Grant Lake Project
(FERC No. 13212)

Aquatic Resources

Final Study Plan

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Table of Contents

Tables

Figures

List of Abbreviations and Acronyms

ADF&G	Alaska Department of Fish and Game
AEIDC	Arctic Environmental Information and Data Center (University of Alaska)
AHRS	Alaska Heritage Resources Survey
APA	Alaska Power Authority
ARWG	Aquatic Resources Work Group
AWC	Anadromous Waters Catalog
BLM	Bureau of Land Management
°C	Degrees Celsius
cfs	cubic feet per second
cm	centimeter
CPUE	catch per unit effort
°F	Degrees Fahrenheit
DNR	Alaska Department of Natural Resources
EPA	Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
FL	Fork Length
fps	feet per second
ft	feet
G&A	general and administrative
GPS	global positioning system
GWh	gigawatt hours
HEP	Hydroelectric Evaluation Program
IFIM	Instream Flow Incremental Methodology
in	inch
KHI	Kenai Hydro Inc.
KHL	Kenai Hydro, LLC
KPB	Kenai Peninsula Borough
kWh	kilowatt hours
LLC	Limited liability company
mg/L	milligrams per liter
mi	mile

MIF	minimum instream flow
mm	millimeter
MSL	Mean sea level
MW	Megawatt
MWh	Megawatt hours
NWI	National Wetlands Inventory
O&M	Operations & maintenance
RM	river miles
RVDs	Recreation visitor days
TL	total length
TWG	technical working group
USACE	U.S. Army Corps of Engineers
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
YOY	Young of the year

Aquatic Resources Study Plan
Grant Lake Hydroelectric Project
(FERC No. 13212)

1 Introduction

On August 6, 2009, Kenai Hydro, LLC (KHL) filed a Pre-Application Document (PAD), along with a Notice of Intent to file an application for an original license, for a combined Grant Lake/Falls Creek Project (FERC No. 13211/13212 ["Project" or "Grant Lake Project"]) under Part I of the Federal Power Act. On September 15, 2009, FERC approved the use of the Traditional Licensing Process for development of the license application and supporting materials. As described in more detail below, the proposed Project has been modified to eliminate the diversion of water from Falls Creek to Grant Lake.

The Project will be located near the community of Moose Pass, Alaska in the Kenai Peninsula Borough, approximately 25 miles north of Seward, Alaska and just east of the Seward Highway (State Route 9).

This Aquatic Resources study plan is designed to address information needs identified in the PAD, during the Traditional Licensing Process public comment process, and through early scoping conducted by FERC. A study report will be produced that presents existing information relative to the scope and context of potential effects of the Project. This information will be used to analyze Project impacts and propose protection, mitigation, and enhancement measures in the draft and final license applications for the Project.

Proposed Project Description

The original PAD Project proposal included diverting water from Falls Creek into Grant Lake to provide additional flows and power generation at the Grant Creek powerhouse. The Falls Creek diversion has been removed from the Project proposal.

The proposed Project would be composed of a diversion dam at the outlet to Grant Lake, an intake structure in Grant Lake, a tunnel, a surge tank, a penstock, a powerhouse, a tailrace detention pond, a switchyard with disconnect switch and step-up transformer, an overhead or underground transmission line, and a pole-mounted disconnect switch where it ties into the existing City of Seward distribution line or Chugach Electric's transmission line. The powerhouse would contain two Francis turbine generating units with a combined rated capacity of 5.0 MW with a total design flow of 385 cfs.

Two modes of operation are likely for the Project: block loading or level control (run-of-river). The primary operational mode will be block loading at a specific output level. Level control, or balancing of outflow to inflow, will likely only occur during periods of low natural inflow to Grant Lake when the reservoir is at or near minimum pool elevation. Due to the small size of the Project in relation to the size of the interconnected system, the Project is not likely to be used to load follow.

Prior to reinitiating planning efforts for natural resource studies, KHL was evaluating two potential access road routes. The Falls Creek route would be approximately 3 miles long beginning at the south end of Lower Trail Lake, and the Trail Lake Narrows route would be about one mile long beginning at the Seward Highway. In early 2012, KHL determined that the

Trail Lake Narrows route was the most feasible and has eliminated the Falls Creek route from consideration. The Trail Lake Narrows route has not been fully assessed from a natural resource perspective and will be comprehensively evaluated in 2013 as part of this study effort

2 Overall Goals Identified during Project Scoping

Together with existing information, the goals of the study efforts described in this plan are to provide baseline information, and where applicable, information on alternative flow regimes, which will allow an assessment of potential Project impacts on aquatic resources in the study report. These impact assessments will identify potential protection, mitigation, and enhancement measures to be presented in the draft and final license applications.

The goals of this suite of studies are to provide supporting information on the potential resource impacts of the proposed Project that were identified during development of the PAD, public comment, and FERC scoping for the License Application, as follows:

- Impact of Project operation on sediment transport (relative to the availability of spawning gravels) due to changes in flow in Grant Creek.
- Impact of Project operation (fluctuating lake levels in Grant Lake, changes in seasonal flow in Grant Creek, reduced flows between the dam and powerhouse on Grant Creek) on fish abundance and distribution.
- Impact of Project construction and operation on biological productivity and abundance of fish food organisms in Grant Creek and Grant Lake.
- Impact of Project intake structure operation on fish populations.
- Impact of Project construction on fish habitat in Grant Creek.
- Impact of Project facilities (increased access) on fish populations due to potential increased recreational fishing.
- Impact of Project construction and operation on commercial, sport, and subsistence fisheries supported by the Kenai River watershed.

