hierarchical and nested classification system developed with input from the Fish and Aquatics Technical Workgroup (TWG). The classification system as proposed includes modifications based on "lessons learned" during implementation of initial ground surveys in 2012, evolving needs of other dependent studies, completion of the aerial video in 2012, and inclusion of licensing participants' comments on the Proposed Study Plan.

The Susitna River habitat classification system has four main mapping components that correspond to river segments and water bodies within those sections. The four components are: 1) the mainstem Susitna River from the Oshetna River confluence (approximately RM 233) downstream to the Chulitna River confluence (approximately RM 98); 2) Upper River and Middle River tributaries up to the upper limit of the zone of hydrologic influence (ZHI); 3) lakes that are within the proposed reservoir inundation zone and 4) the lower River from RM 98 to the upper end of tidal influence (approximately RM 28). The first three mapping components will delineate and map habitats to a mesohabitat level, Level 4 (Figure 9.9-4). However, because of the very large size and channel complexity of the Lower River (Figure 9.9-17) it is impractical to map the Lower River Segment beyond Level 3 (Mainstem Habitat Type). Furthermore, results from the 2012 video imagery indicate that the Lower River appears to contain only two out of five mesohabitat types (glides and riffles). The low gradient and aggraded gravel bed of the Lower River is generally not conducive to the formation of other mesohabitat types, such as pools or runs, although they likely are present in very low numbers. Thus the need to delineate habitat to this finer scale is not necessary in the Lower River.

The Susitna River habitat classification system combines the historic approach (ADF&G 1983a) to mainstem habitat classification and a modified version of the mesohabitat classification system from the USFS Aquatic Habitat Surveys Protocol (USFS 2001). This hybrid classification system will describe habitats that are defined by the unique hydrology of this river system, yet are significant to the day-to-day function and behavior of fish and aquatic organisms.

This study will be valuable for gathering baseline habitat data that can be used along with other data being gathered (e.g., fish distribution and abundance, water surface elevation and discharge relationships, instream flow modeling, flow routing) to assess potential impacts associated with proposed Project operations.

9.9.2. Study Goals and Objectives

Construction and operation of the Project will modify the aquatic habitat in the area inundated by the Project reservoir and has the potential to alter aquatic habitats in the mainstem channel of the Susitna River downstream from the Project dam, including along channel margins, at tributary confluences, at the inlets and outlets to side channel sloughs, and off-channel water bodies in the zone of hydrologic influence. The goal of this study is to characterize and map all aquatic habitats with the potential to be altered and/or lost as the result of reservoir filling, hydropower operations, and associated changes in flow, water surface elevation, sediment regime, and temperature. Study objectives for collecting baseline data vary depending on the nature of the potential Project effects and where in the study area the effects may occur. Study methods will, therefore, also vary within the study area. Objectives are described below according to the following breakdown.

Upper River Tributaries:

a. Characterize and map Upper River tributary and lake habitat for the purpose of evaluating the potential loss or gain in available fluvial habitat that may result from dam emplacement and inundation by the reservoir.

b. Characterize and map Upper River tributary and lake habitat for the purposes of informing other studies including Fish Distribution and Abundance in the Upper River (Section 9.5) and River Productivity (Section 9.8).

Susitna Mainstem: Objectives for the mainstem Susitna River vary depending on the river segment.

a. Characterize and map the Upper River mainstem upstream from the Watana dam site to the confluence with the Oshetna River:

- **i.** To provide baseline data for the purpose of evaluating the potential loss or gain in accessible available fluvial habitat that may result from dam emplacement and inundation by the reservoir.
- **ii.** To inform other studies including Fish Distribution and Abundance in the Upper River (Section 9.5), River Productivity (Section 9.8), and Future Watana Reservoir Fish Community and Risk of Entrainment (Section 9.10).

b. Characterize and map the Middle River mainstem from the Chulitna River confluence to the proposed Watana Dam site:

- **i.** To provide baseline data for the purpose of evaluating the potential loss or gain in accessible available fluvial habitat that may result from flow regulation below the proposed Watana Dam.
- **ii.** To inform other studies including Fish Distribution and Abundance in the Middle and Lower River (Section 9.6), River Productivity (Section 9.8), and Instream Flow (Section 8.5).

c. Characterize and map the Lower River mainstem from the upper limit of tidal influence to the Three Rivers Confluence:

- **i.** To provide baseline data for the purpose of evaluating the potential loss or gain in available fluvial habitat that may result from flow regulation below the proposed Watana Dam.
- **ii.** To inform other studies including Fish Distribution and Abundance in the Middle and Lower River (Section 9.6), River Productivity (Section 9.8), and Instream Flow (Section 8.5).

9.9.3. Existing Information and Need for Additional Information

During the 1980s study efforts, habitat characterization and mapping in the Middle River mainstem were conducted at a relatively coarse scale; mainstem habitat types that were representative of distinct functional hydrology and channel morphology were identified. Under this system, the Susitna River was classified into seven mainstem habitat types: mainstem channel, side channel, side slough, upland slough, tributary mouth, tributary, and lakes, defined by source water and hydrologic connectivity (Trihey 1982; ADF&G 1983a). For example, side channels were described as side channels that carried less than 10 percent of the mainstem flow, whereas sloughs were identified as having a water source derived from some combination of groundwater, tributaries, and/or local runoff. Upland sloughs, unlike side sloughs, were those that were disconnected from mainstem flows at their heads. These seven mainstem habitat types were mapped in the Middle River based on aerial photography and were given individual alpha-numeric identifiers such as “Slough 22” (ADF&G 1983a). Subsequent sampling of fish populations and collection of water quality and habitat suitability data were conducted in subsets of the mapped habitats. Additional habitat characterization and mapping efforts developed during the 1980s defined unique categories of river habitat based on clear or turbid water conditions under specific flows, in combination with presence or absence of open water leads during winter (Steward and Trihey 1984) or hydrologic zones (ADF&G 1983a, 1983b). The habitat categories were focused on main channel and side channel habitats in intensively studied areas in an attempt to scale the information up to the entire Middle Susitna River Segment for simulating the relationship between habitat and flow.

Very little habitat information has been collected in the Upper Susitna River. In the early 2000s, the Alaska Department of Fish and Game (ADF&G) conducted sampling in the Upper Susitna River subbasin as part of its Alaska Freshwater Fish Inventory (AFFI) program (Buckwalter 2011a). These surveys were focused on documenting fish presence and collecting reach-level habitat data in medium and large tributary drainages (Buckwalter 2011b). The AFFI habitat studies were conducted at a scale that is not necessarily informative for understanding impacts to fish use or productivity. Because the upper river surveys were focused on fish inventory, they applied a dispersed sampling design that covered 60 streams; however, habitat data were collected at only one transect per stream. The scale of these historic data collection efforts limits their applicability for evaluating fish-habitat relationships and the potential for changes in fish habitat use throughout the Susitna River as a result of hydropower facility development and operation.

To augment the historic habitat data, this study will characterize and map aquatic habitat at finer scales than did the 1980s studies, including to the mesohabitat level in the main channel and tributaries. Mapping of off-channel habitats will include refinements to the typing of off-channel habitats, quantification of edge habitat in off-channel habitats, and typing and habitat metric sub-sampling in sloughs.

Characterization and mapping of mesohabitats is important in assessing potential impacts to fish populations because it is at this level that fish selectively use different habitats (Hardy and Addley 2001) to support different life stages and life functions. A full complement of mesohabitat types is required to sustain multiple life stages, support a diverse fish community, and furthermore, the distribution of these habitats throughout the river will influence fish distributions. Fine-scale habitat attributes, such as those found at the mesohabitat level, are thought to be particularly relevant to aquatic organisms. Organisms interact with their environment at different scales depending on their size and mobility (Parasiewicz 2007), both of which change with growth and development. Parasiewicz (2007) further suggested that mesohabitats are habitats within which an organism can be observed for a significant portion of its daily routine, similar to functional habitat discussed by Kemp et al. (1999). For this study, information will be collected to support the development of habitat descriptions at more ecologically significant scales by considering several attributes that are biologically important to fishes (Harper et al. 1992; Maddock 1999).

The higher-scale mainstem habitat classifications used in the 1980s will be retained to allow for some level of comparison over time.

In addition to considering the scale of habitat classification, it is also important to consider the use of an objective classification approach that not only captures existing site-specific characteristics, but also can be used for comparisons across space and time. Mesohabitat assessments based on river morphology and ecologically significant habitat attributes should be consistent and reproducible. The USFS Aquatic Habitat Surveys Protocol (USFS 2001) is an example of a standardized protocol that was developed in Alaska to facilitate creation of a regional stream habitat database as well as one that allows for aggregation of habitat data at multiple scales. The USFS 2001 protocol is integrated into the habitat mapping study design described in this study.

Sources of existing information that will directly support habitat mapping are outlined in Table 9.9-1.

Existing fish, habitat, and aquatic resource information appears insufficient to address the following issues that were identified in the PAD (AEA 2011b).

- **F1:** Effect of change from riverine to reservoir lacustrine habitats resulting from Project development on aquatic habitats, fish distribution, composition, and abundance, including primary and secondary productivity.
- **F2:** Potential effect of fluctuating reservoir surface elevations on fish access and movement between the reservoir and its tributaries and habitats.
- **F4:** Effect of Project operations on flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity. The effect of Project-induced changes include stream flow, stream ice processes, and channel morphology (streambed coarsening) on anadromous fish spawning and incubation habitat availability and suitability in the mainstem and side channels and sloughs in the Middle River above and below Devils Canyon.
- **F7:** Influence of Project-induced changes to mainstem water surface elevations from July through September on adult salmon access to upland sloughs, side sloughs, and side channels.
- **F9:** The degree to which Project operations affect flow regimes, sediment transport, temperature, and water quality that result in changes to seasonal availability and quality of aquatic habitats, including primary and secondary productivity.

The information collected during this study will be essential to understanding fish habitat distribution and will provide information relevant to addressing the five potential fisheries issues listed above.

9.9.4. Study Area

The study area encompasses the mainstem Susitna River from the Oshetna River confluence at approximately RM 233 downstream to the upper extent of tidal influence at approximately RM 28. As described above, the mainstem study area is further divided according to geomorphic/hydrologic river segments; the Upper River, Middle River, and Lower River (see

Figure 9.5-1). The study area also encompasses tributaries in the Upper River (RM 180 to 233) and Middle River segments (RM 98 to 184). The study area for tributaries is described as follows:

- The study area for Upper River tributaries extends up to 3,000 feet elevation, unless a permanent impassable barrier exists between 2,200 and 3,000 feet elevation. If a barrier exists within this range surveys will stop at the barrier.
- The study area for Middle River tributaries extends from the confluence with the mainstem up to the upper limit of hydrologic influence.

9.9.5. Study Methods

9.9.5.1. Overview

Given the linear extent and remoteness of the river, an approach that combines analysis of aerial imagery with ground-based collection of habitat data will be used. This combination of methods will allow for maximizing coverage of river habitats in concert with efficient collection of detailed data at selected habitats. Furthermore, the habitat characterization methods can be tailored to accommodate variations in channel size and overall stream length. Habitat data collected in this study will utilize the Susitna-Watana Hydroelectric Project habitat classification system that was developed during 2012 study design and planning process and standard protocols outlined in the USFS Aquatic Habitat Surveys Protocol (USFS 2001). The USFS protocol will be subject to minor modifications regarding parameter data collection to allow for site specific characterization, for example maximum depth will not be collected in deep mainstem channel habitats.

Because of the major differences in channel morphology and hydrology between tributaries and the mainstem river and because Project effects are different in different geomorphic segments of the river, habitat mapping methods are differentiated within the study area as follows.

- Tributaries
  - Tributaries in the Upper River
  - Tributary segments in the Middle River mainstem influenced by mainstem flow
- Mainstem
  - Upper River mainstem
  - Middle River mainstem
  - Lower River mainstem

9.9.5.2. Overview of Aerial Video for Habitat Mapping

Low altitude aerial video can be an excellent tool when mapping mesohabitats over long distances in remote and challenging topography. Low altitude aerial video combined with ground sub-sampling for habitat mapping studies has been used in numerous FERC hydro project relicensings in Washington, California, Texas, and North and South Carolina. When shot with a professional high definition (HD) camera from a helicopter at a slow speed (15 to 40 mph, depending on stream size), low height (75-300 feet), under good lighting conditions, good water clarity, and a fairly open canopy, the video provides an up-close and panoramic view of all the stream's features. To maximize the quality of the video, it is shot in an upstream direction from the right rear of a helicopter with its cabin door removed. A narrator/navigator is positioned in the left front next to the pilot. From this low elevation, the viewer can clearly discern mesohabitat types, channel character, dominant substrate classes, woody debris, and riparian vegetation. Figure 9.9-1 is a screen capture from an aerial video of an Upper Susitna River tributary.

Aerial video collected in early September 2012 (before the mid September flood) included the 12 primary tributaries in the Upper River (Table 9.9-2), the Upper River mainstem, and the Middle River mainstem. While glare and swirling winds were a problem on a few tributaries, conditions were excellent overall. In addition, test video was shot of the Lower River between RM 65 and RM 81 to determine the practical and technical application of aerial video for habitat characterization in the wide and highly braided Lower River. Use of video in the Lower River is discussed further in Section 9.9.5.4.3. The final video product will include live narration, on-screen continuous global positioning system (GPS) position, rivermile to the tenth of a mile, and running time to the tenth of a second.

The digital video file is playable using standard media player software, such as VLC, which supports many useful player controls including screen capture and can be downloaded as freeware at http://www.videolan.org/vlc/download-windows.html. Digital video files will be made available to licensing participants through AEA.

9.9.5.3. Upper River Tributary Habitat Mapping

Upper River tributaries will be mapped using results of the AEA 2012 low-altitude aerial video and in-river habitat ground survey sub-sampling. Low altitude video surveys will only be used to type mesohabitats where they are clearly visible; otherwise, ground based surveys will be conducted. Whether aerial video is also used to describe other habitat variables, such as woody debris or dominant substrate size, will be determined on a stream-by-stream basis and once such application is determined necessary and valid. Aerial video will not be used to directly estimate channel dimensions.

9.9.5.3.1. Application of Aerial Video for Mapping Upper River Tributaries

Habitat in primary tributaries will be typed to the mesohabitat level shown in Table 9.9-3 using a video sampling method. Tributaries that are not conducive to aerial video mapping, such as those with obscured view of the river due to riparian vegetation, will be mapped using ground methods only. The need and method for mapping tributaries of a lower stream order than those listed in Table 9.9-2 will be determined with input form the TWG prior to the 2013 field season. Smaller tributaries may not support fish and as such may not require mapping. Alternatively, if they are mapped, it may be that they are sub-sampled or a representative subset of tributaries could be selected by a randomized method.

In video sampling, first a string is stretched horizontally across the computer monitor at about the center. The video is then played from the beginning at normal or slow speed and paused at a predetermined time interval. When paused, the mesohabitat type that is directly crossed by the line is classified and entered into an Excel spreadsheet with the corresponding running time, e.g.

00hrs:12mins:3secs_riffle. This is repeated at a set interval of between 3 and 5 seconds, depending on the stream width and mesohabitat length, e.g., geomorphic reaches with short habitat units will have 3-second intervals, while reaches with long habitat units may have 5-second intervals. At an average speed of 18 mph and a recommended 3-second interval for tributaries, a sample is taken approximately every 80 feet or 66 samples per mile. Study area tributaries in the Upper River (Kosina, Watana, etc.) are over 10 miles long, resulting in over 600 mesohabitat samples in each tributary.

A library of aerial video screen captures (mesohabitat type-index) will be built that includes several variants of each mesohabitat type (Figure 9.9-2 through Figure 9.9-15). The video “mapper” will constantly refer to the library of image captures to ensure accuracy and consistency in mesohabitat typing. Ideally the type-index images would be ground-verified prior to use in the video mapping. However, ground sub-sampling of all tributaries will not be completed until 2013. Therefore, for some streams, the completed video frequency analysis will need to be reviewed and checked against ground mapping later in 2013 and revised if needed. Given the low altitude perspective and clarity of the video, most mesohabitat types will be easily and accurately classifiable without ground verification.

The primary result of the video mapping is a mesohabitat frequency of 100 percent of the tributary study area. This frequency analysis can also be subdivided by geomorphic reach. Histograms and tables of mesohabitat type frequency will be produced. The metadata can also be used for other studies such as selection of random mesohabitat units for fish population surveys.

The method proposed above is a random sampling and replicable method. It is random for several reasons: a) the speed of the helicopter is changing by a few tenths to a few miles per hour several times per minute; b) because the camera is hand-held and the altitude of the helicopter is constantly changing the angle of the lens relative to the ground is constantly changing; c) the height above the ground is constantly changing by a few to tens of feet; and, d) the sequence and lengths of mesohabitat types is highly variable in mountain streams. All these factors contribute to a constantly varying ground distance between sample points, even though the sample time interval is constant. The video sampling method has also been tested for “replicability”, as described below.

To be certain mesohabitat typing using video is a reliable tool and the results are replicable, an analysis of the replicability of results was conducted recently in a California hydroproject relicensing. To check the general replicability of the habitat type identification, an independent reviewer conducted video mapping of randomly selected ground-verified segments representing 20 percent or more of three PHABSIM reaches. Because ground-truthing is an essential component of video mapping, the independent reviewer had also participated in the habitat mapping ground surveys, but not on the test stream segment. The three PHABSIM reaches selected represented a variety of channel and habitat types: wide, open canopy; variable gradient and canopy coverage; and a smaller, higher-gradient channel. The test concluded that the aerial video habitat mapping method is a reliable tool and that differences between replicates would be minimal; therefore, differences between one investigator and another would be minimal, as long as the investigators were involved with the ground mapping and were given clear definitions and type-index images of the various mesohabitat types. An added value of the video record is the ability to check a habitat typing call with another researcher, if in doubt.

Within each geomorphic reach, habitats will be typed to the mesohabitat level according to a nested hierarchical classification system developed in part with input from the Fish and Aquatic TWG (Table 9.9-3). Note that the mesohabitat categories have been nested and expanded to accommodate the high diversity of habitat types found in the tributaries during 2012 video and ground surveys.

9.9.5.3.2. Ground Mapping Upper River Tributaries

Because of the general inaccessibility, very rugged terrain, and mostly non-wadeable stream channels, near census mapping (100 percent coverage) would be very challenging and in some cases unsafe or impossible. For this reason AEA proposes to map ground habitat in the Upper Susitna River tributaries listed in Table 9.9-2 using a combination of video, as described above, and on-the-ground sub-sampling described below. Ground mapping will be done at a low to moderate flow that is relatively near in discharge as the flow during the aerial video. In other words, at a flow that will allow similar habitat type calls for the two methods. AEA, in collaboration with the TWG, will determine how many and which smaller independent tributaries, and how many and which smaller tributaries to the primary tributaries need to be mapped.

Using desk-top tools including IFSAR topographic contour data, U.S. Geological Survey (USGS) topographic maps, aerial video, and information from reconnaissance flights, tributaries will first be segmented into geomorphic reaches where the channel is relatively homogeneous in stream gradient, confinement, and hydrology. Major breaks in each of these parameters will constitute a geomorphic/hydrologic reach boundary. Hydrologic reach breaks will be established at tributaries that appear to contribute more than approximately 10 percent of total flow to the parent tributary. A segment boundary will not be placed where downstream channel characteristics are primarily controlled by bedrock rather than fluvial processes. Bedrock channels are generally insensitive to short-term changes in sediment supply or discharge. Only a persistent decrease in discharge and/or an increase in sediment supply sufficient to convert the channel to an alluvial morphology would significantly alter fluvial bedrock channels (Montgomery and Buffington 1993). For this reason, flow accretion will only be used as a factor for segmentation at locations where channel characteristic below the contribution point are controlled by fluvial processes.

Within each geomorphic reach type, continuous habitat surveys will be conducted over a distance equivalent to at least 20 channel widths with the goal of sampling at least five units of each of the primary mesohabitat types occurring in the geomorphic reach. Primary is defined as mesohabitat types with a frequency in the geomorphic reach type of greater than 10 percent. Survey distance will be extended, either contiguously or at another location in the geomorphic reach, until the requisite number of replicates is obtained. If accessible by foot or helicopter, e.g. not in the bottom of a gorge, habitats with a frequency lower than 10 percent also will be surveyed, but data will be collected on five replicates or fewer.

Because helicopter landing zones in the uplands near the tributaries are extremely limited, a randomized approach for selecting mapping sections is impractical. A high percentage of randomly selected sites would likely not be accessible, and, when one was accessible, in-channel accessibility over a distance of 20 or more channel widths would likely also be a problem. Instead, sub-sample sites within each geomorphic reach will be selected based first on access to the site by helicopter and foot and second on the availability of multiple and varied mesohabitat types within safe and reasonable hiking/wading access. The concept of segmenting the stream into geomorphic reaches assumes that mesohabitat types within the segment are generally similar.

Channel metrics to be sub-sampled on the ground will be collected using a modified U.S. Department of Agriculture, Forest Service (USFS) Tier I and Tier III stream habitat survey protocol (2001). Note that some of the variables listed in the USFS protocol assume the stream being surveyed is wadeable.

Ground survey crews in 2012 were not able to effectively or safely collect some of the Tier I or Tier III variables that were proposed for collection in the PSP. In many of the primary tributaries in the Upper Susitna, habitat variables that involved crossing the streams were very difficult to collect given the difficult wading conditions in most reaches. Flows, even during late summer seasonal lows, were too fast and deep to negotiate at most points along the streams. Wading factors were typically above 8-9 (product of depth x velocity) over predominantly boulder substrate. Depths of 2.5 – 3 feet in combination with velocities of 3 to 4 feet per second around boulder substrates were very common in the Upper Susitna tributaries. Crossings with lesser wading factors were few and far between. As a result, some variables that were included for collection in the PSP have either been eliminated or the collection method or frequency of collection has been modified in this RSP.

Aquatic habitat surveys will be conducted by two-person survey crews. Each survey crew will consist of a fish biologist and qualified fisheries technician. Survey sections will begin at a predetermined location based on the survey section selection process described above and will progress in an upstream direction. If a permanent impassable barrier is encountered below the 2,200-foot elevation point, the barriers will be documented and surveys will continue upstream to the survey end. If a permanent impassable barrier is encountered above the 2,200-foot elevation point ground sub-sampling surveys will not be conducted beyond that point.

In stream sections with complex channel morphology (e.g., three or more parallel channels), the primary and one secondary channel will be designated and will be fully mapped. The remaining secondary channels will be identified and typed using the aerial video. In a highly complex channel type (Figure 9.9-15) the unit will be more characterized than mapped, e.g. length, width, number, type of sub-channels, and the general mesohabitat type present.

Habitat data will be recorded on the stream survey field data form. Separate stream survey data sheet(s) will be completed for each geomorphic reach. Habitat parameters to be measured for this component of the study are described below.

9.9.5.3.2.1. Tier I Data Collection

The following habitat metrics will be collected for each geomorphic reach:

- Geomorphic reach type (confined, similar gradient, similar hydrology)
- Channel type (primarily single thread, primarily split, primarily braid, or combination with estimated percent of each type)
- Measured bankfull width
- Measured or estimated bankfull maximum depth
- Measured gradient
- Estimated dominant substrate composition

- GPS location of channel measurements

Note that incision depth was eliminated at Tier I because collection generally requires crossing the stream.

9.9.5.3.2.2. Tier III Data Collection

The following habitat metrics will be collected for each mesohabitat unit.

- Habitat unit type
- Measured unit length
- Measured average wetted width (three measurements per unit)
- If pool, estimated or measured maximum depth
- If pool, estimated or measured pool crest depth
- Estimated average maximum depth of unit
- Measured width of unit
- Woody debris count in unit
- Estimated percent substrate composition in unit
- Estimated percent undercut, each bank in unit
- Estimated percent erosion, each bank in unit
- Estimated percent riparian vegetation cover in unit
- Dominant riparian vegetation type for each unit
- Estimated percent instream cover in unit
- Photograph of each unit
- GPS location of each unit

Habitat units within the survey section will be sequentially numbered as they are encountered during each survey, and data will be recorded for each habitat unit. Data collected for all habitat units will include the unit length, the mesohabitat type according to Table 9.9-3, three measurements of wetted width from which an average wetted width will be calculated, percent substrate composition, percent eroding bank on each side of the channel, percent undercut bank on each side of the channel, dominant riparian vegetation type, cover type, and cover percent.

Additional data will be recorded for pool habitat units. The maximum pool depth and depth at the pool tail crest will be measured to the nearest 0.1 foot, whenever possible. These data will be used to calculate residual pool depth. The structural feature responsible for forming the pool will be identified (e.g., boulder, undercut bank, large or small wood).

Split channels are defined as separate flow paths located within the bankfull channel and separated from each other by gravel bars that are barren or support only annual vegetation. When split flow is encountered, each split will be surveyed and the proportion of flow conveyed by the split will be estimated, recorded, and used to classify each channel as primary (majority of the flow) or secondary (minority of the flow). Habitat units in the split that convey the most flow will be designated primary units and will continue to be numbered sequentially as part of the main channel survey. Where more than two split channels exist, only the primary and secondary splits will be numbered. The data form will note the total number of split channels.

Side channels are defined as features with a fluvially-sorted mineral bed that are separated from the main channel by an island that is at least as long as the main channel bankfull width and that supports permanent vegetation. At a minimum, the inlet and outlet of each side channel will be documented by collecting a GPS waypoint and taking a photograph looking upstream from the outlet and downstream from the inlet. The side channel will be identified as entering from the left or right bank (looking downstream) and classified as wet or dry. Habitat data will be collected in wetted side channels according to the methodology described above. Where more than two side channels exist, only the primary and secondary channels will be numbered. The data form will note the total number of split channels.

Relative flow levels on the day of the survey will be estimated according to the following:

- **Dry**
- **Puddled:** Series of isolated pools connected by surface trickle or subsurface flow.
- **Low Flow:** Surface water flowing across 50 to 75 percent of the active channel surface. Consider general indications of low flow conditions.
- **Moderate Flow:** Surface water flowing across 75 to 90 percent of the active channel surface.
- **High Flow:** Stream flowing completely across active channel surface but not at bankfull.
- **Bankfull Flow:** Stream flowing at the upper level of the active channel bank.
- **Flood Flow:** Stream flowing over banks onto low terraces or floodplain.

In addition, Susitna River mean daily discharge will be obtained from the nearest downstream USGS stream gauge and entered onto each day's survey forms.

Special Habitat Features

Special habitat features include tributary channels, seeps and springs that contribute groundwater to the mainstem, and temporary (e.g., subsurface flow) or permanent barriers to upstream fish migration. A separate data sheet will be maintained for each reach listing the type, location, and a description of special habitat features.

For features classified as stream barriers, the following information will be recorded in the comments section. Only cursory information will be collected under the Habitat Mapping study as most of the following barrier data is being collected under the Fish Passage Barrier Study Plan (Section 9.12).

- Barrier type (beaver dam, debris dam, vertical falls, chute/cascade, boulder, other)
- Temporal nature (ephemeral or permanent)
- Maximum height of falls or biggest single step if cascading
- Maximum depth of plunge pool
- Chute/cascade gradient and length
- Length of feature.

A GPS waypoint and a photograph will be taken of each special feature. Additional photographs will be taken of representative channel conditions throughout each reach. The photo number, waypoint, date, and associated habitat unit or feature number will be recorded for each photograph.

9.9.5.4. Mainstem Habitat Mapping

The mainstem Susitna River from the Oshetna River to the upper extent of tidal influence includes approximately 200 miles of river and many times more than that distance when the lengths of side channels, braided channels, and sloughs, are included. An approach that includes the use of aerial imagery and collection of ground-based habitat data is required given the linear extent of this large river, its channel complexity, and its remoteness. This combination of methods will allow for maximizing coverage of river habitats in concert with ground sub-sampling at selected habitat areas. Furthermore, this combination allows habitat characterization and mapping methods to be tailored to accommodate different study objectives, different mapping tools available, and different methods, depending on the specific river segment.

9.9.5.4.1. Upper River Mainstem

The Upper River will be mapped using hierarchically-nested habitat typing adapted to feasible identification levels based on the use of aerial still imagery, LiDAR, and aerial videography. A linear network will be created in GIS by drawing lines through the middle of the stream channel as viewed by aerial imagery or LiDAR. The reference imagery was collected at river flows generally ranging from 10,000 to 12,000 cfs, which will be considered a representative mid-flow to conduct mapping. Divided channels will have multiple lines representing that stream section. Main channel and off-channel habitat will be delineated. The length of the lines will be based on mesohabitat classification for the main channel and macrohabitat classification for off-channel habitat. Each individual vector line will have a length and a hierarchical-tiered habitat classification organized in "Levels".

The habitat classification hierarchy will be composed of five levels representing (1) major hydraulic segment; (2) geomorphic reach; (3) mainstem habitat type; (4) main channel mesohabitat; and (5) edge habitat (Table 9.9-4). Level 1 will generally identify the Upper, Middle, and Lower River from each other. Level 2 will identify one of six unique reaches established from the channel’s geomorphic characteristics (established from the Geomorphology Mapping Study). Level 3 will classify the mainstem habitat type of main, off-channel, and tributary habitat using an approach similar to the 1980s historical habitat mapping definitions (ADF&G 1983a). All off-channel habitat will be classified to Level 3 and all main channel habitat will be identified to Level 4 mesohabitat type (i.e., riffle, pool, run, etc.). The final Level 5, edge habitat, will be a calculated length of shoreline based on habitat linear units and classification from Levels 1 through 4. Off-channel habitat will also have this calculation conducted based on Level 3 habitat lengths. Edge habitat typing is further described below.

Identifying small-scale habitat features from aerial imagery (i.e., still or video) can be difficult. In contrast, limiting habitat typing to only broader levels may insufficiently represent the amount of nearshore habitat available in more complex, divided, or backwater habitat units of larger rivers. Beechie et al. (2005) suggested that the shoreline edges of banks and bars provided excellent habitat for juvenile salmonids in large river systems and should be a focus of stream sampling. Beechie et al. (2005) conducted a ground-based fish sampling and habitat identification effort, but principles from this study can be applied to aerial habitat typing. Level 5 edge habitat typing will be a quantification of shoreline habitat based on the length of each habitat unit. The type of habitat will be based on prior hierarchical tier classification (i.e., Levels 1 through 4). For example, a 100-meter (m) confined (Level 1), mainstem (Level 2), single channel (Level 3), glide (Level 4) will have 200 m (i.e., two shorelines of 100 m) of edge-type shoreline habitat. Off-channel habitat length will be determined by the Level 3 classification, because Level 4 mesohabitat typing only will occur in the main channel and tributary habitat. Using the prior levels and identifying the quantity of edge habitat will help identify complexity, inform fish sampling effort, and interpret fish relative abundance results.

A series of tables and figures were created to illustrate the habitat mapping approach and also the analyses that will be conducted from the data. Figure 9.9-16 shows an example of how habitat will be visually mapped from a GIS layer. An example of the raw database is shown in Table 9.9-5. The GIS database will create a hierarchical table that will be used to summarize the proportion of habitat by mapped unit of length (Tables 9.9-6 and 9.9-7). The tiered approach will allow for summaries at all five levels to support resource study planning. The table will also provide individual identification of all unique habitat types. Also, edge length will be calculated to identify sections of river with relatively higher complexity (i.e., more channels result in more shoreline habitat). This information will be important to understand how to best represent the Upper River.

Several controls will be established to ensure that the habitat mapping effort is both precise and accurate. Habitat typing will be conducted by no more than two unique GIS technicians to ensure typed habitat is consistent. Examples of specific aerial images of habitat as related to the levels will be created. These examples will be reviewed and confirmed by the technical lead and provide a voucher reference to help identify habitat types. Also, all typed data will be identified as having clear or turbid water to better identify slough habitat and correct any habitat typing errors. Final habitat typing will be reviewed by the technical lead to ensure consistency and accurate habitat mapping.

In addition to the remote mapping, on-the-ground truthing and refinement will occur. In 2013, a subset of off-channel and main channel habitat units will be ground-mapped and will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate, for off-channel and main channel habitats. Five to ten main channel mesohabitat units and five to ten off-channel habitat units of each type will be randomly selected for sub-sampling. If there is fewer than the selected number, all units of that habitat type all will be sub-sampled.

9.9.5.4.2. Middle River Mainstem

The Middle River mainstem will be mapped in similar fashion to the Upper River. The hierarchical tiered classification system will be implemented to identify habitat from aerial still imagery, LiDAR, and aerial videography. The Middle River habitat data will also be used by the Instream Flow study to establish habitat complexity and frequency. All habitat segments will be identified using a mid-channel line, which will provide habitat length; however, off-channel slough habitat will be drawn separately in an area (polygon) in the Middle River to identify the size of each slough and better characterize slough diversity for Instream Flow Study needs. Area mapping will be reported separately from the linear database.

Tributary segments in the Middle River mainstem that are within the zone of hydrologic influence will be mapped according to the methods described in Section 9.9.5.3, Upper River Tributary Habitat Mapping. The extent to which aerial video is used versus ground-mapping will depend on the length of the segment hydrologically influenced by the mainstem, accessibility, and canopy cover of the tributary segments. The need and method for mapping

Middle River tributary segments will be determined with input from the TWG prior to the 2013 field season. Smaller tributaries may not require mapping, or, if they are mapped, a smaller number could be selected by a randomized method.

As in the Upper River segment, in addition to the remote mapping, on-the-ground truthing and refinement will occur in the Middle River segment. In 2013, a subset of off-channel and main channel habitat units will be ground-mapped and will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate. Separate from Focus Area, 5 to 10 main channel mesohabitat units and 5 to 10 off-channel habitat units or each type will be randomly selected for sub-sampling. If there is fewer than the selected number of units of a habitat type, then all will be sub-sampled. Main channel and off-channel habitats in Focus Sites will be 100 percent mapped to the mesohabitat level. Ground mapping will include metrics described for tributaries, e.g., depth, width, wood, cover, etc., as appropriate, for off-channel and main channel habitats. Mesohabitat metrics of surveyed sloughs will be directly extrapolated to non-surveyed sloughs of like type, i.e., slough or upland slough.

9.9.5.4.3. Lower River Mainstem

Because of the very large size and channel complexity of the Lower River (Figure 9.9-17) it is impractical to map the entire river segment beyond Level 3 (Mainstem Habitat Type). Of the five mesohabitat types in Level 4, the Lower River appears to primarily differentiate into only glides and riffles. The low gradient and aggraded gravel bed of the Lower River is generally not conducive to the formation of other mesohabitat types, such as pools or runs, although they are likely present in very low numbers.

Whether the Lower River is mapped to Level 3 depends on the extent of mapping to be conducted under the Geomorphic Mapping Study, which will use existing LiDAR and aerial imagery from the Matanuska-Susitna Borough LiDAR and Imagery Project.

In early September 2012, AEA conducted a test to determine the possible application of aerial video for habitat mapping the Lower River. A one-mile wide segment was selected between RM 65 and RM 81. The test section was flown at three different heights above ground (AG). The number of parallel flight paths necessary to cover the river width at the three different elevations was as follows: one path at 2,650 feet AG; two paths at 1,700 feet AG; and four paths at 400 feet AG. The test showed that a height of 400 feet or lower with three to five paths in a mile-wide section would be necessary to visually differentiate mesohabitat types of riffle, glide, pool, or run, if they did occur. Further, several parallel paths would be extremely difficult to track even with GPS and would be very difficult to follow in the video.

In summary, this study will rely on the Geomorphic Mapping Study to map the Lower River to Level 3. Development of mapping methods beyond Level 3 will wait until results of the 2012 interim studies, particularly the hydrologic study, are reviewed and analyzed. The habitat characterization objectives for the Lower River will then be more clearly identified and defined.

9.9.5.5. Lake Mapping

Lakes in the Upper River basin within the potential zone of reservoir inundation will be located, mapped, and identified in the Project GIS database. Mapping will include elevation, surface area, perimeter, maximum depth, presence of surface water connection to the Susitna River, and other relevant limnology information on a lake-by-lake basis.

Lakes currently known to be within the zone of reservoir inundation, according to the National Hydrography Database (NHD), are listed below. NHD is a hydrography network dataset created by USGS and is the current hydrography layer for the Project.

1. Unnamed lake on North side of the Susitna River adjacent to RM 192.
2. Unnamed lake in the Watana Creek basin on the northwest side of the Susitna River.
3. Unnamed lake on the south side of the Susitna River between RM 195 and 196.
4. Unnamed lake on the north side of the Susitna River between RM 203 and 204.

9.9.5.6. Study Coordination and Updates

Multiple studies will be collecting field data in 2013 to better refine habitat mapping databases. Instream flow studies (Section 8.5) will be mesohabitat typing focus site off-channel habitat. This mesohabitat data may provide additional resolution to select areas of off-channel habitat. Also, the Geomorphology studies (Sections 6.5 and 6.6) will be area mapping Focus Areas in 2013 that could provide more refined area habitat units, where available. All relevant collected data from other studies will be reviewed and assessed to determine if updating or modifying the habitat mapping database with the additional information will be beneficial and supportive to the overall study goals.

9.9.6. Consistency with Generally Accepted Scientific Practices

Studies to map and characterize aquatic habitats are commonly conducted during water resource development projects, including for hydroelectric projects as part of FERC licensing. Field studies will use protocols developed in consultation with agency representatives and modified from standard federal protocols developed for use in Alaska (USFS 2001) and will be consistent with the instream flow analysis. Remote mapping will utilize protocols similar to those performed at other hydroelectric projects.

9.9.7. Schedule

Habitat mapping ground surveys began in 2012 and will continue through 2013 with follow-up work in 2014 (Table 9.9-8). Aerial video data collection was conducted during the first two weeks of September 2012. Although not expected, any follow-up video work will occur in 2013. Habitat characterization of the Upper and Middle rivers began in 2012 and will continue into 2013. The Initial Study Report (ISR) and Updated Study Report (USR) will be filed in February 2014 and February 2015, respectively. Updates on study progress will be presented at Technical Workgroup meetings, to be held quarterly during 2013 and 2014.

9.9.8. Relationship with Other Studies

In addition to providing baseline information about aquatic resources in the Project area, aspects of the Characterization and Mapping of Aquatic Habitats Study are designed to complement and support other AEA studies (Figure 9.9-18). In addition to a review of background information that will aid in study planning and design, five study components will provide the necessary precursor or input information. Inputs from the Geomorphology Study (Section 6.5), Aerial Video Study, GIS Mapping and Aerial Imagery, Fish Distribution and Abundance in the Upper

(Section 9.5) and Middle and Lower Susitna River (Section 9.6) will aid in the physical and biological delineation and mapping of habitat. The characterization of aquatic habitat will then provide useful output or feedback to understanding five AEA studies. The mapping of aquatic habitat will aid in understanding the behavior, movements, and spatial use of fish in the Fish Distribution and Abundance in the Upper (Section 9.5) and Middle and Lower Susitna River (Section 9.6). Habitat characterization will help in understanding the potential Project effects of the flow regime in the Instream Flow Study (Section 8). The characterization of aquatic habitat will allow for the identification of habitat affected by the Project reservoir and this may affect the future reservoir fish community (Section 9.10). Finally, the River Productivity Study (9.8) will use the habitat mapping for identification of study site selection and quantification of habitat types for interpolation.

9.9.9. Level of Effort and Cost

The total estimated cost of the study for 2013 and 2014 is $1,000,000 including remote mapping, field surveys, data analysis, and technical report preparation.

9.9.10. Literature Cited

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9.9.11. Tables

Table 9.9-1. Primary sources of existing information supporting the aquatic habitat study.

River Segment or Tributaries	Existing Information Available for Habitat Mapping
Upper River tributaries	IFSAR 20-foot contour topographic data Low altitude aerial video
Upper River mainstem	IFSAR 20-foot contour topographic data Low altitude aerial video Matanuska-Susitna Borough LiDAR and Imagery River cross-sectional profiles of depth and velocity 2012 geomorphic mapping of channel types
Middle River mainstem	IFSAR 20-foot contour topographic data Low altitude aerial video Matanuska-Susitna Borough LiDAR and Imagery River cross-sectional profiles of depth and velocity 2012 geomorphic mapping of channel types 1980s geomorphic mapping of channel types
Lower River mainstem	IFSAR 20-foot contour topographic data Matanuska-Susitna Borough LiDAR and Imagery River cross-sectional profiles of depth and velocity 2012 partial geomorphic mapping of channel types

[1] IFSAR. Interferometric synthetic aperture radar is a radar technique used in geodesy and remote sensing.

Table 9.9-2. Tributaries in the Upper River conducive to aerial video mapping and mapped in 2012.

Tributary Name	Entering	Approximate Elevation and River Mile of Anadromous Barrier	Approximate Ending Elevation and Approximate Length of Proposed Tributary Study Area
Oshetna	Susitna RM 233.0	None	3,000 feet El. / 15.6 miles
Black River	Oshetna RM 12.3	None	3,000 feet El. / 3.5 miles
Goose Creek	Susitna RM 231.0	None	3,000 feet El. / 7.8 miles
Jay Creek	Susitna RM 208.6	None	3,000 feet El. / 10.4 miles
Jay Creek Tributary	Jay Creek RM 8.1	None	3,000 feet El. / 1.9 miles
Kosina Creek	Susitna RM 206.8	None	3,000 feet El. / 22.1miles
Tsisi Creek	Kosina RM 7.4	None	3,000 feet El. / 3.2 miles

Tributary Name	Entering	Approximate Elevation and River Mile of Anadromous Barrier	Approximate Ending Elevation and Approximate Length of Proposed Tributary Study Area
Watana Creek	Susitna RM194.1	None	3,000 feet El. / 18.4 miles
Deadman Creek	Susitna RM 186.6	1700 feet El./0.4	1,700 feet El. / 21miles
Tsusena Creek	Susitna RM 181.8	None	3,000 feet El. / 4.2 miles
Tributary 181.2	Susitna RM 181.2	1700ft/1.8	1,700 feet El. / 1.8 miles
Devils Creek	Susitna RM 161.5	1400ft/2.2	1,400 feet El. / 2.2 miles
Chinook Creek	Susitna RM 157.0	None	3,000 feet El. / 7.1miles
Cheechako Creek	Susitna RM 152.4	None	3,000 feet El. / 3.1miles

Table 9.9-3. Upper River tributary mesohabitat types and descriptions.

Channel Type (# of channels)	Hydraulic Type	Mesohabitat Type	Definition
Single (1) Split (2) Channel Complex (3 or > channels)	Fast Water	Falls	Steep near vertical drop in water surface elevation greater than approximately 5 feet over a permanent feature, generally bedrock.
		Cascade	A fast water habitat with turbulent flow; many hydraulic jumps, strong chutes, and eddies and between 30-80 percent white water. High gradient; usually greater than 4 percent slope. Much of the exposed substrate composed of boulders organized into clusters, partial bars, or step-pool sequences. [1]
		Chute	An area where most of the flow is constricted to a channel much narrower than the average channel width. Laterally concentrated flow is generally created by a channel impingement or a laterally asymmetric bathymetric profile. Flow is fast and turbulent.
		Rapid	Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0 percent slope, occasionally 7.0-8.0 percent. [1]
		Boulder Riffle	Same flow and gradient as Riffle but with numerous boulders that can create sub-unit sized pools or pocket water created by scour.
		Riffle	A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section.[1] Low gradient; usually 0.5-2.0 percent slope, rarely up to 6 percent.
		Run/Glide	A habitat area with minimal surface turbulence with generally uniform depth that is greater than the maximum substrate size.[1] Velocities are on border of fast and slow water. Gradients are approximately 0 to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[1]

Channel Type (# of channels)	Hydraulic Type	Mesohabitat Type	Definition
Single (1) Split (2) Channel Complex (3 or > channels)	Slow Water	Pool	A slow water habitat with a flat surface slope and low water velocity that is deeper than the average channel depth. Substrate is highly variable. [1]
		Pool subtypes	**Straight Scour Pool**: Formed by mid-channel scour. Generally with a broad scour hole and symmetrical cross-section.[1]
			Plunge Pool: Formed by scour below a complete or nearly complete channel obstruction (logs, boulders, or bedrock). Pool must be Substrate is highly variable. Frequently, but not always, shorter than the active channel width.[1]
			Lateral Scour Pool: Formed by flow impinging against one stream bank or partial obstruction (logs, root wad, or bedrock). Asymmetrical cross-section. Includes corner pools in meandering lowland or valley bottom streams.[1]
			Backwater Pool: Found along channel margins; created by eddies around obstructions such as boulders, root wads, or woody debris. Part of active channel at most flows; scoured at high flow. Substrate typically sand, gravel, and cobble. Generally not as long as the full channel width. [1]
		Beaver Pond	Water impounded by the creation of a beaver dam. Maybe within main, side, or off-channel habitats. [1]
		Alcove	An off-channel habitat that is laterally displaced from the general bounds of the active channel and formed during extreme flow events or by beaver activity; not scoured during typical high flows. Substrate is typically sand and organic matter. Generally not as long as the full channel width. An alcove is differentiated from a backwater being more protected and not scoured at high flows whereas a backwater is part of the active channel and is scoured at high flows [1]
	Off-channel	Percolation channel	A slough characterized by groundwater percolation through the floodplain that comes from main stream channel. Upstream surface connection to active channel cut off due to accumulation of sediment/debris at the upstream end. Upstream surface water connection to the active channel present only during high flows.

[3] Adapted from Moore et al. 2006.

Table 9.9-4. Nested and tiered habitat mapping units and categories.

Level	Unit	Category	Definitions
1	Major Hydrologic Segment	Upper, Middle, Lower River	Defined Segment Breaks *Upper River* – RM 184 - 248 (*habitat mapping will only extend up to mainstem RM 233 and will include the Oshetna River.* *Middle River* - RM 98 - 184 *Lower River* - RM 0 - 98
2	Geomorphic Reach	Upper River Segment Geomorphic Reaches 1-6 Middle River Segment Geomorphic Reaches 1-8 Lower River Segment[1] Geomorphic Reaches 1-6	Geomorphic reaches that uniquely divide the Major Hydrologic Segments based on geomorphic characteristics.
3	Mainstem Habitat	Main Channel Habitat Off-Channel Habitat Types[2] Tributary Habitat	Main Channel Habitat: *Main Channel* – Single dominant main channel. *Split Main Channel* – Three or fewer distributed dominant channels. *Multiple Split Main Channel* – Greater than three distributed dominant channels. *Side Channel* – Channel that is turbid and connected to the active main channel but represents non-dominant proportion of flow[3]. *Tributary Mouth* - Clear water areas that exist where tributaries flow into Susitna River main channel or side channel habitats (upstream Tributary habitat will be mapped as a separate effort). Off-Channel Habitat (also referred to as macrohabitat): *Side Slough* - Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water.[3,4] *Upland Slough* - Similar to a side slough, but contains a vegetated bar at the head that is rarely overtopped by mainstem flow. Has clear water.[3,4] *Backwater* - Found along channel margins and generally within the influence of the active main channel with no independent source of inflow. Water is not clear. *Beaver Complex* – Complex ponded water body created by beaver dams. Tributary Habitat: Tributaries will be mapped to the upper limit of Susitna River hydrological influence.

Level	Unit	Category	Definitions
4	Main Channel and Tributary	Main Channel and Tributary Mesohabitat	<u>Main Channel Mesohabitat</u> *Pool* – slow water habitat with minimal turbulence and deeper due to a strong hydraulic control. *Glide* – An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 percent slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[5] *Run* – A habitat area with minimal surface turbulence over or around protruding boulders with generally uniform depth that is generally greater than the maximum substrate size.[5] Velocities are on border of fast and slow water. Gradients are approximately 0.5 percent to less than 2 percent. Generally deeper than riffles with few major flow obstructions and low habitat complexity.[5] *Riffle* – A fast water habitat with turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross-section. Low gradient; usually 0.5-2.0 percent slope.[5] *Rapid* - Swift, turbulent flow including small chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Lower gradient and less dense concentration of boulders and white water than Cascade. Moderate gradient; usually 2.0-4.0 percent slope.[5] <u>Tributary Mesohabitat:</u> Tributary mesohabitats within the hydrologic zone of influence will be typed using the classification system described in Table 9.9-3, above.
5	Edge Habitat	Length of Shoreline Habitat	*Calculation*- will be determined by doubling the length of the mapped habitat unit.

[1]For the purposes of this RSP, classification of the Lower River segmentwill stop at Level 2. A classification system for the Lower River segment is still in development pending determination of Project effects in the Lower River.
[2] All habitat within this designation will receive an additional designation of whether water was clear or turbid within the database.
[3] The terms Side Channel, Slough, and Upland Slough are similar but not necessarily synonymous with the terms for macrohabitat type as applied by Trihey (1982) and ADF&G (1983a).
[4] All slough habitat will have an associated area created during the mapping process to better classify size. A sub-sample of side sloughs and upland sloughs will be mapped to the mesohabitat level using the tributary habitat classifications system shown in Table 9.9-3.
[5] Adapted from Moore et al. 2006.

Table 9.9-5. Example of raw data from mapping displayed in Figure 9.9-16.

Map ID	Level 1	Level 2	Level 3	Level 4	Turbid	Unit Length	Level 5 Edge Length
1	Middle	MR-7[1]	Main Channel	Glide	Yes	2,819	5,638
2	Middle	MR-7	Main Channel	Glide	Yes	2,339	4,678
3	Middle	MR-7	Side Channel	Run	Yes	2,101	4,202
4	Middle	MR-7	Main Channel	Glide	Yes	1,503	3,006
5	Middle	MR-7	Side Slough	Side Slough	No	824	1,648
6	Middle	MR-7	Side Channel	Run	Yes	978	1,956
7	Middle	MR-7	Side Channel	Glide	Yes	1,356	2,712
8	Middle	MR-7	Main Channel	Riffle	Yes	954	1,908

[1] MR-7 represents Middle Reach 7 of the geomorphic reaches

Table 9.9-6. Example data summarizing percent composition of unique habitat types.

<table>
<tr><th>Level 1</th><th>Level 2</th><th>Level 3</th><th>Level 4</th><th>Segment Count</th><th>Total Length (feet El.)</th><th>% of MR-7</th></tr>
<tr><td rowspan="5">Middle</td><td rowspan="5">MR-7[1]</td><td rowspan="2">Main Channel</td><td>Glide</td><td>3</td><td>6,661</td><td>51.7%</td></tr>
<tr><td>Riffle</td><td>1</td><td>954</td><td>7.4%</td></tr>
<tr><td rowspan="2">Side Channel</td><td>Glide</td><td>1</td><td>1,356</td><td>10.5%</td></tr>
<tr><td>Run</td><td>2</td><td>3,079</td><td>23.9%</td></tr>
<tr><td>Side Slough</td><td>Side Slough</td><td>1</td><td>824</td><td>6.4%</td></tr>
<tr><td colspan="4">Total</td><td>8</td><td>12,874</td><td>100.0%</td></tr>
</table>

[1] MR-7 represents Middle Reach 7 of the geomorphic reaches

Table 9.9-7. Example data summarizing length and percent composition of general habitat units by main channel and off-channel habitat.

Main Channel Mesohabitat	Total Length (feet El.)	Percent	Off-Channel Habitat	Total Length (feet El.)	Percent
Glide	8,017	66.5%	Main Channel	7,615	59.2%
Riffle	954	7.9%	Side Channel	4,435	34.4%
Run	3,079	25.6%	Side Slough	824	6.4%
Total	12,050	100.0%	Total	12,874	100.0%

Table 9.9-8. Schedule for implementation of the Habitat Characterization and Mapping Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Data Collection		—	—			—	—						
Initial Study Report									— Δ				
Follow up Data Collection										—	—		
Updated Study Report													— ▲

Legend:

—— Planned Activity

----- Follow-up activity (as needed)

Δ Initial Study Report

▲ Updated Study Report

9.9.12. Figures

Figure 9.9-1. Video frame capture of a tributary mid-channel scour pool in a confined channel with boulder and cobble substrate and no stream wood visible. ***(For a closer inspection the image can be zoomed to 250 percent).***

Figure 9.9-2. Aerial video tributary habitat mapping type-index – Falls.

Figure 9.9-3. Aerial video tributary habitat mapping type-index – Cascade.

Figure 9.9-4. Aerial video tributary habitat mapping type-index – Chute.

Figure 9.9-5. Aerial video tributary habitat mapping type-index- Rapid.

Figure 9.9-6. Aerial video tributary habitat mapping type-index – Run.

Figure 9.9-7. Aerial video tributary habitat mapping type-index - Boulder Riffle.

Figure 9.9-8. Aerial video tributary habitat mapping type-index - Cobble/Gravel Riffle - Split Channel.

Figure 9.9-9. Aerial video tributary habitat mapping type-index – Glide.

Figure 9.9-10. Aerial video tributary habitat mapping type-index - Mid Channel Scour Pool.

Figure 9.9-11. Aerial video tributary habitat mapping type-index - Lateral Scour Pool - Braided Channel.

Figure 9.9-12. Aerial video tributary habitat mapping type-index – Alcove – Special Habitat Feature.

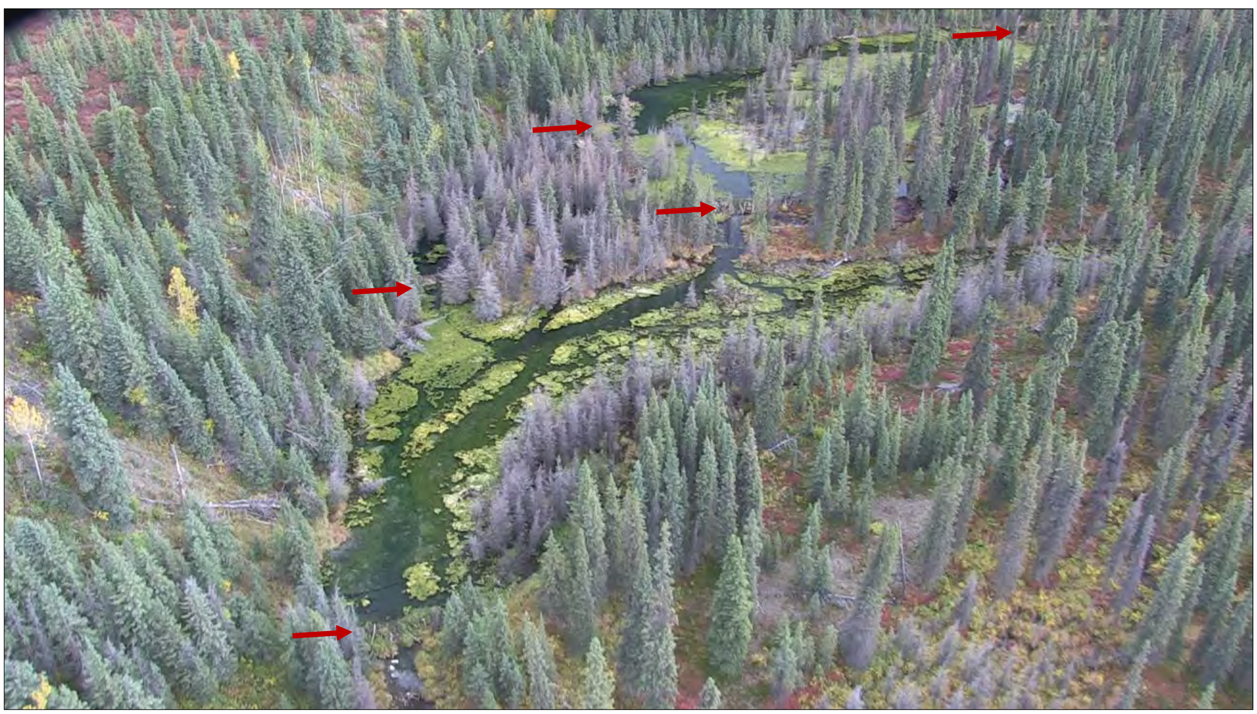

Figure 9.9-13. Aerial video tributary habitat mapping type-index – Beaver Complex – Special Habitat Feature.

Figure 9.9-14. Aerial video tributary habitat mapping type-index - Unclassified - Boulder Riffle?

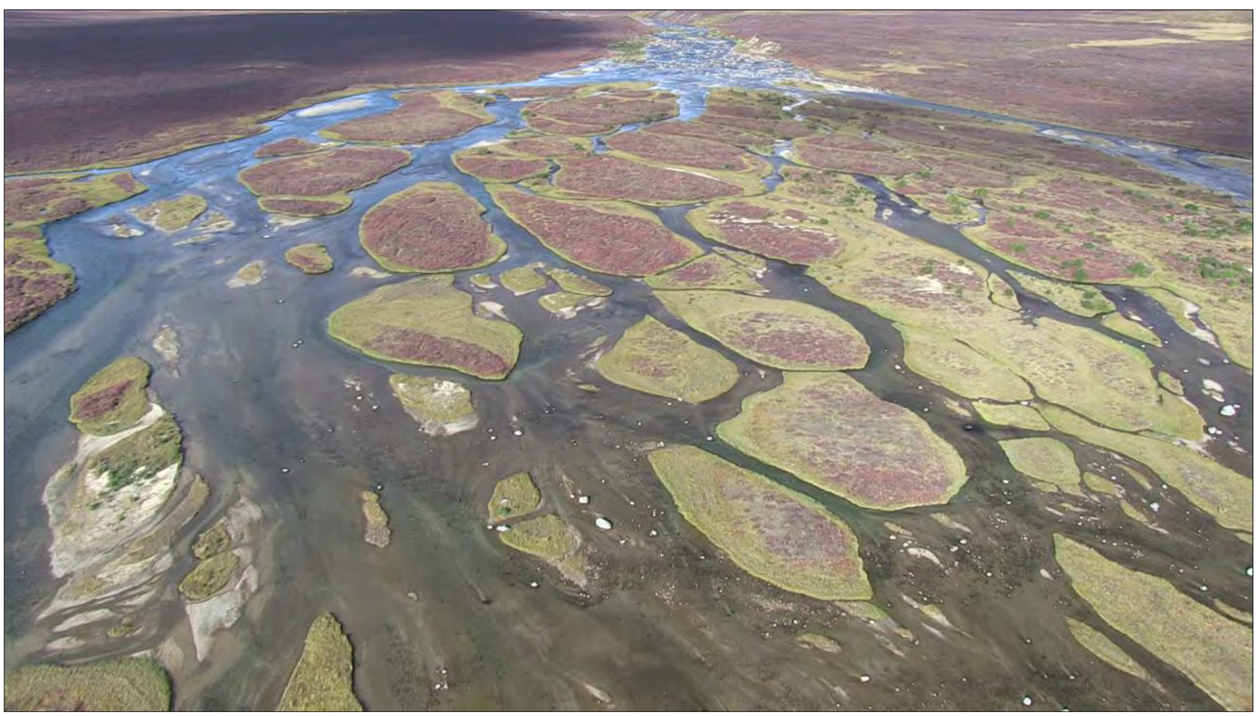

Figure 9.9-15. Aerial video tributary habitat mapping type-index - Unclassified – Braided Channel?

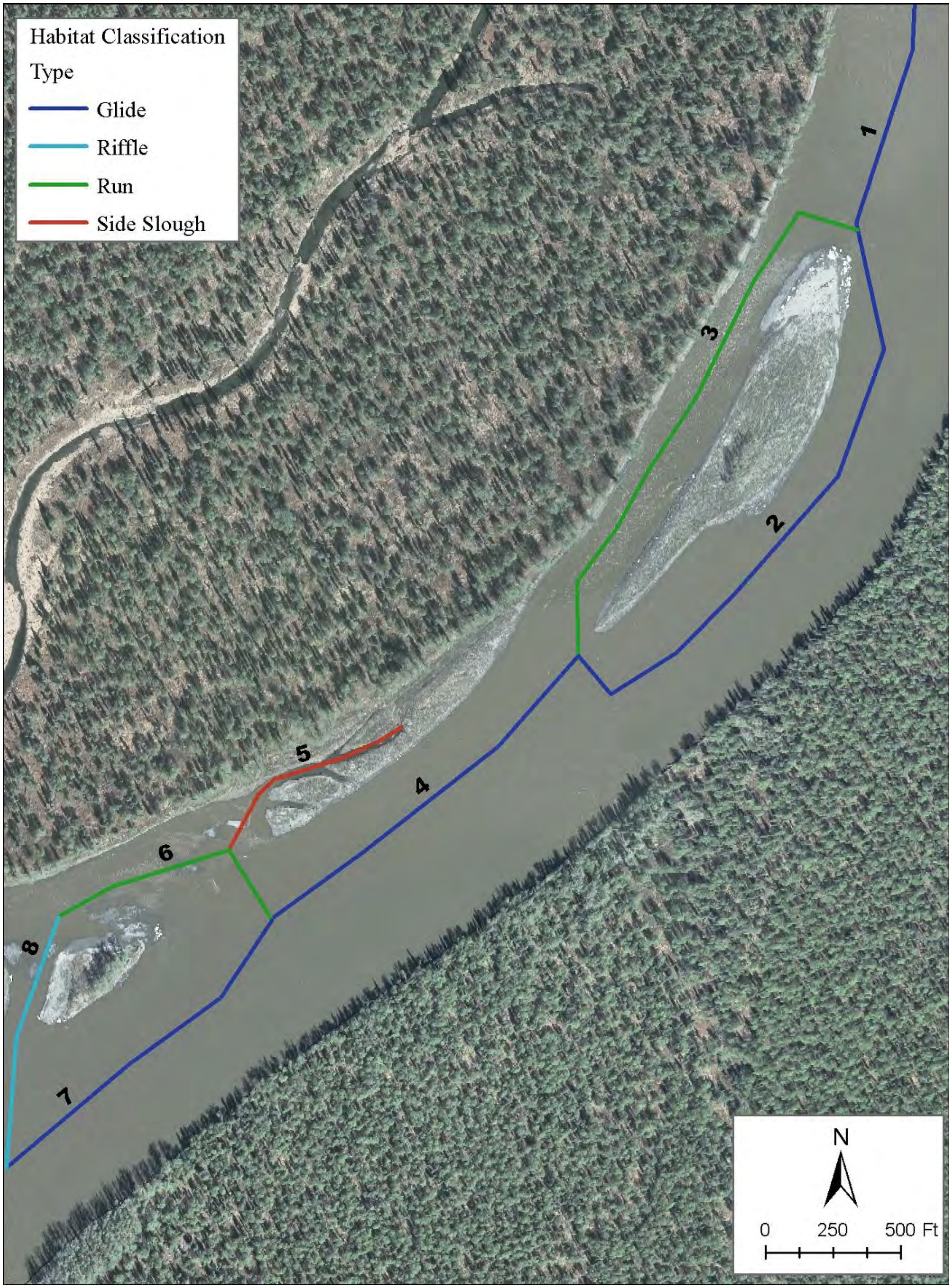

Figure 9.9-16. Example of mapping using the tiered habitat classification system in GIS.

Figure 9.9-17. Aerial video capture of the Lower River mainstem.

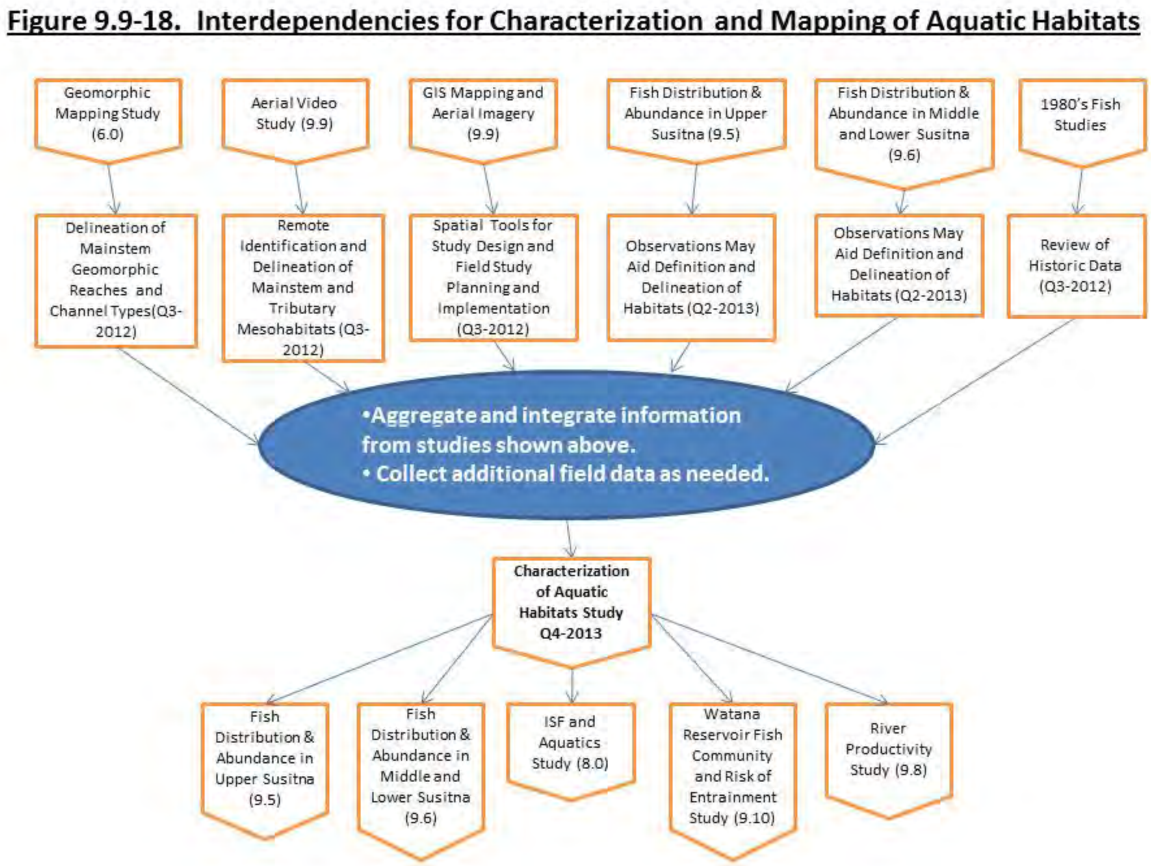

Figure 9.9.18. Interdependencies for Characterization and Mapping of Aquatic Habitats.

9.10. The Future Watana Reservoir Fish Community and Risk of Entrainment Study

9.10.1. General Description of the Proposed Study

The nature of the fish community inhabiting the proposed Watana Reservoir will depend on a suite of interrelated factors affecting fish populations and their habitat. These factors may be influenced by the design and operation of the Project. This study plan describes the efforts that will be implemented to predict the fish community that will develop in the Project's reservoir and identify the effects of the Project on the future reservoir fish community. Figure 9.10-2 shows the relationship between this study and other study programs.

Study Goals and Objectives

Construction and operation of the Project will result in inundation of the river upstream from the dam. Several operational scenarios will also be considered as part of the licensing studies. Some operating scenarios, such as load-following, could result in relatively large and frequent fluctuations of the reservoir water surface elevation. Operations would result in seasonal differences in pool elevation such as a winter or early-springtime drawdown in advance of the annual melt of accumulated snow during early summer.

Construction of the Project will fundamentally change the fish habitat characteristics in the area to be inundated. About 39 miles of mainstem river plus several miles of tributary stream will be converted to lacustrine habitat. Conversion from riverine habitat to lacustrine habitat will be beneficial for some fish species and detrimental to others, resulting in a modified fish community. Depending upon the fish protection measures included in the Project license and specific engineering design elements, the modified fish community may be subject to entrainment and mortality as a result of spill or passage through turbines. This study will provide information and tools needed for predicting the likely changes to the fish community due to habitat conversion, potential mortality from entrainment, and for assessing the potential Project operational effects on lacustrine habitat following Project construction.

Understanding the relationship between Project design, operations, lacustrine habitat, and the potential fish community in the proposed Watana Reservoir is important for assessing potential Project impacts. The proposed Watana Reservoir has the potential to provide public benefits in the form of recreational fishing opportunities as well development of commercial or subsistence fisheries. Identifying the potential fish community and species with commercial, subsistence, and sportfish values is also important for identifying alternative fishery management strategies in advance of Project construction.

The overarching goal of this study is to predict the fish community that will develop in the Project reservoir based on the existing species and the habitat that will be created in the inundation zone, and to characterize the potential loss from entrainment.

Specific objectives include the following:

1. Develop scenarios for anticipated daily and seasonal changes in reservoir habitat characteristics based on predicted reservoir operations, size, temperatures, and water quality and depth profiles.

2. Develop scenarios for future reservoir fish communities based on current fish species composition upstream of the proposed dam site and enhancement potential for select salmon species incorporating anticipated daily and seasonal changes in reservoir habitat characteristics.
3. Characterize potential management options including recreational, commercial, and subsistence uses of the reservoir fishery.
4. Conduct a qualitative desktop analysis on the potential for entrainment of fish species inhabiting the proposed reservoir upstream of Watana Dam.

9.10.2. Existing Information and Need for Additional Information

Information regarding resident species, non-salmon anadromous species, and the freshwater rearing life stages of anadromous salmon was collected as part of the studies conducted during the early 1980s. Existing information includes the spatial and temporal distribution of fish species and their relative abundance. The Aquatic Resources Data Gap Analysis (ARDGA; AEA 2011a) and Pre-Application Document (PAD) (AEA 2011b) summarize this existing information and also identify data gaps for resident and rearing anadromous fish.

At least eight species of fish are known to occur in the Upper Susitna River (AEA 2011a). These species are Arctic grayling, Dolly Varden, humpback whitefish (*Coregonus* spp.), round whitefish, burbot, longnose sucker, Chinook salmon, and sculpin (all assumed to be slimy sculpin). Northern pike, Alaska blackfish, and lake trout may also be present. Chinook salmon are the only anadromous species documented in the Upper Susitna River.

In the proposed impoundment zone, Arctic grayling are believed to be the most abundant fish species (AEA 2011a) and were found to spawn in tributary pools. In tributaries, juvenile grayling were found in side channels, side sloughs, and pool margins and in the mainstem at tributary mouths and clear water sloughs during early summer (AEA 2011b). Dolly Varden populations in the Upper Susitna River are apparently small but widely distributed (AEA 2011b). Burbot in the Upper Susitna River were documented in mainstem habitats with backwater eddies and gravel substrate. Longnose suckers were less abundant in the Upper Susitna River than downstream of Devils Canyon (river mile [RM] 150). Lake trout were documented in lakes near the proposed impoundment zone but the impoundment zone has not yet been sampled.

In the 1980s, the Alaska Department of Fish and Game (ADF&G) completed an investigation of feasibility of upstream salmon passage through Devils Canyon and the enhancement potential in the river basin upstream of Devils Canyon (Barrick et al. 1983). Information from this historic study will be used in combination with data collected in 2013 and workgroup meetings with ADF&G management biologists to characterize the potential future reservoir fish community.

This study is needed to provide information and tools needed for predicting the likely changes to the fish community due to habitat conversion, for determining potential mortality from entrainment, and for assessing the potential Project operational effects on lacustrine habitat following Project construction.

9.10.3. Study Area

The study area (Figure 9.10-1) encompasses all portions of the basin to be inundated by the proposed Watana Reservoir up to the maximum reservoir water surface elevation to be determined during finalization of design and operational scenarios. About 39 miles of mainstem river (beginning at the dam site at RM 184), plus an unknown amount of tributary stream, will be converted to lacustrine habitat. During normal operation, the reservoir level may fluctuate substantially on a daily and seasonal basis. Annual drawdowns are anticipated to exceed 100 feet with a maximum drawdown of 150 feet. The Project is currently planned to be operated in a load-following mode to maximize firm power generation during winter (November through April), but inflows into the reservoir during this period are anticipated to be relatively low.

9.10.4. Study Methods

The following sections describe the approach that will be used to address each of the four interrelated study objectives associated with the Future Watana Reservoir Fish Community and Risk of Entrainment Study. Each component incorporates significant agency recommendations regarding the general study approach and specific methods to be used. These were developed collaboratively during the drafting of the relevant study request. Where appropriate, each study component has been broken down into separate tasks.

9.10.4.1. Reservoir Habitat Scenarios

Based on the alternative Project operating scenarios identified by Project engineers, this study component will develop corresponding scenarios for anticipated daily and seasonal changes in reservoir habitat characteristics. This study component is composed of the three following tasks that will consider reservoir conditions related to the relative size of lacustrine zones, water temperature, and turbidity.

Task 1 – Lacustrine Zone Estimation

Project operations will influence the relative size of different lacustrine zones and, as a result, the amount of habitat for aquatic biota that inhabit each zone. This task will coordinate with the operations modeling study team to adapt an existing model, such as HEC-ResSim, or develop a new unsteady flow hydraulic model of the proposed reservoir that can be used to evaluate daily and seasonal changes in reservoir depth and the amount of exposed shoreline. Based on Light Detection and Ranging (LiDAR) data and a series of transects across the proposed reservoir, model results will provide reservoir water surface elevations and depths that will be used to develop estimates of the size of each of the following lacustrine zones under the alternative operating scenarios identified in coordination with project engineers:

Varial Zone: Area alternately wetted and dewatered by water level fluctuations; can include some or all of the littoral zone.

Littoral Zone: Near-shore area extending to the deepest extent of light penetration sufficient for primary production.

Limnetic Zone: Open-water layer with sufficient light penetration for primary production to occur.

Profundal Zone: Open-water layer too deep for primary production to occur; below the limnetic zone.

Benthic Zone: Bottom layer of the reservoir associated with the substrate and underlying all other zones.

An important part of this task will be the development of assumptions related to reservoir operations to be incorporated into the hydraulic model. These model assumptions will be developed collaboratively with the Fish and Aquatic Technical Workgroup (TWG). Additional assumptions pertain to how the lacustrine zone is defined temporally and spatially. Temporal aspects of the defined lacustrine zone will consider minimum and maximum time intervals appropriate to the frequency and magnitude of water level fluctuations expected under the alternative operating scenarios, in particular those related to peaking operations. Spatial definitions will consider turbidity or other factors related to light penetration that also may vary at least seasonally.

Task 2 – Water Temperature Modeling

This task will involve the development of a water temperature model of the proposed reservoir that can be used to evaluate daily and seasonal changes in water temperatures and the potential for thermal stratification. The water temperature model will be developed in coordination with the water quality assessment team and as part of the proposed Water Quality Modeling Study. It is anticipated that the Environmental Fluid Dynamics Code (EFDC), will be used for this effort based on the review of available models described in Water Quality Monitoring Study (Section 5.6). Model results will be used to predict daily and seasonal variations in reservoir temperatures, including temperature profiles, and identify the potential for thermal stratification. This task will summarize the reservoir temperature model results including an assessment of how the results relate to the future reservoir fish community. Details regarding the implementation of the water quality model are described in Section 5.6 though specific outputs necessary for this study component will be developed through an iterative and collaborative process with the water quality study team. Completion of the initial study report for the Water Quality Modeling Study is expected in the first quarter of 2014. However, model outputs related to reservoir temperature will be obtained as they become available.

Task 3 – Reservoir Turbidity

Turbidity levels can influence the suitability of aquatic habitat for certain fish species. This task will involve reviewing available information to identify turbidity thresholds that can limit reservoir habitat utilization for species that may otherwise overwinter in the Watana Reservoir. The target species for this effort are lake trout, burbot, grayling, and whitefish. Historic information collected in the Susitna basin during the 1980s and synthesized as part of a 2012 study (Synthesis of Exiting Fish Population Data) will be reviewed to identify utilization relative to turbidity levels. Information collected in 2012 as part of the Upper Susitna River Fish Distribution and Habitat Study will also be reviewed as well as turbidity threshold information available for the target species from other out-of-basin literature sources. This information will be compared to turbidity levels expected to occur in the Watana Reservoir that are identified in coordination with the water quality assessment team. Species-specific turbidity exceedances in the Watana Reservoir during winter will be identified to predict the degree, if any, to which turbidity will limit the overwintering use of reservoir habitat by lake trout, burbot, grayling, and whitefish.

9.10.4.2. Reservoir Fish Community Scenarios

Creation of the reservoir and operation of the Project will drastically alter the habitat available to the existing fish community in the inundation zone. The future reservoir fish community will be determined by the altered habitat conditions, as well as the segment of the existing fish community expected to utilize the reservoir. This study component will develop scenarios for future reservoir fish communities based on the current fish species composition upstream of the proposed dam site, anticipated reservoir habitat characteristics, and management practices acceptable to ADF&G. This study component is composed of the following four tasks related to the existing fish community, potential use of the reservoir by these species, and the potential presences of invasive species.

Task 1 – Define Existing Fish Community

Species that comprise the existing fish community in the Susitna River and certain subbasins represent the source stocks from which the reservoir could be colonized. In this task, information from two studies conducted during 2012, the Synthesis of Existing Fish Population Data Study and the Upper Susitna River Fish Distribution and Habitat Study, will be reviewed to characterize the existing fish community in the mainstem river and any tributaries or lakes that could colonize the reservoir. Potential colonizing species will be identified based on their presence in the inundation zone, proximity/connectivity to the inundation zone, and the likelihood of potential movements to the inundation zone.

Task 2 – Identify Potential Use of Lacustrine Habitat

Although the reservoir could be colonized by fish species identified in Task 1, future reservoir habitat may not be suitable for all species. This task will involve a literature review to identify species in the existing fish community that may use lacustrine habitat for one or more life history stages. In the absence of such information, general utilization of lacustrine habitat in other systems will be reviewed. A white paper will be prepared that identifies the life history and habitat requirements for each species, with a focus on lacustrine elements. The white paper will be drafted during 2Q and 3Q, 2013 and findings will be incorporated into the Initial Study Report and the Updated Study Report. The discussion for each species will include an assessment of uncertainty in predicting their lacustrine habitat use. This assessment will be written to aid in the development of a post-construction monitoring program by identifying such uncertainties as expected life histories or those related to future reservoir habitat conditions.

Task 3 – Identify Potential Invasive Species

Northern pike are considered an invasive species in the Susitna drainage and have spread throughout the system from the Yenta drainage after being illegally introduced in the 1950s (AEA 2011b). Alaska blackfish are also considered an invasive species and, while not captured in the Susitna River, may have been introduced to the system. This task will identify the presence of invasive species in lakes and ponds that are currently disconnected from the mainstem but have the potential to be inundated. Information from the two 2012 studies identified above will be reviewed to identify water bodies in which invasive species have been found and that have the potential to be inundated.

Task 4 – Identify Potential for Anadromous versus Land-Locked Salmon-Based Community

This task summarizes the potential to establish viable populations of anadromous salmon upstream of the proposed Project and the potential to affect native fish communities. Enhancement potential upstream of the Project will be based on the 1983 study by Barrick et al. Depending on fish passage considerations, an alternative land-locked salmonid community will also be assessed. Potential effects of these species on native fish communities will be addressed. A literature review will focus on habitat utilization by relevant species in newly created reservoirs where such information is available. This effort will be conducted during 2Q and 3Q 2013 and findings will be synthesized to comprise relevant sections of the Initial Study Report and Updated Study Report.

9.10.4.3. Reservoir Fishery Management Options

This study component will characterize potential management options for a future reservoir fishery. A future fishery in the Watana Reservoir will be dependent upon the habitat conditions and fish community expected to occur in the reservoir, as described by the previous study components. Management options related to a reservoir fishery will be dependent on public access and recreational goals established for the reservoir and consistency with ADF&G management actions, as well as fish passage As such, analyses associated with this study component will be conducted in 2014 when more information on public access and recreational goals for the reservoir are available. Implementation of this study component will involve collaborating with ADF&G in the development of alternative recreational, commercial, and subsistence fishery management strategies for the reservoir. This effort will also coordinate with the recreation team to determine the recreational basis and potential access in support of a potential fishery. The technical memorandum for the overall study will include a section in which the potential management options for a future reservoir fishery, developed in collaboration with ADF&G and in coordination with the recreation team, are described in detail.

9.10.4.4. Entrainment Analysis

Fish inhabiting the proposed reservoir could be susceptible to entrainment through the Project (turbines or spillways) or impingement on the intake trash racks. This study component will involve conducting a desktop analysis of the potential for entrainment and impingement of fish species inhabiting the proposed Watana Reservoir. This study component is comprised of the following three tasks related to identifying Project design and operating scenarios, reviewing relevant literature related to entrainment at other projects and biological information for target species, and analyzing this information to assess entrainment and impingement risks at the Project. Fish passage provisions, and the presence of anadromous fish, have implications regarding the overall number of species and individuals to be considered in evaluating potential entrainment or impingement risks; thus, the selection of target species for entrainment will be drawn from the reservoir fish community scenerios and identified in collaboration with the Fish and Aquatic TWG. The work product for this study component will be a technical memorandum summarizing the entrainment analysis that will entail the following tasks.

Task 1 – Identify Project Design/Operating Scenarios

Potential entrainment risks are influenced by Project design and operations. This task will involve coordinating with Project engineers to understand alternative Project designs and operating scenarios. This task is anticipated to be conducted in 2014 when more dam design and operational details are available. Specific design and operational details to be considered that can directly influence entrainment risks include the following:

- Intake approach velocities
- Trash rack spacing

- Intake depths and design
- Outlet depths and design
- Operating head
- Turbine design
- Turbine speed
- Generation
- Spillway design
- Spill height
- Spill frequency

Task 2 – Literature Review

An abundance of information is available in the literature regarding fish entrainment at hydropower projects (i.e., EPRI 1997; Franke et al. 1997; FERC 1995). This task will entail reviewing such information as well as other analyses of entrainment risks with a focus on deep water intakes and cold water reservoirs. Biological information related to the future Watana Reservoir fish community identified as part of this study will also be considered to identify species and life stages expected to inhabit the reservoir that may be at risk of entrainment or impingement. Additional biological information related to entrainment and impingement risks will be obtained from the literature. Such information includes the swimming ability of target species, which will influence their ability to avoid entrainment as they approach the intakes, as well as fish size (i.e., body length and width), which will influence impingement risks. General behavioral information related to movements in the water column and reservoir habitat use will also be reviewed.

Task 3 – Desktop Analysis

This task will involve synthesizing the information collected in the previous tasks to conduct a desktop analysis identifying the potential vulnerability of target species in the anticipated reservoir community to entrainment and impingement mortality at the proposed dam under alternative design and operating scenarios. Because the size and composition of fish populations comprising the future reservoir community is theoretical under pre-Project conditions, rates of entrainment or impingement will not be predicted as part of this task. Rather, this analysis will focus on identifying species and life stages at risk of entrainment or impingement based on their size, swimming ability, periodicity, and/or behavior. The analysis will also identify the relative risks associated with different potential sources of indirect or direct mortality, including impingement, strike, shear, grinding, turbulence, cavitation, pressure changes, and dissolved gas levels.

9.10.4.5. Work Products

Deliverable work products include the following:

White Paper on Potential Use of Lacustrine Habitat

As described above, a white paper will be prepared that identifies the potential use of lacustrine habitat. This work product will rely on existing information developed in 2012 as well as a review of relevant literature. Because the contents of this work product do not require input from water quality modeling or operational scenarios, it will be completed in 3Q, 2013.

Technical Memorandum on Entrainment Analysis

A technical memorandum will be prepared that summarizes the results of the entrainment analysis, including a summary of relevant Project design/operational scenarios, a review of available literature pertinent to entrainment/impingement risks of target species, and the methods and results of the desktop entrainment analysis. Because this work product is dependent on input regarding Project design and operating scenarios, it will be completed in 2Q, 2014.

Study Reports

Initial and Updated Study Reports that summarize study progress and results gathered to date will be prepared and presented to resource agency personnel and other licensing participants, along with spatial data products. These Study Reports will represent the primary work products for this study and will provide detailed methods and findings associated with all of the aforementioned tasks related to Reservoir Habitat Scenarios, Reservoir Fish Community Scenarios, Reservoir Fishery Management Options, and the Entrainment Analysis. When available, the Initial and /or Updated Study Reports will incorporate results provided in the white paper on potential use of lacustrine habitat, and the technical memorandum related to the entrainment analysis. Along with the study reports, spatial data products will be provided that include shape files of the various lacustrine zones for each alternative operating scenario. All map and spatial data products will be delivered in the two-dimensional Alaska Albers Conical Equal Area projection, and North American Datum of 1983 (NAD 83) horizontal datum consistent with Alaska Department of Natural Resources (ADNR) standards. Naming conventions of files and data fields, spatial resolution, and metadata descriptions must meet the ADNR standards established for the Project.

9.10.5. Consistency with Generally Accepted Scientific Practice

The study methods have been developed in consultation with licensing participants. The methods chosen to accomplish this effort are consistent with standard techniques used throughout the fisheries scientific community. The use of models is a common technique used for assessing potential effects of a proposed project. The proposed modeling frameworks described below were developed by the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency specifically for predicting the behavior of reservoirs and simulating physical water resource processes.

9.10.6. Schedule

This is largely a desktop analysis that will be completed in late 2013 and 2014 as information from other studies becomes available. The schedule for this study is shown in Table 9.10-1. Results from the Reservoir Habitat Study component will inform the Reservoir Fish Community Study component. In turn, results from the Reservoir Fish Community Study component will inform both the Reservoir Fishery and Entrainment Study components. As such, the schedule reflects the appropriate ordering of implementation for each study component. Initial and Updated Study reports documenting actions taken to date will be issued within 1 and 2 years, respectively, of FERC’s Study Plan Determination (i.e., February 1, 2013).

9.10.7. Relationship with Other Studies

The Future Watana Reservoir Fish Community and Risk of Entrainment Study is interrelated to several AEA studies (Figure 9.10-2). The flow of information into and out of this study is anticipated to occur over the two-year study period through an iterative process. As relevant data (described above) is collected, it will be disseminated to other participants in the Fish Program and Recreational Resources. To maximize communication among the Fish Study Program, study leads will participate in regularly scheduled internal meetings where preliminary data will be presented and implications to other studies discussed.

In addition to Project design and operations, five Project studies will interrelate by providing input information useful to the Reservoir Fish Community and Entrainment Study. In the fourth quarter of 2013, the Fish Passage Feasibility Study (Section 9.11.4) will provide input information on concepts and alternatives as an iterative process that will inform the future fish community. The Upper River Fish Distribution and Abundance Study (Section 9.5.4.3.1) will provide information on the potential reservoir fish community in the 2013 and 2014 Study Reports. The Fish Passage Feasibility Study (Section 9.11.4) will also provide information on entrainment risk with preliminary engineering and design alternatives in the 2013 and 2014 Study Reports. The Water Quality Modeling Study (Section 5.6.4) will provide information in the third and fourth quarters of 2014 on temperature and turbidity that will be used to assess reservoir habitat. The Recreational Resources Study (Section 12.5) Initial Study Report will provide information on how recreational use and demand of the reservoir may impact the fishery.

The Future Watana Reservoir Fish Community and Risk of Entrainment Study will also interrelate with three other Project studies by providing useful output information (Figure 9.10-2). The desktop analysis of potential entrainment will provide information on entainment risk to the Fish Passage Feasibility Study (Section 9.11) in the second quarter of 2014 and output back to the Watana Reservoir Fish Community Study (Section 9.10). Evaluating scenarios for reservoir habitat, fishery management options, and future reservoir fish communities in the first quarter 2014 will inform the Future Watana Reservoir Fish Community Study (Section 9.10). The reservoir fisheries component of the Reservoir Fish Community and Entrainment Study will used to evaluate fishery management options in the second quarter of 2014 and used and inform the Recreation Resources Study (Section 12.5).

9.10.8. Level of Effort and Cost

Several components of this study will rely on modeling or other efforts developed in coordination with other study programs. As such, the level of effort and expected cost associated with each study component is dependent upon the distribution of effort among the different study programs. The total estimated cost for this study is $205,000. The estimated costs associated with each study component are provided below and include assumptions related to the distribution of effort. The staffing and costs for this study will be further refined as other related portions of the 2013–2014 study program develop.

Reservoir Habitat Scenarios

The estimated cost to complete this study component is $60,000. This cost assumes that the operations modeling study team will perform the majority of the reservoir hydraulic modeling effort and water quality study team will perform the majority of the water temperature modeling effort.

Reservoir Fish Community Scenarios

The estimated cost for this study component is $65,000.

Reservoir Fishery Management Options

The estimated cost for this study component is $40,000. This cost assumes that the recreation study team will develop the recreational basis for a future reservoir fishery.

Entrainment Analysis

The estimated cost for this study component is $40,000.

9.10.9. Literature Cited

AEA (Alaska Energy Authority). 2011a. Aquatic Resources Gap Analysis. Prepared by HDR, Inc., Anchorage. 107 pp.

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Barrick L., Kepshire, B., G Cunningham. 1983. Upper Susitna River Salmon Enhancement Study. Alaska Department of Fish and Game FRED Report Number 4. 156 pp.

EPRI (Electric Power Research Institute). 1997. Turbine survival and entrainment database – field tests. EPRI Report No. TR-108630. Prepared by Alden Research Laboratory, Inc. Holden, MA. 13 pp and two 3.5-inch diskettes.

FERC (Federal Energy Regulatory Commission). 1995. Preliminary assessment of fish entrainment at hydropower projects – volume 1 (Paper No. DPR-10). Office of Hydropower Licensing, FERC, Washington, D.C.

Franke, G.F., D.R. Webb, R.K. Fisher, D. Mathur, P.N. Hopping, P.A. March, M.R. Headrick, I.T. Laczo, Y. Ventikos, F. Sotiropoulus. 1997. Development of environmentally advanced hydropower turbine system design concepts. U.S. Dept. of Energy and Hydropower Research Foundation. July 1997.

9.10.10. Tables

Table 9.10-1. Schedule for implementation of the Future Watana Reservoir Fish Community and Risk of Entrainment Study.

Activity	2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Reservoir Habitat Scenarios		——	——			--------			
Initial Study Report				——	Δ				
Reservoir Fish Community Scenarios				——	——				
Reservoir Fishery Management Options					——	——			
Entrainment Analysis					——	——			
Updated Study Report								——	▲

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

9.10.11. Figures

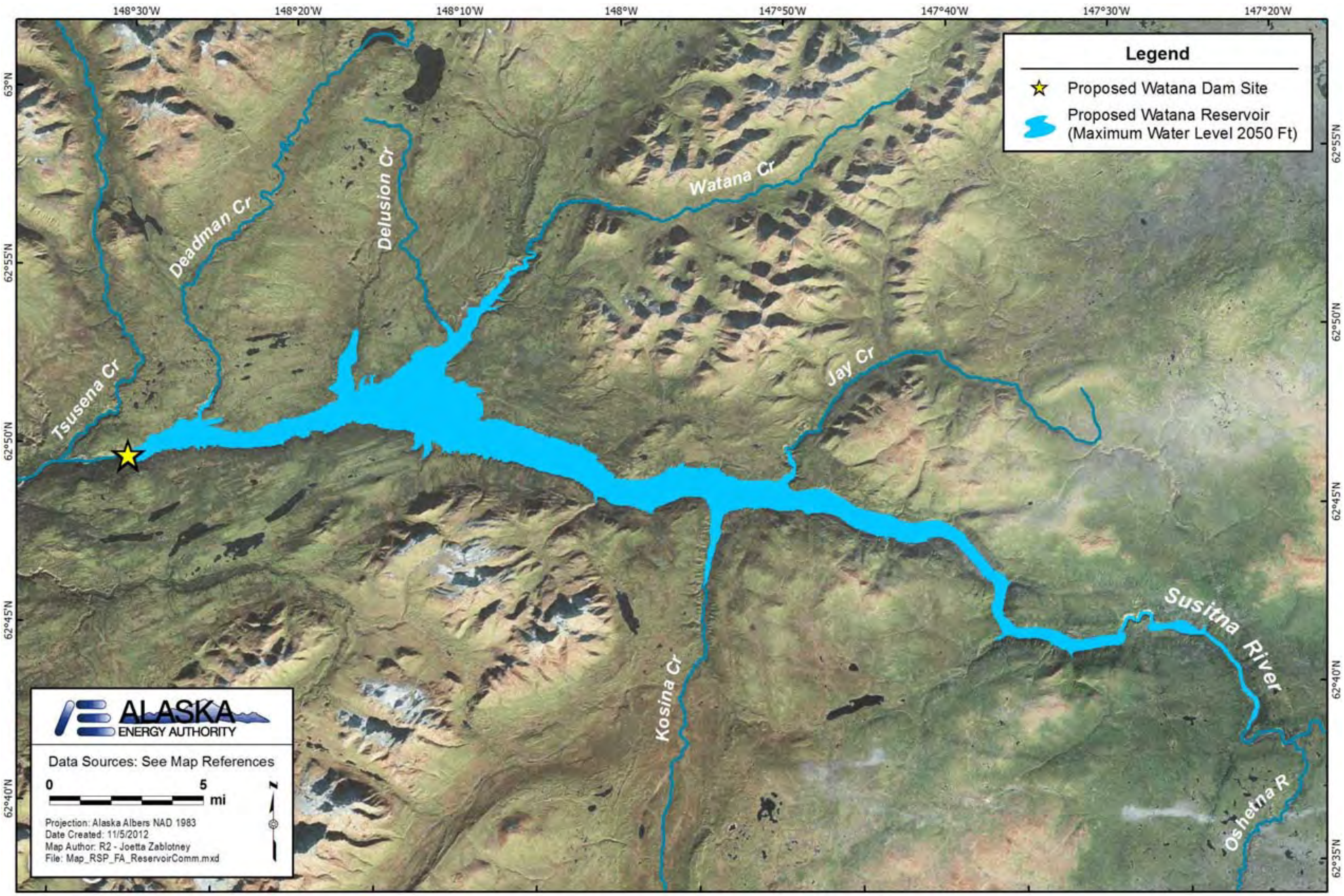

Figure 9.10-1. Map of study area for Future Watana Reservoir Fish Community and Risk of Entrainment Study.

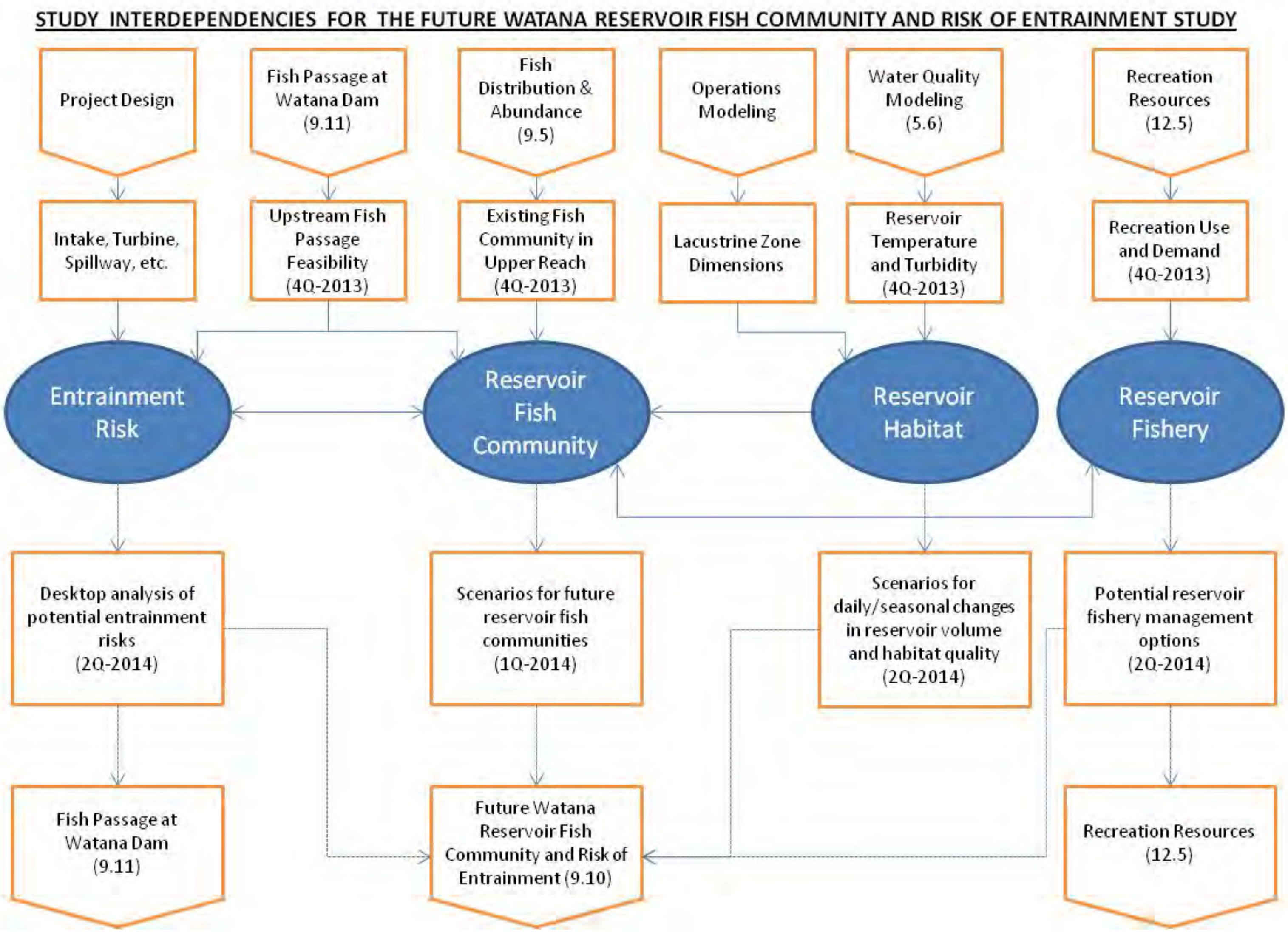

Figure 9.10-2. Flow chart showing relationships between components of the Future Watana Reservoir Fish Community and Risk of Entrainment Study (ovals), other study programs, and related information.