Specific objectives and quantitative objectives are presented below for each individual study component.

3 Existing Information

Information relating to aquatic resources has been collected during previous investigations into the potential development of hydroelectric generation at Grant Creek as well as during pre-licensing studies conducted by KHL in 2009 and early 2010.

3.1 Pre-2009 Studies

Previous FERC licensing efforts in the 1960s and 1980s for a proposed hydroelectric project at Grant Lake included studies of fish resources in Grant Lake and Grant Creek. Arctic Environmental Information and Data Center (AEIDC 1983) conducted fish sampling from 1981 to 1982 as part of a comprehensive environmental baseline study effort and the USFWS (1961) conducted limited sampling from 1959 to 1960. An instream flow study was completed in 1987

as part of a preliminary FERC license application prepared by Kenai Hydro, Inc. (not related to the current Kenai Hydro, LLC; Envirosphere 1987, KHI 1987a, and KHI 1987b).

Grant Creek Fish Resources - Both anadromous and resident fish are present in Grant Creek, including salmon, trout, and other species. Spawning Chinook (*Oncorhynchus tshawytscha*), Sockeye (*Oncorhynchus nerka*), and Coho (*Oncorhynchus kisutch*) salmon, as well as Rainbow trout (*Oncorhynchus mykiss*) and Dolly Varden (*Salvelinus malma*) are found in the lower reaches of Grant Creek (APA 1984; Johnson and Klein 2009; Figure 1). Rearing Chinook, Coho and Rainbow trout are also present (APA 1984, Johnson and Klein 2009). Round whitefish (*Prosopium cylindraceum*) and Arctic grayling (*Thymallus arcticus*) were caught during angling surveys but are not assumed to spawn in Grant Creek (APA 1984).

Upper Grant Creek is impassable to salmon 0.5 mile (APA 1984) to 1 mile (Johnson and Klein 2009) upstream of the mouth; fish habitat is most likely concentrated within the lower portion of stream. Habitat for juvenile fish exists mainly in stream margins, eddies, deep pools, and side channels offering reduced velocities (APA 1984). Substrate material is coarse throughout the entire length of the creek due to high water velocity that tends to wash away smaller gravels (APA 1984). Isolated areas of suitable spawning gravels occur in the lower half of the stream (APA 1984).

Periodic minnow trapping on Grant Creek from July 1959 through January 1961 captured juvenile Chinook salmon, Coho salmon, Dolly Varden char, and sculpin (extent of sampling area unknown; USFWS 1961). Minnow trapping and electrofishing in the lower reaches of Grant Creek for week-long periods in October 1981 and March, May, June, and August 1982 yielded higher catches of trout, salmon, and Dolly Varden in the fall and summer than in winter and spring (AEIDC 1983). Catches of Dolly Varden were generally most abundant in the minnow traps, followed by juvenile Chinook, juvenile Rainbow trout, and juvenile Coho. Juvenile Chinook were the most commonly caught fish during electrofishing surveys (APA 1984).

APA (1984) estimated that Grant Creek supported 250 Chinook spawners and 1,650 Sockeye spawners. The stream was also estimated to support 209 8-inch "trout" (including Dolly Varden and Rainbow trout) (APA 1984). Spawning Coho were not observed (APA 1984) but have been recorded as being present at unknown levels in the stream by the AWC (Johnson and Klein 2009). Maximum counts from intermittent stream surveys by ADFG were 76 Chinook (1963) and 324 (1952) Sockeye salmon.[1]

Grant Lake Fish Resources - Sampling during 1981-1982 found no fish in any of the tributaries to Grant Lake (AEIDC 1983). Sculpin and Threespine stickleback were the only fish found to inhabit Grant Lake. A series of impassable falls[2] near Grant Lake's outlet prevents colonization of the lake by salmonids via Grant Creek (APA 1984). Density of Threespine stickleback was ten times higher in the lower basin than the upper basin of Grant Lake (AEIDC 1983).

[1]Anadromous Waters Catalog Stream Nomination #08-153, http://www.sf.adfg.state.ak.us/SARR/FishDistrib/Nomination/FDDNomHome.cfm

[2] 2007 ADFG Stream survey referenced in Anadromous Waters Catalog Stream Nomination #08-153, http://www.sf.7adfg.state.ak.us/SARR/FishDistrib/Nomination/FDDNomHome.cfm

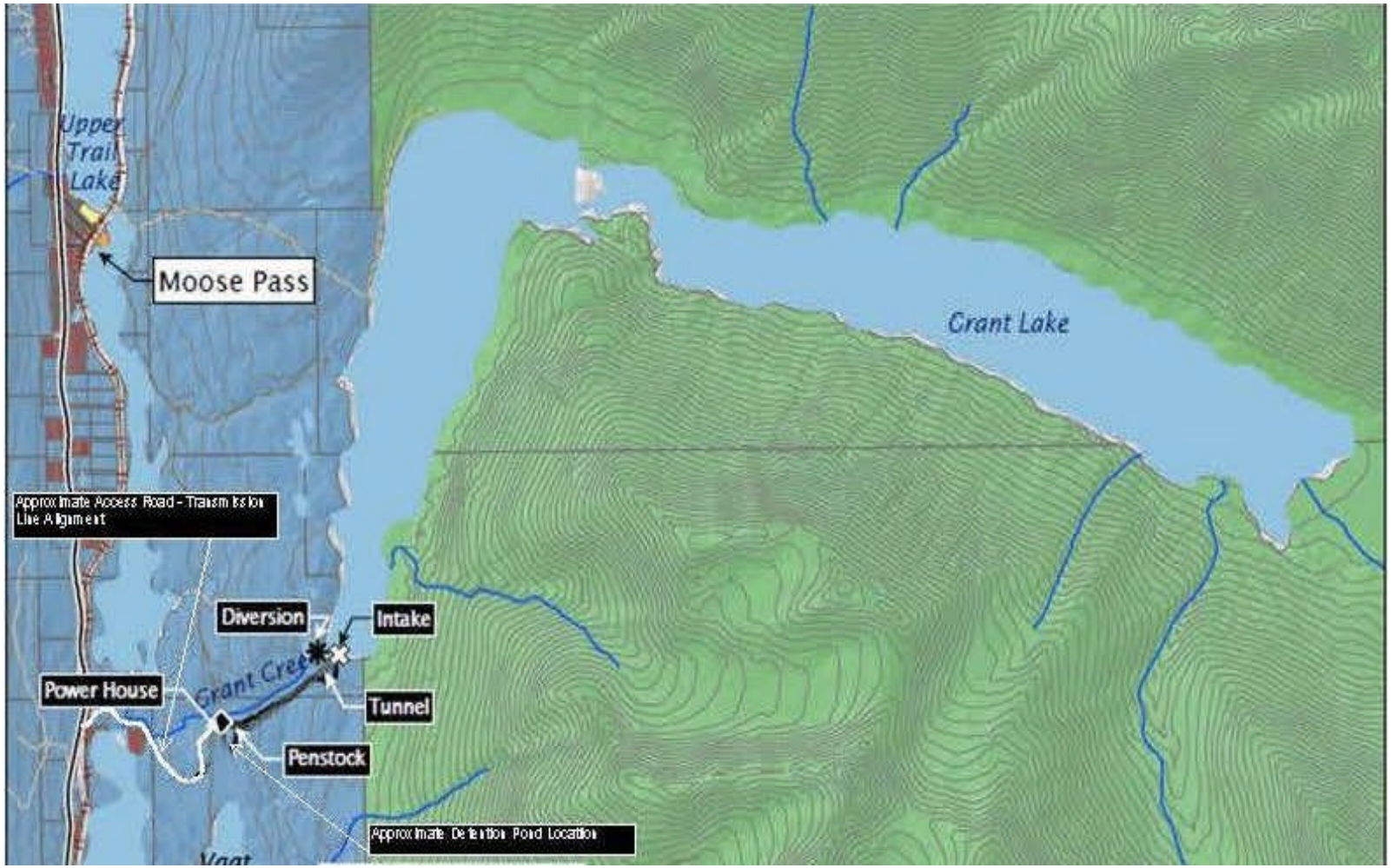

Figure 1. Fish and aquatics resources study area.

Because of the impassable falls below Grant Lake's outlet, no anadromous fish species occur in Grant Lake and its tributaries (USFWS 1961, AEIDC 1983, APA 1984), and Grant Lake is not included in the Anadromous Waters Catalog (AWC) published by ADF&G (Johnson and Daigneault 2008). Grant Lake appears to support only resident populations of sculpin–including Slimy sculpin (*Cottus cognatus*) and Coast Range sculpin (*Cottus aleuticus*)–and Threespine stickleback (*Gasterosteus aculeatus*) (AEIDC 1983, USFWS 1961, Johnson and Klein 2009). Although Sisson (1984) reported that Dolly Varden and a few Rainbow trout occupied Grant Lake, subsequent investigations (USFWS 1961, AEIDC 1983, Marcuson 1989) have documented only sculpin and stickleback. From 1983-1986, coho salmon fry were stocked in Grant Lake by ADF&G, with limited success, though some enhanced returns to Grant Creek were recorded (Marcuson 1989).

Instream Flow - Environmental analyses that emphasized the relationship between stream flow and aquatic habitats (instream flow studies) were conducted on Grant Creek in the 1980s by Kenai Hydro, Inc. (KHI; unrelated to Kenai Hydro, LLC). These documents were compiled in support of a license application for hydropower development on Grant Creek. The documents include reports and written communications between KHI and state and federal agencies in 1986 and 1987 relative to a FERC license application for the proposed Grant Lake Hydroelectric Project (FERC No. 7633-002). Included were draft and final reports of a limited but complete Instream Flow Incremental Methodology (IFIM) investigation and negotiated minimum instream flows and ramping rates (Envirosphere 1987, KHI 1987a, and KHI 1987b). A technical memorandum was drafted and shared with the Instream Flow Technical Working Group (TWG) participants in 2009 detailing the results of the previous instream flow study efforts (HDR 2009b).