9.11. Study of Fish Passage Feasibility at Watana Dam

9.11.1. General Description of the Proposed Study

The proposed Watana Dam would create a fish passage barrier on the Susitna River. Information regarding the fish passage feasibility and the engineering feasibility of passage at this location is important to the resource management decisions that pertain to the License Application for construction and operation of the proposed Project. In implementing this study plan, AEA will compile the available biological information from the 1980s through the 2013–2014 studies and will develop new information regarding the feasibility of engineering alternatives to fish passage at the proposed dam site. AEA will assimilate this information and conduct a feasibility analysis of engineered passage solutions.

In this study plan, *feasibility* is defined in a technical sense and includes both engineering and fish passage feasibility. Engineering feasibility is governed by physical dam and reservoir characteristics, hydrology, primary water storage and release operations, and operating and construction cost. Fish passage feasibility is governed by fish behavioral responses to site conditions, including migration timing, and migratory pathways. The intent of this feasibility assessment is to address two basic questions: (1) Can a fish passage alternative be identified that will effectively and safely collect and pass migratory fish? (2) Can the fish passage alternative be constructed and operated while maintaining the original purpose of the Proposed Project?

This study plan is limited to analyzing the feasibility of fish passage and does not analyze the necessity of fish passage at the proposed Project. AEA has not made any decisions regarding whether to include fish passage as part of its proposed Project. In developing its License Application for the proposed Project, AEA will assess whether to propose fish passage based on the results of other study plans and other available information along with input from federal and state agencies and other licensing participants.

Study Goals and Objectives

The goal of this study is to develop, to the feasibility level, a fish passage strategy in support of the License Application for the proposed Project. This study plan outlines the process that will be used to achieve this goal. A variety of engineering, biological, sociological, and economic factors will be considered during this process. The study will explore various alternatives in support of three basic strategies related to fish passage: (1) proposed Project without fish passage, (2) integration of upstream and downstream passage features into the current dam design, and (3) the retrofit of upstream and downstream fish passage features to a dam designed without passage.

9.11.2. Existing Information and Need for Additional Information

The central feature of the proposed Project is the approximate 750-foot-high Watana Dam (as measured from sound bedrock) 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. Chinook salmon were documented in two tributaries to the proposed reservoir during Alaska Department of Fish and Game (ADF&G) sampling efforts in 2003 and 2011. Juvenile Chinook were found in Kosina Creek in 2003 and one adult was observed in 2011 at an approximate elevation of 2,800 feet; juveniles were also found in the Oshetna River near its confluence with the Susitna River, but none were observed in 2011 (ADF&G 2003a and b, 2011). Aside from these observations, other salmon species have not been documented above the dam site, but little else is known about migration patterns and habitat use upstream of the proposed dam site for other anadromous species in the Susitna River. In addition, there are migratory resident fishes, including burbot, Dolly Varden, and whitefish that have been documented both upstream and downstream of the proposed dam site.

There is currently no specific engineering information and little biological information to provide a basis for determining feasibility of passage at the proposed Watana Dam. Pacific salmon (all five species) were documented throughout the Lower and Middle Susitna River during the 1980s. The extent of their presence in the Upper River has not been well documented. Coho, chum, sockeye, and pink salmon were found in the Lower and Middle Susitna River during the 1980s, but have not been observed upstream of Devils Canyon. Chinook salmon is the one anadromous species that migrates past Devils Canyon at relatively low numbers (Thompson et al. 1986). Recently ADF&G radio-telemetry studies using sockeye, coho, and chum salmon from the Lower River have been conducted for several years and have not documented any tagged fish above Devils Canyon. In 2012, AEA expanded these studies in coordination with ADF&G to include additional species and add a focused investigation of distribution of coho, Chinook, sockeye, chum, and pink salmon above Devils Canyon.

Preliminary results from 2012 indicated that 12 Chinook salmon that were radio-tagged at Curry station passed upstream of the uppermost impediment within Devils Canyon. Four of these fish migrated to Kosina Creek and were last observed as mortalities. The rest of the tagged fish detected upstream of Devils Canyon were last detected in Cheechako Creek, Portage Creek, in Devils Canyon itself, or in the mainstem river downstream of the canyon. Additionally, information regarding Chinook salmon distribution comes from the 2012 spawner surveys. During these aerial surveys, 19 Chinook salmon were observed spawning in Kosina Creek, including the 4 radio-tagged fish mentioned earlier. No other adult Chinook salmon were observed upstream of the proposed dam site during the 2012 field observations.

Chinook salmon are the only anadromous species known to rear in the Upper Susitna River and tributaries. Juvenile Chinook salmon have been documented in Fog Creek, Kosina Creek, and the Oshetna River (Buckwalter 2011). Little is known about Upper Susitna Chinook salmon in terms of run size and inter-annual variability; locations of spawning, rearing, and over-wintering areas; and timing and duration of key life history events (e.g., upriver migration and spawning, period of freshwater residency, smolt out-migration). However, historic data from the 1980s did document the life history of Chinook salmon in the Middle River. In summary, these historic studies indicated that Susitna River Chinook salmon spawning is limited to tributary habitat. No Chinook salmon have ever been documented spawning in the mainstem river. These fish overwinter in the gravels and fry emerge in March or April (Harza-Ebasco 1985). Chinook salmon fry remain near their natal areas in tributaries for a brief period—one or two months—before beginning a downstream movement into rearing and overwintering areas (ADF&G 1984). Some Chinook salmon juveniles move into the Susitna mainstem and have been collected throughout the basin during summer (Harza-Ebasco 1985). Other juveniles apparently remain in natal tributaries for early rearing and overwintering (ADF&G 1984).

In addition to the anadromous salmon, humpback whitefish and Dolly Varden also express anadromous life history patterns (Morrow 1980), but these life history patterns have not been documented for Susitna River populations. Both of these species have been documented in the Upper Susitna River (Delaney et al. 1981). In 2012, otoliths were collected in order to evaluate the presence of anadromy for Susitna populations of Dolly Varden and humpback whitefish. Pacific lamprey exhibit an anadromous life history pattern and have been observed in nearby river systems (Chuit River; Nemeth et al. 2010), but do not have a documented presence in the Susitna River. Other resident fishes present in the Upper Susitna River that may have migratory components and may be affected by changes in connectivity between the Upper and Lower River include Arctic grayling, burbot, round whitefish, and possibly rainbow trout.

9.11.3. Study Area

The study area (Figure 9.11-1) extends from the confluence with Portage Creek (RM 148) upstream to the Oshetna River (RM 233.4). It is assumed that any potential upstream passage facilities to be considered (e.g., a trap-and-haul facility) would be located in the mainstem upstream of the confluence with Portage Creek.

9.11.4. Study Methods

This feasibility evaluation includes six tasks needed to determine fish passage technical feasibility for the Project. This study will generally follow the guidance provided in the National Marine Fisheries Service (NMFS) *Anadromous Salmonid Passage Facility Design* document (NMFS 2011). These tasks are summarized below.

1. Establish a Fish Passage Technical Workgroup (TWG) to provide input on the feasibility assessment.
2. Prepare for feasibility study.
3. Conduct site reconnaissance.
4. Develop concepts.
5. Evaluate feasibility of conceptual alternatives.
6. Develop refined passage strategy(ies).

Task 1: Establish the Fish Passage Technical Workgroup to provide input on the feasibility assessment.

In cooperation with state and federal agencies and other interested licensing participants, AEA will establish a Fish Passage TWG with representatives from state and federal agencies, FERC, and other interested licensing participants. This workgroup will be convened regularly (likely bi-monthly [once every other month]) throughout the study to provide input on assessing additional data needs, developing evaluation criteria, and developing conceptual design passage strategies.

As part of this process, the regular meetings may be substituted with workshops that engage a broader group of participants. Four workshops will be scheduled at study milestones addressing the following topics: (1) review of dam design and operational concepts, biological, physical and site specific information, (2) conceptual alternatives brainstorming, (3) critique and refinement of concepts and packaging of conceptual components into alternatives, and (4) alternatives selection, refinement, and costs. The first Fish Passage TWG meeting will be convened to identify goals, set schedules, establish process, and refine and obtain input on list of information needed for Task 2.

Task 2: Prepare for feasibility study.

Task 2 is focused on technical preparation for the concept development brainstorming session described in Task 4. AEA will compile the existing and salient background information listed below, and the information will be disseminated and presented to the Fish Passage TWG. In addition, AEA will prepare workshop materials including further development of evaluation criteria and an evaluation process. The review will allow the Fish Passage TWG to become familiar with the operational, physical, hydrologic, and biological setting of the Watana Dam. This information will assist the Fish Passage TWG in providing input to alternatives identified by AEA that can reasonably and realistically fit within the construct of the proposed Project operations, and that are compatible with hydrological and physical constraints.

Existing data will be obtained from the 1980s Susitna studies, ADF&G surveys conducted between 2003 and 2011, AEA survey reports, and engineering documents prepared in 2012. Additional data will be developed during the licensing baseline study program in 2013 and these data will be used to inform development of alternatives and conceptual design. The following information will be compiled as part of Task 2.

- Biological
    - List of potential target fish species and life stages that will benefit from passage
    - Species and life stage-specific periodicity
    - Life stage-specific parameters: size, migratory behavior, swimming behavior, swimming ability, and other physical passage constraints
    - Fish relative abundance and distribution upstream and downstream of the proposed Watana Dam site
    - Locations of spawning and rearing habitats
    - Migratory characteristics (seasonal timing, duration) by species and life stage
    - Identification of existing ecological conditions (e.g. presence of predatory and/or invasive species, light, temperature and flow) and how they might be affected by passage facilities

- Physical
    - Topographic survey
    - Water quality and water temperature
    - Hydrologic and hydraulic information (e.g., 5 percent and 95 percent exceedance flows)
    - Ice processes
    - Sedimentation transport processes
    - Geomorphology

- Project Features
    - Project conceptual drawings
    - Project operations (e.g., reservoir storage, powerhouse, and spillway flows)
    - Aerial photos
    - Seasonal flows downstream of the Project (e.g., tailwater rating curves, flow duration curves)
    - Seasonal pool elevation (e.g., forebay rating curves, fluctuations, etc.)

- o Project design components (e.g., dam layout, cross-sections, turbine type, draft tube velocity, sediment capacity, power availability, etc.)
- o Project access or restrictions to access for operations and maintenance

Due to the nature of this Project, particularly with respect to its location in the Upper River and the uncertainty around the potential benefits and risks of passage to fish species, this task also involves development of a spreadsheet-based biological performance tool. This tool will be used to qualitatively estimate potential passage success using concepts to be identified and refined in the feasibility study. Examples of challenging issues that can be addressed with this tool include the following: low survival success of downstream migrants through the reservoir, the potential for transporting adult Chinook salmon upstream that do not intend to go there, and the potential for spread of non-native fishes. The biological performance tool will present the positive and negative biological effects associated with the various passage concepts under consideration. In addition, compiling information on migratory behavior, preferably behavior specific to the Susitna River, will help identify the type, location, size, and timing of potential upstream and downstream fish passage facility components. Additional information needs may be defined during the compilation.

The deliverables for this task are a draft of the biological performance tool; base drawings; maps; synthesized biological, physical, and site data listed above; and operational protocols necessary to conduct the study.

Task 3: Conduct site reconnaissance.

AEA will conduct a site reconnaissance to observe conditions and collect information, as appropriate, for concept development. At a minimum, the reconnaissance will consist of a helicopter fly-over of the study area from the mouth of Portage Creek to the proposed Watana Dam site at RM 184, as well as tributaries to the proposed reservoir where Chinook salmon have been documented (i.e., Kosina Creek and Oshetna River).

Task 4: Develop concepts.

This task will utilize a facilitated two-day brainstorming workshop to identify fish passage concepts. Two days will be required to ensure that the brainstorming covers upstream and downstream passage for both the integrated with-dam design and retrofit strategies. The workshop environment will allow rapid and complete generation of fish passage concepts, based on the Fish Passage TWG's diverse expertise and experience with related facilities. During the workshop, AEA will develop concepts based on the professional judgment of participants as well as on studies, experience, and history of other fish passage facilities and specific criteria and guidelines published by NMFS. Concepts might be components of fish passage facilities, operational procedures, locations of facilities, or entire facilities.

Following the brainstorming workshop, AEA will organize the concepts, and, with input from the Fish Passage TWG, will perform an initial "fatal flaw analysis" to eliminate any concept that cannot meet the basic criteria. Concepts at this early phase of development that are fatally flawed will be documented, but will not be further developed. Fatal flaws might include dam or personnel safety issues, constructability concerns, or poor chance of satisfying fish passage objectives. Concepts without fatal flaws will be further analyzed and developed.

The biological performance tool developed in Task 2 will be reviewed by the Fish Passage TWG and tested at the meeting to ensure that all necessary parameters and data are provided to address the short list of passage concepts. The goal of this exercise is to obtain feedback and critique of the biological tool by all participants to ensure that all parameters and tool needs are included prior to more formal use of the tool in Task 5.

After the workshop, AEA will refine the fish passage concepts identified in this task into fish passage alternatives applicable to the proposed Watana Dam site to address site-specific applicability, hydraulic functional design, construction and operating cost estimates, and general layout, and to identify any uncertainties for further examination. Performance of the alternatives will be identified using the biological performance tool (Task 2). Alternatives that are not technically feasible will be dropped from consideration and the reasons for them being dropped will be described. The alternatives will be combined into strategies consistent with an integrated dam design and a retrofit. The explanation of operation and biological performance of the alternatives will be presented to the Fish Passage TWG at the third workshop.

Task 5: Evaluate feasibility of conceptual alternatives.

Based on the alternatives developed through Task 4, an evaluation of the alternatives will be performed and documented in Task 5. An evaluation matrix will be used to prepare the first evaluation of the alternatives that will advance the existing state of each alternative's conceptual design for better performance, and will allow a relative comparison of the alternatives. The evaluation will be done by using a grid analysis technique, or Pugh Matrix, which breaks the alternatives down into discrete elements for comparison, evaluation, and optimization. Breaking the alternatives into discrete elements reduces the possibility of alternatives being selected based on general prejudiced opinions. The matrix will result in consolidated scores that reflect the relative success of achieving criteria, and will thus help rank or prioritize alternatives.

The results of the grid analysis can be used to further refine facility components, identify data gaps, and assess the potential influence of uncertainties. However, the grid analysis is only a tool to help the Fish Passage TWG evaluate, repackage, and refine alternatives; the results of the matrix exercise are used to influence but not dictate decisions. Therefore, it is important to consider all relevant criteria with the potential to inform the feasibility of the alternatives. Through this process, the characteristics and effectiveness of upstream and downstream fish passage facilities will be evaluated, and the results used to refine and optimize the location, size, and timing of each type of passage facility.

Based on the results of this initial evaluation, AEA will work to update descriptions and drawings for the fish passage alternatives. The results will be presented to the Fish Passage TWG at the fifth and final workshop, with the goal of selecting a final list of alternatives for refinement in Task 6.

Task 6: Develop refined passage strategy(ies).

Task 6 will focus on the refinement of the remaining fish passage alternatives that may be technically feasible. In addition to further development of the conceptual design drawings, AEA will prepare an opinion of probable construction and operating cost for each alternative, describe operational protocols and issues, address comments from Task 5, perform final runs of the biological performance tool, prepare a final quantitative evaluation of the alternatives using the final Pugh Matrix and evaluation criteria, and address constructability issues and any remaining data needs or significant risks. A minimum of three distinct passage strategies will be evaluated and compared under this task, including one each for (1) Watana Dam without fish passage, (2) integration of upstream and downstream passage features into the dam design, and (3) the retrofit of upstream and downstream fish passage features to a dam designed without passage.

9.11.5. Consistency with Generally Accepted Scientific Practices

The study approach generally follows steps outlined in federal guidelines for anadromous fish passage design published by NMFS (2011).

9.11.6. Schedule

Upstream and downstream fish passage facilities can have a significant effect on the overall design and cost of the Project. Consequently, conceptual alternatives will be completed during 2013 so that further refinement of the top-ranked conceptual design(s), if determined to be needed and technically feasible, can continue during 2014 (Table 9.11-1). Anticipated milestones are as follows:

- Establishment of the Fish Passage TWG
- Preparation for the study with compilation, review, and summary of information
- Site reconnaissance
- Development of concepts
- Evaluation of conceptual alternative feasibility
- Refinement of passage strategies
- Completion of an Initial Study Report
- Completion of an Updated Study Report

The preliminary schedule for these tasks and workshops is shown in Table 9.11-1. In addition, Fish Passage TWG meetings will be held bimonthly, beginning the first quarter of 2013.

9.11.7. Relationship with Other Studies

The Study of Fish Passage Feasibility at Watana Dam will interrelate with other AEA Project studies (Figure 9.11-2). Along with a comprehensive literature review, the Study of Fish Distribution and Abundance in the Upper Susitna River (Section 9.5), the Study of Fish Distribution and Abundance in the Middle and Lower Susitna River (Section 9.6), the Salmon Escapement Study (Section 9.7), and the Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries (Section 9.12) will provide baseline biological inputs on migratory timing and behavior as well as distribution over various life stages in the vicinity of the proposed dam site. The Future Watana Reservoir Fish Community and Risk of Entrainment Study (Section 9.10) will interrelate by providing and receiving biological information on the anticipated reservoir fish assemblage and entrainment risk. Along with information on Project design and operations, physical studies on Geology and Soils (Section 4), Water Quality (Section 5), Ice Processes (Section 7.6), Geomorphology (Section 6.0), hydraulics, sediment transport, and others will provide input for the Study of Fish Passage Feasibility at Watana Dam.

The Study of Fish Passage Feasibility at Watana Dam will provide output information back to facility design and operations analyses and to the Future Watana Reservoir Fish Community and Risk of Entrainment Study (Section 9.10), the Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area (Section 9.15), and the Recreation Resources Study (Section 12.5).

The flow of information into and out of the Fish Passage Feasibility Study is anticipated to occur over the two-year study period through an iterative process. As relevant data (described above) is collected, it will be disseminated from the Fish Program to the Fish Passage TWG. In addition, three milestone deliveries of data that has been through a QA/QC procedure are anticipated: (1) data from the 2012 Upper River Fish and Escapement Studies will be incorporated into the Feasibility Study in Q1 2013; (2) data from the Salmon Escapement Study (Section 9.7) will be delivered by October 2013 and, if necessary, again in October 2014; and (3) data from Upper and Middle River radio telemetry studies will be delivered quarterly in 2013 and for the first two quarters of 2014 as necessary.

Information flowing out from this feasibility study regarding target species and passage alternatives will be communicated amongst study leads. Additional formal data sharing will also occur among studies after completion of QA/QC procedures and with delivery of the Initial Study Report (Q1 2014) and Updated Study Report (Q1 2015).

9.11.8. Level of Effort and Cost

This study will not include any fieldwork other than the site reconnaissance. However, coordination with resource agency engineers and biologists is anticipated. In addition, engineering design work will be necessary to develop conceptual drawings. The anticipated cost for completing this study is $1,000,000.

9.11.9. Literature Cited

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9.11.10. Tables

Table 9.11-1. Schedule for implementation of the Study of Fish Passage Feasibility at Watana Dam.

Activity	2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
T1. Establish Team and Define Process	—— W1 ●								
T2. Prepare for Feasibility Study		——							
T3. Site Reconnaissance		——							
T4. Develop Concepts			● W2 ——	——					
T5. Evaluate Feasibility of Alternatives					● W3 ——	——			
T6. Develop Refined Passage Strategies							● W4 ——	——	
Initial Study Report				——	Δ				
Updated Study Report								——	▲

Legend:

—— Planned Activity

----- Follow-up activity (as needed)

● W1: Workshop 1

Δ Initial Study Report

▲ Updated Study Report

9.11.11. Figures

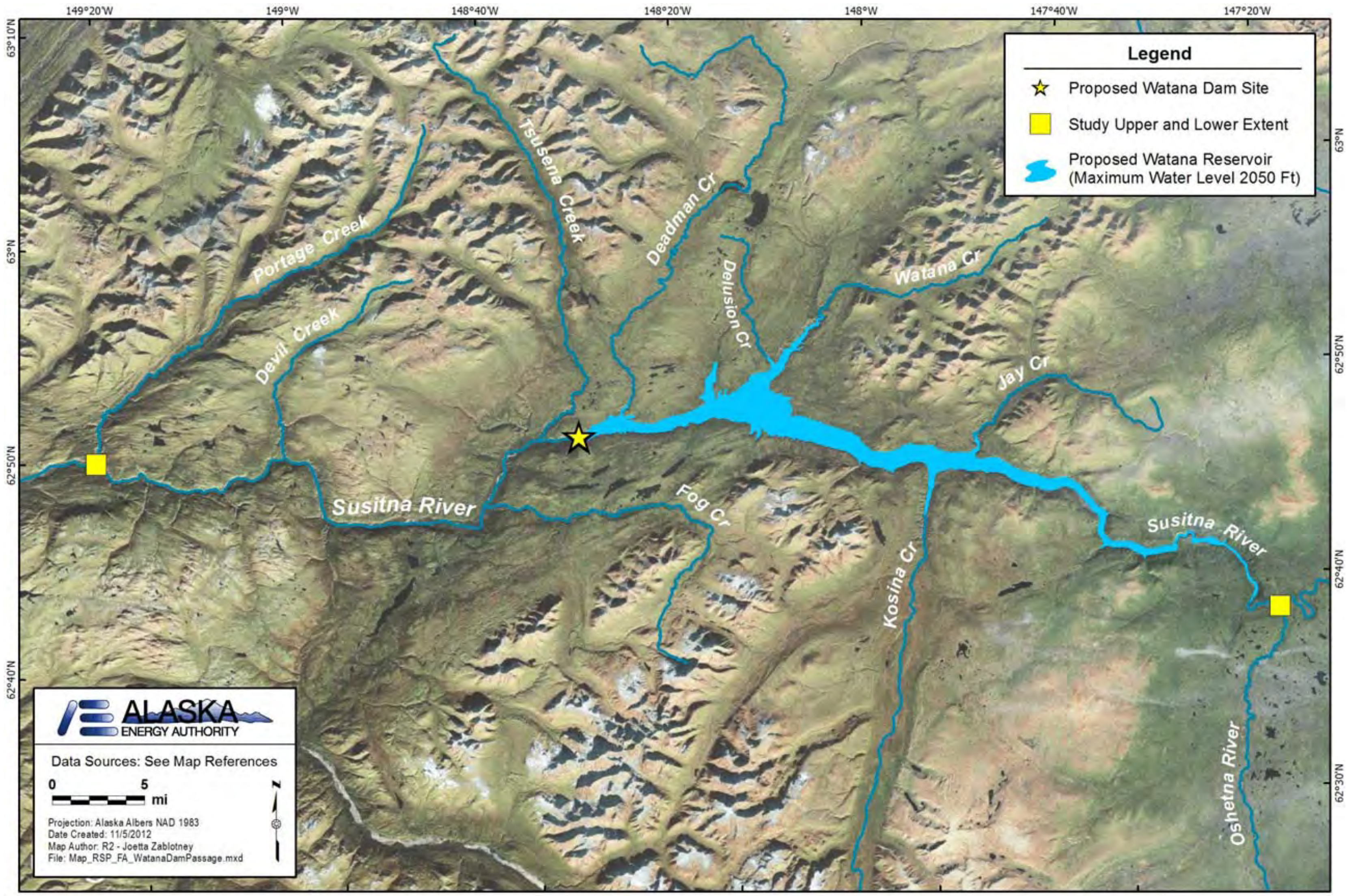

Figure 9.11-1 Study area for Fish Passage Feasibility, from the confluence with Portage Creek (RM 148) upstream to the Oshetna River (RM 233.4).

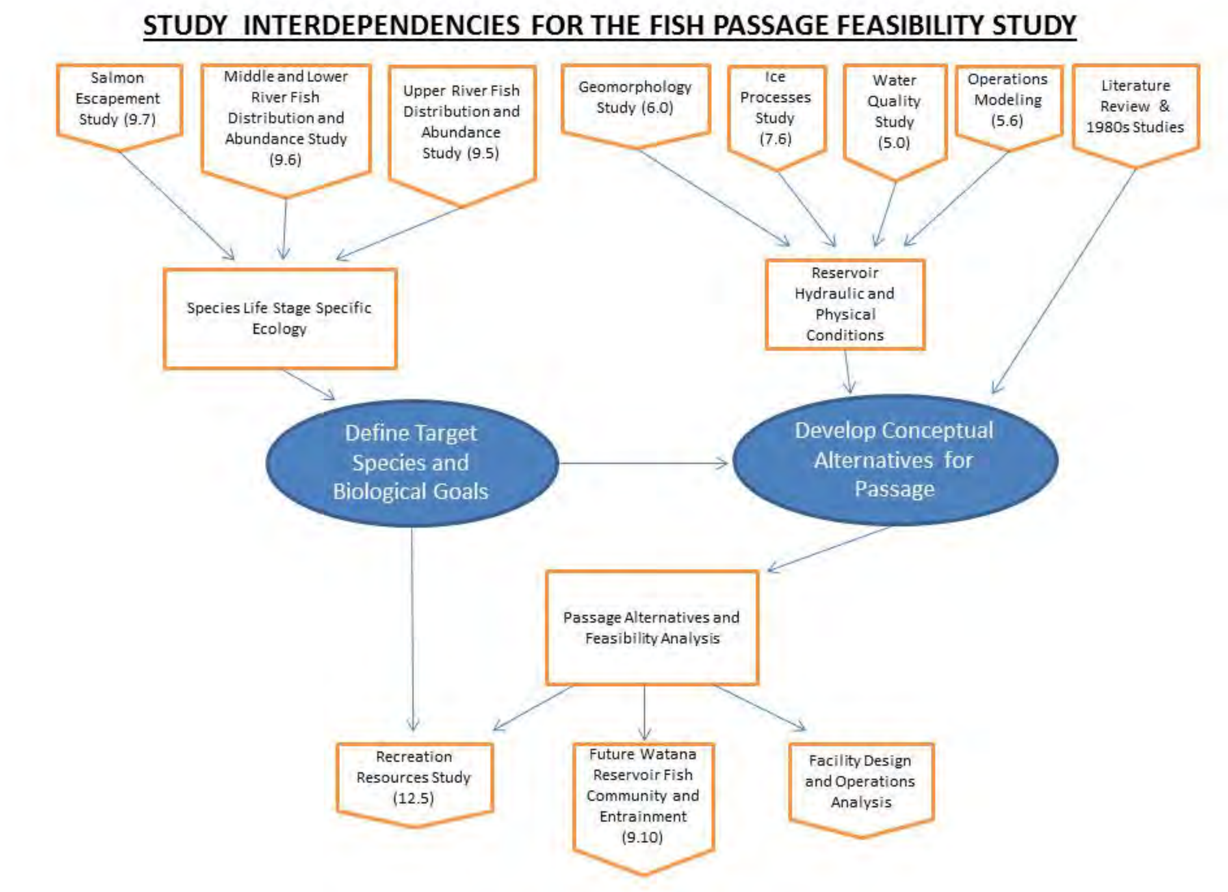

Figure 9.11-2. Fish passage feasibility interdependencies with other AEA studies.

9.12. Study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries

9.12.1. General Description of the Proposed Study

Construction and operation of the Project will likely affect flow, surface water elevation, sediment load and transport, and water depth in the mainstem channel of the Susitna River at tributary confluences as well as at the inlets and outlets to side channels, sloughs, and various off-channel habitat features both in the area of the inundation upstream from the Watana Dam site and downstream in the Project's potential zone of hydrologic influence (ZHI). These changes in mainstem flow, water elevations, and sediment transport can potentially inhibit fish passage into, within, and out of aquatic habitats. Understanding existing conditions of barriers[32], how those conditions change over a range of stream flows, and the relative importance of habitats upstream of barriers will provide baseline information needed for predicting the likely extent and nature of potential changes to barriers resulting from flow and water elevation changes that will occur due to Project operations.

Environmental variables affecting fish passage in streams are dynamic; therefore, results of this study must be considered representative of only a "snapshot-in-time". The height and configuration of cascades and waterfalls change from season to season with the rise and fall of stream flow, and the feature itself can be present or absent over time with the natural shifting or displacement of keystone rocks or logs. The dynamic alluvial river bed of the mainstem Susitna River also changes with variable flows over time. Thus, the bed elevations into and within sloughs, side channels, and at the mouths of tributaries can change within a year, or perhaps not for a decade, or longer. These shifts in bed elevation may change the passage depth conditions, sometimes eliminating and sometimes creating the opportunity for fish passage where it may or may not have previously existed.

Deltas formed at the mouths of tributaries also change in size, height, and composition over time, possibly affecting fish passage into and out of the tributaries. The dynamics of tributary delta formation are primarily a function of tributary sediment load and the erosive power of the mainstem at the tributary mouth. Long-term changes in land use in the tributary watershed, such as increased timber harvest or road building, and changes in the timing and volume of mainstem flow will change tributary mouth passage conditions over time.

This study plan describes a coordinated effort that will be undertaken to identify and evaluate the effects of potential Project-induced changes in water depth and stream bed elevation on fish passage over barriers. Several other fish and aquatic resource studies to be conducted in 2012 and 2013–2014 will be integrated with this passage study to address future Project effects related to flow and sediment transport. This study will describe existing barriers, identify barriers that may be eliminated or created by the Project operation, and will identify potential impacts to fish associated with these anticipated changes. The results will be used to determine what, if any, protection, mitigation, and enhancement measures may be appropriate.

[32] The term "barrier" includes both natural and man-made features.

Study Goals and Objectives

The goal of this study is to evaluate the potential effects of Project-induced changes in flow and water surface elevation on free access of fish into, within, and out of suitable habitats in the Upper Susitna River (inundation zone above the Watana Dam site) and the Middle Susitna River (Watana Dam site to the confluence of Chulitna and Talkeetna rivers). This goal will be achieved by meeting the following objectives:

1. Locate and categorize all existing fish passage barriers (e.g., falls, cascade, beaver dam, road or railroad crossings) located in selected tributaries in the Middle and Upper Susitna River (Middle River tributaries to be determined during study refinement).
2. Identify and locate using GPS the type (permanent, temporary, seasonal, partial) and characterize the physical nature of any existing fish barriers located within the Project's ZHI.
3. Evaluate the potential changes to existing fish barriers (both natural and man-made) located within the Project's ZHI.
4. Evaluate the potential creation of fish passage barriers within existing habitats (tributaries, sloughs, side channels, off-channel habitats) related to future flow conditions, water surface elevations, and sediment transport.

These objectives will be met through the use of existing information, consulting with the Fish and Aquatic TWG and other licensing participants, and by using the methods described in the this study plan.

9.12.2. Existing Information and Need for Additional Historic Information

Historic information on anadromous fish passage in sloughs and side channels was collected in the 1980s (ADF&G 1984a). These efforts focused on collection of multi-disciplinary data at specific sloughs and side channels (Table 9.12-1).

Studies conducted in the 1980s by ADF&G evaluated passage in side channels and sloughs for six fish species, including chum, Chinook, sockeye, coho, and pink salmon, and Dolly Varden. Chum salmon were used as a surrogate for the other five species. These studies did not address access changes at existing barriers or access into tributaries.

Current information specific to the Susitna River includes aquatic studies being conducted by AEA for Project licensing. Project licensing studies that will support the Fish Passage Barriers Study are described in Section 9.12.7.

The need for additional information regarding potential Project effects on fish passage was identified in the Pre-Application Document (PAD) (AEA 2011):

- **F2:** Potential effect of fluctuating reservoir surface elevations on fish access and movement between the reservoir and its tributaries and habitats.
- **F6:** Potential influence of the proposed Project flow regime and the associated response of tributary mouths on fish movement between the mainstem and tributaries within the Middle River Reach.

- **F7:** Influence of Project-induced changes to mainstem water surface elevations July through September on adult salmon access to upland sloughs, side sloughs, and side channels.

9.12.3. Study Area

The study area includes the mainstem and selected tributaries in the Upper and Middle segments of the Susitna River that would be affected by the construction and operation of the Project. For purposes of this study, the study area has been preliminarily divided into two segments:

- Upper River—Susitna River and selected tributaries within this segment up to the 3,000 foot elevation and extending upstream from Watana Dam site (RM 184) to the upper extent of river influenced by Watana Reservoir up to and including the Oshetna River (see Section 9.5, Figure 9.5-1).
- Middle River—Susitna River and selected tributaries within this segment, extending from Watana Dam site to the confluence of the Chulitna River (RM 98). Passage studies in the mainstem Middle Segment will include sloughs, upland sloughs, side channels, and tributary mouths and deltas.

Passage studies in tributaries to the Middle River will include select tributaries and will extend from the mouth to the upper extent of Project hydrologic influence. The upper limit of hydrologic influence will be determined from supporting studies including the Instream Flow Study (Section 8.0) and the Geomorphology Study (Section 6.0), among others.

9.12.4. Study Methods

Study methods will vary primarily depending on the type of barrier being assessed. In this study, depth barriers are more of a concern in sloughs, side channels, and mouths of tributaries. Physical barriers (cascades and waterfalls) are more of a concern within tributaries. Beaver dam barriers can occur in sloughs, side channels, and tributaries. While the specific methods for each barrier type differ, the general study components and steps are similar for locating and assessing the various types of barriers.

Methods for the study of fish passage barriers will likely consist of the following study components (these components will be refined in response to Fish and Aquatic Technical Workgroup [TWG] and licensing participant input):

- Identify fish species to be included in the passage barrier study.
- Define the passage criteria for the identified fish species.
- Select specific study sites and representative study sites.
- Conduct field studies.
- Coordinate with other interdependent studies, as described in Section 9.12.7 and illustrated in Figure 9.12-1.
- Evaluate potential effects of altered fluvial processes on fish passage in sloughs, upland sloughs, side channels, and at tributary mouths.

- Evalutate the potential for impeded movement or “pooling” of fish that could result in increased predation below a barrier[33].

9.12.4.1. Identify Fish Species

The fish community of the Susitna River includes approximately 18 documented fish species. Within this community, some fish species exhibit life history patterns that rely on multiple habitats during freshwater rearing and are thus more sensitive to changes in access to side channels, sloughs, and/or tributary habitats (Table 9.12-3). A subset of species will be selected to target for the fish passage barrier analysis based on passage sensitivity, the known distribution of the species, and the locations of potential barriers. The species list will be refined in response to input from the Fish and Aquatic TWG and licensing participants.

9.12.4.2. Passage Criteria for the Identified Fish Species

Salmonid passage criteria are well researched and some criteria exist for all species, while passage criteria for many non-salmonids has not been researched and therefore criteria do not curently exist. The need for species-specific passage criteria for different species will depend on the results of consultation with licensing participants. Which criteria are used and whether “surrogate” salmonid species criteria can be substituted for other species will be determined in consultation with licensing partipants.

Basic categories of fish passage criteria for use in this study include water depth, water velocity, and fish leaping ability. Depth criteria will establish the minimum water depth and the maximum distance (at the minimum depth) through which a fish can successfully pass. Depth requirements for successful passage increase with an increase in the length of passage. Depth criteria will be used to assess access into, within, and out of side channels, sloughs, and tributaries. The ability of adult fish to enter or exit slough and side channel or tributary habitats from the mainstem Susitna River and access spawning or rearing areas within these habitats is primarily a function of water depth in relation to the length of shallow reaches a fish must navigate (ADF&G 1984b). Velocity criteria pertain to the ability of adult and juvenile fish to swim against the flow, which varies with fish length and, similar to depth, with the distance over which the velocity is maintained.

Leaping criteria will be established for the vertical and horizontal distances fish must leap to pass a physical barrier. The velocity component of passage at a physical or depth barrier will be applied where velocity may influence successful passage. Velocity criteria will also be applied at chutes. Leaping criteria and velocity criteria will be applied only in tributaries (including their deltas) and at beaver dams.

9.12.4.2.1. Depth Criteria for Adult Upstream Migration

Existing depth criteria for evaluating fish passage include the transect criteria (Thompson 1972) and the depth/distance criteria (ADF&G 1984b). Thompson (1972) involves establishing cross-sectional and water surface elevation transects at one or more locations to represent the shallowest conditions a fish may encounter while moving upstream. Although there is no

[33] Methods to evaluate the potential for delayed movement or pooling of fish below a barrier are not provided in this RSP. These studies would be designed on a barrier-by-barrier basis with input from licenscing participants.

longitudinal factor measured in this method, one can assume the criterion represents a minimum depth over a relatively short stream distance. With this method, depth criterion for an individual species should be based on literature values and would be determined in consultation with the Fish and Aquatic TWG.

The depth/distance method evaluates fish passage in two dimensions: depth of water and distance of travel required. This method and criteria for select species were developed for the 1980s Susitna River studies to assess passage into and within side channels and sloughs (ADF&G 1984b). One component of the depth/distance method is the development of species-specific fish passage curves that define relationships between passage depth and reach length in different habitats. Parameters that were used in the 1980s to differentiate habitats within channels and side sloughs were channel complexity, substrate, and velocity (ADF&G 1984b).

The resulting ADF&G (1984b) chum salmon passage criteria curves for small substrate and uniform, unobstructed channel are presented in Figure 9.12-2. Chum salmon passage curves for large substrate and non-uniform obstructed channel are presented in Figure 9.12-3. As needed, depth, length, and substrate criteria can be modified for chum and developed for other species as a part of this study with input from licensing participants.

9.12.4.2.2. Leaping Criteria for Adult Upstream Migration

The ability of a fish to pass a vertical barrier is determined by species- and life stage-specific endogenous factors such as burst speed, swimming form, and leaping capability. Exogenous factors include water depth, stream flow, and barrier geometry. Powers and Orsborn (1985) present a detailed analysis of passage at physical barriers to upstream migration by salmon and trout. Their analysis is based on collecting data on barrier geometry and stream hydrology to define the existing hydraulic conditions within the barrier. The hydraulic conditions are compared to known fish capabilities to determine if fish passage is feasible. Predicting successful passage at flows outside of those at the time the data were collected depends on knowing the stage versus discharge or other flow indicators for the site. Powers and Orsborn (1985) present criteria for Chinook, coho, sockeye, pink, and chum salmon passage at waterfalls and cascades. Other sources of leaping height criteria are available from Reiser and Peacock (1985) and the USFS (2001). Table 9.12-4 presents the leaping criteria from the three sources.

Leaping curves and jumping equations assume that the depth of the pool the fish must leap from is adequate. Stuart (1964) suggests a ratio of 1:1.25 (barrier height/leaping pool depth). Reiser and Peacock (1985) also suggest a ratio of 1:1.25 and a pool depth of at least 2.5 meters (8.2 feet). Aaserude (1984) concluded that for optimum leaping conditions the depth of the leaping pool must be on the order of, or greater than, the length of the fish attempting to pass. Because assessment of the leaping pool is fundamental to determining fish passage, leaping pool depth criteria will be investigated as part of the study. The refinement of leaping criteria for use in this study will be determined in consultation with licensing participants.

9.12.4.2.3. Upstream Velocity Criteria

Stream velocities higher than a fishes swimming speed can create barriers to upstream migration. Velocity barriers within the ZHI may currently exist, may be created by Project operation, or existing barriers may be eliminated by the presence of the Project.

If velocity barriers to upstream adult migration currently exist or if they are potentially created by the Project, they would likely only occur in tributaries. Gradients or channel constrictions at the entrances to sloughs and side channels are likely not sufficient to create velocity barriers to adult fish or juveniles with or without the Project.

For juveniles and fry, an exception is at tributary mouths where the tributary may flow over a steep slope just before entering the main channel. Under current conditions, this section of steep slope immediately upstream of the tributary confluence may be inundated at high flow, thereby eliminating any velocity barrier associated with the higher gradient. During some periods of time under Project operation, these steep gradient sections may not be inundated, thereby creating higher velocities, along with shallower depths, at the stream entrance. If these tributaries are utilized by rearing juveniles, the higher velocities may exceed juvenile swim speeds and thereby create a barrier to utilization.

Juvenile salmonid swim speeds have been well researched so there is abundant existing critieria. Swim speed criteria for non-salmonid juveniles have not been well researched and existing criteria are not generally available. Velocity criteria will be determined with input from licensing participants where velocity criteria do not exist for species of interest.

9.12.4.2.4. Downstream Passage Criteria

In natural systems, a section of very shallow surface flow or dry streambed is the most likely type of barrier to downstream fish migration or movement (beaver dam barriers to downstream migration are discussed in Section 9.12.4.4, Physical Barriers subsection). Although impassable depths can occur in any reach due to large-scale erosion of stream banks or subsurface slow, a more common concern is the deposition of large amounts of cobble and gravel at tributary mouths.

Fish requiring adequate flows for downstream passage in the Susitna River include anadromous juvenile and migratory resident species that move between summer rearing and overwintering habitats. Most research on downstream passage is related to passage at physical structures such as hydroelectric projects, irrigation diversions, and culverts. There is minimal information on depth criteria for downstream passage in natural environments. Alaska requires that passage depth be greater than 2.5 times the depth of a fish's caudal fin (ADF&G and ADOT&PF 2001 as cited in FHWA 2011). Other sources (Powers and Orsborn 1985 and Webb 1975) suggest that only full submergence is necessary. Maine Department of Transportation (2008) suggests 1.5 times the body thickness.

The species, life stage, and respective depth criteria for passage of downstream migrating fish will be determined in collaboration with licensing participants as part of this study.

9.12.4.3. Study Site Selection

Selection of tributaries and tributary mouths for passage study in the Upper River will expand upon the 2012 Upper Susitna River Fish Distribution and Habitat Study.

Upper River 2013–2014 passage studies will supplement the 2012 passage study and include the following:

- Passage studies in any streams or stream segments requiring study that were not completed in 2012.

- Second assessment of barriers identified in 2012 that require confirmation.
- Passage survey within the projected reservoir drawdown (or varial) zone. Selection of tributaries for varial zone passage study will be based on those streams selected for study in 2012 initial surveys.

In the Middle River, tributaries and their mouths and deltas will be selected for passage study unless any of the following is true (based on existing information; if any are true, the tributary will not be studied for passage):

- A fish barrier (depth or velocity barrier for upstream or downstream movment) does not currently exist under natural low flow conditions within the ZHI.
- The Instream Flow Study (IFS) or geomorphology models do not indicate the potential for future changes in channel form, channel geometry, and/or water depth.
- The tributary does not currently support fish species identified as target species for passage study.

In the Middle River, the expanse, large number, and complexity of sloughs and side channels will prohibit total coverage of all such potentially affected areas. Thus, sub-sampling of these habitats will be necessary. This study will coordinate with licensing participants, IFS study leads, and geomorphology study leads to identify a subset of tributary mouths, sloughs, and side channels for Focus Areas that represent the range of conditions present in the mainstem Middle River. These intensively studied habitats will likely be located within the ISF Focus Area. Passage into, within, and out of the selected sloughs and side channels can then be modeled to evaluate how Project-induced flow and sedimentation may affect fish passage conditions on a local scale and extrapolated to the larger river segment.

Researchers who conducted the 1980s APA studies encountered a similar dilemma of conducting passage studies in such a large number of off-channel habitats with complex hydrodynamics. Instead of studying all possible passage barriers, a total of 12 slough and side channel sites were selected for passage evaluation studies. These study sites were considered representative of the major slough and side channel spawning areas for chum, sockeye, and pink salmon in the middle reach of the Susitna River.

9.12.4.4. Field Studies

Studies in the Middle River will rely upon data collected as part of IFS and geomorphology studies. However, the need is anticipated to collect additional information at IFS and geomorphology study sites and at additional sites primarily for physical barriers but also for potential depth barriers. The following methods describe field activities to be conducted for this study.

To maximize access to habitats, passage barrier field efforts will be conducted under lower flow conditions. Discharge relationships developed from the routing and IFS studies will enable passage to be analyzed under a wide range of flows. Field data collection methods will vary among physical barriers and depth passage barriers.

Physical Barriers

Physical barriers (geologic and beaver dam barriers) will be assessed by following the methods of Powers and Orsborn (1984). Physical barriers in tributaries and beaver dams in sloughs and side channels will be located by first reviewing existing information including the following:

- Topographic maps
- Current high-resolution aerial imagery including aerial imagery and LiDAR from the Geomorphic Mapping Study and the 2011 Mat-Su LiDAR and Imagery Project
- Low elevation aerial video imagery
- Results of the 2012 Upper River Fish Distribution Study
- Results of the Flow Routing Study coupled with the projected effects of proposed Project operations on the zone of hydraulic influence
- Other relevant and available sources

A field survey team of two will walk up tributaries or stream reaches where barriers may be present or where their presence could not be ruled out by existing information. Each potential barrier (including beaver dams) will be assessed in two phases. If a stream feature is a possible obstacle to the species of concern, the geometry of the obstacle will be surveyed including measurements of barrier height, leap distance, and estimated depth of leaping pool at high and low flow. It will be drawn to scale, photographed, and its location fixed with GPS. If the obstacle is clearly not a barrier, its location and basic dimensions will be noted with no further measurements.

If the surveyors have uncertainty regarding the barrier status of an obstacle, a decision tree analysis (URS and HDR 2010) (Figure 9.12-4) will be implemented that is consistent with Powers and Orsborn (1984) and modified as necessary for site-specific species and barrier conditions. Field data forms will be designed around this decision tree. A draft prototype of the field data form is presented in Figure 9.12-6. The final field data form will be developed as part of study planning prior to the 2013 field season.

The barrier analysis decision tree is a step-wise process for evaluating potential barriers in the field. Quantitative metrics are used at each step in the decision tree to identify the impassability of the potential barrier. Decision tree questions logically break down the barrier into its physical component parts, allowing a systematic, repeatable, and comparable evaluation of each potential barrier. An advantage to sequentially evaluating each component of a barrier is that if the answer to the first decision tree question suggests that a barrier is impassable, the evaluation is terminated and additional questions need not be addressed to determine barrier passability.

Beaver dams are built in many shapes and sizes. Most beaver dams stretch from bank to bank and range in height from 2 to 5 feet, but can reach 8 to 10 feet above the tailwater level at low flow. Coho, Chinook, and sockeye can easily leap over a 4-foot-high blockage and a chum or pink can leap over a 2-foot-high blockage if the depth and distance of the leaping pool from the crest of the barrier are within criteria (Powers and Orsborn 1984). Hetrick and Nemeth (2003) found that the early run of coho in Clear and Sandy creeks on the Alaska Peninsula were blocked until the onset of frequent and higher flows in October. Pink and chum salmon appeared to have been blocked from the upper reaches of the stream over their entire run period.

The depth of the leaping pool and its location relative to the crest of the blockage is critical to successful passage by an upstream migrant (Powers and Orsborn 1984). Because beaver dams are temporary structures and there is not a continuous plunge of flow over the crest, scour pools do not generally form below the dam as they would in a free-flowing stream below a cascade or waterfall. At low flow, tailwaters below most beaver dams are shallow relative to dam height.

Not all beaver dams in sloughs and side channels will be surveyed on the ground. All significant beaver dams will be identifiable in high-resolution aerial imagery and will be included on the GIS fish barrier layer and/or the wildlife layer. Beaver dams in sloughs and side channels that are selected as representative passage study sites will be surveyed on the ground. Beaver dams may also be surveyed in high-use salmon spawning areas.

Beaver dams are not typically thought to impede the downstream movement of juvenile fish. In the Black River drainage, Alaska, Brown and Fleener (2001) found that "high flows in the drainage provided multiple opportunities for both juvenile and adult fish to move over beaver dams during the season." In *Beaver Management Guidelines*, Canada Ministry of Environment (2001) states "When water is flowing over the dam, juvenile fish are able to migrate downstream, making use of small rivulets at either end of the dam." Pacific Stream Keepers website on controlling beavers states that "Generally, downstream migrating young salmon are not held back by a beaver dam (Kambietz 2003)."

9.12.4.5. Depth Barriers in Sloughs, Side Channels, Tributaries, and Tributary Deltas

Several environmental variables may affect fish passage in sloughs and side channels and tributary deltas. In general, at a given passage reach the water conditions (primarily depth) interact with conditions of the channel (length and uniformity, substrate size) to characterize the passage conditions that a particular fish encounters when attempting to migrate into, within, and out of a slough, side channel, or tributary delta. The likelihood of a particular fish successfully navigating through a difficult passage reach will depend on the environmental conditions as well as the individual capabilities and condition of the fish.

Depth passage for adults and juveniles in sloughs, upland sloughs, side channels, and at tributary delta mouths will be assessed following methods similar to ADF&G (1984b) and will focus on salmon passage in sloughs, side channels, and tributary deltas. Two-dimensional modeling, not available in the 1980s, may also be applied. Although salmon passage remains a key concern, the passage methods are generally applicable to other species where depth passage criteria are known or can be developed.

Passage reaches in the ADF&G study were evaluated under three types of hydraulic conditions: breaching, backwater, and local discharge. Breaching and backwater analyses were used to evaluate all passage reaches within a study site, whereas the local flow analysis was used to evaluate only a subset of passage reaches that were identified as most problematic for salmon passage (ADF&G 1984b). Length and depth of passage reaches were used as the primary criteria.

To separate the influence of breaching and backwater from local-flow-only conditions, a flow duration curve (based on a 32-year record at the USGS gage near Gold Creek) was developed by ADF&G for the period between August 20 and September 20, the period of time adult salmon would be entering the study sites. These date ranges were based on ADF&G 1981, 1982, and 1983 adult salmon spawner survey data for middle river sloughs and side channels. As part of this study, current information on adult spawner timing will be examined in collaboration with licensing participants. Timing of other species will be examined and applied as determined in consultation with licensing participants.

9.12.4.5.1.1.1. Breaching

The breaching discharge is generally defined as the mainstem discharge at which the overtopping of the head of a side channel or side slough occurs. Sub-definitions of breaching discharge include initial, intermediate, and controlling breaching discharge. The controlling discharge is a higher discharge that directly governs hydraulic characteristics within a slough or side channel. Passage conditions were considered to be successful within a site under controlled breaching conditions (ADF&G 1984b).

9.12.4.5.1.1.2. Backwater

The backwater analysis included an evaluation of all passage reaches that were physically located in areas directly influenced by the rising stage of the mainstem Susitna River at the mouth of each site (backwater area) before breaching occurs. Backwater area is defined as a segment of flowing water in which the depth of water is greater than that which would otherwise exist for a given discharge due to an obstruction (including hydraulic obstruction) downstream of the channel (ADF&G 1984b).

The analysis of backwater effects required stage/discharge relationships at the mouth of the study site plotted over the thalweg bed profile. Generally, passage was determined to be successful when the water surface elevation at the mouth equaled or exceeded the highest point on the thalweg profile plus the threshold passage criteria of 0.41 feet for a small substrate, uniform channel, and 0.54 feet for a large substrate non-uniform passage reach (ADF&G 1984b).

9.12.4.5.1.1.3. Local Flow

The local flow analysis estimated the amount of local flow (flow deriving from upwelling, tributaries, precipitation) required at a study site to provide adequate depth of flow for each passage reach when the reach is not influenced by backwater and breaching effects. Although the database varied for each study site, the general approach required two pieces of information:

- Surveyed cross-sections within each passage reach that represented the most difficult passage condition within the reach
- Stage versus discharge rating curves for each cross-section

These data were analyzed for each passage reach to determine the discharge required to equal or exceed the “passage depth” criteria established for cross-sections. In this report, the passage depth is defined as the depth of water through which a fish must pass in order to proceed upstream. Passage depth for cross-sections was calculated as the average of the mean depth and maximum depth at a transect (ADF&G 1984b). In the ADF&G 1984 study, for successful fish passage the passage depth had to exceed the appropriate threshold passage criteria of 0.41 or 0.54 feet. For juveniles, the species, life stage, and respective depth passage criteria for downstream migrating fish will be determined with input from licensing participants as part of this study.

Two-dimensional modeling and other survey and hydraulic modeling methods, not available in the 1980s, will be applied to collect the same field data. Although salmon passage is a key concern, the passage methods are generally applicable to other species where depth passage criteria are known or can be developed.

Figure 9.12-7 is a flow chart of the methods used by ADF&G (1984b) for evaluating passage in representative sloughs and side channels.

Where necessary to supplement the data collected under the Geomorphology Study, similar data collection methods, as described above for sloughs and side channels, will be applied at tributary mouths and deltas. The thalweg profile from the lowest extent of the delta or tributary flow upstream to and slightly beyond the upper extent of the delta, or tributary mouth, will be surveyed at low flows. Cross-sections will be surveyed at thalweg breakpoints and tributary discharge will be measured. Stage-discharge relationships in the mainstem will be derived from the closest Flow Routing Study transect. If necessary, the stage-discharge rating will be interpolated between the nearest upstream and downstream Flow Routing Study transects. Substrate along the thalweg and uniformity of channel will be recorded. Mainstem water surface elevation will be measured and the site will be photographed. Once analyzed, these data will enable decision-makers to determine the effects of mainstem discharge on fish passage from the mainstem into the selected tributaries.

Changes in the channel morphology may alter the accessibility by important fish species, into, within, and out of important riverine aquatic habitat types such as side channels, sloughs, and tributaries. Analysis of the complex interaction of water and sediment with the channel and floodplain boundaries to evaluate potential Project effects requires development and application of a sediment transport model.

Fluvial processes that may alter access to tributaries, sloughs, and side channels due to the proposed Project will be investigated and evaluated primarily in the Fluvial Geomorphology Study (Section 6.6). The passage study will coordinate and work closely with the Fluvial Geomorphology Study to achieve passage study objectives.

9.12.4.6. Velocity Barriers over Tributary Deltas

Velocity barriers over tributary deltas will be assessed at the same time and use some of the same methods as decribed in Section 9.12.4.5 for depth barriers. Longitudial survey data will be obtained from the depth barrier field studies. Relationships between main channel water surface elevation and the ZHI will be determined during the depth studies as well. Velocity profiles will be obtained across the steepest sections of the reach that are within the ZHI. Velocities will be measured as the main channel flow receeds in order to obtain the highest velocity that is likely to occur within the ZHI with no backwater effect from the main channel. All velocity measurements will target the conditions coincident of migratory timing of target species into the tributaries with modeled main channel flows that would occur under Project operation.

9.12.4.7. Data Analysis

Fish passage is a mechanistic analysis that compares the physical capabilities and periodicity of a fish species or life stage with the environmental variables of the barrier. Each barrier is analyzed on a case-by-case basis.

For adult fish passage analyses at physical barriers, the primary factors that must be considered to determine probable passage success are as follows:

- Fish species and respective adult leaping criteria
- Adult migration timing of fish species
- Geometry of the physical barrier
- Estimate of flow range and hydraulics of the barrier present during adult migration timing
- Projected seasonal reservoir elevations (Upper River)

For passage analyses at depth barriers, the primary factors that must be considered to determine probable passage success are as follows:

- Fish species/life stage and respective depth/distance criteria
- Migration timing of fish species/life stage
- Longitudinal and cross-sectional geometry of the passage reach
- Mainstem breaching discharge
- Mainstem backwater discharge

The upper extent of tributary use by target species in the Upper River will be determined by the analysis of physical barriers in tributaries. The immediate effects of the proposed Project on depth passage in the Middle River, due to changes in river hydrology and hydraulics, will be analyzed based on the factors listed above.

Analyses and modeling will involve the integration of flow routing and water surface elevation results with site-specific topographic profile data. Two-dimensional model results from the Instream Flow Study (Section 8.5) will also be used to model depth and velocities in and at the exits of sloughs and side channels at Focus Areas.

Physical barriers will be analyzed on a case-by-case basis according to the methods described in Section 9.12.4.4, Physical Barriers subsection.

9.12.5. Consistency with Generally Accepted Scientific Practice

The study methods presented above are consistent with the study methods commonly followed in investigations of fish passage. These include, but are not limited to, ADF&G (1984b, c, and d), Powers and Orsborn (1984), Powers and Orsborn (1985), Reiser and Peacock (1985), Thompson (1972), URS and HDR (2010), and USFS (2001). Methods are specifically adapted from these and other well-known contemporary researchers in the science of fish passage, as cited in this study plan.

9.12.6. Schedule

This is a multi-year study. Baseline data collection of natural fish passage barriers in Susitna River tributaries between Devils Canyon and the Oshetna River was initiated in 2012. It is anticipated that the 2013–2014 study of Fish Passage Barriers in the Middle and Upper Susitna River and Susitna Tributaries will be completed according to the schedule shown in Table 9.12-5.

9.12.7. Relationship with Other Studies

The Fish Passage Barriers Study is interrelated with eight other Project licensing studies (Figure 9.12-1). This study will rely on data and analyses inputs from six studies conducted in 2012 and upcoming 2013–2014 studies.

The 2012 aquatic habitat and geomorphic mapping of the Middle River using aerial photography (Geomoprphology Study 6.0) will provide a comparison of the habitat mapping conducted in the 1980s with habitat mapping developed at similar discharges in 2012.

Aerial photography at the various flows ((Geomoprphology Study 6.0) will help inform the selection, characterization, and demarcation of Fish Barriers Study sites and help identify breaching flows and the backwater influence on fish passage at the selected passage study sites.

Aerial videography collected as part of the Characterization and Mapping of Aquatic Habitats (Section 9.9) will be used to locate possible physical barriers in sloughs, side channels, and tributaries.

The 2012 river flow routing model data collection study results will be used as needed to simulate various physical and biological processes. The close proximity of the proposed flow routing transect locations to the previous passage study sites (Table 9.12-2) will inform the assessment of the stability of passage conditions over time.

The 2012 Upper Susitna River Fish Distribution and Habitat Study (Section 9.5) will be identifying and characterizing potential fish barriers in tributaries between Devils Canyon and the Oshetna River. The first upstream salmon fish passage barrier encountered in tributaries below approximately 3,000 feet elevation, the highest elevation at which Chinook salmon have been documented, will be located, described, photographed, and measured. Results of the Fish Distribution and Abundance in the Upper River Study (Section 9.5) conducted in 2013–2014 will also be used to evaluate fish use of reaches with barriers.

The Instream Flow Study (Section 8.0) is focused on development of models that can reliably estimate flow-habitat response patterns for different species and life stages of fish and other aquatic biota. In addition, this study will model the effects of flow on passage conditions into and out of specific mainstem habitats. Results of the instream flow model will be integrally linked to the barrier analysis to provide complete coverage of existing and potential future depth barriers as well as to synthesize the relevance of passage condition changes to fish populations in the Middle and Lower Susitna River. Results of the reservoir operations model with scenarios of how Project operation may affect flow and stage level will be used as input to simulate how physical and biological processes may affect passage barriers. Results from the Geomorphology Study (Section 6.0), in particular the outputs from the two-dimensional model at Focus Areas, will be used to predict the potential for alteration of channel morphology that may result in creation of fish passage barriers.

The Fish Passage Barriers Study will provide useful output to two AEA Project studies. Analysis of the potential for creation or alteration of fish passage barriers under Project operations will inform the Instream Flow Study (Section 8.0) and the fish passage feasibility study (Section 9.11). The Fish Passage Barriers Study will synthesize the relevance of geomorphic passage condition changes to fish populations in the Middle and Lower Susitna River.

9.12.8. Level of Effort and Cost

The schedule, staffing, and costs will be detailed as the 2013–2014 Study Plan develops. Total study costs are estimated at $500,000.

9.12.9. Literature Cited

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9.12.10. Tables

Table 9.12-1. Co-location of 1984 aquatic studies pertinent to fish passage at sloughs and side channels.

Slough or Side Channel Name	River mile[1]	Study Name				
		Salmon Passage	Stage/Q	Channel Geometry	Instream Flow	Adult Salmon Use
Whiskers Creek Slough	101.2	X	X	X		X
Mainstem 2 Side Channel	114.5	X	X	X		X
Slough 8A	125.3	X	X	X	X	X
Slough 9	128.3	X	X	X	X	X
Slough 9A	133.2	X		X		X
Side Channel 10	133.8	X	X	X	X	X
Slough 11	135.3	X	X	X		X
Lower Side Channel 11	136.1				X	X
Upper Side Channel 11	136.2	X	X	X	X	X
Slough 20	140.1	X	X	X		X
Side Channel 21	140.6	X	X	X	X	X
Slough 21	141.8	X	X	X	X	X
Slough 22	144.2	X	X	X		X

Notes:

1. River mile is determined from the most downstream point of the study site
2. ADF&G 1984b
3. ADF&G 1984c
4. ADF&G 1984d
5. ADF&G 1984e
6. ADF&G 1984f

Table 9.12-2. Location of proposed 2012-13 flow routing transect relative to locations of 1984 slough and side channel study sites.

1980s Slough or Side Channel Name	River mile[1]	Salmon Passage Study	River mile[1] Location of Proposed 2012-13 Flow Routing Study Transect
Whiskers Creek Slough	101.2	Yes	101.52
Mainstem 2 Side Channel	114.5	Yes	114.0
Slough 8A	125.3	Yes	124.41/126.11
Slough 9	128.3	Yes	128.66
Slough 9A	133.2	Yes	133.33
Side Channel 10	133.8	Yes	133.3/134.28
Slough 11	135.3	Yes	135.36
Lower Side Channel 11	136.1		136.4
Upper Side Channel 11	136.2	Yes	136.4
Slough 20	140.1	Yes	140.15
Side Channel 21	140.6	Yes	140.83
Slough 21	141.8	Yes	141.49/142.13
Slough 22	144.2	Yes	143.18/144.83

Notes:

1 River miles –based on 1984 river mile index.

Table 9.12-3. Fish and potential fish species within the lower, middle, and upper Susitna River, based on sampling during the 1980s.

Common Name	Scientific Name	Life History	Passage Sensitive
Arctic grayling	*Thymallus arcticus*	Fresh water	X
Dolly Varden	*Salvelinus malma*	Fresh water/ Anadromous	X
Humpback whitefish	*Coregonus pidschian*	Fresh water/ Anadromous	X
Round whitefish	*Prosopium cylindraceum*	Fresh water	X
Burbot	*Lota lota*	Fresh water	X
Longnose sucker	*Catostomus catostomus*	Fresh water	X
Sculpin	*Cottid*	Fresh water/ Marine	--
Eulachon	*Thaleichthys pacificus*	Anadromous	--
Bering cisco	*Coregonus laurettae*	Fresh water/Anadromous	X
Threespine stickleback	*Gasterosteus aculeatus*	Anadromous/Fresh water	X
Arctic lamprey	*Lethenteron japonicum*	Anadromous/Fresh water	X
Chinook salmon	*Oncorhynchus tshawytscha*	Anadromous	X
Coho salmon	*Oncorhynchus kisutch*	Anadromous	X
Chum salmon	*Oncorhynchus keta*	Anadromous	X
Pink salmon	*Oncorhynchus gorbuscha*	Anadromous	X
Sockeye salmon	*Oncorhynchus nerka*	Anadromous	X
Rainbow trout	*Oncorhynchus mykiss*	Fresh water	X
Northern pike	*Esox lucius*	Fresh water	X

Table 9.12-4. Pacific salmon leaping height capabilities from three sources.

Species	Leaping Height (in feet)		
	Powers and Orsborn (1984)[1]	Reiser and Peacock (1985)	USFS (2001)
Chinook	7.5	7.9	11.0
Coho	7.5	7.3	11.0
Sockeye	7.5	6.9	10.0
Pink	3.5	4.0	4.0
Chum	3.5	4.0	4.0

Notes:

1 Assumes a trajectory of 80^0 with a condition factor of 1.0. Maximum leaping height is less at a lower trajectory and lower fish condition factor.

Table 9.12-5. Schedule for implementation of the Fish Passage Barrier Study.

Activity	2013				2014			
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q
Study Site Selection								
Define Passage Criteria								
Data Collection								
Initial Study Report				Δ				
Follow up Data Collection								
Copordination With Interdependent Studies								
Updated Study Report								▲

9.12.11. Figures

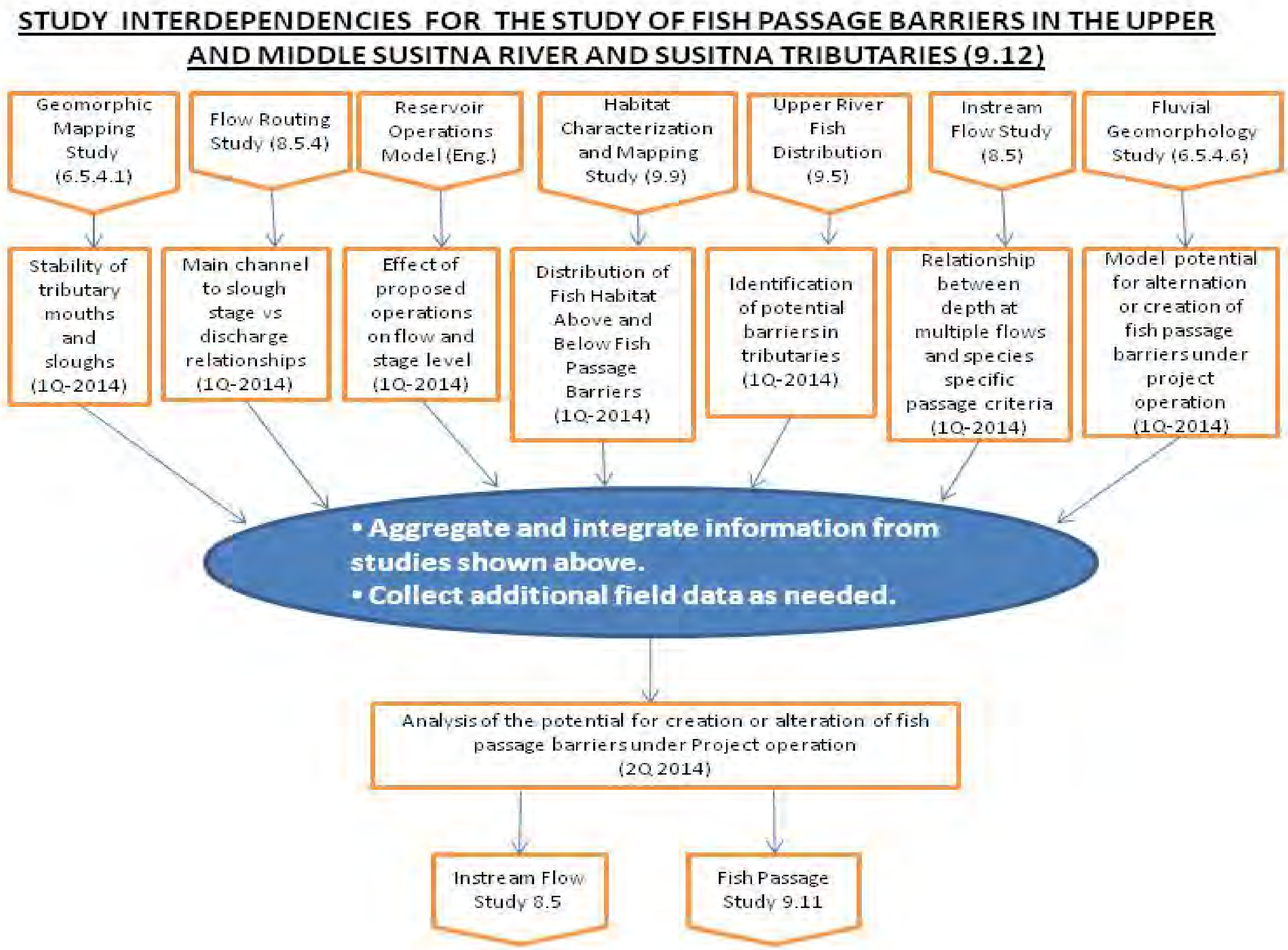

Figure 9.12-1. Study interdependencies for the Fish Passage Barriers Study.

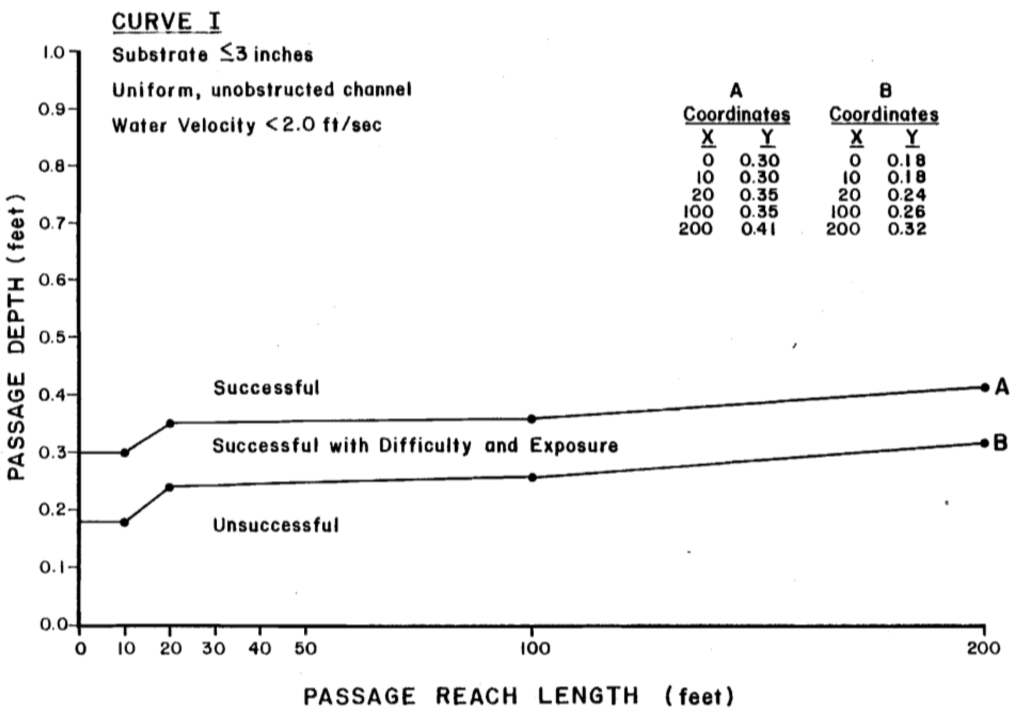

Figure 6-4. Passage depth requirements for chum salmon as a function of passage reach length within sloughs and side channels having substrates less than 3.0 inches in diameter, uniform morphology and water velocities less than 2.0 ft/sec.

Figure 9.12-2. Depth/distance passage criteria for chum salmon in unobstructed uniform channels with smaller substrates. Source ADF&G 1984d.

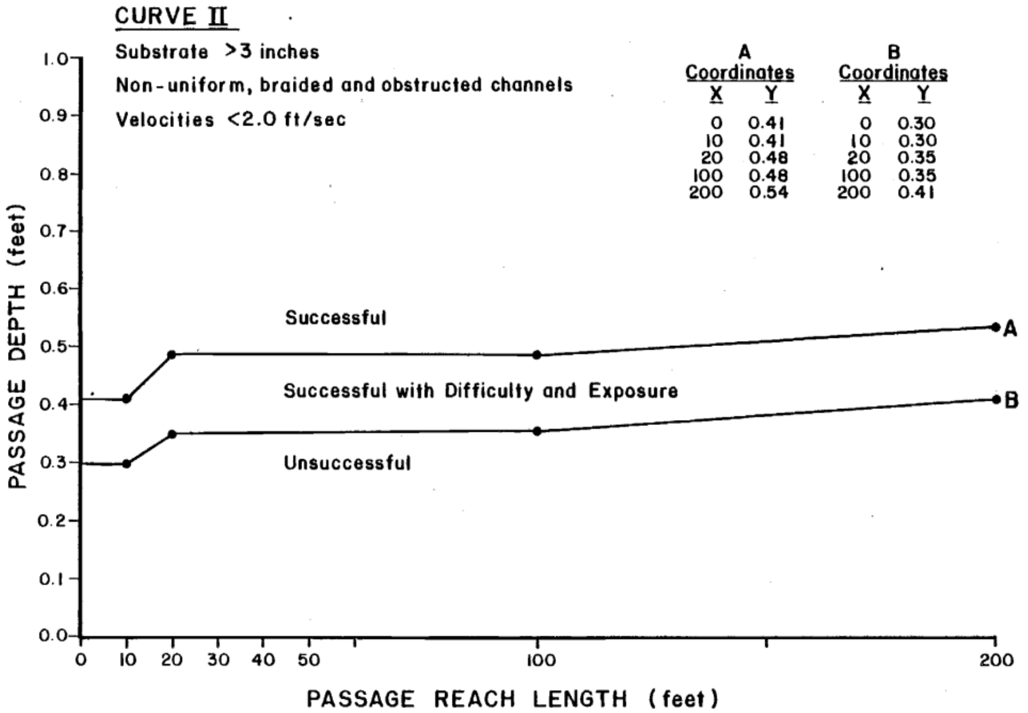

Figure 6-5. Passage depth requirements for chum salmon as a function of passage reach length within sloughs and side channels having substrates greater than 3.0 inches in diameter, non-uniform, braided and obstructed channels and velocities less than 2.0 ft/sec.

Figure 9.12-3. Depth/distance passage criteria for chum salmon in obstructed non-uniform channels with larger substrates. (ADF&G 1984b).

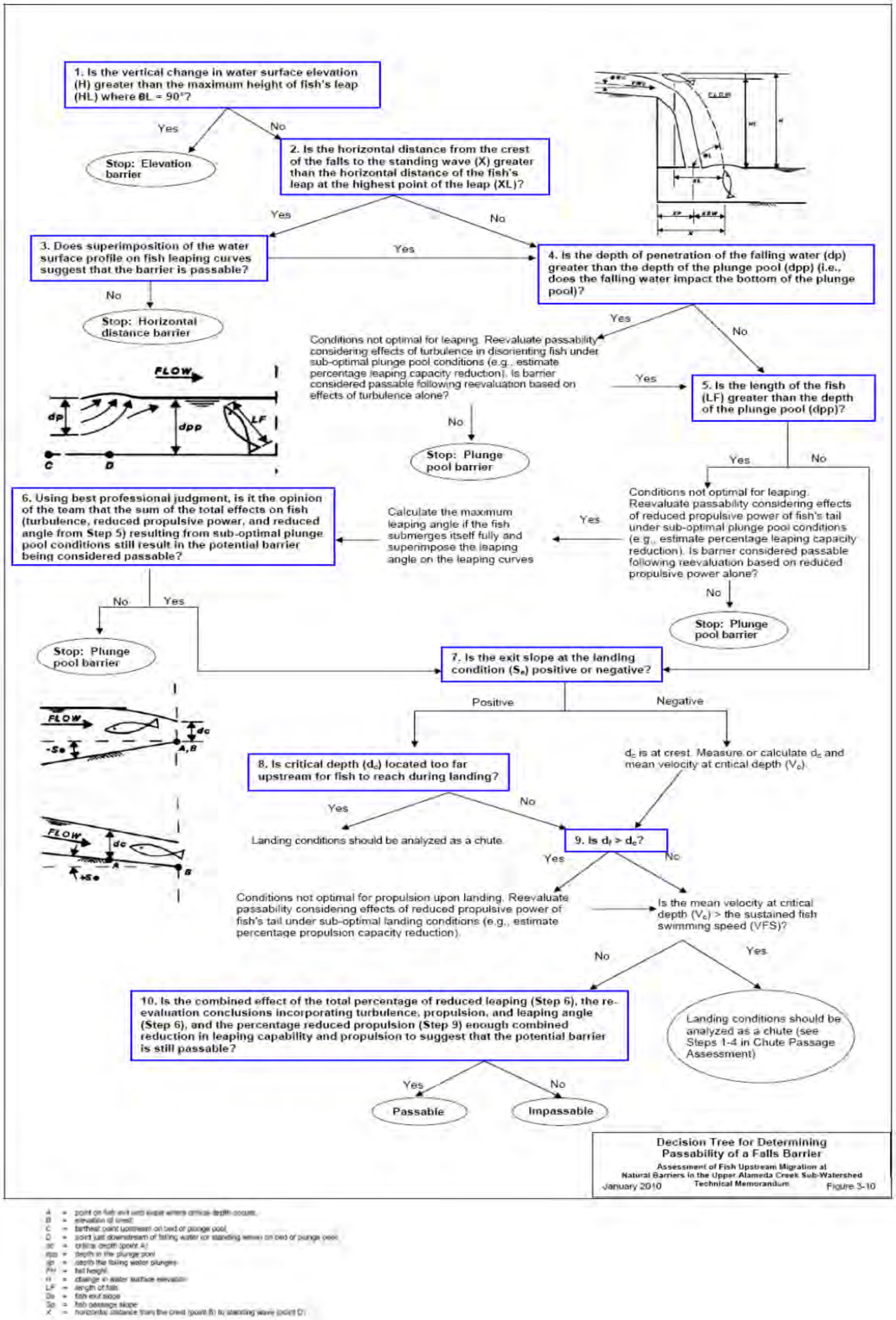

Figure 9.12-4. Barrier analysis decision tree (URS and HDR 2010).

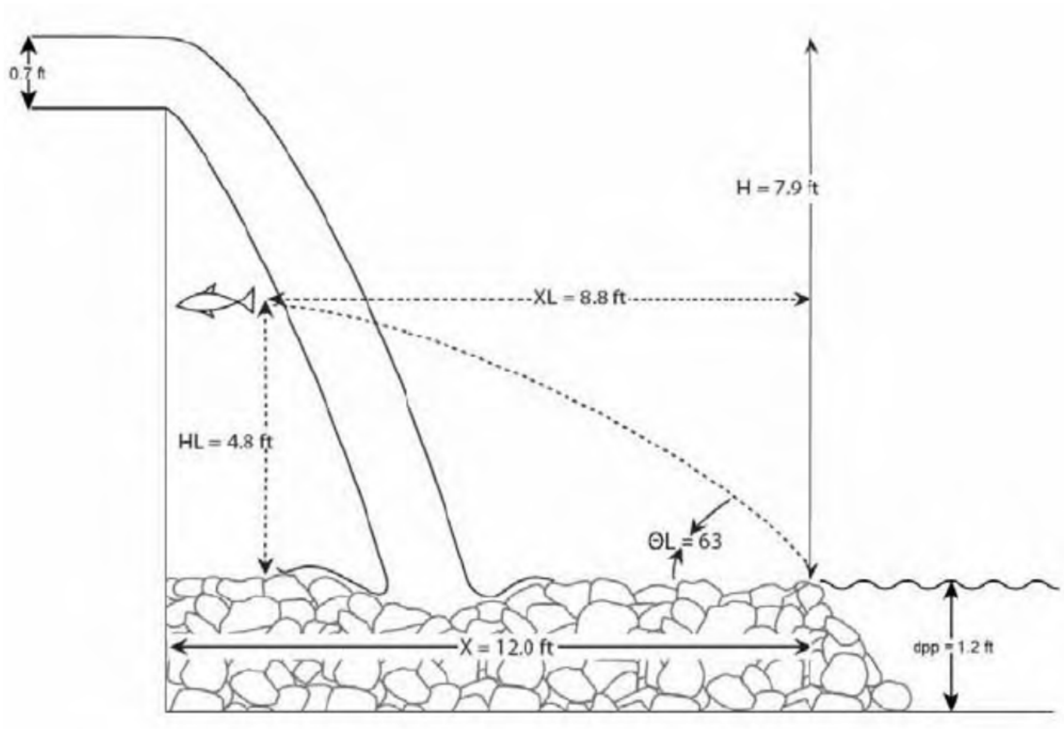

Figure 9.12-5. Example of barrier field drawing with measurement notation (URS and HDR 2010).

Physical Barrier Field Form		
Date:	Stream Name:	Reach Name:
Barrier Number: (numbered sequentially from mouth)	Barrier Location (UTM):	
Estimated Discharge:	Photo Numbers:	
Evaluation Species: Generic Fish		
Leap Height (LH) = 8 ft		
Leap Distance (LX) = 5 ft		
Fish Length (FL) = 2 ft		
Fish Body Depth (d_f) 8 in		
Fish Sustained Swim Speed (VFS) = 6 fps		
Observers:		
Passable/Impassable: Passable		

Decision Tree Step	Determination	Measurement or Judgment Basis for Determination
1	No	H = 5 feet
2	No	X = 4.5 feet
3	Skip	
4	No	dp = 3 ft and dpp = 1 ft
5	No	LF (2 ft) < dp (3 ft)
6	Skip	
7	Positive	Exit slopes up
8	No	d_c is within fishes horizontal leaping distance of 6 ft.
9	No	d_f (8 in)< d_c (12 in)
10	No	All factors suggest barrier is passage
Comments: All factors suggest barrier is passable by (species) at flows present on day of observation……other comments as needed.		

Figure 9.12-6. Draft physical barrier field form.

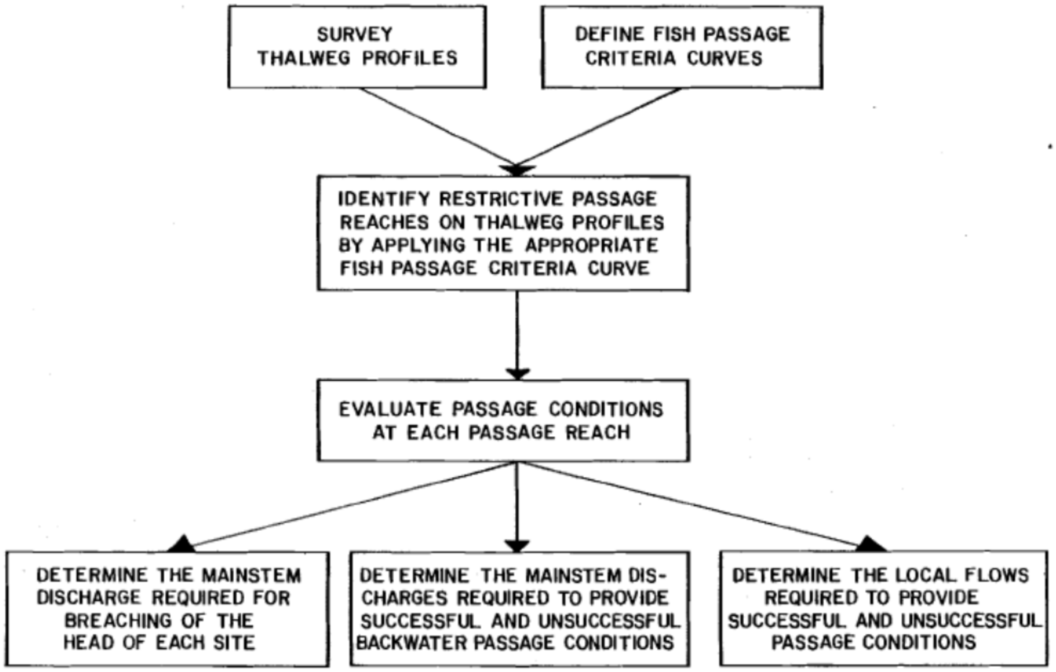

Figure 9.12-7. ADF&G (1984b) flow chart for slough and side channel assessment methods.

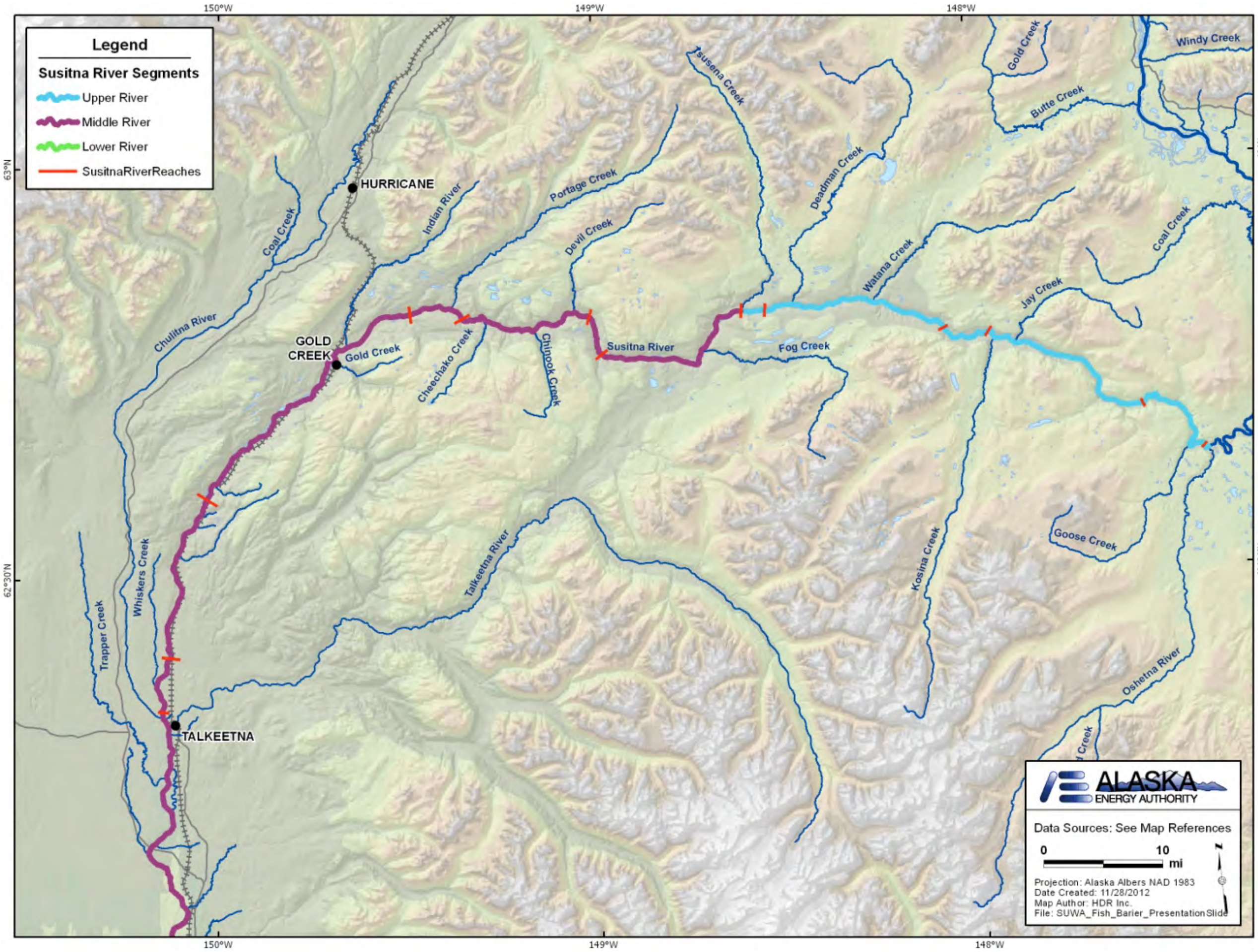

Figure 9.12-8. Study of Fish Passage Barriers in the Middle and Upper Susitna Basin.

9.13. Aquatic Resources Study within the Access Alignment, Transmission Alignment, and Construction Area

9.13.1. General Description of the Proposed Study

Construction and operation of facilities associated with the proposed Project will require both temporary and permanent infrastructure including road, railroad siding, airstrip, transmission lines, and construction camps and staging areas (ADOT&PF 2012). Construction and operation of the Project could affect aquatic habitat where Project access roads, transmission lines, airports, and construction areas cross or encroach on streams and other water bodies.[34] A baseline description of aquatic habitats and fish species present in the vicinity of Project-related infrastructure is needed to provide a basis for assessing potential Project effects and to assist in developing plans for protection, mitigation, and enhancement (PM&E) measures, including resource management and monitoring plans.

Study Goals and Objectives

The goals of this study are as follows: (1) characterize baseline condition of the aquatic habitat and fish species composition in the vicinity of the proposed Project's infrastructure including access roads, transmission lines, airports, construction areas, and operation facilities; (2) evaluate the potential for the proposed Project's infrastructure to affect these resources; (3) provide data for determining the least environmentally damaging alternative for purposes of U.S. Army Corps of Engineers (USACE) issuance of a dredge and fill permit under Section 404(c) of the Clean Water Act; and (4) provide data for developing any necessary PM&E measures, which may include resource management and monitoring plans.

Specific study objectives are as follows:

1. Characterize the aquatic habitats and fish assemblages at potential stream crossings within a 200-meter (650-foot) buffer zone along proposed access road and transmission line alignments.
2. Describe aquatic habitats and species present within the construction area for the dam and related hydropower facilities.

9.13.2. Existing Information and Need for Additional Information

Alaska Energy Authority (AEA) will evaluate up to three possible access alternatives for road and transmission lines. The Denali Corridor would run north from the Watana Dam site and connect to the Denali Highway by road (Figure 9.13-1). Within this corridor, the transmission lines would generally parallel the road to the Denali Highway and would run west along the existing Denali Highway to connect to the Anchorage–Fairbanks Intertie. The Chulitna Corridor would accommodate east–west running transmission lines and a road along the north side of the Susitna River that would connect to the Anchorage–Fairbanks Intertie and the Alaska Railroad near the Chulitna station. The Gold Creek Corridor would also accommodate an east–west

[34] Streams would be crossed using standard Alaska ADOT&PF bridge design, or using culverts, as appropriate. AEA anticipates that construction would be completed using standard methods and would rely on local borrow pits/quarries within the corridor for fill and surfacing (AEA 2011).

access and transmission corridor but would run along the south side of the Susitna River (Figure 9.13-1).

Fisheries and aquatic habitat work specific to each of the proposed transportation access and transmission line alignments has not been conducted since the 1980s. Because these data were collected a number of years ago, it will be useful for corridor planning to have updated data. Given the 30-year timespan, it is possible that shifts in fish species distribution and range expansion may have occurred since the historic data were collected. Thus, a description of current aquatic habitats and fish species in the vicinity of Project-related infrastructure is needed to inform Project design, impact assessment, and development of potential PM&E measures, as necessary.

The most comprehensive fish and aquatic habitat dataset relevant to this study was generated during the 1980s. In 1983, the Alaska Department of Fish and Game (ADF&G) established study sites to characterize aquatic habitat and document fish species presence at 42 stream crossings within the then-proposed access and transmission corridors. Study sites were established at 22 stream crossing sites from the Denali Highway to the Watana Dam site, 14 sites along the Devils Canyon access corridor, and 6 sites along the then-proposed Gold Creek rail portion of the corridor (Schmidt et al. 1984). The 22 crossing sites along the then-proposed Denali-North (Seattle Creek) alignment correspond reasonably well to the present-day Denali Corridor crossing sites. The 14 study sites along the then-proposed Devils Canyon access, which extended from corridor mile 38 of the old Denali Corridor to Devils Creek dam site to the old Gold Creek intertie, relate fairly well to a portion of the present-day Chulitna Corridor. The 6 sites along the old Gold Creek intertie correspond to some of the crossings associated with the western portion of the present day Gold Creek Corridor.

In addition to the *Access and Transmission Corridor Aquatic Investigations* (July–October 1983) report (Schmidt et al. 1984), relevant existing information sources include fish species presence and aquatic habitat data collected and maintained under the *Alaska Freshwater Fish Inventory* (AFFI) program (e.g., Buckwalter 2011) and anadromous fish presence data maintained by the ADF&G *Anadromous Waters Catalog* (*AWC*; ADF&G 2011). The Aquatic Resources Data Gap Analysis (ARDGA; HDR 2011) and AEA's Pre-Application Document (PAD) (AEA 2011) summarized existing information and identified data gaps for aquatic conditions and fish species.

The Alaska Department of Transportation and Public Facilities (ADOT&PF) recently conducted a transportation access study to evaluate access corridors to the Watana Dam site (ADOT&PF 2012). In 2011, the ADOT&PF study team used a helicopter to fly over each access route and identified each stream crossing (those previously mapped and those that did not appear on the U.S. Geological Survey [USGS] map; ADOT&PF 2012). The ADOT&PF team landed at selected stream crossings and estimated channel width and incision depth, and where possible, identified more efficient crossing locations (ADOT&PF 2012). Based on the 2011 field reconnaissance coupled with review of existing aquatic resource data, the ADOT&PF identified the number of stream crossings that would be necessary under each alternative. The ADOT&PF considered the number of stream crossings and associated fish passage requirements as part of the screening criteria evaluation (ADOT&PF 2012).

The access and transmission line corridors for the proposed Project have not been finalized. Historic data on fish species presence and aquatic habitat are available for many of the streams that would be crossed; however, an updated characterization study is needed to assess current conditions and to ensure fish presence is accounted for in all streams and water bodies within the vicinity of the proposed crossing locations. Additionally, a more comprehensive and systematically-collected aquatic habitat dataset is necessary to characterize baseline conditions prior to potential development.

A brief summary of the existing information for each of the proposed access/transmission line corridors is presented below.

9.13.2.1. Denali Corridor

The current Denali access alignment corridor (referred to by ADOT&PF as the Seattle Creek [North] alignment) would require approximately 15 stream crossings from the Watana Dam site to the Denali Highway (ADOT&PF 2012). The Denali Corridor alignment would cross streams within both the Nenana River and Susitna River watersheds. Seattle Creek and Brushkana Creek are the two major drainages crossed within the Nenana River watershed. The Denali Corridor would require eight crossings of tributaries within the Nenana River basin and two crossings in the Susitna River watershed. Deadman Creek is the major stream crossed within the Susitna River watershed.

In the 1980s, biologists conducted fish presence surveys in the vicinity of 10 of these 15 stream crossing sites and recorded general habitat and water quality conditions (Schmidt et al. 1984). Resident fish species were confirmed to be present in the vicinity of nine proposed crossing locations, three sites with intermittent flow were deemed unsuitable for fish use and were not sampled for fish presence, and one site had no fish present (Schmidt et al. 1984).

Schmidt et al. (1984) documented that Dolly Varden, slimy sculpin, and Arctic grayling were relatively widespread along the Denali Corridor. Sculpin were captured near nine of the proposed crossing locations and Dolly Varden and Arctic grayling near six of the proposed crossings. No anadromous fish habitat was documented during these surveys. These streams will be re-surveyed in 2013 along with a subset of streams that would be crossed by the transmission line along the Denali Highway.

The Denali Corridor is the only study area with existing infrastructure. Under this alignment corridor, upgrades to the existing Denali Highway would be necessary to accommodate Project traffic (ADF&G 2012). ADF&G has indicated that a comprehensive survey of Denali Highway stream crossings would be required if the Denali Corridor is chosen (ADF&G 2012). From 2006 to 2007, ADF&G conducted a Level 1 assessment of stream crossings for central and Interior Alaska road systems including the Denali Highway (O'Doherty 2010). The ADF&G methodology followed a standardized protocol focusing on juvenile salmonid fish passage. Culverts were surveyed for type, size, slope, outfall height, and other physical parameters. Of the 1,591 culverted stream crossings evaluated throughout the state, the Denali Highway crossings were classified among those "having the greatest potential to pass juvenile fish" (O'Doherty 2010). If the Denali Corridor is chosen, all crossings will be re-inventoried and surveyed to the ADF&G Level 1 standard. This survey work will be completed in 2014.

9.13.2.2. Chulitna Corridor

The current Chulitna Corridor alignment (referred to by ADOT&PF as the Hurricane [West] alignment) would require approximately 36 stream crossings. All streams and water bodies that would be intersected by this corridor drain into the Susitna River watershed. The majority of streams that would be crossed by this alignment are smaller tributary streams. However, this alignment would also cross a number of larger streams, including Pass Creek, the Indian River, and Thoroughfare, Portage, Devil, Tsusena, and Deadman creeks.

The Chulitna Corridor alignment would cross several known anadromous fish streams (ADF&G 2011). A crossing of Granite Creek, west of the Parks Highway, would facilitate access to the existing railroad line. The ADF&G *AWC* lists Granite Creek (AWC No. 247-41-10200-2381-3600) as anadromous fish habitat (ADF&G 2011). Bader and Sinnott (1989) captured juvenile Chinook and coho salmon at a point downstream of the proposed Granite Creek crossing (ADF&G 2011; Bader and Sinnott 1989), and no passage barriers have been identified in that creek between the fish capture site and the proposed crossing.

Pass Creek, located southwest of the Chulitna route crossing, is specified as an anadromous fish stream in the *AWC* (AWC No. 247-41-10200-2381-3236) and is designated to provide habitat for all five species of Pacific salmon (ADF&G 2011). However, a waterfall located downstream of the Chulitna alignment crossing presents a barrier to upstream migration of anadromous fish (ADF&G 2011). The Chulitna alignment intersects nine small, unnamed tributaries to Pass Creek; however, only limited electrofishing assessment data are available and indicate the presence of Dolly Varden and slimy sculpin at the one location sampled (Buckwalter et al. 2003).

Three additional streams—Indian River (AWC No. 247-41-10200-2551), Thoroughfare Creek (AWC No. 247-41-10200-2582-3201), and Portage Creek (AWC No. 247-41-1020-2585)—have been cataloged (ADF&G 2011) as providing habitat for anadromous fish at the potential crossing sites.

The Chulitna alignment would cross ten small, unnamed tributaries of Portage Creek, the mainstem of Devils Creek and three of its tributaries, seven smaller tributaries to the Upper Susitna River (in the Swimming Bear drainages; Schmidt et al. 1984), as well as Tsusena Creek and two of its tributaries. Fish presence sampling has not been conducted in many of these tributary streams, and passage barriers have not been identified. The presence of barriers on some of the Susitna River tributaries above Devils Canyon is being documented as part of the 2012 Upper Susitna River Fish Distribution and Habitat Study.

9.13.2.3. Gold Creek Corridor

The current road and transmission line alignment within the Gold Creek Corridor would require approximately 23 stream crossings (ADOT&PF 2012). All streams and water bodies that would be intersected by this alignment drain into the Susitna River watershed. The major streams that would be crossed include Gold Creek, Fog Creek, and Cheechako Creek. Smaller streams that would be crossed include tributaries to Prairee and Jack Long creeks and a number of unnamed tributaries to the Susitna River.

The Susitna River (including side channels and sloughs), Fog Creek, Cheechako Creek, and Gold Creek are known to provide habitat for anadromous Pacific salmon (ADF&G 2011). Many of the streams that would be crossed are unnamed tributaries of the Susitna River. Fish data are available for a number of streams that would be crossed. However, much of the available fish data were collected downstream from (i.e., not in the direct vicinity of) the proposed crossing sites (Delaney et al.1981; ADF&G 2011; Schmidt et al. 1984). A total of 8 of the 23 streams intersected by the southern alignment are known to provide habitat for anadromous fish downstream of the proposed crossing sites (ADF&G 1981, 2011; Schmidt et al. 1984).