3.2 2009 and 2010 Aquatic Resources Studies

The 2009 aquatic resources study program was intended to begin the process of acquiring resource information needed for FERC licensing and other regulatory requirements. Emphasis was on updating existing information, acquiring more complete information required for specific issue analysis, and providing background information needed to develop more focused studies after initiation of the formal FERC licensing process. The studies were continued in 2010 but the program was discontinued in July, 2010 to revise the study plans as a result of comments received during the FERC scoping process. Most of the studies planned for 2010 were not completed.

Fish - The 2009 fisheries study (HDR 2009a) focused on the following objectives:

- Determine the relative abundance and distribution of juvenile fish in Grant Creek.
- Determine the relative abundance and distribution of resident Dolly Varden and Rainbow trout in Grant Creek.
- Estimate abundance and run timing of spawning salmon.
- Estimate abundance and run timing of spawning adult resident fish.
- Determine fish presence and distribution in Grant Lake.

Consistent with studies conducted by AEIDC (1983), Grant Creek was divided into study Reaches 1 through 6. Reaches 1 through 4 were roughly 0.25 mi each in length and Reaches 5 and 6 were established based on geomorphologic characteristics (HDR 2009a; Figure 2).

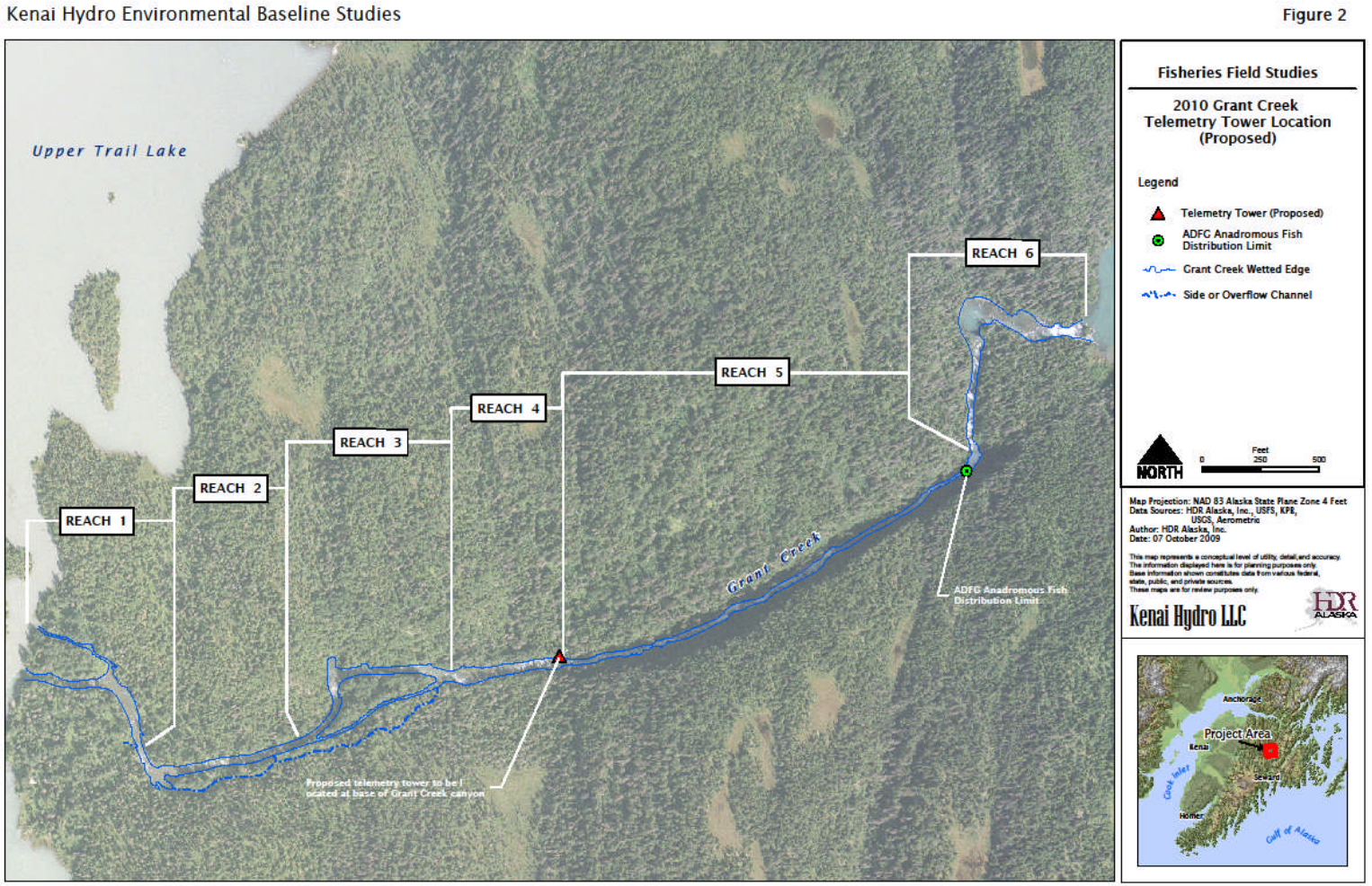

Figure 2. Study reaches designated on Grant Creek and proposed telemetry tower location.

Relative abundance and distribution of juvenile fish were determined by minnow trapping and calculating the catch-per-unit-effort (CPUE) for each reach. Reaches 1 through 4 were sampled relatively evenly, with nine to 13 minnow traps per reach. Terrain was difficult to access in Reaches 5 and 6, so these reaches were sampled less frequently and with only three and five sites, respectively. A total of 50 baited minnow traps were placed throughout the creek in Reaches 1 through 6; mesh size was 0.25 inch. The creek was sampled monthly, with the exception of Reach 6, which was sampled in June and August only. Dolly Varden were found to be the most abundant species in Grant Creek and distributed throughout Grant Creek Reaches 1 through 5, although they had a greater relative abundance in Reaches 4 and 5. Coho salmon was the next most abundant species and individuals were distributed throughout Reaches 1 through 5. However, coho appeared to have the greatest relative abundance in Reach 1. Chinook salmon was the next most abundant species. There was a noticeable decrease in Chinook abundance in upstream reaches, and they were not caught above Reach 4. Other fish present in small numbers were Sockeye salmon, Rainbow trout, sculpin, and threespine stickleback. Most salmon captured were young-of-the-year with few larger juveniles present (HDR 2009a).

Relative abundance of larger size resident salmonids (i.e., Rainbow trout and Dolly Varden) was determined by calculation of angling CPUE (HDR 2009a). A total of 18 angling sites were established along the creek, and each site was fished for 30 minutes approximately every 10 days, from early June through late September. Rainbow trout (n = 68) were found to be more abundant than Dolly Varden (n = 9) and were caught throughout the creek, although their relative abundance was higher in Reaches 3 through 5 than in Reaches 1 and 2. Dolly Varden were captured in Reaches 1, 2, and 3; their relative abundance was highest in Reach 1. This study was also aimed at determining the timing of spawning of adult resident fish; however, it appeared that spawning, if present, occurred before or after the 2009 study period, since little evidence of spawning fish was seen (HDR 2009a). Rainbow trout angling studies were continued in the spring and early summer of 2010 to confirm the presence of spawning and determine fish numbers. The progression of reproductive condition and the presence of adult rainbow trout in spawning condition confirmed that spawning did occur in Grant Creek in 2010. Capture success was too low to allow population estimates. Adult rainbow trout were observed in the upper portions of the canyon reach.

Abundance and run timing of spawning anadromous fish was estimated through data collected during foot surveys (HDR 2009a). Foot surveys occurred approximately every 10 days beginning in mid-June and ending in late September. Both Sockeye and Chinook salmon were seen in the lower five reaches. Chinook salmon reached Grant Creek first around the beginning of August. Sockeye salmon did not arrive until the end of August. Escapement of Chinook salmon was estimated to be 231 fish, and escapement of Sockeye salmon was estimated at 6,293.

Fish distribution and presence in Grant Lake and its tributaries were assessed using minnow traps, electrofishing, and gill nets (HDR 2009a). Sampling occurred at nine gill netting sites, 18 electrofishing sites, and 28 minnow trapping sites. Threespine stickleback was the dominant species in the lake followed by sculpin. No other species of fish was captured (HDR 2009a).

Instream Flow - The collaborative process for a study of "instream flow" effects in Grant Creek was initiated in 2009 (HDR 2009a). The primary goal of the 2009 instream flow study program was to establish a Technical Work Group (TWG) consisting of state and federal resource agency staff, KHL staff, and interested members of the local community. Once established, the TWG met three times during the 2009 study season to review the results of the 2009 aquatic baseline

study efforts, discuss and agree upon an acceptable instream flow evaluation method, and request additional information to support the selection of an instream flow method (HDR 2009a).

As part of the instream flow study, and at the request of the TWG, a sampling event was conducted from 23 to 25 June 2009 on Grant Creek to characterize the types of aquatic habitats used by resident fish and rearing fish (HDR 2009a). Aquatic habitat was described at each sample site by recording macro-, meso-, and micro- habitat characteristics. During the June sampling event, snorkeling was the primary method used to document fish presence. Electrofishing was used primarily to confirm species identification and calibrate fish length estimates (HDR 2009a).

Collaboratively, the TWG and KHL decided to select an instream flow study methodology based on the knowledge obtained from the summer 2009 aquatic resources and hydrology studies (HDR 2009a). Data and analyses from these studies were shared with the TWG in July and September. Based on the knowledge gained of Grant Creek's fish and hydrologic resources, KHL presented a proposed instream flow approach to the TWG on 23 September (HDR 2009a). Physical stream data required for instream flow modeling per the proposed approach were collected at 18 transects during low- and mid-flow conditions in 2010.

Macroinvertebrates, Plankton, and Periphyton - Benthic macroinvertebrate and periphyton samples were collected in Grant Creek in August, 2009 (HDR 2009a). Macroinvertebrate population density and taxa diversity can be used to assess stream water and habitat health and macroinvertebrates are an important source of food for fish. Periphyton (algae attached to large rocky substrate) is used to assess chlorophyll *a* content, an indicator of primary productivity. The sampling event was scheduled to occur during the time of year that typically displays the peak of diversity and population densities.