9.13.3. Study Area

The access corridor study area includes streams and water bodies within both the Susitna River and Tanana River watersheds (Figure 9.13-1). The Denali alignment would cross streams within both the Nenana River (a tributary of the Tanana River) and Susitna River watersheds. Seattle Creek and Brushkana Creek are the two major drainages that would be crossed within the Nenana River watershed. Deadman Creek is the major stream that would be crossed within the Susitna River watershed. All streams and water bodies that would be intersected by the Chulitna and Gold Creek alignments drain into the Susitna River watershed.

The study area will include the aquatic habitats (streams and lakes) in the vicinity of both temporary and permanent Project-related infrastructure including access roads, transmission lines, airports, and construction areas. AEA will establish study sites in aquatic habitats within a 200-meter (650-foot) buffer zone along each access alignment corridor, in the vicinity of the potential airport and hydropower facility construction areas. Figure 9.13-1 shows the streams and lakes (based on the most current hydrography layer) within the three access corridors.

The study area will be adjusted as refinements are made to the proposed Project features and specific alignment routes. AEA expects that the initial 2013 sampling effort will occur over a broad area and that collection of more detailed information within refined alignments will be necessary during subsequent sampling efforts in 2014.

9.13.4. Study Methods

9.13.4.1. Synthesis of Existing Information

Historic data for aquatic resources sampling reported in Schmidt et al. 1984 (and associated data to the extent possible), the AWC, and AFFI will be incorporated into a geospatial database for the proposed access alignments. AEA will consult with the agencies and will identify gaps in the historic aquatic habitat and fish species presence database to prioritize the initial 2013 sampling efforts and refine the overall field sampling approach. Based on the existing data review, the overall priority for data collection will be as follows: (1) sites not previously surveyed; (2) sites with no previously documented fish presence; (3) sites with fish presence documented downstream of the potential crossing location; and (4) sites with fish presence documented upstream of the potential crossing location. In this study, AEA does not propose to survey for fish presence in streams where the known anadromous fish distribution extends upstream of a proposed crossing location, but aquatic habitat surveys may be conducted in these locations.

At the onset of this study, locations where aquatic habitat and fish species presence data have been previously collected in the vicinity of the proposed access corridors will be identified. AEA will code streams and water bodies by fish presence (e.g., anadromous fish, resident fish, no fish captured or observed) and will identify streams and water bodies for which no data records were found. For areas where no sampling data are available, the team will review connectivity to adjacent streams and water bodies (e.g., where fish/habitat data are available) to aid in field sample planning.

AEA initiated studies in 2012 to begin the characterization of fish communities, fish distribution, and aquatic habitat throughout the Susitna River. Studies will continue and expand in 2013–2014. AEA also began a study to document the presence of fish passage barriers in the Upper Susitna River, with a focus on streams within the proposed inundation zone. In 2013 and 2014, AEA will expand these efforts to identify the presence of existing fish passage barriers to tributaries downstream of the proposed Watana Dam site. Data collected as part of the fish distribution and aquatic habitat mapping studies will be used to supplement data collection and analysis specific to this study, where appropriate.

9.13.4.2. Field Data Collection

Study sites will be established at proposed crossing sites in streams along the three potential access and transmission corridors and within the vicinity of construction areas and potential airport locations. To account for potential alignment changes or refinements, sampling will occur within a 200-meter (650-foot) buffer along each alignment corridor in 2013. Study sites will also be established on lakes that fall within the proposed access corridors and in the vicinity of construction locations.

Each alignment will be flown to verify that all streams and/or water bodies within 200 meters (650 feet) of the access and transmission corridors and construction areas are included in the field study. The field team will record the location of each area to be sampled with a global positioning system (GPS) unit. The field team will also take photographs to document channel conditions during each field data collection effort. The team will sample for fish presence and record aquatic habitat parameters at each study site, as described below.

AEA expects that the initial fisheries and aquatic habitat data collected for the Project in 2012 and 2013 will be assessed during the facilities alternatives analysis and will be used to refine Project design. AEA anticipates that the collection of additional site-specific data may be necessary in 2014 to address any newly identified crossing locations and/or fill data gaps.

9.13.4.2.1 Aquatic Habitat Data Collection

The field team will record aquatic habitat characteristics in the vicinity of each potential crossing site. At stream crossing locations, AEA will characterize habitat units to the mesohabitat level in accordance with the channel typing and aquatic habitat classification system currently being developed for the Project by the Fish and Aquatic TWG, as presented in Section 9.9. Habitat characterization will be based on a modified version of the USFS Aquatic Habitat Survey Protocol (2001). Habitat units encountered will be typed, and parameters that describe the current condition of the habitat unit will be measured. If sections of stream contain two or more different habitat units they will be delineated to the mesohabitat level, denoting a primary and secondary unit, and recorded correspondingly. Field data collection methods will be consistent with those identified for the ground-based surveys described in Section 9.9. The habitat survey for each stream will be conducted by a two-person field team. A GPS point will be used to identify the upstream boundary of each mesohabitat unit. For pools, maximum depth and pool crest depth will be measured with a stadia rod and recorded in meters, where possible. Wetted and bankfull widths and the lengths of each mesohabitat unit will be measured with a tape or laser range finder and recorded in meters. Percent substrate composition will be estimated by visual identification based on USFS (2001) classifications. Slope measurements representative of the potential crossing location within the 200-meter corridor will will also be recorded.

Large woody debris (LWD) observed will be counted for each habitat unit. For a piece of wood to be considered LWD, it must be at least 0.1 meter (4 inches) in diameter, and at least 1.0 meter (39 inches) of the LWD must be below the water's surface at bankfull flow (USFS 2001).

The amount of undercut bank (UCB) on each side of the stream will be measured to the nearest meter for each habitat unit. A bank will be considered undercut if the undercut is greater than or equal to 0.3 meter (12 inches) incised into the bank and greater than 1.0 meter (39 inches) long. If, at bankfull stage, the bank would be considered undercut, then it will be measured even if it is above the current surface of the water (USFS 2001).

The linear distance of stream habitat characterized at the mesohabitat unit level will be a function of wetted channel width (40 times the wetted width up to a maximum of 400 meters [1,300 feet]). AEA developed a systematic approach to characterize lake habitats in the Characterization and Mapping of Aquatic Habitats Study (Section 9.9); this study will utilize results as they become available in 2013.

As Project features are refined, additional site-specific data will be recorded along transects in the close vicinity (in accordance with the Habitat Characterization Protocol) of the anticipated crossing location. Data recorded along transects will include but not be limited to channel bed width, wetted channel width, several water depth measurements across each transect (where feasible), gradient[35], Rosgen channel type (Rosgen 1994), and water quality field parameters. AEA anticipates the need for such parameters to meet permitting requirements (e.g., ADF&G Fish Habitat Title 16 Permit).

Several water quality parameters that affect aquatic life will be measured during the aquatic habitat assessment, including field measurements of surface water temperature, pH, dissolved oxygen (DO), and specific conductivity. Alaska Department of Environmental Conservation (ADEC) water quality criteria for all applicable water use classes and subclasses will be used to evaluate measured parameters. Water quality sampling will be conducted in coordination with water quality sampling protocols currently being developed for the Project.

9.13.4.2.2 Fish Data Collection

The goal of this task is to characterize fish assemblages in the vicinity of potential stream crossings. Therefore, sampling will not be conducted throughout the entire length of the stream but instead within close proximity to crossing sites (see below). Species richness in stream fish assemblages is related to both environmental conditions within the stream and stream spatial position within the drainage (Grenouillet et al. 2004). In an effort to characterize species composition at each stream crossing, the field team will establish segments of stream habitat to sample for fish presence at each crossing site. Streams will be sampled as described below. As requested by ADF&G during Fish and Aquatic TWG meetings, sampled water body crossings where no fish are found will be sampled again during a different season to adequately assess fish presence.

[35] One study considered stream width and gradient as two of the most influential factors that affected species richness among different habitat variables (Grenouillet et al. 2004).

The field team will use backpack electrofishing gear (Smith-Root LR-24 or similar) as the primary capture method to inventory streams for fish presence. Single-pass electrofishing was selected as the primary fish capture method because it is considered to be the most effective (Barbour et al. 1999; Simon and Sanders 1999; Flotemersch and Blocksom 2005) and widely applied (Hughes et al. 2002) method used in streams and rivers. Electrofishing typically captures more species with less size selectivity than other gear types (Hendricks et al. 1980), electrofishing equipment is relatively compact and portable, and electrofishing is recommended as a standard sampling method for coldwater fishes in streams (Bonar et al. 2009; J. Buckwalter, ADF&G/Habitat Biologist II, personal communication, October 17, 2011).

Electrofishing settings will be determined in the field based on water quality conditions (e.g., conductivity) and professional judgment. Backpack electrofishing will be conducted by trained staff consistent with established protocols and guidelines (e.g., NMFS 2000; Temple and Pearsons 2007; Buckwalter et al. 2010; J. Buckwalter, ADF&G/Habitat Biologist II, personal communication, October 17, 2011). If adult salmonids or aggregations of large (>300 millimeters [11.8 inches]) salmonids are encountered, electrofishing activities in the immediate vicinity will cease, except to capture fish for species identification (Buckwalter et al. 2010). Other fish sampling methods (e.g., fyke nets, minnow traps, snorkeling, etc.) may be used when adult anadromous fish are present (or when habitat conditions are not suitable for electrofishing).

The length of stream habitat sampled at each crossing site will be directly proportional to the stream channel's wetted width. The linear distance of stream habitat sampled needs to be long enough to provide a true representation of the fish species present but not so long that it becomes more labor intensive than is necessary to meet the study's objectives (Temple and Pearson 2007). In general, large streams require longer sampling sections than smaller streams to assess community structure (Temple and Pearsons 2007). Temple and Pearsons found that a sample reach with a length between 27 and 31 wetted channel widths was the minimum sampling distance required to detect 90 percent of the fish species present (2007). For small streams, such as headwater streams, other studies report minimum sampling distances of 12 to 50 wetted channel widths (Patton et al. 2000), 35 wetted channel widths (Lyons 1992), and 40 wetted channel widths (Reynolds et al. 2003; Buckwalter et al. 2010). Recent analysis of data collected by single-pass electrofishing using the 40 wetted channel width reach length found that species richness was typically underestimated on intermediate (e.g., drains 200 square kilometers) and mainstem (e.g., drains 1,500 square kilometers) streams in Alaska (as opposed to target headwater (drains 50 square kilometers) streams (J. Buckwalter, ADF&G/Habitat Biologist II, personal communication, October 17, 2011). Based on the study results described above and the anticipated channel size for crossing surveys, AEA proposes to survey a stream length of 40 wetted channel widths, a minimum of 50 meters and up to a maximum of 400 meters (1,300 feet) of stream length.

One or more alternative fish sampling methods may be used in stream habitats not suitable for electrofishing and in lake habitats. Sampling may include the use of multi-mesh gillnets, baited minnow traps, fyke nets, seine nets, and angling gear. The gear used at individual sampling locations will be a function of habitat conditions encountered. Gear type specifications are as follows:

- Gillnets used in lakes will be situated perpendicular to shore and fished at varying depths. The team will deploy nets for a minimum of two hours and check nets frequently to minimize potential fish mortality. To the extent possible, the team will sample multiple locations throughout lakes, including around the inlet and outlet areas. If no fish are captured within several hours, gear will be set overnight. The team will use a boat and/or drysuits to deploy gear in offshore habitats.

- Minnow traps (also known as basket traps) will be baited with commercially processed roe and secured to vegetation or substrate. Soak times are anticipated to be 90 minutes (Bryant et al. 2000). These authors demonstrated that 45 percent of total catch can be obtained from an initial soak of this duration.
- Fyke nets will be used with attached wings and detachable center leads with floats and weighted line. Alternative fyke net sizes and designs may also be used depending on conditions encountered.
- Beach seines may be used to target fish too small to be captured by traps or species that typically are not susceptible to sampling with traps. The team may use a variety of sizes, including a 1.2-meter (4-foot) by 6.1-meter (20-foot) black mesh beach seine with 6.4-millimeter (0.25-inch) mesh. Beach seine sampling area will be recorded and involve a single pass through the sample area.
- Angling gear will target larger fish in deeper portions of streams and lakes. A variety of gear will be used.

Captured fish will be held in buckets and/or live wells until the sampling of each segment is complete. Fish will be identified to species and counted. Up to 100 fish of each species collected at each sampling location will be measured to the nearest millimeter to record fork or total length as appropriate. Fish will be released within the sampling location once sampling activities have ceased. Fish disposition (e.g., released, unintended mortality, voucher specimen, injury) will be recorded for each fish handled. Data will be recorded on a standardized datasheet or field computer form.

AEA will obtain a fish resource permit (FRP) from ADF&G prior to initiation of field sampling activities. Sampling activities will be carried out in compliance with FRP stipulations. Any deviations from the approved study plan will be communicated to ADF&G during or immediately following sampling activities.

9.13.4.2.3 Data Analysis and Reporting

Data generated during this study will provide baseline data related to fish and aquatic habitat in the vicinity of potential water body crossing locations associated with potential transportation access alignments, transmission alignments, and construction areas. AEA will complete a technical report that summarizes methods and results of the aquatic habitat characterization and fish species assemblages in the study area.

Data generated during this study will be incorporated into the Project's geospatially-referenced relational database. Naming conventions of files and data fields, spatial resolution, and metadata descriptions will meet the standards established for the Project. Use of the Project's geospatial database will also allow data specific to each stream crossing to be queried and readily accessible for Project reporting. The database will be designed to create individual reports by crossing location.

Fish capture data will be submitted to ADF&G per FRP requirements. Fish species assemblage (composition and species richness) and distribution will be reported by sampling location and by stream drainage or lake. Catch per unit effort (CPUE) will be determined by dividing the catch (number of fish captured or observed) by the effort (e.g., sample time). To the extent possible, data collected using different methods will be normalized so results can be appropriately compared. CPUE will be determined for each species by location (e.g., stream reach sampled) and gear type. CPUEs will be used to develop an index of relative abundance (as related to sample time, not sample area) for each species captured at stream crossing sites.

9.13.5. Consistency with Generally Accepted Scientific Practice

Electrofishing, gillnets, seine nets, minnow traps, angling, fyke nets, and snorkel surveys are commonly used methods for sampling fish populations (Murphy and Willis 1996; Backiel and Welcomme 1980). Angling using single barbless lures or flies has become a common method for capturing subject fish. These methods described herein have been developed in consultation with the agencies and other licensing participants. All data collection efforts will follow state guidelines and FRP permit stipulations.

9.13.6. Schedule

Table 9.13-1 shows the study activity timeline. AEA will begin this study by reviewing results of the efforts currently underway to compile existing fisheries and aquatic habitat data. AEA anticipates that the historic and more recent existing data on stream crossings will be available in early 2013.

The field team will conduct fish surveys primarily during July and August 2013, at which time fish should be well distributed throughout feeding or rearing habitats. It is possible that some sampling efforts may start earlier and extend beyond August, such as those in lake habitats or those associated with migration periods. Aquatic habitat surveys are typically conducted at low flows. The timing of low-water events is not known for all crossing locations; in general, low water during the open-water season may occur during fall months just prior to freeze up. Aquatic habitat surveys will be conducted concurrent with fish sampling as conditions allow. However, crossing locations may need to be visited more than once. For sites where no fish are encountered on a first survey, a second survey during a different season of 2013 or in 2014 (if conditions do not permit a second event in 2013) will be conducted to help confirm seasonal fish use of habitat. As discussed in the methods section, additional surveys are anticipated in 2014 to refine the alignments and/or fill in data gaps. The number of 2014 surveys that will be needed cannot be determined until more information is available. Initial and Updated Study Reports discussing actions to date will be issued within 1 and 2 years, respectively, of FERC's Study Plan Determination (i.e., February 1, 2013).

This study is dependant on well-defined access and transmission corridor alignment center lines and construction area boundaries.

9.13.7. Relationship with Other Studies

The Aquatic Resources Study within the Access Alignment, Transmission Alignment, and Construction Area (Access) Study will interrelate with at least five other AEA Project studies (Figure 9.13-2). Potential transmission route options and construction areas as a component of Project design will provide input for some of the relevant sampling locations. The Characterization of Aquatic Habitat Study (Section 9.9), and the Upper River Fish Distribution and Abundance Study (Section 9.5) will provide aquatic habitat and fish species presence data in areas that overlap the potential corridors. This information may eliminate or reduce the data collection needs for sites sampled on the respective alignments. The Fish Passage Barriers Study (Section 9.12) will work cooperatively by providing physical locations of anadromous fish passage barriers for tributary streams crossed by the respective alignments. The flow of information into and out of the Access Study is anticipated to occur over the two-year study period through an iterative process. As relevant data (described above) is collected, it will be disseminated from the Fish Program to the Access Study team. To maximize communication among the Fish Study Program, study leads will participate in regularly scheduled internal meetings where preliminary data will be presented and implications to other studies discussed. Two milestone deliveries are anticipated of data that has been subject to QA/QC procedures: (1) the 2012 Upper River Fish Barrier Study will be incorporated in Q1 2013, and (2) video habitat assessment data of Deadman Creek will be available in Q4 2013. The Access Study will also provide findings as output information to the Upper River Fish Distribution and Abundance Study (Section 9.5).

9.13.8. Level of Effort and Cost

This study will require that data be collected over at least two field seasons, primarily to accommodate potential refinements in Project design. AEA anticipates that data will be collected over a broader study area in 2013, for example, within the larger access corridors shown in Figure 9.13-1. As elements of the Project are refined and specific crossing locations are chosen, additional sites may need to be sampled and the collection of more detailed, site-specific information may be necessary at selected crossing sites throughout the study area.

The study will require at least one part-time senior biologist as study lead and additional support staff including multiple field biologists, a Geographic Information System (GIS) team, and administrative staff. The 2013 field effort will require helicopter support for a minimum of two field teams to collect fish and habitat data at potential water body crossings over the span of approximately 30 field days. The remainder of the 2013 study effort will be office-based, with data entry and quality assurance/quality control, analysis, GIS and database queries, and report development. AEA anticipates that the study area within which additional data will need to be collected in 2014 will be refined and therefore reduced. AEA estimates the 2014 field effort will require helicopter support for potentially two field teams for up to 20 days. The remainder of the 2014 effort will be office-based.

The initial cost estimate for completion of the study objectives for all three access corridors is roughly $600,000 for the two-year study period. However, costs could be reduced if the number of proposed corridors is reduced and the alignment(s) is refined for year 2014.

9.13.9. Literature Cited

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9.13.10. Tables

Table 9.13-1. Preliminary schedule for the Aquatic Resources Study within the access alignment, transmission alignment, and construction area.

Activity	2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Existing Information Summary	- - - -				- - - -				
Fish Distribution Surveys		—	—	—		—	—	—	
Aquatic Habitat Surveys		—	—	—		—	—	—	
Data Analysis and Reporting				—	Δ			—	▲

Legend:

— Planned Activity
- - Follow- up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

9.13.11. Figures

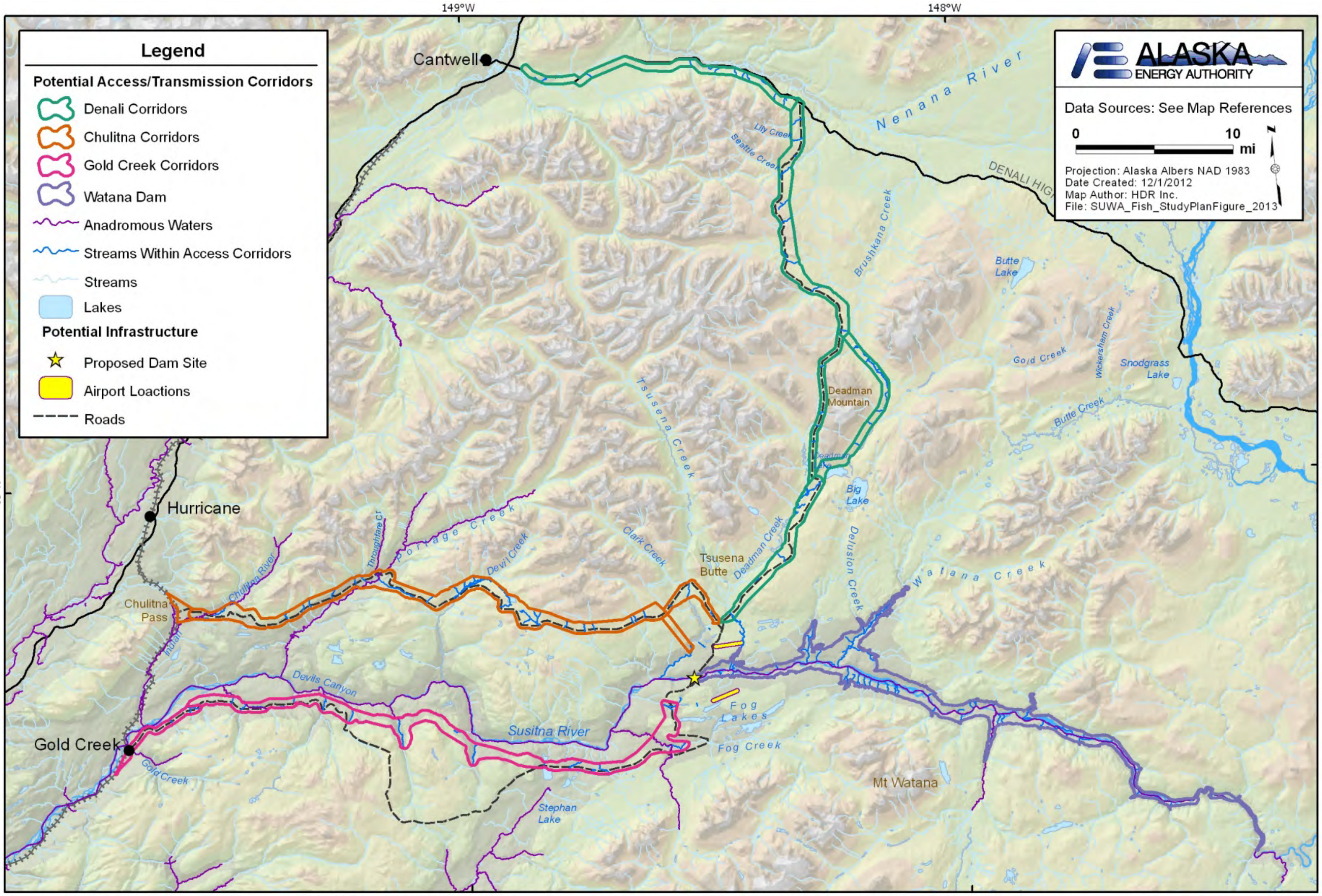

Figure 9.13-1. Study area for aquatic resources in the potential access and/or transmission alignment corridors.

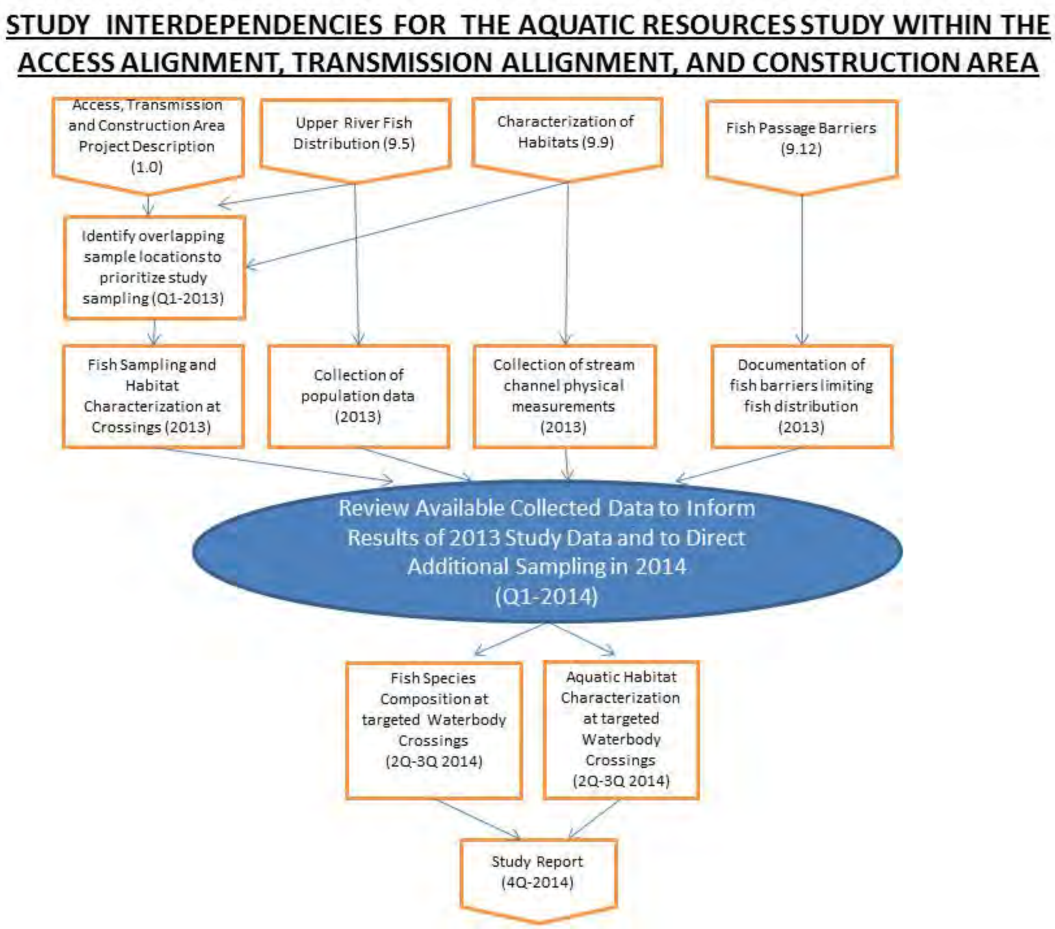

Figure 9.13-2. Study interdependencies for Aquatic Resources Study within the access alignment, transmission alignment, and construction area.

9.14. Genetic Baseline Study for Selected Fish Species

9.14.1. General Description of the Proposed Study

Construction and operation of the Project will modify the flow, thermal, and sediment regimes of the Susitna River, which may alter the composition and distribution of fish populations.

Genetic analysis methods can be used to address several goals associated with assessing potential Project impacts. First, there is a potential for the Project to affect genetic diversity and local adaptation of fish populations. Second, genetics can be used as a tool to assess other forms of impacts, however the usefulness of genetics as a tool to assess other impacts derives from the degree of population segregation of particular species among areas of the Susitna watershed. If breeding isolation among areas occurs over sufficient time, the unique genetic characteristics act as naturally occurring "tags" of spawning populations.

As part of the first application of genetics, this study will develop a repository of fish tissues from many resident and anadromous fish for use with future studies that may be needed to characterize the genetic legacy and variation for species and populations of interest. As a tool for assessing non-genetic impacts, this study will provide a means of assessing the degree to which Chinook salmon from the Middle and Upper River rear in areas downstream of the Middle River. If known to occur, such information alters the methods that are needed to characterize potential effects of the Project. For example, monitoring the abundance of Chinook salmon smolt leaving the Middle River to the sea would underestimate the actual contribution of the Middle and Upper River to the overall Susitna Chinook salmon population.

This work will be conducted through collaboration among Alaska Energy Authority (AEA), Alaska Department of Fish and Game (ADF&G), and other licensing participants. Information developed in this study may also assist in the development of protection, mitigation, or enhancement measures to address potential adverse Project impacts to salmonid resources, as appropriate.

Study Goals and Objectives

The goals of this study are to (1) acquire genetic material from samples of selected fish species within the Susitna River drainage, (2) characterize the genetic structure of Chinook salmon in the Susitna River watershed and (3) assess the use of Lower and Middle River habitat by juvenile Chinook salmon originating in the Middle and Upper Susitna River.

Objectives:

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.

9.14.2. Existing Information and Need for Additional Information

The baseline genetics data in the Susitna River is limited to the five Pacific salmon species. Assessing genetic relatedness and isolation of fishes in the watershed can be used to help determine potential impacts from the Project. Interbreeding among areas might be hindered by the Project, thereby potentially reducing the fitness of some stocks of resident fishes. Breeding isolation of stocks may be a sign of uniquely adapted traits for particular features of the habitats; such information would alter the impact assessment, and possibly the design of any proposed mitigation measures. To characterize relatedness and any isolation of particular resident fishes, tissue samples for genetic analysis must be collected from a range of locations.

Tissue collections and genetic analyses of Pacific salmon stocks in Alaska are relatively well developed and are used for applied research in several watersheds. The Susitna River salmon stocks are not well represented in the state's tissue repository, and samples obtained here will enable the application of genetic methods to address the four objectives listed above. The genetics samples collected during this study will be used to create a genetic respository for Susitna River fishes and will provide additional data to characterize the genetic baseline for Susitna River salmon populations. Furthermore, this genetic information will help increase our knowledge of the population structure and life history expression of Susitna River Chinook salmon.

9.14.2.1. Uncertainty in Assessing Chinook Population Structure

During the 2012 season, Chinook salmon ascended and remained above Devils Canyon during the spawning season. Ten of these fish from Kosina Creek were sampled for genetics. This observation leads to questions about whether these fish represent self-sustaining population(s) (Hypothesis 1), or, they are individuals originating from other geographic spawning aggregates (Hypothesis 2; e.g., Portage Creek), or are some combination of a local population and a nearby stock (s).

Genetic analysis can help to distinguish between these hypotheses, especially when combined with radio-tagging results from the Salmon Escapement Study, (Section 9.7). Distinguishing can be done by examining the genetic profile of fish above Devils Canyon (and their behavior) relative to other nearby spawning aggregates within the drainage, and by examining how stable the genetic profiles of these fish are through time. Non-divergent (i.e., similar) genetic profiles from those in nearby potentially-contributing spawning aggregates would indicate that the fish ascending Devils Canyon are likely strays or colonizers, but have not established into a self-sustaining population (support for Hypothesis 2). It may be possible to sample sufficient numbers of fish from the three years of this study to address Hypothesis 2 (i.e., no divergence seen from a sufficiently large sample). However, providing evidence for Hypothesis 1 may be difficult in three years, even if a large number of fish can be sampled in locations above and below Devils Canyon if the samples do not represent fish from multiple cohorts and/or our ability to detect a trend is weak.

High divergence from likely contributing spawning aggregates could mean either: a self-sustaining population with little genetic flow with other populations (Hypothesis 1a) or a recent colonization event(s) with small numbers of successfully contributing families (Hypothesis 1b). (A recent colonizing attempt with small number of successfully contributing families is likely an indication of a non-self-sustaining spawning aggregate.) The stability of genetic profiles through time (i.e., temporal stability of allele frequencies) can provide a means to start to distinguish between these two hypotheses (1a and 1b). Stable genetic profiles from aggregates above Devils Canyon would support Hypothesis 1a. A lack of temporal stability of allele frequencies would support Hypothesis 1b. The statistical power to detect temporal stability of allele frequencies is only possible with samples obtained over multiple years and across cohorts of returning salmon. Therefore, sampling across three years (2012-14) to assess temporal stability in allele frequencies from fish above Devils Canyon, given potentially low numbers of fish available for sampling, may limit the ability to conclusively distinguish between Hypothesis 1a and 1b. Finally, samples from three calendar years may represent fish from as many as 5 or 6 brood years given the multiple ages of maturity in any given year. If large numbers of fish could be sampled in each of the remaining calendar years (2013 and 2014), it may be possible to detect instability in allele frequencies if it existed (some support for Hypothesis 1a).

In summary, the degree of genetic divergence between fish sampled from above and below Devils Canyon in 2012–2014 will dictate the ability to rule out or support local adaptation. A lack of divergence from a sufficiently large set of samples would provide an indication that these are not different spawning aggregates; high divergence would likely require more years to answer the question than with the new information from 2013/2014.

9.14.2.2. Approach to Study Design and Implementation, Chinook Salmon above Devils Canyon

The sample sizes, and geographic and temporal scope of sampling from the Upper, Middle, and Lower River required to address the issue of the genetic divergence/uniqueness of Chinook salmon above Devils Canyon will be a function of the following:

- Numbers of fish passing through the canyon in 2013 and 2014.
- The age structure of fish sampled for genetics.
- The degree of genetic divergence and temporal stability between fish above and below Devils Canyon.
- The behavior of radio-tagged salmon below and above Devils Canyon.
- Genetics baseline information on the distribution of any spawning aggregates not currently known.

Given the outcome of each of these is unknown, AEA proposes a comprehensive sampling effort to help answer as many or all possible hypotheses about the genetic structure of Chinoook salmon in the Middle and Upper River. Some outcomes may preclude or significantly affect which and what numbers of samples to analyze. In addition to many sources of opportunistic sample collection (Sections 9.5, 9.6, and 9.7), this study plan includes dedicated sampling effort by a field crew for 2 months each year during the spawning period of adult salmon.

To ensure that data sources (and hypotheses) are rigorously examined, AEA will work closely with geneticists from State and Federal genetics laboratories. This collaboration will come in the form of formal contracting to ADF&G's Gene Conservation Lab, and through regular updates to the agency Technical Workgroup (TWG) over the course of 2013 and 2014, when federal and other geneticists can provide input to the developing information set that includes results from the genetic analyses and the radio telemetry study. Detailed annual project operational plans will be prepared and circulated to TWG members by April 30 of 2013 and 2014. These plans will establish additional details for field sampling efforts, including relative priorities, and temporal and spatial sampling considerations, beyond those presented in this document.

9.14.3. Study Area

The study area encompasses the Susitna River and its tributaries from Cook Inlet upstream to the Oshetna River confluence (river mile [RM] 233.4). For baseline data related to stock-specific sampling, there is an emphasis on tributaries of the Middle River and the Upper River. For assessing habitat use (juveniles) of fish originating in the Middle and Upper River, Chinook salmon tissues from juveniles will be collected in the Lower River (< RM 98).

9.14.4. Study Methods

9.14.4.1. Samples to Collect

The annual targets for data collection to meet the study objectives are indicated below. The sample sizes associated with each collection listed below represent a target rather than a sample size requirement because the abundance of each species or sub-stock is currently unknown. For baselines used for stock composition estimates, we used a sample size of 100 fish per population (Allendorf and Phelps 1981; Waples 1990). For mixtures used in stock composition estimates, we used a sample size of 200 fish or 100 fish per collection to provide stock composition estimates that are within 7% and 10%, of the true estimate 95% of the time, respectively (Thompson 1987). Sample sizes of 50 fish for other species are adequate to estimate allele frequencies for coarse-scale genetic population structure (Nei 1978).

- Collect tissue samples to obtain samples from at least 100 (total archived and new samples) spawning Chinook salmon from any Susitna River tributary with evidence of Chinook spawning (Table 9.14-1; Objectives 1 and 2).
- Collect tissue samples to obtain samples from at least 100 (total archived and new samples) spawning Chinook salmon from flanking region (Knik Arm and northwestern Cook Inlet) tributaries with evidence of Chinook spawning (Table 9.14-1; Objectives 1 and 2).
- Collect 100 tissue samples from each spawning aggregate of pink, sockeye, chum, and coho salmon from the Susitna River upstream of the Three Rivers Confluence (Objective 1).
- Collect 200 tissue samples from juvenile Chinook salmon at each of the following: Chinook Creek, Oshetna River, Indian River, Portage Creek, the mainstem Susitna River upstream of the Three Rivers Confluence, as well as Talkeetna and Chulitna rivers (1,400 fish; Objectives 1, 2, and 3).
- Collect 100 juvenile Chinook salmon from 16 sites across five mainstem habitat types in the Lower Susitna River (1,600 fish; Objective 3).
- Collect 50 representative samples from each of the species listed in the Table 9.14-2, with an emphasis on fish collected in the Middle and Upper Susitna River (Objective 4).

The Project scope includes a dedicated team of two people and logistics support for two months each year to collect samples. The efforts by this study team will be in addition to the sample collection efforts that will be done by the study teams associated with fish distribution in the Lower, Middle, and Upper River (Sections 9.5 and 9.6) and Salmon Escapement (Section 9.7).

9.14.4.2. Tissue Storage

While in the field, tissue samples will be preserved in ethyl alcohol in a 125–500 milliliter (ml) bulk sample bottle for each location. After samples are received by the Gene Conservation Laboratory (GCL), samples will be preserved as follows: At least five pieces of each sample will be placed into plastic plates and freeze-dried. Once dry, moisture-indicating desiccant beads will be added and the plate sealed completely with aluminum foil heat-activated tape. Tissue samples will then be stored at room temperature.

9.14.4.3. Laboratory Analysis

DNA from the baseline collections will be extracted from axillary processes using DNeasy 96 tissue kits. Chinook salmon samples will be analyzed for at least 96 single nucleotide polymorphism (SNP) markers and 13 microsatellite markers.

The DNA samples will be analyzed using Fluidigm 96.96 Dynamic Arrays (http://www.fluidigm.com). The Fluidigm 96.96 Dynamic Array contains a matrix of integrated channels and valves housed in an input frame. On one side of the frame there are 96 inlets to accept the sample DNA from each individual fish and on the other are 96 inlets to accept the assays for each SNP marker. Once in the wells, the components are pressurized into the chip using the IFC Controller HX (Fluidigm). The 96 samples and 96 assays are then systematically combined into 9,216 parallel reactions. Each reaction is a mixture of 4 microliters (μl) of assay mix (1x DA Assay Loading Buffer [Fluidigm], 10x TaqMan SNP Genotyping Assay [Applied Biosystems], and 2.5x ROX [Invitrogen]) and 5 μl of sample mix (1x TaqMan Universal Buffer [Applied Biosystems], 0.05x AmpliTaq Gold DNA Polymerase [Applied Biosystems], 1x GT Sample Loading Reagent [Fluidigm], and 60-400ng/ul DNA) combined in a 6.7 nanoliter (nL) chamber. Thermal cycling is performed on an Eppendorf IFC Thermal Cycler as follows: an initial “hot mix” of 30 minutes at 70^{o}C, and then denaturation of 10 minutes at 96°C followed by 40 cycles of 96^{o}C for 15 seconds and 60^{o}C for 1 minute. The Dynamic Arrays are read on a BioMark Real-Time PCR System (Fluidigm) after amplification and scored using Fluidigm SNP Genotyping Analysis software.

For some SNP markers, genotyping will be performed in 384-well reaction plates. Each reaction is conducted in a 5 μL volume consisting of 5–40 ng of template DNA, 1x TaqMan Universal PCR Master Mix (Applied Biosystems), and 1x TaqMan SNP Genotyping Assay (Applied Biosystems). Thermal cycling is performed on a Dual 384-Well GeneAmp PCR System 9700 (Applied Biosystems) as follows: an initial denaturation of 10 minutes at 95°C followed by 50 cycles of 92°C for 1 second and annealing/extension temperature for 1.0 or 1.5 minutes. The plates are scanned on an Applied Biosystems Prism 7900HT Sequence Detection System after amplification and scored using Applied Biosystems’ Sequence Detection Software (SDS) version 2.2.

For microsatellite markers, samples will be assayed for DNA loci developed by the Genetic Analysis of Pacific Salmon group funded by the Pacific Salmon Commission for use in U.S.-

Canada Treaty fisheries. Polymerase chain reaction (PCR) will be carried out in 10ul reaction volumes (10mM Tris-HCl, 50mM KCl, 0.2 mM each dNTP, 0.5 units Taq DNA polymerase (Promega, Madison, WI)) using an Applied Biosystems (AB, Foster City CA) thermocycler. Primer concentrations, MgCl concentrations and the corresponding annealing temperature for each primer are available upon request. PCR Fragment analysis will be done on an AB 3730 capillary DNA sequencer. 0.5ul PCR product will be loaded into a 96 well reaction plate along with 0.5ul of GS500LIZ (AB) internal lane size standard and 9.0ul of Hi-Di (AB). PCR bands will be visualized and separated into bin sets using AB GeneMapper software v4.0.

All genotypes collected will be entered into the GCL Oracle database, LOKI. Quality control measures include re-extraction and re-analysis of 8 percent of each collection for all markers to ensure that genotypes are reproducible and to identify laboratory errors and rates of inconsistencies. Genotypes are assigned to individuals using a double-scoring system.

9.14.4.4. Data Retrieval and Quality Control

Genotypes will be retrieved from LOKI and imported into *R* (R Development Core Team 2011) with the *RODBC* package (Ripley 2010). All subsequent analyses will be performed in *R*, unless otherwise noted.

Prior to statistical analysis, three analyses will be performed to confirm the quality of the data. First, SNP markers will be identified that are invariant in all individuals or that have very few individuals with the alternate allele in only one collection. These markers will be excluded from further statistical analyses. Second, individuals will be identified that are missing substantial genotypic data because they likely have poor quality DNA. Individuals missing substantial genotypic data will be identified using the 80 percent rule (missing data at 20 percent or more of loci; Dann et al. 2009). These individuals will be removed from further analyses. The inclusion of individuals with poor quality DNA might introduce genotyping errors into the baseline and reduce the accuracies of mixed stock analyses.

The final QC analysis will identify individuals with duplicate genotypes and remove them from further analyses. Duplicate genotypes can occur as a result of sampling or extracting the same individual twice, and will be defined as pairs of individuals sharing the same alleles in 95 percent of screened loci. The sample with the most missing genotypic data from each duplicate pair will be removed from further analyses. If both samples have the same amount of genotypic data, the first sample will be removed from further analyses.

9.14.4.5. Genetic Baseline Development

9.14.4.5.1. Hardy-Weinberg Expectations

For each locus within each collection, tests for conformance to Hardy-Weinberg expectations (HWE) will be performed using Monte Carlo simulation with 10,000 iterations in the *Adegenet* package (Jombart 2008). Probabilities will be combined for each collection across loci and for each locus across collections using Fisher's method (Sokal and Rohlf 1995), and collections and loci that violated HWE will be excluded from subsequent analyses after correcting for multiple tests with Bonferroni's method (α = 0.05 per number of collections).

9.14.4.5.2. Pooling Collections into Populations

When appropriate, collections will be pooled to obtain better estimates of allele frequencies following a step-wise protocol. First, collections from the same geographic location, sampled at similar calendar dates but in different years, will be pooled, as suggested by Waples (1990). Then differences in allele frequencies between pairs of geographically proximate collections that were collected at similar calendar dates and that might represent the same population will be tested. Collections will be defined as being “geographically proximate” if they were collected within the same river. Fisher’s exact test (Sokal and Rohlf 1995) of allele frequency homogeneity will be used, and decisions will be based on a summary across loci using Fisher’s method. Collections will be pooled when tests indicate no difference between collections ($P > 0.01$). When all individual collections within a pooled collection are geographically proximate to other collections, the same protocol will be followed until significant differences are found between the pairs of collections being tested. After this pooling protocol, these final collections will be considered to be populations. Finally, populations will be tested for conformance to HWE following the same protocol described above to ensure that pooling was appropriate, and that tests for linkage disequilibrium will not result in falsely positive results due to departure from HWE.

9.14.4.5.3. Linkage Disequilibrium

Linkage disequilibrium between each pair of nuclear markers will be tested for in each population to ensure that subsequent analyses are based on independent markers. The program *Genepop* version 4.0.11 (Rousset 2008) will be used with 100 batches of 5,000 iterations for these tests. The frequency of significant linkage disequilibrium between pairs of SNPs ($P < 0.05$) will then be summarized. Pairs will be considered linked if they exhibited linkage in more than half of all populations.

9.14.4.6. Analysis of Genetic Structure

9.14.4.6.1. Temporal Variation

Temporal variation of allele frequencies will be examined with a hierarchical, three-level analysis of variance (ANOVA). Temporal samples will be treated as sub-populations based on the method described in Weir (1996). This method will allow for the quantification of the sources of total allelic variation and permit the calculation of the among-years component of variance and the assessment of its magnitude relative to the among-population component of variance. This analysis will be conducted using the software package *GDA* (Lewis and Zaykin 2001).

9.14.4.6.2. Hierarchical Log-likelihood Tests

Genetic diversity will be examined with a hierarchical log-likelihood ratio (G) analysis.

9.14.4.6.3. Visualization of Genetic Distances

To visualize genetic distances among collections, two approaches will be used. Both approaches are based on pairwise F_{ST} estimates from the final set of independent markers with the package *hierfstat* (Goudet 2006). The first approach is to construct 1,000 bootstrapped neighbor-joining

(NJ) trees by resampling loci with replacement to assess the stability of tree nodes. The consensus tree will be plotted with the *APE* package (Paradis et al. 2004). While these trees provide insight into the variability of the genetic structure of collections, pairwise distances visualized in three dimensions are more intuitive. In a second approach, pairwise F_{ST} will be plotted in a multidimensional scaling (MDS) plot using the package *rgl* (Adler and Murdoch 2010).

9.14.4.6.4. Estimating Effective Population Size

Effective population size will be measured using single-year sample (Tallmon et al. 2008), multiple-year sample (Waples 1991, Tallmon et al. 2004), linkage disequilibrium (Waples 2006), and heterozygote excess (Luikart and Cornuet 1999) methods. Effective population size estimates will be compared with estimates of the numbers of fish acending Devils Canyon based on tagging data to measure genetic success rate of fish acending the Canyon.

9.14.4.7. Habitat Utilization in the Lower River by Chinook Salmon Progeny Originating in the Middle and Upper Susitna River

If the results of the Chinook salmon genetics studies conducted during 2012 are sufficient to indicate that the Chinook salmon spawning upstream of Devils Canyon and in the Middle River and its tributaries are sufficiently unique, ADF&G will characterize the presence and relative proportion of fish originating from the Upper and Middle River in selected Lower River habitats.

In both 2013 and 2014, 75 juvenile Chinook salmon from each of 16 mainstem locations (across five habitat types) will be collected and preserved as outlined above. These 1,200 tissue samples collected in each year will be analyzed and the results will be pooled into a range of spatial strata to identify any Middle and Upper River fish, and where feasible, estimate the proportion of fish originating from upstream of the Three Rivers Confluence (RM 98).

9.14.5. Consistency with Generally Accepted Scientific Practice

Each method described above employs scientifically accepted principles as noted by regular citations of peer reviewed methods, where they are presented. The laboratory and analytical methods to be used for this study are widely applied in North America and Asia to characterize the origin and genetic variation in salmonid and non-salmonid fish species. ADF&G’s Gene Conservation Laboratory (GCL) located in Anchorage, Alaska, is on the leading edge of applied fish genetics, and it has a long history of publishing techniques and results from its studies in the peer-reviewed literature. GCL personnel serve on many multi-national scientific work groups from around the Pacific Rim.

9.14.6. Schedule

- Baseline sample collection: June through October 2013 and 2014 (in conjunction with other AEA field studies) (see Table 9.14-3).
- Mixture sample collection from the Lower River: June through August 2013 and 2014.
- Analysis of juvenile and adult Chinook salmon tissue: November 2013 through December 2014.

- Initial and Updated Study Reports explaining actions taken and data collected to date will be issued within 1 and 2 years, respectively, of FERC's Study Plan Determination (i.e., February 1, 2013).

9.14.7. Relationship with Other Studies

The Genetic Baseline Study for Selected Fish Species will interrelate with six other AEA Project studies (Figure 9.14-1). Four studies will provide input as predecessor studies and two that receive output from the genetic study. The four predecessor studies each provide "information" input in the form of fish tissue samples and observations to help meet the sample sizes specified in the design of the fish genetic study. Coordination among studies will be critical to meet the objectives of this study, and the predecessor studies and successor studies. The four predecessor studies providing these samples or information to help collect these samples by the dedicated sampling team are: the Upper River Fish Distribution Study (Section 9.5), the Middle and Lower River Fish Distribution Study (Section 9.6), the Salmon Escapement Study (Section 9.7), and the Eulachon Study (Section 9.16). Output from the fish genetic study will include information on the genetic structure of Chinook salmon; depending on the results, this information may be useful to the Middle and Lower River Fish Distribution Study (Section 9.6), the Salmon Escapement Study (Section 9.7) and the Fish Passage Feasibility (Section 9.11).

9.14.8. Level of Effort and Cost

The total estimate for the cost of the study over two years is approximately $900,000. The estimated cost for each of the four study objectives described above is as follows:

1) $50,000 annually
2) $170,000 annually
3) $150,000 annually
4) $80,000annually

9.14.9. Literature Cited

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9.14.10. Tables

Table 9.14-1. Area, location, and sublocation of desired baseline samples of adult Chinook salmon spawning aggregates for genetic analysis. Samples (Total) and sample years for collections in the Gene Conservation Laboratory archives, desired remaining nmber (Need), and number slated for genetic analysis (To analyze) and indicated. Some systems listed may not have spawning stocks in them, including some of those noted from above Devils Canyon.

Area	Location	Sublocation	Year(s) Collected	Total	Need	To analyze
West Cook Inlet						
	Chuitna River		2008, 2009	142	0	96
	Beluga River	Coal Creek	2009, 2010, 2011	120	0	96
	Theodore River		2010, 2011, 2012	189	0	96
	Lewis River		2011, 2012	86	10	96
Yentna Drainage						
	Clearwater Creek		2012	25	71	96
	Red Creek		2012	29	67	96
	Happy River		2012	19	77	96
	Red Salmon Creek		2012	12	84	96
	Hayes River tributary		2012	5	91	96
	Canyon Creek		2012	32	64	96
	Talachulitna River		1995, 2008, 2010	180	0	96
	Lake Creek	Sunflower Creek	2009, 2011	127	0	96
	Kahiltna River	Peters Creek	2009, 2010, 2011, 2012	110	0	96
Susitna Drainage						
	Chulitna River	East Fork	2009, 2010, 2011	13	83	96
		Middle Fork	2009, 2010	169	0	96
		Honolulu Creek			96	96
		Byers Creek			96	96
		Troublesome Creek			96	96
		Spink Creek			96	96
		Tokosintna River (Bunco Creek)			96	96
	Indian River		2012	1	95	96
	Portage Creek		2009, 2010, 2011	141	0	96
	Susitna above Devils Canyon	Kosina Creek	2012	10	86	96
		Chinook Creek			96	96
		Fog Creek			96	96
		Tsusena Creek			96	96
		Watana Creek			96	96
		Devils Creek			96	96
		Oshetna River			96	96
	Talkeetna River	Upper mainstem			96	96
		Stephan Lake weir	2008	19	77	96
		Prairie Creek	1995, 2008	150	0	96
		Disappointment Creek			96	96
		Larson Creek			96	96
		Chunilna Creek (Clear Creek)	2009, 2012	130	0	96
	Brich Creek				96	96
	Montana Creek		2008, 2009, 2010	218	0	96
	Sheep Creek				96	96
	North Fork Kashwitna				96	96

Area	Location	Sublocation	Year(s) Collected	Total	Need	To analyze
	Little Willow Creek				96	96
	Willow Creek		1991,1997, 2005, 2009	309	0	96
	Deshka River	Moose Creek	1995, 2012	103	0	96
		Deshka River weir	2005	200	0	96
	Alexander Creek	Sucker Creek	2011, 2012	143	0	96
Knik Arm						
	Matanuska River	Kings River			96	96
		Granite Creek			96	96
		Moose Creek	1995, 2008, 2009, 2012	155	0	96
	Eagle River	South Fork	2009, 2011, 2012	73	23	96
		Meadow Creek	2009	6	90	96
	Ship Creek		2009	311	0	96
	Little Susitna River		2009, 2010	125	0	96
Total					2838	4896

Table 9.14-2. Potential Susitna River fish species for targeted for genetic analysis sampling.

Common Name	Scientific Name
rainbow trout	*Oncorhynchus mykiss*
humpback whitefish	*Coregonus pidschian*
round whitefish	*Prosopium cylindraceum*
lake whitefish	*Coregonus clupeaformes*
Alaska whitefish	*Coregonus nelsonii*
Bering cisco	*Coregonus laurettae*
eulachon	*Thaleichthys pacificus*
Pacific lamprey	*Lampetra tridentata*
longnose sucker	*Catostomus catostomus*
slimy sculpin	*Cottus cognatus*
prickly sculpin	*Cottus asper*
coastal range sculpin	*Cottus aleuticus*
Pacific staghorn sculpin	*Leptocuttus armatus*
Burbot	*Lota lota*
Arctic grayling	*Thymallus arcticus*
Dolly Varden	*Salvelinus malma*
lake trout	*Salvelinus namaycush*
northern pike	*Esox lucius*
threespine stickleback	*Gasterosteus aculeatus*
ninespine stickleback	*Pungitius pungitius*
Alaska blackfish	*Dallia pectoralis*

Table 9.14-3. Preliminary schedule for the Genetic Baseline Study for Selected Fish Species.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Sample Collection						——	——	——		——	——	——	
Initial Study Report								——	——Δ				
Sample analysis								——	——	——	——		
Updated Study Report											——	——	——▲

<u>Legend:</u>

——Planned Activity
----- Follow-up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

9.14.11. Figures

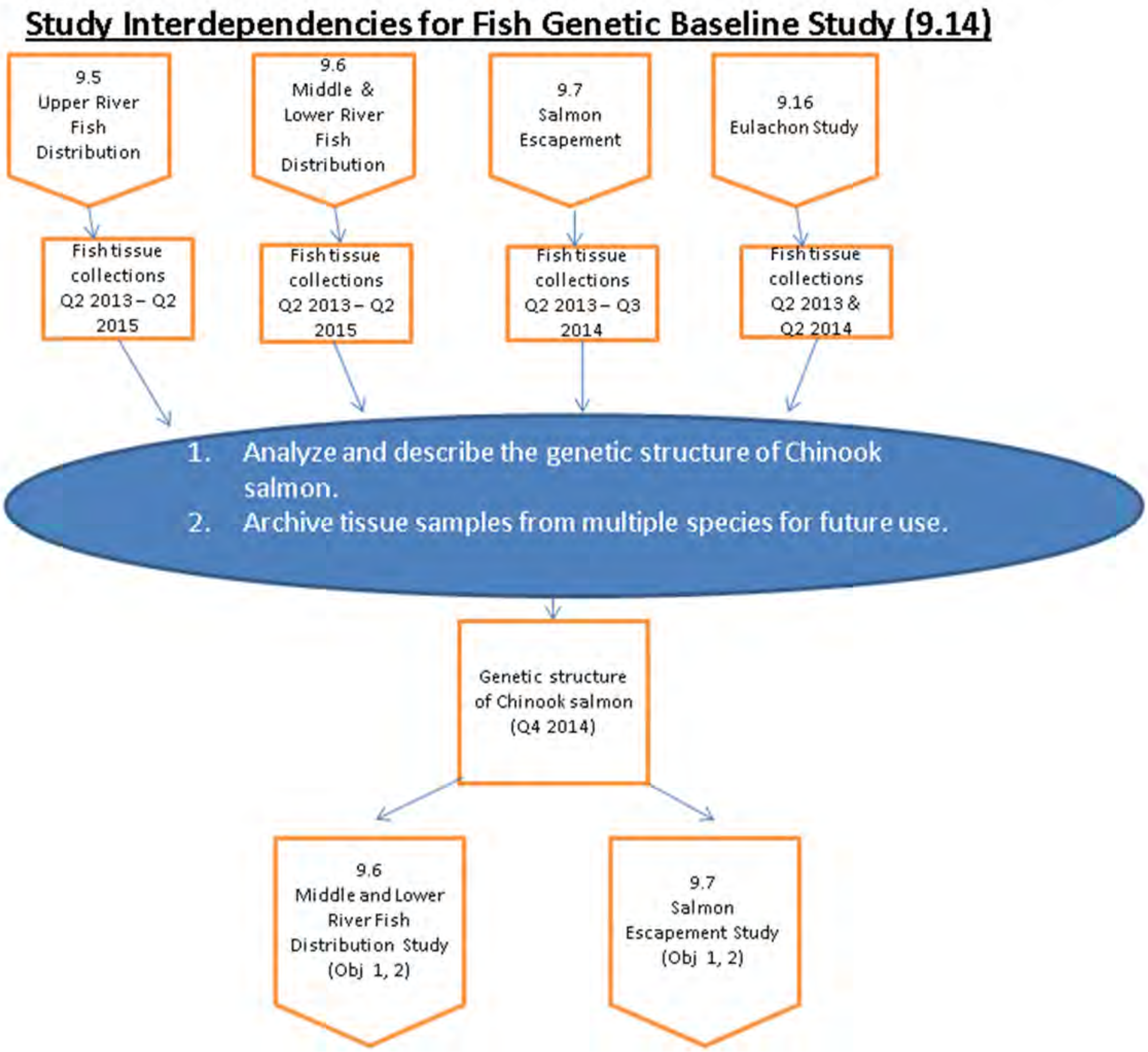

Figure 9.14-1. Study interdependencies for the Genetic Baseline Study for Selected Fish Species.

9.15. Analysis of Fish Harvest in and Downstream of the Susitna-Watana Hydroelectric Project Area

9.15.1. General Description of the Proposed Study

Information from this fish harvest study will be used in combination with other studies to inform the licensing process by analyzing baseline harvest data from the Project area downstream to where the Susitna River joins Upper Cook Inlet and into the marine waters of the Upper Cook Inlet commercial fisheries management area (Figure 9.15-1). This study will provide a basis for assessing impacts on fisheries resources and developing protection, mitigation, and enhancement measures, if necessary.

Study Goals and Objectives

The goal of this study is to compile and analyze baseline information on the harvests of resident and anadromous fishes in and downstream of the proposed Project area to understand the potential for Project construction and operation to alter harvest levels and opportunity. This study has two primary objectives:

1. Describe baseline harvest levels and harvest locations for commercial, sport, personal use, and subsistence fisheries for Susitna-River-origin resident and anadromous fish.
2. Describe the potential for the Project to alter harvest levels and opportunities on Susitna-River-origin resident and anadromous fish based on potential Project-induced changes in fish abundance and distribution from flow- and habitat-related changes as estimated from other Project studies.

9.15.2. Existing Information and Need for Additional Information

The Alaska Department of Fish and Game (ADF&G) documents legal catches from commercial, sport, personal use, and subsistence fisheries. Fishing effort and harvest success data are collected annually by fishery, management area, district, subdistrict, and in some cases by smaller statistical harvest reporting areas. Historic harvest statistics are stored by ADF&G in statewide databases.

9.15.2.1. Commercial Fisheries

The Susitna River watershed is within the Upper Cook Inlet Management Area (UCIMA) for commercial fisheries. Commercial salmon fisheries in the UCIMA target salmon stocks bound for the major river systems of Cook Inlet, including the Susitna River. Salmon are harvested during seasons and according to regulations established by the Alaska Board of Fisheries. The ADF&G Division of Commercial Fisheries, based in Soldotna, monitors salmon returns in Cook Inlet and sets fishing periods based on the perceived strength of the returns to achieve escapement goals for the major rivers of the area. The UCIMA includes central and northern districts (Figure 9.15-1), each being further divided into subdistricts (Shields and Dupuis 2012). Two commercial gear types are permitted in the limited entry commercial fishery: drift gillnets (Central District only) and set gillnets (allowed in portions of both districts). Commercial harvests are recorded at the time of sale on a fish ticket, which includes the date, location code (statistical area), and the number and pounds of each species of salmon delivered. These data are stored in a statewide fish ticket database.

Five species of Susitna River salmon are commercially harvested in Upper Cook Inlet: Chinook (*Oncorhynchus tshawytscha*), sockeye (*O. nerka*), chum (*O. keta*), pink (*O. gorbuscha*), and coho salmon (*O. kisutch*). Sockeye salmon make up the largest component of the harvest and commercial value. Harvest data are summarized and reported annually by the ADF&G Division of Commercial Fisheries (Shields and Dupuis 2012). The ADF&G Gene Conservation Laboratory has successfully used genetic mixed stock analysis techniques to identify stock-of-origin in commercial fishery catches such that the contribution of Susitna River-origin sockeye salmon can be estimated (Barclay et al. 2010). Efforts are underway to develop the baseline and resolution for other salmon species.

Eulachon (*Thaleichthys pacificus*), also known as smelt or hooligan, are harvested commercially in the UCIMA (Shields and Dupuis 2012; Shields 2005, 2010). Managed under the *Cook Inlet Smelt Fishery Management Plan* (5 AAC 21.505), the fishery has a harvest cap of 100 tons. Harvesters use dip nets, and a majority of the harvest is taken in the vicinity of the Susitna River delta. Harvest statistics have been reported since 1978; the 2011 season was the first year in which the harvest cap was reached (Shields and Dupuis 2012).

9.15.2.2. Sport Fisheries

The Susitna watershed lies within the Northern Cook Inlet Management Area (NCIMA) (Figure 9.15-2) established for the management of recreational fisheries. For the purposes of harvest reporting the NCIMA is divided into four subunits:

- Knik Arm Management Unit lying south of Willow Creek and east of the Susitna River.
- Eastside Susitna Management Unit including all waters of the Upper Susitna River above the Chulitna River to and including the Oshetna River.
- Westside Susitna Management Unit including the Chulitna and Yentna rivers.
- West Cook Inlet Unit including freshwater drainages entering Cook Inlet to the west of the Susitna River mouth (Figure 9.15-2).

Sport fisheries in the NCIMA are managed by the ADF&G Division of Sport Fisheries office in Palmer. The Statewide Harvest Survey (SWHS) annual postal survey of sport fish license holders is the primary method used by ADF&G to compile harvest estimates for NCIMA sport fisheries (Jennings et al. 2007). Sport fishing harvest and effort by species have been estimated and reported annually for the four NCIMA management units since 1977.

Sport fisheries in the NCIMA target the five species of Susitna River salmon, with coho salmon and Chinook salmon making up the largest contributions to the harvest (Jennings et al. 2007). Other species taken in the sport fishery, ordered by amount harvested, include northern pike (*Esox lucius*), rainbow trout (*O. mykiss*), Arctic grayling (*thymallus arcticus*), lake trout (*Salvelinus namaycush*), Dolly Varden (*S. malma*), burbot (*Lota lota*), round whitefish (*Prosopium cylindraceum*), and humpback whitefish (*Coregonus clupeaformis*) (Jennings et al. 2007).

9.15.2.3. Personal Use Fisheries

Three personal use fisheries currently occur within the NCIMA:

- A sockeye salmon dip net fishery at Fish Creek located in Knik Arm.
- A dip net fishery for Alaska residents 60 years or older at the Beluga River (to the west of the Susitna River mouth).
- A eulachon fishery in the Lower Susitna River (Oslund and Ivey 2010).

Participants in these fisheries obtain a permit from ADF&G and are required to record daily harvest information on the permit. Permits are returned to ADF&G at the end of the season. Personal use harvest data are reported annually in ADF&G annual management reports (for example, Ivey et al. [2009]).

9.15.2.4. Subsistence Fisheries

Subsistence fishing regulations in the Susitna River watershed are complex and restrictive. A portion of the watershed falls within a “nonsubsistence area” defined under the Alaska Administrative Code (AAC) 5 AAC 99.015 (3). Trout, char, grayling, and burbot may not be taken for subsistence in fresh water (5 AAC 01.575. (c)). The only subsistence salmon fishery authorized within the Susitna watershed is a fishwheel fishery on the upper Yentna River near the community of Skwentna (5 AAC 01.593). A subsistence gillnet fishery is authorized in the Tyonek drainage for whitefish (5 AAC 01.580), and smelt may be taken in fresh and salt water (5 AC 01.599). A coastal set gillnet subsistence fishery operates near the community of Tyonek in Northern Cook Inlet, which targets salmon returning to the Susitna and other river systems of northern Cook Inlet. Educational subsistence fisheries are permitted on the east side of the Central District between Kenai and Anchor Point.

Subsistence salmon harvest data are reported annually in ADF&G annual fishery management reports (for example Oslund and Ivey 2010, and Shields and Dupuis 2012) and in the Alaska subsistence salmon fisheries annual reports (for example, Fall et al. 2011). Additional data have been gathered in targeted studies (for example, Fall and Foster 1987). Historic subsistence harvest data are stored in the Alaska Subsistence Fisheries Database (ASFDB) managed by the ADF&G Division of Subsistence in Anchorage (Caylor and Brown 2006). Harvest data for non-salmon species may not be regularly reported.

9.15.2.5. Additional Information Needs

To assess potential Project effects on harvest rates, it is necessary to draw upon other studies that are designed to estimate abundance and distribution of the various fish stocks in the Susitna River system. Existing information includes fish spatial and temporal distribution and relative abundance information from recent and early 1980s studies. The *Aquatic Resources Data Gap Analysis* (HDR 2011) and the *Susitna-Watana Hydroelectric Project Pre-Application Document* (AEA 2011) summarized existing information and identified data gaps for adult salmon, resident and rearing fish, and for subsistence resources (Northern Land Research, Inc. 2011). In recent years, ADF&G has conducted adult salmon (sockeye, coho, and chum salmon) spawning distribution and abundance studies in the Susitna River (e.g., Yanusz et al. 2011, Merizon et al. 2010). In 2012, ADF&G expanded its scope to include Chinook and pink salmon. Concurrent studies to be conducted as part of the licensing process for the Project include salmon escapement and run apportionment, fish distribution and abundance in the Susitna River, characterization of aquatic habitats in the Susitna River, and subsistence use.

9.15.3. Study Area

The study area includes the Susitna River from its mouth upstream to and including the Oshetna River (river mile [RM] 233.4). The study area includes tributaries that are connected to the mainstem of the Susitna River and marine waters of Upper Cook Inlet where anadromous fish species originating from the Susitna River are intercepted in commercial fisheries north of the latitude of Anchor Point (59° 46.15’ N. lat.).

9.15.4. Study Methods

Baseline data on commercial, sport, personal use, and subsistence harvests of resident and anadromous fish in the Project area and other potentially affected areas downstream of the Project will be gathered and synthesized. Specific tasks include compilation and apportionment of ADF&G commercial harvest records, compilation of harvest and effort from sport fisheries, compilation of harvest and effort from personal use fisheries, compilation of subsistence harvest data, and evaluation of potential project effects. ADF&G opens and closes fishing areas each year by issuing emergency orders. These orders are necessary to achieve escapement goals for the various salmon returns to the Cook Inlet area as well as adhering to regulatory directives for allocation of harvest between user groups. To minimize the effect that emergency order closures may have on a given year, harvest data will be averaged over a 20-year time period.

These data will be used in combination with the results of fish abundance studies conducted as part of Project licensing to assess potential Project impacts; further, these data will feed into analyses to be completed by recreation, socioeconomic and subsistence study teams. Specific methods are detailed below.

9.15.4.1. Compilation and Apportionment of ADF&G Commercial Harvest Records

Evaluating potential Project effects on commercially harvested fish species is a two-step process to identify the following: (1) how many Susitna River fish are harvested in the area’s commercial fisheries, and (2) how many of those fish use mainstem Susitna River habitats that have the potential to be affected by the Project.

Investigators will contact ADF&G Commercial Fisheries staff in area and regional offices to better understand the spatial and temporal resolution of commercial harvest records in the UCIMA. Harvest statistics for each of the salmon species commercially harvested in the UCIMA are stratified spatially and temporally and are reported annually (Shields and Dupuis 2012). Investigators will compile a minimum of 20 years of harvest and effort statistics from the ADF&G statewide fish ticket database. Data will be requested at the smallest geographic reporting units (statistical areas) and time strata. The number of fish and pounds harvested by species, by day, and by harvest area will be compiled, and trends will be noted. Minimum, maximum, and mean harvest statistics will be calculated over the 20-year period. These data represent a mixture of stocks returning to a combination of river systems draining into Upper Cook Inlet. A review of available genetic stock identification studies will be used to estimate the proportion of Susitna River stocks in the harvest mixtures. Genetic stock composition data are of higher resolution for sockeye salmon (Barclay et al. 2010) than for other species, though some progress has been made apportioning chum and coho salmon stocks (Merizon et al. 2010). Species that lack sufficient genetic data for run apportionment will be assessed based on the best available geographic distribution and timing information from telemetry studies, escapement counts, and harvest reports.

Commercial harvest data from the eulachon fishery will be requested from the state database at the smallest temporal strata that will produce meaningful interpretation. Because of low participation, broad time strata may be required to prevent the identification of individual fishermen. Because the eulachon fishery takes place at the Susitna River mouth, all reported harvest will be assumed to represent stocks potentially affected by the Project.

9.15.4.2. Compilation of Harvest and Effort from Sport Fisheries

Sport fishery harvest and effort data for the 13 species identified in Section 9.15.2 will be compiled at the finest geographic resolution available for freshwater fisheries in the Susitna watershed. Catch, harvest, and angler-day information will be compiled for a minimum of 20 years, and minimum, maximum, and mean values calculated by geographic area. Sources of information will include annual management reports from the ADF&G Sport Fish Division (e.g., Ivey et al. 2009) and from statewide harvest reports (e.g., Jennings et al. 2007). ADF&G Division of Sport Fish Division staff will be interviewed to better interpret the data available from the SWHS, and to uncover whether focused creel surveys have been conducted in select Susitna tributaries. Geographic harvest reporting areas best conforming to the area of potential Project effects will be selected from the SWHS data. In general, SWHS estimates from smaller fisheries with low participation are less accurate than those of larger fisheries (Mills and Howe 1992). If the fishery size or level of participation is too small to be adequately assessed by the SWHS, qualitative information on angler success and participation will be obtained by interviewing guides, outfitters, fishery participants, and lodge owners operating in the Upper Susitna.

9.15.4.3. Compilation of Harvest and Effort from Personal Use Fisheries

Harvest and effort data will be compiled for the Fish Creek and Beluga River personal use salmon fisheries. Sources of information will include annual management reports from the ADF&G Sport Fish Division, for example Ivey et al. (2009). These fisheries target stocks returning to a number of river systems including the Susitna River; hence, the likelihood of detecting significant Project effects is low. Regardless, harvest and effort data will be compiled for the eulachon fishery at the mouth of the Susitna River from permit return data and annual reports produced by ADF&G.

9.15.4.4. Compilation of Subsistence Harvest Data

All Cook Inlet subsistence fisheries will be reviewed. However, due to their proximity to the Susitna River watershed it is likely that the only fisheries that would have any potential linkage to the Susitna Project are the Tyonek gillnet fishery and the Yentna fishwheel fishery. A minimum of 20 years of harvest and effort data will be compiled for the Tyonek Subdistrict subsistence gillnet fishery from the ASFDB and/or available reported harvest data. Because this is a marine fishery, an estimate will need to be made about the proportion of Susitna River stocks in the harvests. The estimate will use available genetic stock identification information (e.g., Barclay et al. 2010) and other sources such as run timing and proximity to other salmon systems. Harvest statistics will be compiled for the fishwheel fishery on the upper Yentna River near the community of Skwentna.

9.15.4.5. Evaluation of Potential Project Effects

Evaluating the potential for flow- and habitat-related changes to alter harvest rates for Susitna River fishery resources will require an integration of the results from multiple studies (Figure 9.15-3). Potential effects will differ based on species, fishery type, fishery location, life history and periodicity of affected species, and the magnitude of flow and habitat effects and other Project-related changes. The following studies initiated in 2012 and/or conducted during 2013–2014 will provide information useful for evaluating effects on fish harvest and opportunity.

- The *River Flow Routing and Instream Flow Models Data Collection* initiated in 2012 will predict stage versus discharge relationships for approximately 100 transects in the mainstem of the Susitna River below the proposed reservoir.
- The *Aquatic Habitat and Geomorphic Mapping of the Middle River Study* will provide a comparison of the habitat mapping conducted in the 1980s with habitat mapping developed at similar discharges in 2012. One of the intents of the *Geomorphic Mapping Study* is to help address the potential effect of Project operations on the stability of tributary mouths and access to tributaries within the Middle Susitna River. It is also intended to provide baseline information to evaluate the influence of Project-induced changes to mainstem water surface elevations in July through September on adult salmon access to upland sloughs, side sloughs, and side channels used for spawning.
- The *Fish Passage Barriers Study* (Section 9.12) will help inform how Project-induced changes to mainstem water surface elevations in July through September influence adult salmon access to upland sloughs, side sloughs, and side channels.
- The *Upper Susitna River Fish Distribution and Habitat Study* will quantify the amount of riverine habitat likely to be lost due to inundation and interruption of fish passage.
- The *Fish Distribution and Abundance Studies* in the Upper, Middle, and Lower Susitna River will provide necessary information on fish abundance by habitat type.
- The *Eulachon Distribution and Abundance Study* (Section 9.16) will estimate the abundance of eulachon in the Lower Susitna River.
- The *Susitna-Watana Instream Flow Study* (ISF) is focused on development of macrohabitat-specific models that can reliably estimate flow-habitat response patterns for different species and life stages of fish and other aquatic biota.
- The *Salmon Escapement and Run Apportionment Study* will provide a watershed perspective on the salmon returns to the Susitna River and apportion runs to the major tributaries (Yentna River, Chulitna River, Talkeetna River, etc.) as well as the mainstem areas potentially affected by the Project.

A synthesis of the results from these studies will be required to estimate Project effects on fisheries as a proportion of the returns to the entire Susitna watershed. It is important to note that there will be high inter-annual variability in fish abundance estimates used to quantify potential impacts; in some cases the error associated with these estimates may exceed harvest levels for a particular fishery. For this reason, potential changes to harvest level and opportunity will be expressed as a range.

Potential effects to marine fisheries

For commercial salmon fisheries in the Northern and Central Districts and the Tyonek subsistence salmon fishery, estimates of harvest rates for Susitna River stocks based on genetic stock allocation will be analyzed to quantify potential effects on harvests. Northern District set gillnet fisheries likely harvest a higher proportion of Susitna River salmon than Central District drift and set gillnet fisheries. Thus, effects will need to be assessed by district and on a gear type basis, taking the timing of fishery openings and closures into account. Outputs from the flow routing model and riverine process models developed as part of the instream flow studies will provide simulations of Project effects under various proposed operational scenarios. These localized effects from the models will need to be put into the context of population level of harvested species within the Susitna River system and the mixtures of Susitna River and non-Susitna River stocks in the marine fisheries in the Northern and Central districts of the UCIMA. Potential impacts will be analyzed over the 20-year record of harvest.

Potential effects to eulachon fisheries

Eulachon harvested in the commercial and personal use fisheries operating in the mouth of the Susitna River will be treated as a single stock in the effects analysis. Abundance estimates generated from the Eulachon Distribution and Abundance Study of the RSP, coupled with the reported harvest information, will be used to estimate exploitation rates for the years that abundance data are available. Quantitative estimates of Project effects resulting from proposed operational scenarios will be obtained from the flow routing model and riverine process models developed as part of the instream flow studies.

Potential effects to sport fisheries

Effects on sport fisheries will be analyzed spatially based on the four broad reporting areas and on a species-by-species basis within the Susitna River system. Potential Project effects within the reservoir and tributaries upstream of the proposed dam site will be assessed by studies conducted in 2013–2014 as part of the Project licensing process, i.e., the Fish Distribution and Abundance Study, the Aquatic Habitat Study, the Fish Passage Study, and the Instream Flow Study and related operational models. Analysis will be conducted on a species-by-species basis taking into account migratory versus non-migratory and other life history characteristics. The future Watana Reservoir Fish Community Study will provide information on potential sport fishing opportunities anticipated in the proposed Project reservoir.

Middle and Lower River sport fisheries will be analyzed spatially and on a species-by-species basis. Outputs from the flow routing model and riverine process models developed as part of the instream flow studies will provide quantitative results of Project effects under various proposed operational scenarios. These localized effects will need to be put into the context of the species populations within the major tributaries of the Susitna River system to estimate potential effects on harvest opportunity and catch rates.

9.15.5. Consistency with Generally Accepted Scientific Practices

This study plan was developed by fisheries scientists in consultation with ADF&G and the U.S. Fish and Wildlife Service (USFWS). The data used in this study have been and will be collected by ADF&G as part of its annual harvest assessments and rely upon regionally accepted methods for estimation of harvest.

9.15.6. Schedule

Harvest and effort statistics will be compiled in 2013 along with a synthesis of the best available genetic apportionment of salmon stocks harvested in commercial and subsistence fisheries (Table 9.15-1). Analyses of potential Project-related effects on harvest levels and opportunity will be conducted in 2014 as results from other Project studies become available. Initial and Updated Study Reports discussing actions taken to date will be issued within 1 and 2 years, , respectively, of FERC's Study Plan Determination (i.e., February 1, 2013).

9.15.7. Relationship with Other Studies

The Fish Harvest Study will interrelate with eight other AEA Project studies (Figure 9.15-3). Evaluating the potential for flow- and habitat-related changes to alter harvest rates for Susitna River fishery resources will require an integration of the results from multiple studies. The River Flow Routing and Instream Flow Study (Section 8.0) will predict stage versus discharge relationships for approximately 100 transects in the mainstem of the Susitna River below the proposed reservoir. The Aquatic Habitat (Section 9.9) and Geomorphic Mapping (Section 6.0) studies will provide a comparison of the habitat mapping conducted in the 1980s with habitat mapping developed at similar discharges in 2012. One of the intents of the Geomorphic Mapping Study is to help address the potential effect of Project operations on the stability of tributary mouths and access to tributaries within the Middle Susitna River. It is also intended to provide baseline information to evaluate the influence of Project-induced changes to mainstem water surface elevations in July through September on adult salmon access to upland sloughs, side sloughs, and side channels used for spawning. The Fish Passage Barriers Study (Section 9.12) will help inform how Project-induced changes to mainstem water surface elevations may influence adult salmon access to upland sloughs, side sloughs, and side channels. The Aquatic Habitat Study (Section 9.9) will quantify the amount of riverine habitat likely to be lost due to inundation and interruption of fish passage. The Lower/Middle (Section 9.5) and Upper (Section 9.6) Susitna River Fish Distribution and Abundance will provide necessary information on fish abundance by habitat type. The Eulachon Distribution and Abundance Study (Section 9.16) will estimate the abundance of eulachon in the Lower Susitna River. The Susitna-Watana Instream Flow Study (ISF, Section 8.0) is focused on development of macrohabitat-specific models that can reliably estimate flow-habitat response patterns for different species and life stages of fish and other aquatic biota. The Escapement Study (Section 9.7) will provide a watershed perspective on the salmon returns to the Susitna River and apportion runs to the major tributaries (Yentna River, Chulitna River, Talkeetna River, etc.) as well as the mainstem areas potentially affected by the Project. A synthesis of the results from these studies will be required to estimate Project effects on fisheries as a proportion of the returns to the entire Susitna watershed. Results of the Fish Harvest Study will be used as output to inform the Recreational Resources Study (Section 12.5).

The flow of information into the Fish Harvest Study is anticipated to occur over the two-year study period through an iterative process. Relevant analyses of potential Project effects, from studies described above, will be disseminated from the Aquatic Resources and Instream Flow Programs to the Fish Harvest Technical team. To maximize communication among the Fish Study Programs, study leads will participate in internal meetings where preliminary data will be presented and implications to fish production will be discussed. These discussions will occur to a limited degree in Q1 2014 and more significantly in Q4 of 2014, feeding directly into study results.

9.15.8. Level of Effort and Cost

This study will focus on compiling and analyzing existing harvest data and new data collected from other fish, habitat, subsistence, and recreational studies. This study will be primarily a desktop exercise. It is estimated that this study will cost approximately $200,000.

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9.15.10. Tables

Table 9.15-1. Schedule for implementation of the Analysis of Fish Harvest Study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Compile harvest & effort statistics					——	——				--------			
Apportion commercial harvests using genetics					——	——							
Estimate potential changes to abundance											——	——	
Estimate potential changes to distribution											——	——	
Analyze changes to harvest and opportunity											——	——	
Initial Study Report									——Δ				
Updated Study Report											——	——	—▲

Legend:

—— Planned Activity
----- Follow-up activity (as needed)
Δ Initial Study Report
▲ Updated Study Report

9.15.11. Figures

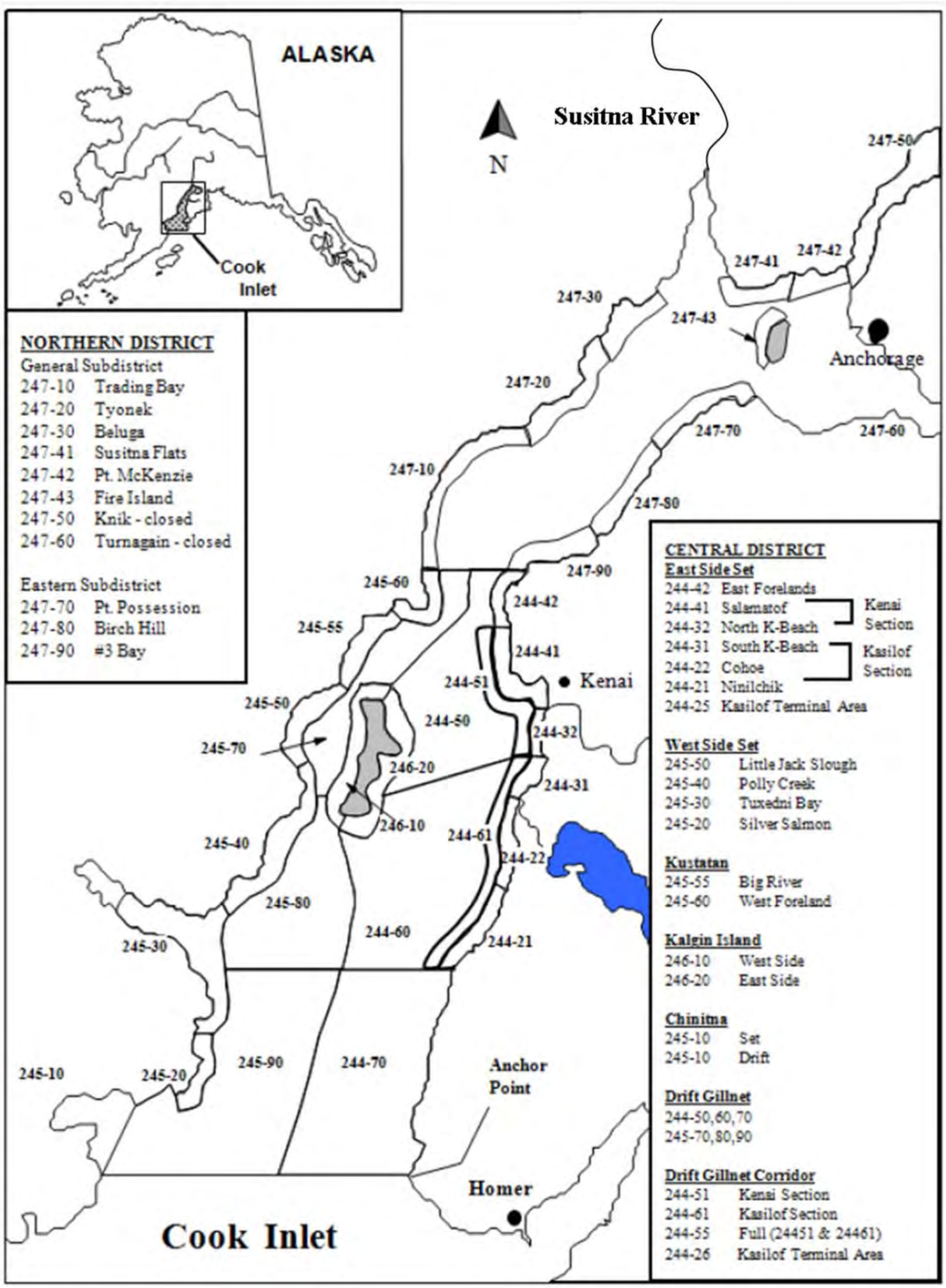

Figure 9.15-1. Upper Cook Inlet Management Commercial Fishing Districts and Statistical Reporting Areas (Shields and Dupuis 2012).

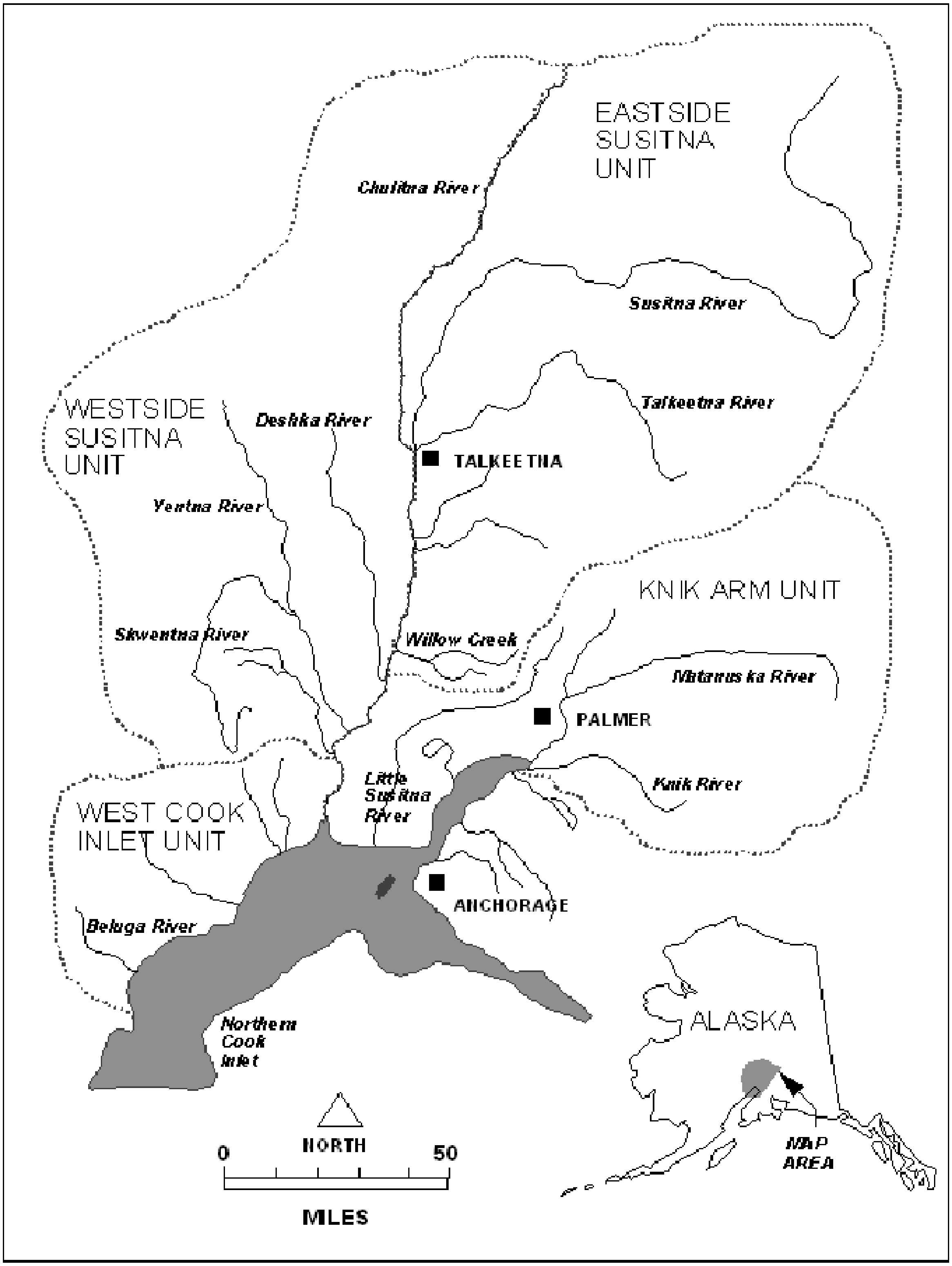

Figure 9.15-2. Northern Cook Inlet Management Area Sport Fishing Management Units (Oslund and Ivey 2010).

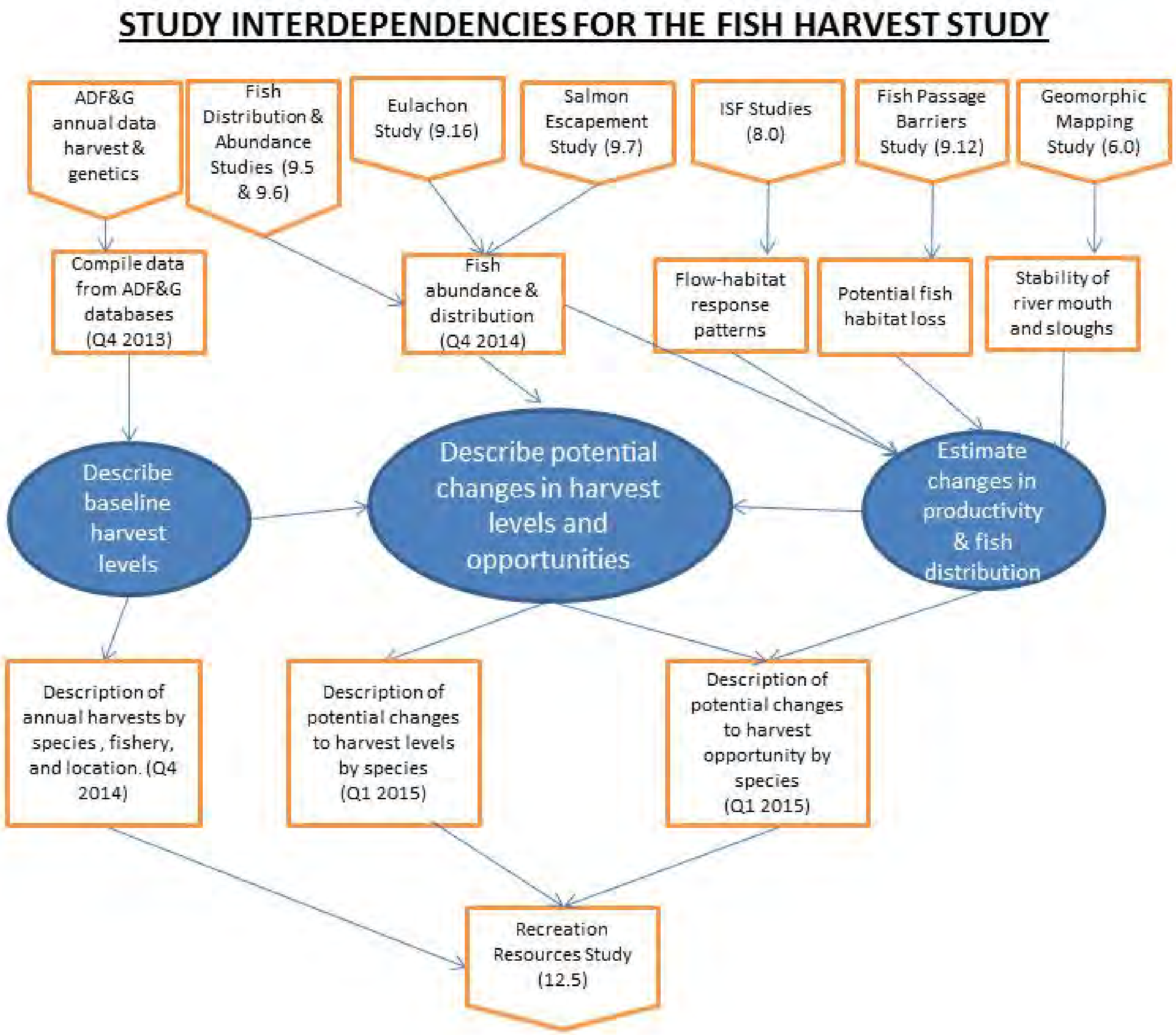

Figure 9.15-3. Study Interdependencies for Analysis of Fish Harvest Study.

9.16. Eulachon Run Timing, Distribution, and Spawning in the Susitna River

9.16.1. General Description of the Proposed Study

The goal of the study is to collect baseline information regarding eulachon (*Thaleichtys pacificus*) run timing, distribution, and habitat use in the Susitna River in 2013 and 2014. Eulachon are an important prey species for the endangered Cook Inlet beluga whale (CIBW; *Delphinapterus leucas*); therefore, this study has been designed to support the Cook Inlet Beluga Whale Study (Section 9.17). Together with existing information, data collected as part of this study will provide necessary baseline information to address issues identified in the Pre-Application Document (PAD) and assess potential Project effects (AEA 2011).

The objectives of this baseline study are as follows:

3. Determine eulachon run timing and duration in the Susitna River in 2013 and 2014.
4. Identify and map eulachon spawning sites in the Susitna River.
5. Characterize eulachon spawning habitats.
6. Describe population characteristics of eulachon returning in 2013 and 2014.

9.16.2. Existing Information and Need for Additional Information

9.16.2.1. Background Information

Eulachon are relatively small (<250 mm (10 inch) fork length), anadromous forage fish from the family Osmeridae (Scott and Crossman 1973). They occur on the West Coast of North America from the Pribilof Islands and the eastern Bering Sea in Alaska southward to the Klamath River in California (Scott and Crossman 1973). In Alaska, eulachon travel short distances upriver to spawn after ice-out. Lewis et al. (2002) concluded that water velocities greater than 0.4 meters per second (m/s; 1.2 ft/s) may limit upstream eulachon movements.

In most cases, eulachon spawn once, then die; however, Scott and Crossman (1973) found some evidence of repeat spawning. Eulachon generally spawn on silty or sandy substrate in water temperatures ranging from 4°C to 10°C (39°F to 50°F), although exceptions have been documented (Willson et al. 2006). Eggs are not buried, and therefore may drift downstream after spawning. Existing research on eulachon reproduction is limited (Stables et al. 2005).

Eulachon contain as much as 21 percent oil, thus giving them a high energetic content (Payne et al. 1999). This high energetic content, coupled with their abundance at the mouth of the Susitna River, makes eulachon an important prey resource for CIBWs (NMFS 2008). CIBWs are opportunistic feeders and need high prey densities for successful foraging (NMFS 2008). Stomach content analyses from 21 CIBWs from 1995 to 2007 indicated they consumed eulachon during the spring eulachon migration into Upper Cook Inlet (NMFS 2008).

In addition to their importance to CIBWs, a small commercial and personal use fishery for eulachon operated at the mouth of the Susitna River periodically from 1978 to 1999, then continuously since 2005 (Shields and Dupuis 2012). Since 2005, the total commercial fishery for eulachon is not permitted to exceed 100 tons per year, and has averaged 62.4 tons (Shields and Dupuis 2012). Between 2006 and 2011, the Alaska Department of Fish and Game (ADF&G) has sampled approximately 200 eulachon each year from the commercial harvest to collect information on age, length, and sex (Shields and Dupuis 2012). ADF&G found three age classes of eulachon (3, 4, and 5), with age 4 consistently being most numerous. These results differ from data collected during the 1980s Susitna Hydro studies, when age 3 fish dominated (ADF&G 1983a; 1984). It is unclear whether this difference is a true age shift or an artifact of differences in sampling methods.

9.16.2.2. Historic Information

The Susitna River eulachon population was previously studied in 1982 and 1983. At that time, it was determined that the run had an early component (i.e., escapement) of several hundred thousand fish and a later component of several million fish (ADF&G 1984), suggesting they were likely the most abundant fish species in the Susitna River (Vincent-Lang and Queral 1984). The early run entered the river May 16–30 in 1982 and May 10–17 in 1983. The late run entered the river June 1–8 in 1982 and May 19–June 6 in 1983 (ADF&G 1984).

During these studies, ADF&G surveyed by boat-based electrofishing from river mile (RM) 4.5 upstream to RM 60. ADF&G found that the uppermost extent of eulachon spawning was near RM 50 (Little Willow Creek; ADF&G 1983b).

Given their high abundance, eulachon were chosen as an evaluation species for the 1980s project (ADF&G 1983b). Potential Project-related impacts to eulachon that were identified were related to decreased mainstem discharge and increased surface water temperatures during the spawning migration (Vincent-Lang and Queral 1984). During 1982 and 1983, ADF&G initiated studies to identify naturally occurring hydrologic and water temperature relationships with spawning migrations of eulachon (ADF&G 1983a; 1983b). These studies identified eulachon spawning habitats at 20 locations between RM 8.5 and RM 44 (ADF&G 1983b). Water depth, velocity, surface water temperature, water quality parameters, and substrate composition were sampled and summarized (ADF&G 1983a, 1983b; Vincent-Lang and Queral 1984). Spawning depth ranged from 0.3 feet to 4.5 feet, and water velocities ranged from 0.0 to 3.4 feet per second. Spawning usually occurred in riffle habitats or cutbanks along the mainstem, and the most frequently used substrates were loose sand and gravel or silt to silty sand intermixed with gravel and rubble (ADF&G 1984; Vincent-Lang and Queral 1984).

During the 1983 study, eulachon were captured with sinking gillnets at RM 2, RM 4, and RM 4.5 during a subset of high tides from May 10 to June 8 (ADF&G 1984). To determine run timing, eulachon were classified by sex and spawning condition (either pre-spawning/spawning or post-spawning). Concurrent with gillnetting at RM 4, 100 eulachon were captured by hand dip nets to characterize sex and condition (ADF&G 1984). Fork length (nearest millimeter) and weight (nearest 0.1 gram) were also collected from the first 10 pre-spawning eulachon per sex. Age analysis (from otoliths) indicated that three-year-old fish were the dominant age class in both peaks. The length/weight analysis indicated that eulachon in the first peak were generally larger and weighed more.

During 1983, the main channel was surveyed daily for eulachon spawning locations between RM 4.5 and RM 60 using a combination of boat electrofishing and hand-operated dip nets (ADF&G 1984). A site was considered a spawning site if the following ADF&G (1983c) criteria were met:

1. Fish captured at the site freely expelled eggs or milt.
2. Fish were in vigorously free-swimming condition.
3. Twenty or more fish were caught in the initial or subsequent site sampling effort, which met criteria 1 through 2 above.

A total of 61 eulachon spawning locations were identified (ADF&G 1984; Figure 9.16-2). The majority of the spawning occurred below the confluence of the Yentna and the Susitna rivers (ADF&G 1984).