Sampling in 2009 was postponed due to a large rain event (HDR 2009a). This rain event may have scoured Grant Creek, dislodging many larger genera of macroinvertebrates and washing them out of the system. The macroinvertebrates that were found were typically smaller genera, although taxa diversity was at levels expected for south central Alaska streams. Periphyton is not affected as easily by high flow.

Zooplankton and phytoplankton were collected in Grant Lake in August (HDR 2009a). Phytoplankton samples were analyzed for chlorophyll *a* concentrations similar to periphyton in the creek. Concentrations in the lake were lower than that found in the creek.

3.3 Need for additional information

Early study programs and the 2009-2010 baseline study program conducted by KHL have provided a significant amount of background information regarding aquatic resources in the Project area. Following analysis of the 2009 and 2010 study results, information gaps were identified for further study to support the FERC licensing process and accompanying permit requirements. Proposed additional field studies are intended to provide information on the following general topics. Specific objectives for study components will be described below for each component.

- Juvenile fish use of winter habitats.
- Better definition of fish use of microhabitats and overall species composition and relative abundances in Reaches 1 through 4.

- Extent of Rainbow trout spawning in Grant Creek.
- Use of Reach 5 by juvenile and adult fish, with additional emphasis on spawning Chinook salmon use of Reach 5.
- Delineation of aquatic habitats available in Grant Creek; identify key habitats for fish and describe and distinguish the factors that may influence fish use of the key habitats over those habitat units not occupied by fish in Grant Creek.
- Estimation of salmon spawning escapement in Grant Creek.
- Examination of how important individual habitat units may be affected by changes in flow due to the operation of the proposed Project using instream flow assessment methods.
- Baseline diversity and abundance characteristics of benthic macroinvertebrates in Grant Creek.
- Baseline primary productivity of Grant Creek as measured by chlorophyll *a* concentration in phytoplankton samples.
- Fish resources and habitat use of the Trail Lake Narrows at the proposed bridge site.

4 Methods

Aquatic resources of Grant Creek will be studied through an integrated study program with three main disciplines: fish biology, instream flow, and an aquatic ecology element that includes macroinvertebrates and periphyton. Specific methods for aquatic resources are described below.

4.1 Study Area

Water bodies to be investigated as part of the Aquatic Resources Study Plan include Grant Lake and Grant Creek, located near the community of Moose Pass, Alaska, approximately 25 miles north of Seward, Alaska, and just east of the Seward Highway (State Route 9). The proposed Project location is in the Kenai Peninsula Borough. The study area is shown in Figure 1.

4.2 Field Study Components

Field studies will include the following principal components, each designed to address one or more specific concerns:

1. Grant Creek salmon spawning distribution and abundance:
    - Use of a counting weir to inventory upstream migrating salmon.
    - Supplemental foot surveys of Grant Creek to determine distribution and abundance of spawning salmon.
    - Telemetry study of Chinook, Sockeye, and coho salmon spawning distribution, with emphasis on the inaccessible canyon section of Grant Creek (Reach 5).

2. Grant Creek resident and rearing fish distribution and abundance:
    - Use of a counting weir to inventory the movements and abundance of adult resident species.
    - Telemetry study of Rainbow trout to determine the distribution of spawning and feeding areas in Grant Creek.
    - Surveys to determine fish presence in suspected overwintering habitats.
    - Surveys of Grant Creek to estimate distribution and abundance of juvenile fish by habitat type, with emphasis on areas not surveyed in 2009 including Reach 5.
    - Juvenile fish outmigration monitoring in spring and fall.
3. Grant Creek aquatic habitat mapping:
    - Synthesis of fish use and aquatic habitat data for Grant Creek.
    - Delineation of aquatic habitats in Reaches 1 through 5 of Grant Creek.
    - Surveys to ground-truth office-based habitat delineation, fill spatial data gaps, and verify fish use of aquatic habitats.
    - Identification of key habitats based on observed fish use.
    - Analysis of habitat factors that distinguish key habitats from other habitats available in Grant Creek.
4. Grant Creek Instream Flow Study, including the following components:
    - Habitat availability analysis using measurements of stream geometry at the 18 previously selected transect sites.
    - Fish use of meso- and microhabitats.
    - Integration of flow and temperature monitoring.
    - Analysis and modeling to predict habitat response to changes in flow regime.
5. Benthic macroinvertebrates in Grant Creek:
    - Sampling using pseudo-replication Surber sampling methods to estimate population density in riffle/run habitats.
    - Macroinvertebrate identification to genus level (when possible) identification for use in calculating population metrics.
6. Periphyton in Grant Creek:
    - Collecting periphyton samples from riffle areas at two locations within Grant Creek.
    - Analyzing chlorophyll a concentration in individual samples.
7. Trail Lake Narrows Aquatic Resource and Habitat Use
    - Seasonal fish abundance and distribution in the vicinity of the proposed bridge crossing site
    - Assessment of the aquatic habitats at the bridge crossing – Fish habitat use and distribution

4.3 Grant Creek Fish Weir

A weir is being proposed as a principal means of fish capture and inventory for several of the study components. Because of its application to multiple studies, weir methodology is being described in this separate section. Its specific applicability to each of the study components will be described in the appropriate sections below.

Grant Creek is a high gradient stream with substantial flow variation over the course of the open water study season. Consequently, a weir on Grant Creek will need to be designed to accommodate the difficult stream conditions. Many different weir designs have been used in fisheries research that could potentially be adapted to Grant Creek conditions. Resistance board, floating picket weir has been used successfully in fast streams in Alaska and other western states (Stewart, 2002). Such designs use a resistance board and floating pickets to allow debris and high water to pass over the top of the weir. This design minimizes the amount of maintenance required during weir operation and reduces the chance that high water will damage the weir. Regardless of the weir design selected, the spaces between pickets must be small enough to intercept adult sized Rainbow trout. A Grant Creek weir could be custom constructed, borrowed from fish research agencies, or purchased from one of several vendors. Resistance board weirs generally consist of the following components: a trap box to hold fish diverted by the weir, floating panels hinged to the stream bottom, a rail system to attach the panels to the stream bottom, and rigid picket modules at each bank. Other designs consist of rigid pickets extending across the stream. Potential configurations are highly variable depending on the stream characteristics and project needs. The primary intent of the weir is to catch upstream migrating fish. Some designs will also allow downstream passage.

Ideally, the spacing of the weir pickets should be such that it will capture fish of a size range from adult Rainbow trout to adult salmon. However, it is recognized that there are limitations to how closely spaced the pickets can be and still be practical in a high gradient stream. Consequently, a maximum 3 inch spacing is specified to assure capture of all salmon species. Closer spacing would be desirable so that some larger resident species would also be captured.

It may be desirable for the weir to be opened to allow unobstructed passage of fish during part of the open water season when few fish are moving within the stream or when high water makes weir monitoring impractical. When the weir is in place, it will be monitored at least twice per day and trapped fish will be released upstream of the weir. All fish caught in the weir will be identified to species and enumerated. Captured fish will also be measured if time allows and fish quantity is not too large to allow safe handling. Additional processing of fish is described below for the individual study components.

The Grant Creek weir will be installed at a suitable location as close to the stream mouth as possible during low flow in April with monitoring to begin May 1, 2013. It will be left in place until early November, at which time all components will be removed from the stream.

4.4 Grant Creek Salmon Spawning Distribution and Abundance

The purpose of this study component is to characterize spawning salmon distribution, run timing, and relative abundance in Grant Creek. This study effort will consist of two principal components and several subcomponents:

- Use of a counting weir to obtain a direct count of all salmon entering Grant Creek during the open water season.
    - Weir counts will be compared to counts from foot surveys similar to those conducted during 2009 to calibrate earlier surveys and obtain an estimate of observer error when viewing fish from the stream bank.
- A radio telemetry study to further assess the spawning distribution of Chinook, Sockeye, and coho salmon, with emphasis on Reach 5 (Canyon Reach). Coho salmon and Dolly Varden may be included in the study if conditions allow.

4.4.1 Salmon Escapement to Grant Creek – Relative Species Abundance

Project-Related Objectives

- Assessment of numbers and species of salmon in Grant Creek as a whole.
- Identification of key species and critical time periods as required for environmental assessment.
- Identification of key species and critical time periods as may be applied to design of Project mitigation measures.
- Calibration of escapement estimates from foot surveys conducted in 2009.

Quantitative Objectives

- The primary objective is to obtain a nearly complete count of salmon of each species entering Grant Creek. It is recognized that some fish will likely escape the weir and that extreme flow events can interrupt complete counts. Such events, if they occur, will be documented. Use of the complete count methodology requires no specific statistical analysis.

During 2009 foot surveys, salmon counts were conducted approximately every 10 days from mid-June through September resulting in escapement estimates for Chinook and Sockeye salmon using an area-under-the-curve method based on a trapezoidal approximation using linear interpolation to estimate the number of fish present in the stream for the days not surveyed (Neilson and Geen, 1981; English et al., 1992; Bue et al. 1998). Survey life (the number of days a fish is alive in the survey area) and observer efficiency (the proportion of fish actually seen by the observers) were estimated based on professional judgment. Because of marginal visibility and untested estimates of stream life and observer efficiency (both required for area under the curve estimates), the accuracy of the 2009 estimates was questionable. It was decided that the use of a counting weir, while difficult in Grant Creek, was a preferable method for relative abundance estimation. Use of a weir will have several additional benefits as follows:

- It will provide exact timing of stream entry.
- It will allow capture of fish for age and length measurements.
- It will allow capture of fish for tagging and radio tag implantation (see below).
- It will allow monitoring of larger resident species as well as salmon.
- It will make possible a calibration of the 2009 foot surveys by comparing known fish numbers with visual estimates.

A weir, as described in Section 4.3 above, will be established near the mouth of Grant Creek to monitor the Chinook salmon run in mid-July and will continue to be monitored until early November. The time period will encompass the full run of Chinook and Sockeye salmon and most of the coho salmon run, if possible. The intent will be to keep the weir in place until the coho salmon run is completed; however, icing conditions might require premature removal of the weir. Information regarding the abundance and timing of coho salmon is currently scarce; consequently, the success of a weir at capturing cohos is unknown. If coho salmon are continuing to move upstream after the weir is removed, the run will continue to be monitored using foot surveys, at least through the first week of November. All salmon passing through the weir will be counted and representative samples will be sexed, measured, and tagged with Floy spaghetti tags. Scale samples will be taken from selected fish for aging. To determine the uniqueness of Grant Creek salmon, limited tissue samples for genetic analysis will be collected from selected fish, provided that a cooperative agreement can be arranged with ADF&G to conduct the appropriate analyses.