Catch per unit effort (CPUE) of eulachon indicated that the June peak of the run included more fish than the May peak. Males outnumbered females, indicating that males mature earlier and spawn over a longer period than females (ADF&G 1984). An analysis of tidal height (feet), temperature (°C), and catch indicated that eulachon were most frequently caught when tides were between 27 and 28 feet and water temperature was between 3.5°C and 10.5°C.

9.16.2.3. Need for Additional Information

Given the importance of eulachon to CIBWs, personal use, and commercial fisheries, the information on eulachon from the 1980s will be updated and expanded to fully evaluate potential post-Project impacts. Information on timing and duration of the eulachon migration, location and number of spawning sites, spawning site characteristics, and population characteristics are needed to characterize the current situation and provide information necessary for future evaluations of the potential impacts of the Project. Changes in run timing and duration could change the availability of eulachon to CIBWs. Project operations could change the number and distribution of spawning sites. Spawning site characterization is needed to allow comparisons of pre- and post-Project habitat availability, which could affect eulachon relative abundance. Biological parameters such as age, fork length, weight, and sex are needed to assess the energetic values eulachon provide to CIBWs. Incidental observations of marine species will assist in documenting other CIBW primary constituent element (PCE) species (i.e. Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), saffron cod (*Eleginus gracilis*), and yellowfin sole (*Limanda aspera*) that may be periodically utilizing the Lower Susitna River.

9.16.3. Study Area

The eulachon study extends from the mouth of the Susitna River to the uppermost extent of spawning, which will be determined by a combination of telemetry and acoustics (see Figure 9.16-1). A split beam sonar device will be positioned at a fixed site near RM 10 to collect information on run timing and duration. This is within the area sampled daily in 1983 (RM 4.5 to RM 60; ADF&G 1984). Few spawning locations were detected below RM 10.

9.16.4. Study Methods

Eulachon studies will be conducted from approximately May 1 (or ice-out) through June 30 (or the end of the eulachon migration onto spawning grounds) in both 2013 and 2014. A combination of acoustic surveys, radio telemetry, and standard fish capture and habitat sampling methods will be used to characterize the eulachon spawning migration. Telemetry and mobile acoustic surveys will be used jointly to identify the full distribution of spawning locations in the study area and to evaluate fish behavior on spawning sites. Acoustic sampling will also be used at a fixed site in the Lower River to assess the timing and duration of the spawning migration, and assess relative abundance of eulachon (measured by CPUE where effort is equal to sampling time). Active capture methods will be used to confirm eulachon spawning concentrations, collect information on eulachon population characteristics, and document incidental observations of marine fish species. Standard methods will be used to characterize physical habitat at confirmed spawning sites.

9.16.4.1. Objective 1: Determine Eulachon Run Timing and Duration in the Susitna River in 2013 and 2014

Tasks to address Objective 1 include the following:

- Use two types of sonar to obtain indices of passage over time for migrating eulachon. Sonar types will be a split beam and a multibeam, which will be either a dual frequency identification sonar (DIDSON) or an adaptive resolution imaging sonar (ARIS).
- Use active fish sampling to confirm presence of eulachon.
- Process multibeam sonar data to provide fish size, counts of fish when the number of fish passing upriver is low, and a relative abundance (as measured by CPUE where effort is equal to sampling time) when fish counts are high. The split beam sonar will provide relative abundance (as measured by CPUE, where effort is equal to time sampled) over time by processing echo integration and scaled by the size of individual eulachon.

9.16.4.1.1. Indices of Passage for Migrating Eulachon

The multibeam and split beam sonars will be positioned at a fixed site in the Lower Susitna River near RM 10 to detect migrating eulachon. The sample site will be selected as low on the river as possible, but will be (1) above the tidally-affected area, (2) on one bank in the major river channel, and (3) at a site with suitable bottom profile for sampling with sonar. A fixed sample site will likely be remote and require a power supply and protection for the equipment. Both sonar systems will be positioned near the bank and aimed horizontally toward mid-channel to sample a range of 5 to 10 meters. A blocking weir will be constructed around the sonars to exclude eulachon from the 70–100 centimeter range in front of the sonar face. Data will be collected continuously over a period from soon after ice-out in early to mid May through the end of the eulachon run in mid to late June. The run will be considered to have ended when, after June 10, no eulachon are detected at the fixed site or during nearby sampling for five consecutive days.

9.16.4.1.2. Active Fish Sampling

The team will sample from boats near and downstream from the fixed sonar site to help verify species composition and overall representativeness of sonar results, collect fish for radio telemetry (Objective 2), and describe eulachon population characteristics (Objective 4). When fixed-site sonar has identified concentrations of fish that are likely to be eulachon, the team will use dip nets to collect fish to verify species composition. The team will also conduct standard sampling with dip nets and/or gillnets to assess representativeness of results from the fixed site.

9.16.4.1.3. Acoustic Data Processing

Multibeam sonar data will be processed both during and after the survey season using empty frame removal to remove the time when fish are not passing through the sonar beam. In-season processing is critical for determining run start and end times. Remaining images will be processed either by counting individual eulachon when counts are low, and/or measuring cluster size to estimate relative abundance (as measured by CPUE, where effort is equal to time sampled). Split beam data will be processed using echo integration and scaling the total backscattered energy from fish by the mean size of an individual eulachon. Cross-sectional densities will be made for the sample range and expanded to index fish passage over time using water velocity at the site. Water velocity will be measured weekly.

9.16.4.2. Objective 2: Identify and Map Eulachon Spawning Sites in the Susitna River

Tasks to address Objective 2 include the following:

- Use radio telemetry to locate possible eulachon spawning sites.
- Use multibeam sonar (DIDSON or ARIS) to identify likely eulachon spawning sites.
- Confirm presence of spawning eulachon through active fish sampling methods.
- Map confirmed eulachon sampling sites.

Radio telemetry, acoustics, and active fish sampling methods will be used to identify eulachon spawning sites. Radio telemetry will be used to follow the tagged fish throughout the river until behavior indicates spawning; acoustics will be used at these locations to identify and narrow down the spawning location, verify the presence of other untagged eulachon, verify spawning behavior, and assess the size of the spawning ground. Radio telemetry fieldwork will include tagging and tracking, each performed in conjunction with other Project components. Eulachon will be tagged in the Lower River in the process of sampling fish for Objective 1 of this study. Fish will then be tracked with aerial surveys, using a similar approach to that described in Salmon Escapement Study, Section 9.7. Depending on run timing of the different study species, there may be some overlap in dates/flights needed for the two studies, thereby increasing efficiency. Initial and final distribution of tagged fish will be calculated using the same approach and software as for tagged fish used in the Salmon Escapement Study.

Prospective spawning sites will be confirmed and described using a combination of multibeam sonar (DIDSON or ARIS) and active sampling to capture fish. Multibeam sonar will be used to obtain video-type images of spawning eulachon. Fish sampling (electrofishing, tow nets, etc.) will confirm that detections are eulachon and allow assessment of spawning condition.

9.16.4.2.1. Locate Likely Eulachon Concentrations

Fish capture and tagging, sample sizes

Eulachon will be radio-tagged using a sampling strategy designed to be representative of the entire run migrating into the Susitna River to spawn. This will entail capturing the fish low in the river, from a population representative of the eulachon run in space (e.g., different river corridors) and time (e.g., run timing). Eulachon to be tagged will be captured using dip nets or seine nets, similar to methods described by Spangler et al. (2003). Fish to be tagged will be selected immediately upon capture, and will only be tagged after it is verified that they are vigorous, free of any obvious injuries, and are in pre-spawning condition (Spangler et al. 2003). Tagging below RM 10 may depend on obtaining a permit for sampling in the Cook Inlet beluga whale ESA-designated critical habitat area.

Early in the tagging season, a test group of 15 tagged and 15 untagged fish will be held for approximately 48 hours to test for tag retention and mortality. This test group will be held in a live well in the main river, and thus be subject to ambient river conditions. The results will be used to modify capture and handling methods, to help with inseason interpretation of data, and to draw inferences about any unresolved tag locations at the end of the season.

In 2013, a target sample of 150 eulachon in pre-spawning condition (in addition to the test group described above) will be tagged and tracked in the Lower Susitna River to identify spawning areas. Tags will be placed in proportion to the relative abundance of the run (following a schedule similar to the one used for salmon (see Section 9.7). A given spawning site that contains 2.5 percent of the run will have a 97 percent likelihood of receiving one tag from a release group of 150 tags. For sites with 5 percent of the total run, this likelihood rises to > 99 percent. The team will release 200 tags in the Lower River to conservatively achieve this sample size of 150 viable tags, after which the key to detecting each major spawning area will be ensuring that the total eulachon population is represented, and that final spawning locations are detected. The exact tagging schedule will be developed using as much information as possible from earlier eulachon studies (e.g., ADF&G 1984). All tagged fish will be measured, classified as male or female, and categorized for spawning condition (Spangler et al. 2003). It is important to note that the goal of the spawning ground distribution component using radio tags is primarily to *identify locations of the main spawning areas used in 2013*, which requires fewer tags than precisely determining the *relative importance of different spawning areas* (which is not the issue to be addressed).

Tags will be designed based on literature values of eulachon body sizes from Upper Cook Inlet. The tags will be gastrically implanted, following the methods used by Spangler et al. (2003) on the nearby Twentymile River. Tags will have a minimum battery life of 20 days, and weigh 2.0 grams (2.8 to 3.5 percent of body weight of eulachon, based on the 95 percent range of weights sampled in 1982 and 1983).

Fixed-station tracking

Fixed-receiver stations will be established at the lower and upper bounds of the study area (approximately RM 10 and RM 50), and on the Yentna River near the confluence with the Susitna River (RM 27). A fourth fixed-receiver station may be established at RM 97 to detect fish at the upper end of the anecdotal range. Each fixed-receiver station will include a radio receiver, power supply, and antennas, and will be serviced and downloaded weekly, as described in further detail in the Salmon Escapement Study (Section 9.7).

Aerial surveys will be flown every other day to track the tagged eulachon, using the same procedures described in Section 9.7. It is anticipated that the entire Lower River can be flown in a single day based on experience with the salmon radio-tagging study conducted by AEA in 2012. Tag detections will be stamped for time, location, and mortality status. Location and behavior recorded will be as follows:

- Direction of fish travel

- Fish residence time at specific locations/positions
- Fish travel time between locations/positions
- Identification of fish migratory, holding, and spawning locations/positions
- Fish movement patterns in and between habitats in relation to water conditions (e.g., discharge, temperature, turbidity)

Data analysis

The goal for tag detections from the aerial surveys will be to to classify the most likely locations of fish as mainstem, side channel, or off-channel habitat. Antenna configurations on the helicopter that were developed in 2012 for the adult salmon radio-tagging will be used to geo-reference the tag signal to within the nearest 200 meters. The surveyor will carry a plot of last-seen detections for each tag from prior surveys. During the season, likely spawning locations will be identified based on a combination of duration at a site and groupings of tags; these potential locations will then be followed up adaptively by the boat-based sonar crew that can use underwater imagery to evaluate fish behavior (see below).

Data will be analyzed using custom software that organizes telemetry data, validates records, and allows user-defined criteria for analyses. Output for each tag will include fish entrance to and exit from the study area; all detections from aerial, boat, and fixed-station receivers; movement rate; holdover locations and times; estimated time of death; and residence time.

9.16.4.2.2. Identify Likely Eulachon Spawning Sites

At potential spawning sites as identified by radio telemetry, multibeam sonar from stationary locations will be used to obtain video-type images of spawning eulachon. DIDSON is high-resolution imaging sonar that provides video-type images over a 29-degree field of view. It is well suited for observing dynamic fish behavior, such as spawning, as well as enumerating fish passage. To collect good quality images the platform must be stable, i.e., DIDSON is best suited for sampling from a fixed location. Because of the relatively small size of eulachon, the range over which they can be reliably detected will probably be limited to approximately 15 meters (49 feet). At 15 meters, the beam array will cover an area that is approximately 7 meters (23 feet) wide. Given the shore-oriented migration behavior of eulachon, the team will sample from an anchored boat looking toward shore. DIDSON will normally be deployed for 10 minutes.

All acoustic data will be time-stamped and geo-referenced. Geo-referenced analysis results will be provided in a format that is compatible with ArcGIS.

9.16.4.2.3. Confirm Presence of Spawning Eulachon

When acoustic surveys have identified concentrations of fish that are likely to be spawning eulachon, the team will collect fish by boat electrofishing, dip net, or tow net to confirm species identification and assess spawning condition. Additional sampling with plankton nets or artificial substrates downstream of suspected spawning sites may be conducted to confirm that eggs are being released. This may also facilitate confirmation of spawning in areas not accessible to boats.

The team will use the same criteria as ADF&G (1983c) to confirm spawning sites:

1. Fish captured at the site freely expel eggs or milt.
2. Fish are in vigorously free-swimming condition.
3. Twenty or more fish are caught that meet criteria 1 and 2 above.

As the team collects more data and develops a better sense of how much data are needed to determine presence or absence, the amount of data collected per sample may be modified. The team will provide station ID, location, date, time, eulachon presence/absence, and a description of fish behavior (i.e., moving in continuous band, discrete schools, milling, spawning).

9.16.4.2.4. Map Confirmed Spawning Sites

Acoustics will be synchronized with differential global positioning system (GPS) to map transects and identify acoustic targets. Data including latitude, longitude, time, water depth, and acoustic targets will be uploaded to an Access database to allow for intra-program coordination (i.e., ArcGIS).

Sites that meet spawning criteria will be marked with a GPS. Data summary and analysis will provide bounding coordinates of the areas sampled, eulachon presence/absence, and fish behavior (i.e., migrating, spawning). These sites will be compared to the original 1980s spawning locations to determine changes in spawning locations. Aquatic habitat will be recorded to the mesohabitat level based on the Project mesohabitat classification system.

9.16.4.3. Objective 3: Characterize Eulachon Spawning Habitat

Tasks to address Objective 3 include the following:

- In 2013, determine the feasibility of using acoustics to identify substrate composition at eulachon spawning habitats:
  - Estimate substrate composition using side scan sonar.
  - Verify accuracy using bottom grab samples and visual surveys.
- In 2014, continue to collect substrate composition data:
  - If side scan sonar proves feasible, then collect more data over a wider area of spawning habitats.
  - If it is not feasible to use side scan sonar, then continue using grab samples and visual surveys.
- In both years, describe physical characteristics of spawning habitats, including water quality parameters, depth, and velocity.

9.16.4.3.1. Feasibility of Using Acoustics to Determine Substrate Composition

The team will determine if EdgeTech 4125 1600kHz high-resolution side scan sonar can delineate substrate type (i.e., cobble, gravel, and sand/silt) at eulachon spawning sites. Side scan sonar is well suited for sampling large areas using mobile surveys. The side scan images have a very high across-track resolution of 0.6 centimeters (0.2 inches). The side scan will be run along the shore, looking toward shore. As a rule of thumb, if the transducer is 1 meter (3.3. feet) above the bottom, a swath approximately 10 meter (33 feet) wide along the side of the survey boat can be surveyed. Surveys will occur at a range of 15–20 meters (49-66 feet) from shore and move parallel to the shoreline.

Side scan sonar data will be geo-referenced with a differential GPS and written to file. Data will be processed using HyPack software with the Geocoder module. Geocoder generates bottom classifications using angular response analysis from the side scan sonar to produce substrate classification areas. These area classifications are then matched to known bottom types and the data are output to DXF geo-referenced files.

Preliminary acoustic substrate classifications will be compared to physical grab samples, or where possible, visual surveys. Visual surveys were the primary method used in the 1980s (Vincent-Lang and Queral 1984). The team will use an Ekman Bottom Grab Sampler where visual surveys are not feasible. Overall substrate composition will be recorded based on substrate characterization protocols of the Instream Flow Study (Section 8.5). The percent composition for each substrate size category for each sample will be recorded.

9.16.4.3.2. Continue to Collect Substrate Composition Data

If successful, acoustic substrate classifications will be expanded in 2014. If side scan sonar does not accurately distinguish substrate composition in 2013, then only physical grab samples and visual surveys will be used in 2014. Substrate composition will be compared among spawning sites to describe preferred spawning substrates.

9.16.4.3.3. Describe Physical Characteristics of Spawning Habitats

Water quality will be sampled using a YSI® meter for pH, water temperature, dissolved oxygen, and specific conductance. Turbidity samples will be collected in the field in amber glass vials and analyzed every evening in a Hatch Turbidimeter. Water quality data will be collected once at each spawning location for each survey. Continuous water temperature (°C) will be downloaded from U. S. Geological Survey (USGS) gages and gathered from the Baseline Water Quality Study (Section 5.5).

A grid system for the collection of water depth and water velocity data may be developed similar to the grid used by Vincent-Lang and Queral (1984) for systematic sampling. The length of the grid will be equal to the length of the spawning habitat, and the width of the grid will be equal to the distance from shore in which eulachon are spawning. Size of individual cells within the grid will be determined by total size of the grid. Water depth and water velocity will be sampled in a subset of cells. Water depth at spawning locations will be measured with a metric stadia rod and water velocity will be measured with a velocity flow meter (measured in feet per second). These data will provide the water depth and velocities needed for eulachon spawning and will be averaged across the area sampled and also reported as ranges.

Water quality parameters will be compared among sites to facilitate description of preferred water quality characteristics. Water quality samples recorded for this study will also be compared with the water quality samples collected for the Baseline Water Quality Study (Section 5.5).

Correlation analyses will be used to evaluate the relationship between water temperature and run timing. Similar analyses will evaluate relationships between other water quality and hydrologic parameters and eulachon spawn timing.

All data gathered will be coordinated with the Instream Flow Study (Section 8.5) to help determine the relationship between natural flows and existing habitats. Physical habitat data associated with spawning locations will be collected over a wide range of flows and stages. This will enable (1) characterization of habitat associated with eulachon spawning, and (2) evaluation of the availability of spawning habitat during expected post-Project flows and stages.

9.16.4.4. Objective 4: Describe Population Characteristics of Eulachon Returning in 2013 and 2014

Tasks to address for Objective 4 include the following:

- Determine present baseline population characteristics
- Collect baseline genetic samples
- Document incidental observations of marine fish species

Describing baseline population characteristics was a main focus on 1980s studies; however, subsequent data indicates that population characteristics such as age may have changed since that time (Shields and Dupuis 2012). Additional data will be collected to establish current baseline biological characteristics and archive genetic samples.

9.16.4.4.1. Baseline Population Characteristics

During active fish sampling to confirm presence of eulachon in the Lower Susitna River (Objective 1), the sex and spawning condition of all eulachon collected will be documented. Fork length and weight will be measured, and otoliths will be collectd from a maximum of 30 pre-spawn eulachon of each sex daily. Stomach samples will be collected from a subset of eulachon retained for otolith extraction. Stomachs will initially be evaluated for fullness, and then for diet if feeding is documented.

Biological data such as fork length, weight, and sex will be used to build length and weight frequency distributions by sex and run. Otoliths will be used for age analysis. Age data will be used to assess age-length and age-weight relationships. Sex ratios will be determined for each sampling day.

9.16.4.4.2. Baseline Genetic Samples

In support of the ADF&G's development of genetic baselines for various species, genetic samples from a subset of eulachon (approximately 50 total) will be collected. Genetic samples will be anal fin clips cut from the fish with scissors. Tissue samples will be preserved in ethyl alcohol in a 125–500 milliliter bulk sample bottle for each site. Samples will be delivered to ADF&G's Gene Conservation Laboratory for archiving and potential future analysis.

9.16.4.4.3. Document Incidental Observations of Marine Fish Species

Marine fish species sometimes venture into fresh water for limited periods of time and some prefer shallow coastal water in and around river mouths (Morrow 1980; Cohen et al. 1990). Because walleye pollock, yellowfin sole, saffron cod, and Pacific cod are designated as PCE species for CIBWs, their occurrence in the Susitna River is of special interest to the Project for impact analyses. Marine fish caught while sampling for eulachon as described above and under Objective 1 will be identified, and any fish in question will be photographed and identified later by a marine species expert. All marine fish will be measured (either fork length or total length [tip of the snout to tip of the caudal fin]; nearest millimeter).

Catch per unit effort will be calculated for all fish species. All information regarding marine fish species presence in the Lower Susitna River will be shared with the Fish Distribution and Abuandance in the Middle and Lower River Study (Section 9.6).

9.16.5. Consistency with Generally Accepted Scientific Practice

The methods described in this study plan have been developed in consultation with the agencies and other licensing participants. Radio telemetry was used to study eulachon migration and spawning in Alaska by Spangler et al. (2003). DIDSON has been used by ADF&G for at least five years (Burwen et al. 2007). All data collection efforts will follow State of Alaska guidelines. Acoustical methods will be used to minimize disturbance to eulachon spawning habitat.

9.16.6. Schedule

Table 9.16-1 depicts the study schedule. ADF&G Fish Research Permit applications will be submitted to ADF&G in February of 2013 and 2014. The anticipated field study for both 2013 and 2014 will run from May 1 (or ice-out) through June 30 (or the end of the spawning runs). Most tasks will run concurrently in May and June of 2013 and 2014 (Table 9.16-1). Data processing and analyses will extend through the third quarter of each year, Quality Assurance/Quality Control (QA/QC) on data analyses will be completed by the middle of October each year, and reporting will be completed by the middle of December each year. The Initial Study Report and Updated Study Report will be filed with FERC in February of 2014 and 2015, respectively. Updates on study progress will be provided to the licensing participants during Technical Workgroup meetings to be held quarterly in 2013 and 2014.

9.16.7. Relationship with Other Studies

The eulachon study will be coordinated closely with other studies (Baseline Water Quality [Section 5.5]; Water Quality Modeling [Section 5.6]; Geomorphology [Section 6.5]; Fluvial Geomorphology [Section 6.6]; Ice Processes [Section 7.6]; Fish and Aquatics Instream Flow [Section 8.5]; Salmon Escapement [Section 9.7]; and Cook Inlet Beluga Whale Study [Section 9.17] (see Figure 9.16-3). Continuous water temperature data loggers were deployed during June 2012 in 10 locations between RM 10.1 and RM 97.2 (Baseline Water Quality Study, Section 5.5) to provide current water temperature data in the Susitna River. Because eulachon upstream migration and spawning may be temperature-dependent (Spangler et al. 2003; Willson et al. 2006), any Project-induced changes to water temperature may alter run timing and duration. Seven of the ten continuous surface water temperature monitoring sites will also have monthly in situ water quality parameters measured (i.e., pH, dissolved oxygen [DO], specific conductance, turbidity, etc.; Baseline Water Quality Study, Section 5.5). This information will correspond with the water quality parameters collected at the identified eulachon spawning sites. The baseline water quality information collected during the spawning season will serve two purposes: 1) to help determine if a correlation exists between eulachon presence and water quality, and 2) to aid in eventual analyses of Project effects on baseline conditions. The Water Quality Modeling Study (Section 5.6) will evaluate various models to determine the Project's potential to alter flow, water temperature, and sediment transport downstream of the dam, all of which could impact eulachon. The Geomorphology Study (Section 6.5) will evaluate Project-induced changes to channel formation processes, which in turn could affect spawning habitat. Channel formation modeling will occur under Section 6.6 (Fluvial Geomorphology) and will determine the effects of the dam downstream of the reservoir. The Ice Processes Study (Section 7.6) will determine the baseline ice break-up conditions. It will also model the expected Project-induced changes to break-up. If break-up is altered because of the dam, then spawn timing may also change. Coordination will occur with the Fish and Aquatic Instream Flow Study (Section 8.5) to share spawning habitat characteristics gathered by both teams. Some methods and scheduling may overlap with those of the Salmon Escapement Study (Section 9.7), opening the possibility of increased efficiency through collaboration and sharing. Any potential changes to eulachon relative abundance (as measured by catch per unit effort [CPUE]) will be shared with the Cook Inlet Beluga Whale Study (Section 9.17) because eulachon are a primary prey species for CIBWs.

9.16.8. Level of Effort and Cost

Fieldwork will occur from May 1 or ice-out until June 30 or the end of the eulachon spawning. The Project will consist of two teams of personnel, both based out of a field camp in the Lower River. Team 1 will be responsible for operating the Lower River sonar site (Objective 1), placing radio tags (Objective 2), and sampling eulachon for population characteristics (Objective 4). One individual from Team 1 will also fly the river to track radio tags. Team 2 will conduct mobile sonar surveys for spawning eulachon (Objective 2), and measure and sample spawning ground characteristics (Objective 3).

The approximate cost for the eulachon studies is $635,000 per year for 2013 and 2014. The cost estimate is based on a seven-week eulachon sampling period. If the actual eulachon run is shorter, then the cost will decrease.

9.16.9. Literature Cited

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9.16.10. Tables

Table 9.16-1. Schedule for implementation of the eulachon study.

Activity	2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Objective 1 – Run Timing and Distribution									
Indices of Passage		—				—			
Active Fish Sampling		—				—			
Acoustic Data Processing		—	—	—		—	—	—	
Objective 2 - Identify and Map Spawning Sites									
Locate Likely Spawning Concentrations		—				—			
Identify Likely Spawning Sites		—				—			
Confirm Presence of Spawners		—				—			
Map Confirmed Spawning Sites		—	—	—		—	—	—	
Objective 3 – Characterize Spawning Habitat									
Feasibility of Using Acoustics to Determine Substrate Composition		—							
Continue to Collect Substrate Data		—				—			
Describe Physical Habitat Characteristics		—	—	—		—	—	—	
Objective 4 – Describe Population Characteristics									
Baseline Population Characteristics		—	—	—		—	—	—	
Baseline Genetic Samples		—				—			
Document Marine Species		—	—	—		—	—	—	
Initial Study Report			—	—	Δ				
Updated Study Report							—	—	▲

Legend:

—— Planned Activity

----- Follow up activity (as needed)

Δ Initial Study Report (ILP due date 2-3-2014)

▲ Updated Study Report (ILP due date 2-2-2015)

9.16.11. Figures

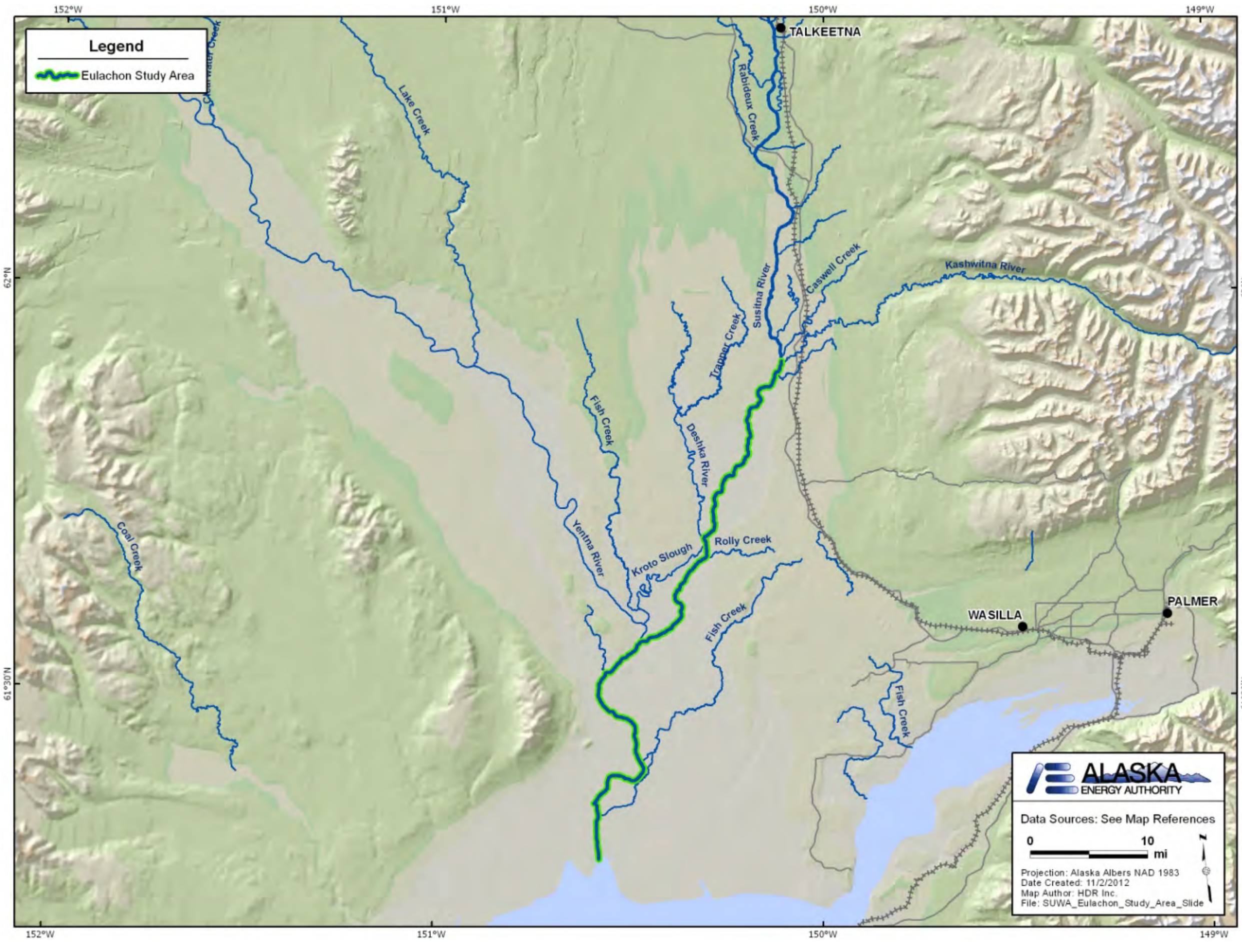

Figure 9.16-1. Eulachon study area.

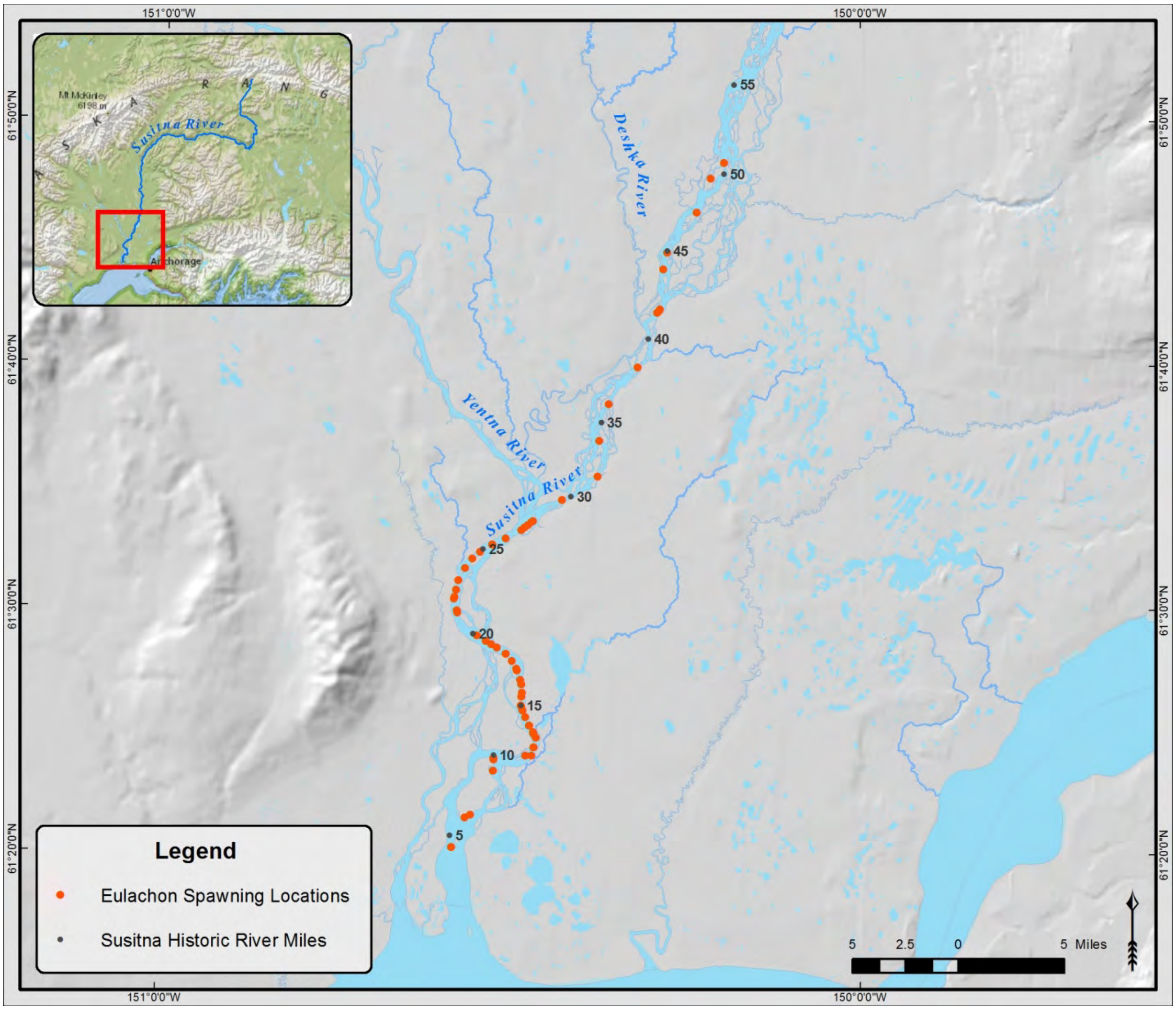

Figure 9.16-2. Historic eulachon spawning locations (ADF&G 1984).

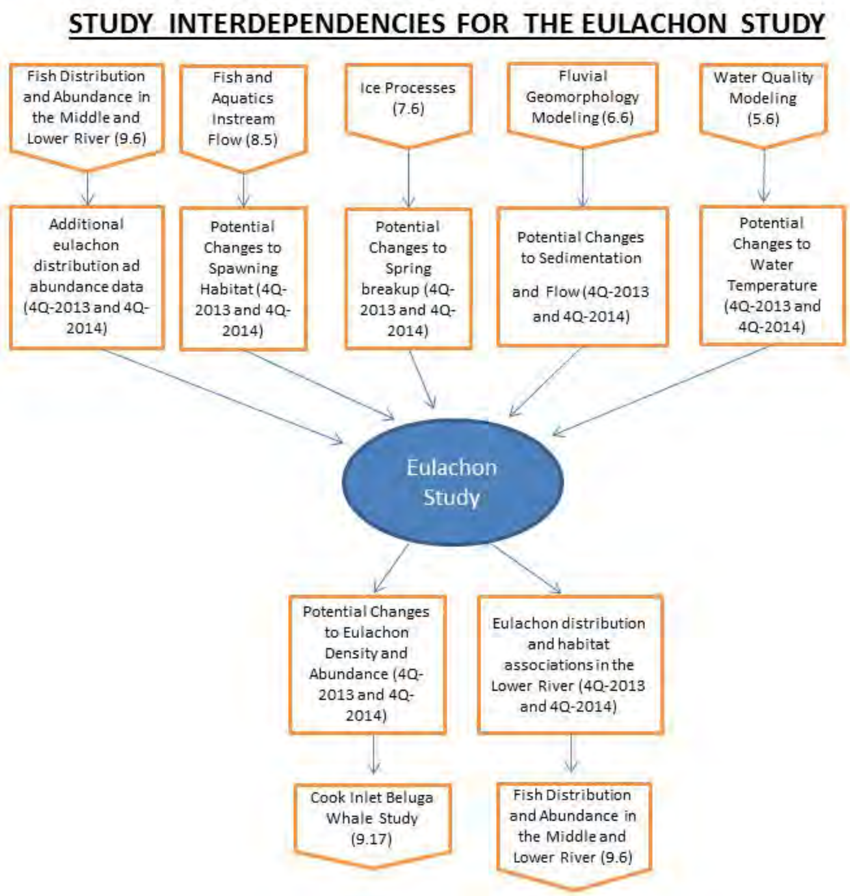

Figure 9.16-3. Eulachon study interdependencies.

9.17. Cook Inlet Beluga Whale Study

9.17.1 General Description of the Proposed Study

The goals of this study are threefold: (1) to provide current, fine scale information on Cook Inlet Beluga Whale (*Delphinapterus leucas*; CIBW) distribution and movements within the Susitna River delta, (2) to correlate these data with information on the ecology and habitat parameters of CIBW prey species, including eulachon and Pacific salmon, and (3) to record incidental observations of all marine mammals sighted during beluga whale studies. Information is needed regarding CIBWs and their prey in the Susitna River and delta to facilitate future analysis of the potential effects that may result from the construction and operation of the Project. CIBW prey species information (i.e., eulachon and salmon) will be coordinated with fish studies both currently ongoing and those proposed for the lower river (see Fish Distribution and Abundance in the Upper River [Section 9.5], Fish Distribution and Abundance in the Middle and Lower River [Section 9.6], Salmon Escapement [Section 9.7], Characterization and Mapping of Aquatic Habitats [Section 9.9], and Eulachon Run Timing, Distribution, and Spawning [Section 9.16]). Collectively, this information will be used by FERC in its National Environmental Policy Act (NEPA) and licensing processes, for the NMFS Marine Mammal Protection Act (MMPA) and Endangered Species Act (ESA) reviews, and for the development of potential protection, mitigation, and enhancement (PM&E) measures.

Three specific objectives have been identified for this study:

1. Document CIBWs and other marine mammals in the Susitna River delta, focusing on CIBW distribution and upstream extent.
2. Document CIBW group size, group composition, and behavior within the Susitna River delta.
3. Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River.

9.17.2 Existing Information and Need for Additional Information

Cook Inlet beluga whales reside in Cook Inlet year-round, which makes them geographically and genetically isolated from other beluga whale stocks in Alaska (Allen and Angliss 2012). Given their limited geographic range, changes in environmental conditions, including temperature and prey distributions among others, have the potential to influence CIBW distribution within the Inlet. Since the early 1990s, a variety of studies have been conducted to assess CIBW spatial and temporal distribution. Beginning in 1993, aerial surveys have been conducted annually by NMFS-National Marine Mammal Laboratory. These surveys have been flown annually in June and August with the focus of survey effort concentrated along northern, coastal waters of the Inlet (within 1.5 kilometers [0.9 miles] from shore) and a reduced survey effort in the middle and southern portions of the Inlet (NMFS 2008; Hobbs et al. 2011). Historic aerial surveys for beluga whales also were completed in 1982 and 1983 (Harza-Ebasco 1985). In addition to aerial surveys, land- and boat-based surveys have been conducted to investigate CIBW movement and residency patterns in the Susitna Flats State Game Refuge and adjacent areas. These latter efforts have been focused on characterizing distribution and habitat use by individuals and groups of whales (Funk et al. 2005; Prevel-Ramos et al. 2006; Markowitz and McGuire 2007;

Markowitz et al. 2007; Nemeth et al. 2007; McGuire et al. 2008; McGuire and Kaplan 2009; McGuire et al. 2009, 2011a, b).

From 1999 to 2003, researchers applied satellite tags to 14 CIBW individuals to examine year-round movements (Goetz et al. 2012). The tagged whales were documented moving in Upper Cook Inlet even when ice was present. The whales present were documented in dispersed groups and they spent more time in offshore waters, south of the Susitna River delta (Rugh 2000). In a separate study, Hobbs et al. (2005) reported that CIBWs dive deeper in the winter than during summer which suggests that shallow, ice-covered mudflats are not the primary winter foraging grounds. These data indicate a reduced likelihood of beluga whale presence in the Susitna delta habitats during winter.

Passive acoustic monitoring (PAM) has been used to monitor whales in Cook Inlet (ADF&G 2010). Results of this study showed varied CIBW residency patterns throughout the year which may be difficult to interpret due to challenges with this technology. The ability to detect marine mammals acoustically depends on several factors including the type of equipment, proximity of the animal to the recording device, vocal behavior of the animal, and environmental factors such as high flow noise, which may mask marine mammal calls (e.g., river discharge and tidal fluctuations). Therefore, the absence of an acoustic detection does not necessarily indicate the absence of whales. These false negatives impose a high level of uncertainty on acoustic-based distribution studies.

Although these studies have documented large aggregations of CIBWs in Upper Cook Inlet in late summer and fall (Funk et al. 2005; NMFS 2008; Allen and Angliss 2012), they did not document information on the spatial and temporal use of the Susitna River delta. This finer-scale information on CIBW distribution and movement patterns within the Susitna River delta is needed to understand the potential for Project-related effects on CIBWs.

Minimal site-specific data is available on use of Susitna River delta habitats. The Susitna Flats portion of upper Cook Inlet appears to be important calving grounds for CIBWs (Huntington 2000). The use of Susitna delta mudflats by CIBWs has been documented (McGuire et al. 2009, 2011a, b; Hobbs et al. 2011). Given these data on the distribution of CIBWs within and around the Susitna River delta, additional information is needed to describe specifically how and when the CIBWs use Susitna River habitats.

The existing information on CIBWs listed above is incomplete and depicts only a partial picture of CIBW habitat needs. However, additional information is available regarding habitat that has been deemed essential to the conservation of this species. The CIBW was listed as an endangered species under the ESA in October 2008 (73 FR 62919) and critical habitat for CIBWs was designated in April 2011 (76 FR 20180; Figure 9.17-1). When determining critical habitat, NMFS also identified the following five primary constituent elements (PCEs) essential to the conservation of the CIBWs:

1. Intertidal and subtidal waters of Cook Inlet with depths <30 feet (mean lower low water; MLLW) and within 5 miles of high and medium flow anadromous fish streams.
2. Primary prey species consisting of four species of Pacific salmon (Chinook, sockeye, chum, and coho), Pacific eulachon, Pacific cod, walleye pollock, saffron cod, and yellowfin sole.
3. Waters free of toxins or other agents of a type and amount harmful to CIBWs.
4. Unrestricted passage within or between the critical habitat areas.

5. Waters with in-water noise below levels resulting in the abandonment of critical habitat areas by CIBWs.

Based on these criteria, NMFS identified two specific marine area types in Cook Inlet that contained one or more PCE. Type 1 critical habitat encompasses 1,909 square kilometers (738 square miles) of Cook Inlet northeast of a line from the mouth of Threemile Creek to Point Possession. Type 1 critical habitat has the highest concentrations of beluga whales from spring through fall. Type 2 critical habitat consists of 5,891 square kilometers (2,275 square miles) of known fall and winter use areas. It is located south of Type 1, and includes nearshore areas along the west side of the Inlet and Kachemak Bay on the east side of the lower inlet. Type 1 critical habitat extends into the Susitna River approximately 8.6 nautical miles from MLLW. Because the critical habitat designations include the lower Susitna River it is important to understand the potential for the Project to affect the habitat of the CIBW.

Seasonal movement patterns of CIBWs, as well as site fidelity, appear to be closely linked to prey availability. Whale movement patterns coincide with seasonal salmon and eulachon concentrations (Moore et al. 2000). CIBWs have been documented upriver in Cook Inlet tributaries during spring, summer, and fall. Historic records also indicate that CIBWs have been seen in the eastern channel of the Susitna River as far as 30 to 40 miles upriver, yet are most commonly found within the first 5 miles of the Susitna River delta (Funk et al. 2005). It is thought that these excursions into tributaries are associated with foraging on prey species. Because these whales are following prey species into river habitats, any Project-related impacts to prey species abundance, run timing, and/or density have the potential to have indirect impacts on CIBWs (PCE 2). It is, therefore, important to collect baseline information on CIBW prey species that will facilitate future analysis of potential Project impacts.

In addition to CIBWs, three other marine mammals have been documented in Cook Inlet. Harbor seals (*Phoca vitulina*), harbor porpoise (*Phocoena phocoena*), and killer whales *(Orcinus orca*) may use Susitna River delta habitat. Harbor seals are distributed throughout Cook Inlet with higher concentrations in lower Cook Inlet compared to the upper inlet. However, sightings of harbor seals in the upper inlet have been increasing over the past few years. The most recent aerial survey documented approximately 1,750 harbor seals in the Susitna River delta (Shelden et al. 2011). Harbor seals in Alaska are not classified as strategic or depleted stocks under the MMPA and are not listed as threatened or endangered under the ESA (Allen and Angliss 2012). The most recent population estimate for the Cook Inlet/Shelikof Strait harbor seal stock is 22,900 (Allen and Angliss 2012). Harbor porpoise have been documented throughout Cook Inlet (Shelden et al. 2011; ADF&G 2009, 2010). Harbor porpoise in Cook Inlet belong to the Gulf of Alaska stock, which is not classified as a strategic or depleted stock under the MMPA and is not listed as a threatened or endangered species under the ESA (Allen and Angliss 2012). The most recent abundance estimate is 31,046 for Gulf of Alaska harbor porpoise. While unlikely, resident killer whales have also been acoustically detected in upper Cook Inlet (ADF&G 2010). The presence of these other species in upper Cook Inlet indicates the need to further consider the potential for them to utilize Susitna River delta habitats.

9.17.3 Study Area and Timing

The study area encompasses the Susitna River delta upstream to the upper extent of CIBW distribution. Since the upper extent of the distribution is unknown, surveys will extend up to RM 50, 10 to 20 miles upstream of existing whale sightings (Figure 9.17-1). Surveys will be conducted during the open-water season (April through October). Due to logistics and safety concerns, as well as lower concentrations of belugas in the Susitna River during winter months (as documented through satellite tags), winter surveys (November through March) will not be conducted.

9.17.4 Study Methods

9.17.4.1 Document CIBW and Other Marine Mammal Presence within the Susitna River Delta

Aerial surveys conducted by NMFS occur only in June and August; therefore, the distribution of CIBWs throughout the open-water season is not well-documented. Fine-scale information on CIBW seasonal distribution, particularly during times coinciding with spawning and migrations of prey species, is needed to evaluate potential Project-related impacts to CIBWs, critical habitat, and prey availability. To address this current lack of information, this study proposes to conduct aerial surveys for CIBWs in the Susitna River delta (Figure 9.17-1) during the open-water season. The survey schedule will consist of 15 to 20 surveys conducted annually from ice-out to freeze-up depending on weather conditions, aircraft availability, and timing so as not to interfere with NMFS aerial surveys. The specific survey schedule is presented in Section 9.17.6.

The survey schedule allows for increased survey effort during the spawning season of prey species (May and June) and during times when beluga calves may be present (July and August) and will be adjusted, as necessary, to avoid potential interference with the NMFS surveys in June and August. Each survey will be scheduled for four flight hours to ensure adequate coverage of the Susitna River delta up to RM 50 and will allow for additional time to circle around areas where CIBWs are encountered. Flights will be scheduled around low and high tides. Surveying during low tide is most effective for documenting group sizes because animals congregate in areas due to lower water levels. Surveying during high tide will be advantageous for determining the upstream extent of belugas in the Susitna River. If possible, both low and high tides will be surveyed on the same day (i.e., two hours for each tide). Flights will be conducted at 1,000 feet to avoid disturbance to marine mammals and, by extension, avoid the need for a marine mammal take permit.

The aerial survey team will consist of one pilot and two experienced marine mammal observers (MMOs), one of which will serve as the data recorder. Survey protocol will follow Hobbs et al. (2011) and will generally include the following steps. The MMOs will scan the water visually to locate CIBWs via unaided eyes. Data will be recorded on a hand-held global positioning system (GPS) (i.e., Archer) that will be programmed with a custom data acquisition program. For each sighting, the time and position will be captured through the GPS-enabled data program. The MMOs will enter the angle of the sighting, which will be obtained from an inclinometer to obtain the degrees relative to the survey aircraft. Data for marine mammals will include location, group size, group composition (i.e., adults, juveniles, and cow-calf pairs), and overall group behavior. Environmental data will be updated every 30 minutes. Effort data recorded will include environmental conditions that can affect the observers' ability to sight animals (e.g., high sea state, glare, and sun position).

While all marine mammal sightings will be documented during the aerial surveys, more detailed methods will be used when a group of CIBWs is encountered. Each observer will independently count the number of animals in each group, and multiple passes (up to five) may be performed to get the most accurate count of each CIBW group. All counts from both observers will be combined and the median will be used to achieve the most accurate group size and reduce the effect of outliers within counts (Hobbs et al. 2011). Video and still cameras will be available to document encounters, when possible, but will not be used for group counts. Additionally, the team will immediately report to NMFS any observations of stranded or distressed marine mammals.

9.17.4.2 Document CIBW Group Size, Group Composition and Behavior in the Susitna River

While aerial surveys are appropriate to document the spatial distribution of CIBWs in the Susitna River delta, these surveys only represent one point in time during each month to evaluate CIBW presence. To increase the ability to detect CIBW presence in the Susitna River over a more continuous timeframe and to document group composition and individual behavior (i.e., foraging), a combination of remote live-feed video camera systems and high-resolution still cameras will be utilized. Live-feed video cameras will provide real-time data over longer time periods (i.e., weeks to months). Remote camera systems (video and still) allow for data collection without disturbing study animals and will provide behavior and life history details that may not be obtained through aerial surveys, such as the presence of calves. This technology was successfully used in the Little Susitna River for CIBWs in 2011 by the Alaska Sea Life Center. In addition to documenting CIBWs, this technology was also successful at identifying harbor seals within the river.

9.17.4.2.1 Camera Stations

Two stations with live-feed video camera arrays will be established at the mouth of the Susitna River. Each station will include an array of two video cameras, for a total of four video cameras. One video camera will be used to provide a wide-angle coverage maximizing the field of view, while the other video camera will be capable of focusing in on groups or individual animals, providing more detailed behavioral data. The video camera system will utilize remotely-operated camera technology (SeeMore Wildlife Systems, Homer, AK), which will allow observers to remotely manipulate the cameras (e.g., pan, zoom, capture still images, wipe lens, etc.) in real-time via a microwave link. The camera systems will be mounted to 9-meter steel towers embedded in the ground. Batteries, electronics, and the recharging system to run the cameras will be located in hard cases mounted at the base of the steel towers and the live images from the cameras will be transmitted via microwave signal to a receiver.

In addition to the video camera arrays, up to four still camera stations, with one camera per station, will be located along the river within a reach that extends from the mouth upstream to RM 10. The still camera stations will be located along the river at approximately evenly spaced intervals to collect incidental observations of marine mammals. The specific location of the both still and video cameras will be determined during a field reconnaissance planned for Q1 2013 and will be dependent upon on field-of-view, permits and co-location with instruments from other studies (i.e., Ice Processes [Section 7.6] and Instream Flow [Section 8.5]).

9.17.4.2.2 Monitoring Live-feed Cameras

Camera observers will be used to remotely monitor the live-feed video cameras. Monitoring will be conducted over a continuous 8-hour period for five out of every seven days from May through September. The entire 8-hour video period will occur during daylight hours but start and end times will vary in order to focus on high tides. The five days monitored each week will be randomly selected and will include both weekend and weekdays. During each monitoring period, camera observers will remotely scan the study area with one of the two video cameras every 20 minutes. For each scan, the observers will focus the camera at the farthest south or north position and slowly move the camera focal point across the study area. Camera movement will be in timed increments, not continuous. With each movement of the camera the observers will pause the camera long enough to determine if whales are present before moving the camera to the next increment. Scans will last between 10 and 15 minutes, but may be longer if beluga whales are present to allow for accurate data collection. During intervals between scans, the cameras will be focused on a single location and checked frequently for opportunistic sightings. The focus of the cameras between scans will be the area with the greatest possibility of having an opportunistic sighting, determined by distance from the camera and visibility due to tidal stage.

9.17.4.2.3 Data Collection

Two camera observers will be assigned to each video camera station for each 8-hour monitoring period. Upon sighting a group of whales, one observer will conducted focal group sampling, while the second observer will continue to scan the study area for the presence of other groups of whales. The use of two video cameras allows for independent tracking and division of labor among camera observers; thus, one camera can be used for focal group sampling while the other is viewing the study area.

To obtain the precise location of CIBW activity, the study area will be divided into segments using a numbered grid covering the camera’s field-of-view. When beluga whales are present, observers will record the group location by grid number, the number of animals in the group, group composition (life stage, gender), and behaviors of individuals. Once a group enters the field-of-camera-view, the camera observer will begin focal group sampling and will keep the camera focused on that group for as long as is possible given the time of observation within the monitoring period, the presence of other CIBW groups or other marine mammals, and environmental conditions. The goal of focal group sampling is to extract the most information possible from the group without compromising data from additional groups.

9.17.4.2.4 Behavior Logs

Camera observers will record beluga behavior using three activity codes to indicate primary, secondary and tertiary group activities. The primary activity is defined as that which best describes the activity of the group as a whole (e.g., traveling). The secondary and tertiary activities are defined as behaviors of individuals within the group such as tail slapping and/or eye spying. If observers are able to obtain close-up video of whales with distinctive markings, still photos of these events will be collected for potential use in photo-identification. Presence and behavior of any other marine mammals or humans (including vessel traffic), will also be recorded and all video footage will be digitally archived with AEA.

9.17.4.2.5 Group Counts

Each whale sighting will be assigned two identification numbers: a “day group” number that reflects the actual order of when a specific group was detected that day and an “archive group” that defines the group and thus, remains constant for all sightings during the study period. For example, a group sighted on four successive camera scans in one day will be assigned “day group” numbers of 1, 2, 3, and 4, and if it is the first unique group of that day the “archive group” number would be 1. If a single group of whales splits into distinct segments, letters will be used to denote archival subgroups of the same parent group (e.g. 1a, 1b, etc.). The only time that an archival group number will change is if two known groups merge into one. In such an instance, e.g., Group 1 joins Group 2, the combined group will be given the archive group number of the group that joined, in this case, Group 2. This method of documentation allows for detailed tracking of animal groups, movements, and interactions without inflating animal numbers.

For reporting purposes, beluga whale sightings will be in reference to archive groups in order to accurately reflect the total number of groups and individuals observed. Sightings also will be in reference to behavior, composition, and/or location data recorded within the confines of a single scan (day group) in order to reflect dynamic changes within the study area by a single group.

Data will be available in a real-time format and can be accessed during the study as needed. In addition post-processed data will be presented in monthly reports that reflect monitoring effort and beluga whale activity (presence, group size, location, composition) as well as environmental conditions. While not the focus of this study, if photographs are high quality enough to be used for photo-identification purposes, AEA will collaborate with LGL to include this information in the CIBW catalogue.

9.17.4.3 Develop a model to describe the relationships between river flows, water surface elevation, and CIBW foraging habitats in the Susitna River delta.

Satellite tagging of CIBWs and hydrodynamic statistical modeling of CIBW distribution from aerial surveys and tagging data indicate that seasonal CIBW distributions are correlated with water temperature, ice coverage, and the seasonal flow patterns of various rivers (Goetz et al. 2012). Additional data suggests that availability of salmon and other prey fish, such as eulachon, in river mouths can influence CIBW movements (Ezer 2011). CIBWs are known to be present in the Susitna River delta from late April through September (NMFS 2008) and this timing is coincident with the spawning migrations of eulachon and then Pacific salmon into the river.

To help understand the relationship between Susitna River hydrology and CIBW foraging habitats, AEA develop a river discharge versus water surface elevation (WSE) model. As a first step in model development, AEA will develop a predictive relationship between freshwater discharge, the tide, and WSE based on current conditions that can be applied to future with-Project conditions. The WSE model will evaluate the influence of river discharge on water surface elevation under four operational scenarios. The four scenarios represent the existing condition, a maximum load-following, an intermediate load-following, and a base-load scenario. The three with-Project scenarios will provide bookends and an intermediate assessment of potential Project effects.

If it is determined that Project-induced flow changes may alter WSE within the CIBW foraging distribution, the model can then be used to assess how changes in WSE in the delta may affect CIBW foraging habitats. Specific details of model development follow.

9.17.4.3.1 Model Background

Because the intertidal and tidal areas less than 30 feet deep (MLLW) at river mouths is one of the critical habitat PCEs for CIBW, AEA's modeling effort will focus on these areas. The degree of Project effects on WSE is likely insignificant or discountable compared to the high tidal flux in the Susitna River delta. However, to assess the likelihood and degree of a potential effect on the PCE, AEA will analyze the relationship between alternative instream flows under several Project operational scenarios and water levels in the Susitna estuary. Water level (or depth) is a key component for evaluating whether the proposed Project affects CIBW habitat within the Susitna estuary.

The model AEA will apply is a spreadsheet based WSE model that has been successfully developed and applied in an instream flow study of the Skagit River estuary in Northwest Washington State (DE&S 1999). The Skagit River estuary is the second largest saltwater estuary in Washington and is similar to the Susitna River estuary in its size, channel complexity, and its annual discharge range of >5,000 cfs to <60,000 cfs.

The WSE Model was selected as it meets the need of the following analytical objectives.

- The model must be predictive of water levels over the range of possible instream flow alternatives under current and future Project operations.
- The model must be predictive of water levels under Project operations accounting for the temporal and spatial complexities and interaction of tide and discharge in the Susitna estuary.
- The analysis must be based on empirical, site-specific data.

9.17.4.3.2 Model Development

The WSE model will compute the effects of river discharge on water levels in selected estuarine channels under both tidal and non-tidal periods. In this analysis, the periods when estuary hydrodynamics are a function of river discharge (and prior-tide drainage) only and the periods when estuary hydrodynamics are a function of both discharge and tide are referred to as non-tidal and tidal, respectively. The analysis will delineate zones (longitudinally up the river beginning in the intertidal zone) that are primarily controlled by tidal influence from zones primarily controlled by river discharge. The method will predict the effects of instream flow alternatives in these zones on the magnitude, duration, and frequency of inundation (depth) of estuarine channels under both tidal and non-tidal periods. The analysis will involve the development of two separate water surface elevation simulation regressions. The non-tidal period is analyzed using a multiple regression equation between channel WSE and the combination of discharge and tidal drainage potential. The tidal period is analyzed with a multiple regression between channel WSE and the combination of discharge and tide level in Cook Inlet in the vicinity of the Susitna estuary. Both regressions predict WSE in the estuary as a function of discharge for selected estuary study channel(s).

Three data sets (tide level, site WSE, and channel profiles) will be referenced to the common datum plane of mean lower low water (MLLW). The required data sets are listed below:

8. 1) Time-indexed WSE at selected estuary channels over a wide range of river discharges and tide levels.
9. 2) Time-indexed river discharge entering the estuary.
10. 3) Time-indexed tide level in Cook Inlet near the Susitna estuary.
11. 4) Cross-sectional channel profile at each estuary channel study site.
12. 5) Reference of WSE, tide, cross-section, and physical habitat features to the datum plane of MLLW.

Wind speed and direction, barometric pressure, and ambient air temperature will be continuously recorded at a station located on the southern tip of Big Island on the Susitna Flats. Simultaneous measurements of barometric pressure will be subtracted from each pressure transducer water level recording at the estuary channel study sites to obtain actual WSE. Wind data will be used to identify and remove periods of tide "pile-up" from the database.

9.17.4.3.3 Use of Model Results

The output of the WSE model will be water surface elevations that correspond to varying river discharge values and varying tidal conditions. These results will be displayed in graphical and tabular format and can be used to evaluate any future with- or without-Project hydrologic condition. This analysis, combined with ongoing flow, sediment, and water quality modeling will characterize the daily and seasonal variability of intertidal waters in the Susitna delta. These data will then be correlated to seasonal and Project-induced changes in discharge from the Susitna River.

Model results also will be available for use by other studies to evaluate any potential Project effects on changes to CIBW habitat, access by CIBW to the habitat, and potential changes for prey species' habitat in the estuary. Several other studies will provide data that can support such an evaluation including:

- Salmon Escapement Study (Section 9.7).
- Eulachon Run Timing, Distribution and Spawning in the Susitna River Study (Section 9.16).
- Baseline Water Quality Study and Water Quality Modeling Study (Sections 5.5 and 5.6, respectively).
- Geomorphology Study (Section 6.5).
- Fish and Aquatics Instream Flow Study (Section 8.5).
- Ice Processes Study (Section 7.6).

9.17.5 Consistency with Generally Accepted Scientific Practices

The study methods presented are consistent with methods commonly followed in investigations of marine mammal distribution (Hobbs et al. 2011). Aerial surveys are commonly used for documenting marine mammal distribution and have been employed by NMFS for CIBW abundance surveys since 1993 (Hobbs et al. 2011). Aerial surveys were also used to document CIBWs in the study area during the original licensing effort (Harza-Ebasco 1985). The proposed method for live-feed remote video cameras has been successfully used to document CIBWs and other marine mammal movements and behaviors in large river systems in Alaska (Easly-Appleyard et al. 2012). High-resolution still cameras are also used by NMFS to document CIBW group counts and group composition (Hobbs et al. 2011, 2012). The WSE model has been used successfully in the Skagit River, Washington, to evaluate tidal influence on spring Chinook salmon habitat in the estuary (DE&S 1999).

9.17.6 Schedule

The anticipated field schedule for 2013 and 2014 will run from late April (or ice-out) through the end of October (or freeze-up) (see Table 9.17-1). Each year, 15 to 20 aerial surveys will be conducted:

- Two in mid-late April (or after ice-out)
- Three in May
- Three in June (in addition to the NMFS survey)
- Three in July
- Three in August (in addition to the NMFS survey)
- Two in September
- Two in October (or until freeze-up)

This schedule for aerial surveys will allow for increased survey effort during the spawning season of CIBW prey species (May and June) as well as during times when calves may be present (July and August). The survey schedule may be adjusted, as needed, based on weather conditions and aircraft availability, and to avoid potential interference with NMFS surveys in June and August.

Remote cameras will be installed in late April and will operate until the end of October. Data analyses will be completed by the middle of November of each year.

Field efforts for the WSE model will begin in late April 2013 and will operate for four to six months to ensure that a full range of tidal cycles and river discharges are measured. Data analysis will be conducted following the field season. Modeling efforts may continue into 2014.

Quality Assurance (QA)/Quality Control (QC) reviews of the data analyses will be completed by the end of November each year.

Reporting will be completed in February 2014 (Initial Study Report) and February 2015 (Updated Study Report), one and two years, respectively, from FERCs Study Plan Determination. Progress on the study will be presented at the Technical Workgroup meetings to be held quarterly in 2013 and 2014.

9.17.7 Relationship with Other Studies

The Cook Inlet Beluga Whale Study will interrelate with at least seven of AEA's other Project studies (Figure 9.17-2). The flow of information into the CIBW Study is anticipated to occur over the two-year study period through an iterative process.

Information from the following studies will be synthesized with the beluga whale study results to provide an ecologically based description of beluga whale distribution and habitats. The Salmon Escapement Study (Section 9.7) and Eulachon Run Timing, Distribution and Spawning in the Susitna River Study (Section 9.16) will provide information on the distribution of beluga whale prey species in the Lower River while the Baseline Water Quality Study (Section 5.5), Water Quality Modeling Study (Section 5.6), Geomorphology studies (Sections 6.5 and 6.6), Ice Processes Study (Section 7.6), and the Fish and Aquatics Instream Flow Study (Section 8.5) will provide information on physical and chemical processes that may influence distributions of CIBWs and their prey species. In addition, information from these studies will be used for the environmental analysis that will be prepared in support of AEA's FERC License Application. Additional formal data sharing will occur among studies after completion of QA/QC procedures with the delivery of the Initial Study Report (February 2014) and Updated Study Report (February 2015).

9.17.8 Level of Effort and Cost

Fieldwork will occur daily from late April through September. Aerial survey teams will consist of three people (one pilot and two MMOs) and up to four observers will be utilized for remote-camera monitoring and data analysis (depending on the number of cameras installed). Each aerial survey is scheduled for 4 hours for a total of 72 flight hours each year. Approximate yearly cost for aerial surveys is $300,000 and approximate cost for remote-camera equipment and operations is $300,000 per year. The Water Surface Elevation field effort and model will cost approximately $250,000 with the majority of funding being utilized in 2013.

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9.17.10 Tables

Table 9.17-1. Schedule for implementation of the beluga study.

Activity	2012				2013				2014				2015
	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q	2 Q	3 Q	4 Q	1 Q
Permit Applications			——	——	--------								
2013 Aerial Surveys						——	——	--------					
2013 Camera Surveys						——	——	--------					
2013 WSE Modeling Effort						——	——	--------					
Initial Study Report								---——	Δ				
2014 Aerial Surveys										——	——	--------	
2014 Camera Surveys										——	——	--------	
2014 WSE Modeling Effort (if needed)									--------				
Updated Study Report											——	——	▲

<u>Legend:</u>

—— Planned Activity
----- Follow-up activity (as needed)
Δ Initial Study Report (ILP due date 2-3-2014)
▲ Updated Study Report (ILP due date 2-2-2015)

9.17.11 Figures

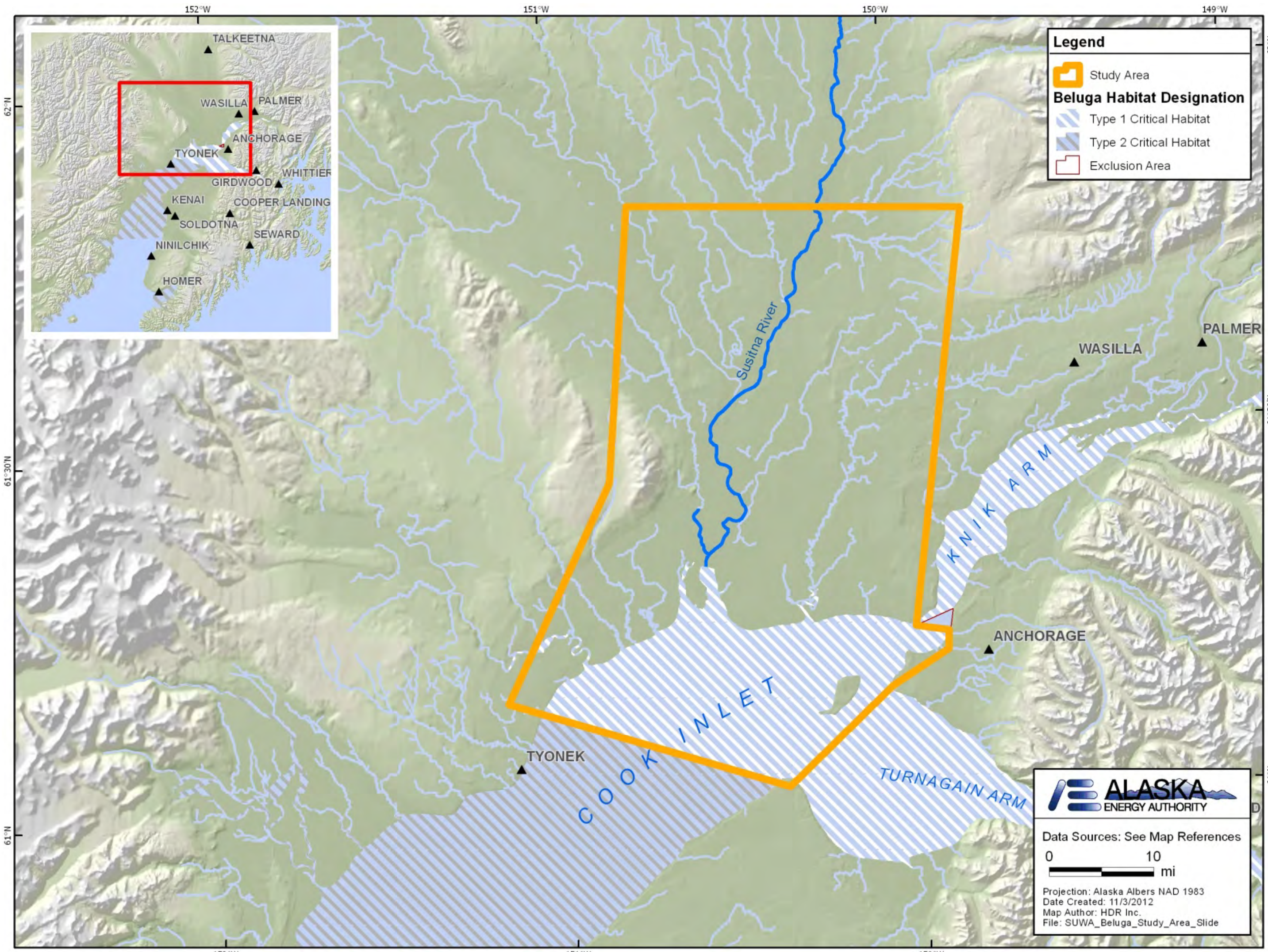

Figure 9.17-1. Study area for Cook Inlet Beluga Whale Study.

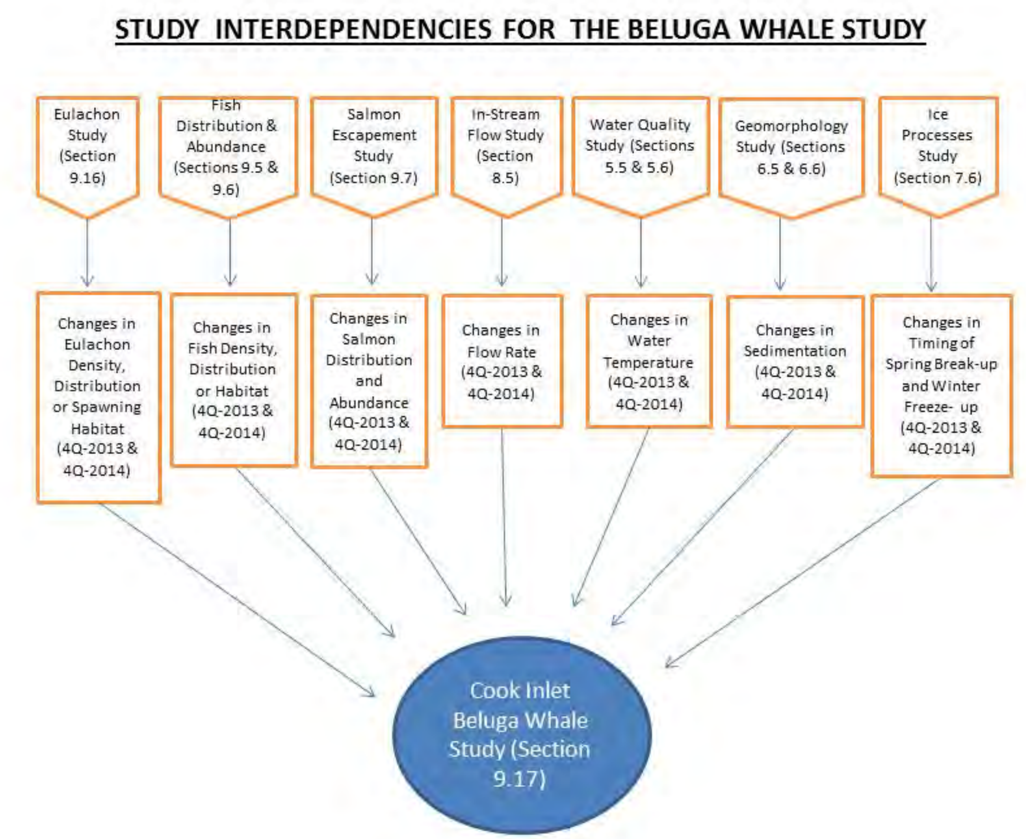

Figure 9.17-2. Cook Inlet Beluga Whale Study interdependencies.

9.18. Attachments

ATTACHMENT 9-1. GLOSSARY OF TERMS AND ACRONYMS – FISHERIES

ATTACHMENT 9-1

GLOSSARY OF TERMS AND ACRONYMS – FISHERIES

Glossary of Terms and Acronyms
Fisheries

Adfluvial	Fish that spend a part of their life cycle in lakes and return to rivers and streams to spawn.
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. In the process of photosynthesis, algae release dissolved oxygen into the water and consume carbon dioxide, which causes an increase of the pH of the waters in which they live. Upon death, algae release organic material and nitrogen compound which are then used by bacteria, but at the expense of dissolved oxygen in water and increases of ammonia, which can often reach levels in water that are toxic to fish (toxicity of ammonia increases at higher pH and higher water temperatures).
Alluvial	Relating to, composed of, or found in alluvium.
Anadromous	Fishes that migrate as juveniles from freshwater to saltwater and then return as adults to spawn in freshwater.
ANOVA	Analysis of variance, a collection of statistical models, and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation.
Assay	Investigative (analytic) procedure in laboratory medicine, pharmacology, environmental biology, and molecular biology for qualitatively assessing or quantitatively measuring the presence or amount or the functional activity of a target entity (the analyte).
AWC	The Anadromous Waters Catalog is a **catalog and atlas maintained by the** Alaska Department of Fish and Game (ADF&G) **of waters important for the spawning, rearing or migration of anadromous fishes**. It currently contains over 17,000 streams, rivers or lakes around the state of Alaska which have been specified as being important for the spawning, rearing or migration of anadromous fish. Based upon thorough surveys of a few drainages it is believed that this number represents less than 50% of the streams, rivers and lakes actually used by anadromous species. It is estimated that at least an additional 20,000 or more anadromous water bodies have not been identified.

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.
Bankfull stage (flow)	The discharge at which water completely fills a channel; the flow rate at which the water surface is level with the flood plain.
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. Under FPA Part I, as discussed in Section 2, the baseline consists of the existing conditions of the waters and lands in the project area at the time of the licensing proceeding. Under the ESA, baseline is defined differently as: past and present impacts of all Federal, State or private actions and other human activities in the action area, the anticipated impacts of all proposed Federal projects in the action area that have already undergone Section 7 Consultation, and the impact of State or private actions which are contemporaneous with the consultation process.
Beacon (tag)	A beacon is an intentionally conspicuous device, in this case a telemetry tag, designed to attract attention to a specific location. A beacon tag is normally deployed in a known fixed location and can be used to evaluate telemetry receiver performance under various environmental conditions.
Beaver complex	Off-channel habitat characterization feature consisting of a ponded water body created by beaver dams.
Benthos (benthic)	Defining a habitat or organism found on the streambed or pertaining to the streambed (or bottom) of a water body.
Biotelemetry	The remote detection and measurement of a human or animal function, activity, or condition (as heart rate or body temperature)
Bonferroni's method	A statistical method used to counteract the problem of multiple comparisons. It is intended to control the Familywise error rate and offers a simple test uniformly more powerful than the Bonferroni correction.
Boulder	Substrate particles greater than 12 inches in diameter. Larger than cobble.

Carbon isotope ratio	The identification of isotopic signature, the distribution of certain stable isotopes and chemical elements within chemical compounds. This can be applied to a food web to make it possible to draw direct inferences regarding diet, trophic level, and subsistence. Isotope ratios are measured using mass spectrometry, which separates the different isotopes of an element on the basis of their mass-to-charge ratio. Carbon isotopes aid us in determining the primary production source responsible for the energy flow in an ecosystem. The transfer of 13C through trophic levels remains relatively the same, except for a small increase (an enrichment < 1 ‰). Large differences of $\delta 13C$ between animals indicate that they have different food sources or that their food webs are based on different primary producers.
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. CPUE is often considered an index of fish biomass (or abundance). Sometimes referred to as catch rate. CPUE may be used as a measure of economic efficiency of fishing as well as an index of fish abundance.
Catchability coefficient (fishwheel)	The relationship between the catch rate (CPUE) and the true population size, aka effectiveness.
Channel bed width	A natural or artificial watercourse that continuously or intermittently contains water, with definite bed and banks that confine all but overbank stream flows.
Cobble	Substrate particles between 3 and 12 inches in diameter. Larger than gravel and smaller than boulder.
Commercial fishery	A term related to the whole process of catching and marketing fish and shellfish for sale. It refers to and includes fisheries resources, fishermen, and related businesses.
Decision tree barrier analysis	A step-wise process for evaluating potential barriers in the field. Quantitative metrics are used at each step in the decision tree to identify the impassability of the potential barrier.
Delta	A low, nearly flat accumulation of sediment deposited at the mouth of a river or stream, commonly triangular or fan-shaped
Denaturation	Denaturation is a process in which proteins or nucleic acids lose the tertiary structure and secondary structure which is present in their native state, by application of some external stress or compound such as a strong acid or base, a concentrated inorganic salt, an organic solvent, or heat.

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. Of the five salmon species in the Susitna, only Chinook salmon have been documented upstream of Devils Canyon.
DIDSON	Sonar imaging instrumentation developed by Sound Metrics Corp. with applications for fish enumeration, behavior and habitat mapping
Dissolved oxygen	The amount of gaseous oxygen (O2) dissolved in the water column. Oxygen gets into water by diffusion from the surrounding air, by aeration (rapid movement), and as a waste product of photosynthesis. More than 5 parts oxygen per million parts water is considered healthy; below 3 parts oxygen per million is generally stressful to aquatic organisms.
Distribution (species)	The manner in which a biological taxon is spatially arranged.
DNA	A nucleic acid containing the genetic instructions used in the development and functioning of all known living organisms.
Edge habitat	The boundary between natural habitats, in this case between land and a stream. Level five tier of the habitat classification system.
Effectiveness (fishwheel)	aka catachability coefficient, the relationship between the catch rate (CPUE) and the true population size
Electrofishing	A biological collection method that uses electric current to facilitate capturing fishes.
Emergence	The process of becoming visible after being concealed, the escape of an organism from an egg.
Entrainment	The unintended diversion of fish into an unsafe passage route.
Escapement (spawning)	The number or proportion of fish surviving (escaping from) a given fishery at the end of the fishing season and reaching the spawning grounds.
Fish barrier	Barriers to fish migration exist in many ways shapes, and forms. The range of salmon and steelhead has historically been limited to some extent by natural features, such as sandbars, landslides, beaver dams, waterfalls, and boulder cascades. Anthropogenic features have further truncated species' range with a variety of instream features and effects, such as dams, culverts, water diversions, tidegates, and many others. Barrier are often classified as: 1) Total: complete barrier to fish passage for all anadromous species at all life stages at all times of year. 2) Partial: only a barrier to certain species or lifestages. 3) Temporal: Only a barrier at certain times of year. 4) Temporal and partial: only a barrier to certain species or lifestages and only at certain times of year. 5) Temporal and total: total barrier at certain times of year.

Fishers exact test	A statistical significance test used in the analysis of contingency tables. Although in practice it is employed when sample sizes are small, it is valid for all sample sizes.
Fishery	Generally, a fishery is an activity leading to harvesting of fish. It may involve capture of wild fish or raising of fish through aquaculture.
Fishing	Any activity, other than scientific research conducted by a scientific research vessel, that involves the catching, taking, or harvesting of fish; or any attempt to do so; or any activity that can reasonably be expected to result in the catching, taking, or harvesting of fish, and any operations in support of it.
Fishing gear	The equipment used for fishing (e.g. gillnet, hand line, harpoon, haul seine, long line, bottom and midwater trawls, purse seine, rod-and-reel, pots and traps). Each of these gears can have multiple configurations.
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.
Fluvial	Of or pertaining to the processes associated with rivers and streams and the deposits and landforms created by them. Also, relative to fish: fish that spend a part of their life cycle in large rivers and migrate to smaller streams and tributaries to spawn.
Focus area	Focus Areas are stretches of river in which a full complement of cross-disciplinary intensive studies will occur to enhance the richness of the data. These multidisciplinary studies include geomorphology, water quality, instream flow, aquatic habitat, and fish sampling.
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	one of the most common stationary nets used in commercial fishing. Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open. To fish a hoop net, the net is staked out in a body of water and the bait is placed in the closed or tail end of the net.
Genepop	A population genetics software package originally developed by Michel Raymond and Francois Rousset, at the Laboratiore de Genetique et Environment, Montpellier, France.

Genetic markers	A gene or DNA sequence with a known location on a chromosome that can be used to identify individuals or species. It can be described as a variation (which may arise due to mutation or alteration in the genomic loci) that can be observed.
Genetic tree	A diagram showing the lineage or genealogy of an individual and all the direct ancestors, usually to analyze or follow the inheritance of trait.
Genotype	The genetic makeup of a cell, an organism, or an individual (i.e. the specific allele makeup of the individual) usually with reference to a specific character under consideration.
Geographic Information System (GIS)	An integrated collection of computer software and data used to view and manage information about geographic places, analyze spatial relationships, and model spatial processes. A GIS provides a framework for gathering and organizing spatial data and related information so that it can be displayed and analyzed. In the simplest terms, GIS is the merging of cartography, statistical analysis, and database technology.
Geomorphic mapping	a map design technique that defines, delimits and locates landforms. It combines a description of surface relief and its origin, relative age, and the environmental conditions in which it formed. This type of mapping is used to locate and differentiate among relief forms related to geologic structure, internal dynamics of the lithosphere, and landforms shaped by external processes governed by the bio-climate environment.
Geomorphic reach	Level two tier of the habitat classification system. Separates major hydraulic segments into unique reaches based on the channel's geomorphic characteristic. The Upper River segment contains six geomorphic reaches (UR 1 – UR 6), the Middle River segment contains eight geomorphic reaches (MR 1 – MR 8), and the Lower River segment contains six geomorphic reaches (LR1 – LR 6).
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 can be used either alone or, as is more usual, in large numbers placed in line. According to their design, ballasting and buoyancy, these nets may be used to fish on the surface, in midwater or on the bottom.
Glide	An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 % slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity.

Global Positioning System (GPS)	A system of radio-emitting and -receiving satellites used for determining positions on the earth. The orbiting satellites transmit signals that allow a GPS receiver anywhere on earth to calculate its own location through trilateration. Developed and operated by the U.S. Department of Defense, the system is used in navigation, mapping, surveying, and other applications in which precise positioning is necessary.
Gradient	The rate of change of any characteristic, expressed per unit of length (see Slope). May also apply to longitudinal succession of biological communities.
Gravel	Substrate particles between 0.1 and 3.0 inches in size, larger than sand and smaller than cobble.
Growth rate	Annual or seasonal. The increase in weight of a fish per year (or season), divided by the initial weight; 2. In fish this is often measured in terms of the parameter K of the von Bertalanffy curve for the mean weight as a function of age.
Growth Rate Potential	The amount of growth predicted for fish with known prey availability and environmental conditions. Fish distribution data are assumed to represent the distribution of prey available to the predator. GRP is a measure of the growth that an individual will receive in a specific location, and is calculated as consumption minus the bioenergetic costs related to metabolism. Spatial models of GRP make use of the spatial heterogeneity in the environment and clearly demonstrate how spatial variability can affect our view of habitat quality.
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.
Habitat Suitability Criteria	A graph/mathematical equation describing the suitability for use of areas within a stream channel related to water depth, velocity and substrate by various species/lifestages of fish.
Habitat Suitability Index	A suitability index provides a probability that the habitat is suitable for the species, and hence a probability that the species will occur where that habitat occurs. If the value of the index is high in a particular location, then the chances that the species occurs there are higher than if the value of the index is low. HSI models use regression techniques to analyze data on several environmental parameters and calculate an index of species occurrence.

Habitat Suitability Modeling	A tool for predicting the quality or suitability of habitat for a given species based on known affinities with habitat characteristics, such as depth and substrate type. This information is combined with maps of those same habitat characteristics to produce maps of expected distributions of species and life stages.
Harvest	The total number or weight of fish caught and kept from an area over a period of time. Note that landings, catch, and harvest are different.
Hierarchical log-likelihood ratio analysis	A technique used in statistics to examine the relationship between more than two categorical variables. The technique is used for both hypothesis testing and model building. In both these uses, models are tested to find the most parsimonious (i.e., least complex) model that best accounts for the variance in the observed frequencies. Hierarchical models contain all the lower order interactions and main effects of the interaction to be examined.
Histogram	A graphical representation showing a visual impression of the distribution of data. It is an estimate of the probability distribution of a continuous variable. A histogram consists of tabular frequencies, shown as adjacent rectangles, erected over discrete intervals (bins), with an area equal to the frequency of the observations in the interval.
Homogeneity	Homogeneity is the state of being homogeneous. Pertaining to the sciences, it is a substance where all the constituents are of the same nature; consisting of similar parts, or of elements of the like nature.
Hook and line	A type of fishing gear consisting of a hook tied to a line. Fish are attracted by natural bait that is placed on the hook, and are impaled by the hook when biting the bait. Artificial bait (lures) with hooks are often used. Hook and line units may be used singly or in large numbers.
Hoop net	One of the most common stationary nets used in commercial fishing. Hoop nets are tubular shaped nets with a series of hoops or rings spaced along the length of the net to keep it open. To fish a hoop net, the net is staked out in a body of water and the bait is placed in the closed or tail end of the net.
Inclined plane trap	This trap consists of a revolving screen suspended between two pontoons. A 12-volt DC motor normally turns the screen. Downstream migrant fish are swept onto the screen by the stream current and transported to the back end of the trap with the aid of perforated L-shaped cups that are attached to the screen at two-foot intervals. Fish reaching the back of the trap are dropped into a live box where they can later be enumerated.
Index count	An index is a statistic that is assumed to be correlated to the true parameter of interest (population) in some way

Instream Flow Incremental Methodology	Developed in the 1970s by physical and biological scientists in the U.S. Fish and Wildlife Service to determine instream-flow needs for fish and wildlife, IFIM integrates concepts of water-supply planning, analytical hydraulic engineering models, and empirically derived habitat-versus-flow functions to address water-use and instream-flow issues and questions concerning life-stage-specific effects on selected species and the general well-being of aquatic biological populations.
Invertebrate	All animals without a vertebral column; for example, aquatic insects.
Juvenile	A young fish or animal that has not reached sexual maturity.
Large woody debris (LWD)	Pieces of wood larger than 10 feet long and 6 inches in diameter, in a stream channel. Minimum sizes vary according to stream size and region.
LiDAR	Light Detection and Ranging is an optical remote sensing technology that can measure the distance to, or other properties of, targets by illuminating the target with laser light and analyzing the backscattered light. Downward-looking LIDAR instruments fitted to aircraft and satellites are used for surveying and mapping.
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.
Loci	The position of a gene (or other significant sequence) on a chromosome.
LOKI	A software package developed by Simon C. Heath. Loki analyses a quantitative trait observed on large pedigrees using Markov chain Monte Carlo multipoint linkage and segregation analysis. The trait may be determined by multiple loci.
Lotic	Refers to flowing water, from the Latin lotus, to wash. Lotic waters range from springs only a few centimeters wide to major rivers kilometers in width. Lotic ecosystems can be contrasted with lentic ecosystems, which involve relatively still terrestrial waters such as lakes and ponds.
Lower segment Susitna	The Susitna River from Cook Inlet (RM 0) to the confluence of the Chulitna River at RM 98.
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. Another common term for the main stem, the final large channel of a riverine system, is the trunk.

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 types include pool, glide, run, riffle, and rapid.
Mainstem	All waterways and aquatic habitats in the floodplain of a particular segment of river.
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. Minimum mesh sizes are often prescribed by regulations in order to avoid the capture of the young of valuable species before they have reached their optimal size for capture.
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. Anadromous types often called "ocean type" or "sea run". Potamodromous types migrate only in freshwater. Non-migratory types are often said to be resident.
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. The trap is disconnected in the middle for easy baiting and fish removal.
Mixed stock (fishery)	A fishery whose stock consists of fish that are of a variety of ages, sizes, species, geographic or genetic origins or any combination of these variables. Mixed stock fisheries offer a challenge to fisheries managers due to the difficulty in targeting fish of a specific type using many commercial fishing methods.

Mixed stock analyses	Traditional mixed stock analyses use morphological, chemical, or genetic markers measured in several source populations and in a single mixed population to estimate the proportional contribution of each source to the mixed population.
Monte Carlo	Monte Carlo simulation is a statistical approach whereby the inputs that are used for a calculation are resampled many times assuming that the inputs follow known statistical distributions. The Monte Carlo method is used in many applications such as Bayesian analyses, parametric bootstraps, and stochastic projections.
Multidimensional scaling	A set of related statistical techniques often used in information visualization for exploring similarities or dissimilarities in data. MDS is a special case of ordination. An MDS algorithm starts with a matrix of item–item similarities, then assigns a location to each item in N-dimensional space, where N is specified a priori.
Multiple split main channel	Main channel habitat characterization feature where more than three distributed dominant channels are present.
Nested design	Nested design (sometimes referred to as a hierarchical design) is used for experiments in which there is an interest in a set of treatments and the experimental units are subsampled.
Nitrogen isotope	Stable isotopes have become a popular method for understanding aquatic ecosystems because they can help scientists in understanding source links and process information in marine food webs. Certain isotopes can signify distinct primary producers forming the bases of food webs and trophic level positioning. Nitrogen isotopes indicate the trophic level position of various marine organisms.
Nodes (genetic tree)	Nodes represent taxonomic units, such as an organism, a species, a population, a common ancestor, or even an entire genus or other higher taxonomic group. Branches connect nodes uniquely and represent genetic relationships.
Non-native	Not indigenous to or naturally occurring in a given area. Presence is usually attributed to intentional or unintentional introduction by humans. Non-native species are also termed “exotic" species.
Off-channel habitat	Those bodies of water adjacent to the main channel that have surface water connections to the main river at some discharge levels.
Otolith	The ear bone of a fish. Otoliths have rings on them like the rings on a tree stump, and are used to find the age of the fish and its growth rate.

Outmigrant trap	Downstream migrant trapping of juvenile salmonids can be a valuable tool to estimate relative abundance, production, size, survival, migration timing and behavior. There are several types of trapping equipment that can be used to estimate the abundance of downstream migrating anadromous salmonid smolts. For the larger stream orders, two primary types of traps are used: inclined plane traps and rotary screw traps. Both of these trap designs are efficient at trapping a wide range of stream orders. Fyke net style traps can also be an effective tool to capture smolts in smaller stream orders where flows are insufficient to operate other traps types.
Overwintering	Many salmonids use freshwater habitat 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. Salmonids rearing in freshwater have been found to shift to different habitats in the winter. The type of habitat preferred differs among species. At the onset of winter the fish may select other microhabitats in the same stream reach or migrate to specific areas in the same watershed that provide refuge from extreme flow events, freezing and predators. Some characteristics of winter habitats are: deep water, cover, and lower water velocity. These conditions can be met in habitats such as: deep pools with cover, off-channel areas such as wall-based channels or spring-fed ponds, and coarse stable substrate.
Partial barrier	A feature that is impassable to some fish species, during part or all life stages at all flows. Results in exclusion of certain species during their life stages from portions of a watershed.
Permanent barrier	A feature that is impassable to all fish at all flows. Results in the exclusion of all species from portions of a watershed.
Personal use fishery	In Alaska, "Personal use" is a legally defined regulatory category of fishery. It is defined as "the taking, fishing for, or possession of finfish, shellfish, or other fishery resources, by Alaska residents for personal use and not for sale or barter, with gill or dip net, seine, fish wheel, long line, or other means defined by the Board of Fisheries".
PHABSIM	A specific model designed to calculate an index to the amount of microhabitat available for different life stages at different flow levels. PHABSIM has two major analytical components: stream hydraulics and life stage-specific habitat requirements.
Pit Tag	Passive Integrated Transponder tags are used individually identify animals and monitor their movements. The tag is most often permanent and will stay with the animal for its' entire life cycle. The small size of PIT tags reduces negative impact on animals with little or no influence on growth-rate, behavior, health, or predator susceptibility. Automated monitoring systems that record temporal and spatial information make recapture unnecessary reducing handling time and stress to the animal.

Pool	Slow water habitat with minimal turbulence and deeper due to a strong hydraulic control.
R (program)	R is an open source programming language and software environment for statistical computing and graphics. The R language is widely used among statisticians for developing statistical software and data analysis.
Radiotelemetry	Involves the capture and placement of radio-tags in adult fish that allow for the remote tracking of movements of individual fish.
Ramping rates	The rate at which (typically inches per hour) a flow is artificially altered to accommodate diversion requirements.
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. In the case of anadromous fish, the end of the juvenile rearing period culminates when the fish undergo smoltification, a process that results in physiological changes to the fish that readies it for transitioning to saltwater.
Recreational Fishery	Harvesting fish for personal use, sport, and challenge (e.g. as opposed to profit or research). Recreational fishing does not include sale, barter, or trade of all or part of the catch.
Redd	The spawning ground or nest of various fishes
Relative abundance	Relative abundance is an estimate of actual or absolute abundance; usually stated as some kind of index.
Reservoir	A body of water, either natural or artificial, that is used to manipulate flow or store water for future use.
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 mile	The distance of a point on a river measured in miles from the river's mouth along the low-water channel.

Rosgen channel-type	In 1994, Rosgen published A Classification of Natural Rivers. Because of its usefulness in stream restoration, this classification system has become popular among hydrologists, engineers, geomorphologists, and biologists. The Rosgen stream classification system categorizes streams based on channel morphology so that consistent, reproducible, and quantitative descriptions can be made. Through field measurements, variations in stream processes are grouped into distinct stream types. Rosgen lists the specific objectives of stream classification as follows: 1. Predict a river's behavior from its appearance. 2. Develop specific hydraulic and sediment relationships for a given stream type. 3. Provide a mechanism to extrapolate site-specific data to stream reaches having similar characteristics. 4. Provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines and interested parties.
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 increased catches as a "run" of fish, a usage often independent of their migratory behavior.
Sand	Substrate particles less than 0.1 inches in diameter, smaller than gravel.
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. The large end of the cone, (either 5 ft or 8 ft in diameter, depending on the size of the stream) is placed upstream into the stream current. With the lower half of the cone in the water, the water pressure forces the cone to turn on a central shaft, much like a turbine. Downstream migrating fish that enter the cone are trapped by the rotating screw and forced into a holding box at the end of the trap.
Seasonal barrier	A feature that is impassable to all fish at certain flow conditions (based on run timing and flow conditions). Can result in a delay in movement beyond the barrier for some period of time.
Sediment	Solid material, both mineral and organic, that is in suspension in the current or deposited on the streambed.

Sediment load	The portion of the sediment that is carried by a fluid flow which settle slowly enough such that it almost never touches the bed. It is maintained in suspension by the turbulence in the flowing water and consists of particles generally of the fine sand, silt and clay size.
Sediment transport	The movement of solid particles (sediment), typically due to a combination of the force of gravity acting on the sediment, and/or the movement of the fluid in which the sediment is entrained.
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	Main channel habitat characterization where channel is turbid and connected to the active main channel but represents non-dominant proportion of flow. Also defined as: flowing water bodies with clearly identifiable upstream and downstream connections to the main channel. Lateral channel with an axis of flow roughly parallel to the main stem, which is fed by water from the main stem; 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 main stem.
Side-scan sonar	Side scan sonar uses transducers that emit fan-shaped acoustic pulses down toward the riverbed or seafloor. The intensity of the acoustic reflections from the riverbed or seafloor of this fan-shaped beam is recorded in a series of cross-track slices. When stitched together along the direction of motion, these slices form an image of the river or sea bottom.
Side slough	Off-channel habitat characterization of an Overflow channel contained in the floodplain, but disconnected from the main channel. Has clear water,
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.
SNP markers	Single-nucleotide polymorphism (SNP) is a change to a single nucleotide in a DNA sequence. The relative mutation rate for an SNP is extremely low. This makes them ideal for marking the history of genetic trees.

Spaghetti tag	A long, thin external tag type used to mark individual fish. Sometimes referred to as anchor or dart tags, they are usually made of vinyl tubing that can have study information printed upon.
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.
Sport fishery	Also known a recreational fishery, a sport fishery consists of fish taken for pleasure or competition. It can be contrasted with commercial fishing, which is fishing for profit, or subsistence fishing, which is fishing for survival.
Stable isotope analysis	Stable isotopes have become a popular method for understanding aquatic ecosystems because they can help scientists in understanding source links and process information in marine food webs. Certain isotopes can signify distinct primary producers forming the bases of food webs and trophic level positioning.
Stage-discharge relationship	The relation between the water-surface elevation, termed stage (gage height), and the volume of water flowing in a channel per unit time.
Stranding	Fish stranding is any event in which fish are restricted to poor habitat as a consequence of physical separation from a main body of water. This phenomenon can occur in both lentic and lotic environments and is caused by natural and anthropogenic processes that generally result in rapidly falling water levels. The majority of stranding research to date has emanated from hydropower studies that have typically focused on quantifying and reducing mortality of salmonids during hydropeaking operations.
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.
Subsistence fishery	A fishery that is typically small-scale and low-technology aimed at supporting oneself at a minimum level. Particularly the fisheries of coastal or island ethnic groups that use traditional techniques such as rod and tackle, arrows and harpoons, throw nets and drag nets, and traditional fishing boats. Subsistence fishing contrasts with large-scale modern commercial fishing practices in that it is often, but not always, less intensive and less stressful on fish populations than modern industrial fishing.
Temporary barrier	A feature that that is impassable to all fish for a period of time and is not flow dependent. Temporary instream barriers are widely used for construction and maintenance purposes, as well as access and erosion control.

Thalweg	A continuous line that defines the deepest channel of a watercourse.
Thermal cycling	Consists of cycles of repeated heating and cooling of the reaction for DNA melting and enzymatic replication of the DNA.
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.
Trap and haul	A fish passage facility designed to trap fish for upstream or downstream transport to continue their migration.
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.
Tributary mouth	Main channel habitat characterization of clear water areas that exist where tributaries flow into Susitna River main channel or side channel habitats.
Trotline	A heavy fishing line with baited hooks attached at intervals by means of branch lines called snoods. A snood is a short length of line which is attached to the main line using a clip or swivel, with the hook at the other end. A trotline can be set so it covers the width of a channel, river, or stream with baited hooks and can be left unattended. There are many ways to set a trotline, with most methods involving weights to hold the cord below the surface of the water.
Turbidity	The condition resulting from the presence of suspended particles in the water column which attenuate or reduce light penetration.
Undercut bank	A bank that rises vertically or overhangs the stream. This type of bank generally provides good cover for macroinvertebrates and fish and is resistant to erosion. However, if seriously undercut, it might be vulnerable to collapse.
Underwater video	Underwater video imaging can record images in real-time over short time intervals and can provide information on fish species presence/absence in the immediate vicinity. 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.
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.
Upstream fish passage	A fishway system designed to pass fish upstream of a passage impediment, either by volitional passage or non-volitional passage.
Volitional passage	Fish passage made continuously available without trap and transport.

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.
Wetted channel width (wetted Perimeter)	The length of the wetted contact between a stream of flowing water and the stream bottom in a plane at right angles to the direction of flow.