During times when the weir is being operated in capture mode, salmon will be directly counted by examining all fish in the capture box and releasing them upstream. During salmon runs, personnel will monitor the weir and empty the catch box at least twice per day, more often if necessary.

Foot surveys of lower Grant Creek (Reaches 1-4) will be conducted at least once a week during the Chinook and Sockeye salmon runs using procedures similar to those used in 2009. Numbers of fish visually observed will be compared to numbers of fish known to be present based on weir counts. Locations of fish will be documented using GPS coordinates and paper maps. Floy tags and radio tags will be recorded at the weir if carcasses are encountered.

Personnel on site will document as much incidental information as time allows. For example, carcasses floating downstream into the weir can be counted and tag numbers recorded and removed to provide insight into the duration of stream life (date originally tagged vs. date the carcass was found).

4.4.2 Distribution of Spawning Salmon in Grant Creek

Project-Related Objectives

- Identification of critical spawning habitats as required for general assessment of Project impacts.
- Identification of habitat areas appropriate for use in instream flow analysis.
- Provide input for Project mitigation needs by identifying sensitive stream segments.

Quantitative Objectives

- Numbers of radio tagged fish must be adequate to provide an acceptable representation of the spawning populations of each species. Hypothesis: distribution of tagged fish is identical to the distribution of the entire population.

During the 2009 preliminary investigations, the crew was unable to access Reach 5 (Figure 2), except for the first 100 meters beyond the reach-break between Reaches 4 and 5. Reach 5 was also not accessed in the 1980s by previous investigators (AEIDC 1983). High-velocity flows

and cascades prevented safe wading of the stream, and precipitous terrain prevented walking along the edge of the stream. As a result, the upstream extent of salmon spawning activity in Grant Creek has not been adequately characterized. Turbid water due to glacial runoff in Grant Creek also lowered observer efficiencies and added to uncertainty of escapement estimates and spawning distribution in the remainder of the stream. A radio telemetry study is proposed to overcome the above shortcomings with emphasis on delineating spawning distribution within Reach 5 (Canyon Reach).

A representative number of Chinook, Sockeye, and possibly coho salmon will be captured near the mouth of Grant Creek in the weir described in Section 4.3 above. The number of Chinook and Sockeye salmon to be tagged will be based on the total escapement numbers estimated in 2009. Chinook salmon will be radio tagged starting in early August, with the goal of distributing the tags proportionately throughout the run, which is expected to last from mid to late August. Sockeye salmon will be radio tagged from August 20 to about September 10. The timing of the coho salmon run is currently unknown, so professional judgment and pertinent literature will be used to assess run timing for Coho. There will be 65 tags allocated for Chinook, 65 tags for Sockeye, and 20 tags for Coho. Once fish are captured, coded transmitters will be inserted into their stomachs. Tags will be lubricated with glycerin and pushed down the esophagus into the stomach using a PVC tube. All radio-tagged fish will also be tagged with Floy spaghetti tags. Radio tags will be programmed to have a 60-day battery life and will include a feature that codes for the death of the fish. A fixed radio telemetry receiver will be installed at the reach-break between Reaches 4 and 5 (Figure 2) to detect when fish enter or exit Reach 5. Tracking surveys using a hand-held mobile receiver will be conducted at least weekly during the period when tagged fish are present in the stream. Frequent telemetry surveys will provide valuable information on stream life (s) and position information of tagged fish as part of area-under-the-curve estimation and spawning locations, respectively. A trail has been established along a safe route on the canyon rim paralleling Reach 5. Once a fish is detected, the crew will use triangulation techniques to identify the tagged fish's position. Locations of the tagged fish will be recorded using GPS coordinates as well as marked on hand-held maps.

Installation of a fixed-telemetry site near the confluence of Grant Creek will be pursued, which will provide information regarding Rainbow trout exodus from Grant Creek. The system will consist of either underwater or aerial antennas monitoring each channel, and be combined so that they are monitored as a single antenna. Our approach will be based on the configuration of each channel, potential ambient electrical noise, and the challenges associated with each type of system.

Movements of all radio tagged fish will be mapped and analyzed. Information will be combined with the results of foot surveys as described in Section 4.4.1 to delineate likely spawning locations for each species and probable proportions of salmon that spawn in various stream reaches. Dates of fish death as indicated by the radio tags will be combined with carcass information and tagging dates to estimate stream life duration.

4.5 Grant Creek Resident and Rearing Fish Abundance and Distribution

The purpose of this study component is to characterize distribution and abundance of all species of resident and rearing fish and run timing of Rainbow trout in Grant Creek. This study effort will consist of the following components:

- Weir inventory and telemetry study to assess run timing, relative abundance, and spawning habitat location for Rainbow trout.
- Investigation of juvenile fish presence in Reach 5 of Grant Creek using minnow traps and other sampling techniques.
- Minnow trap and video sampling in late winter/early spring at likely overwintering habitats to determine salmonid overwintering presence in Grant Creek.
- Snorkel sampling to determine fish use of mesohabitats in Grant Creek.

4.5.1 Adult Rainbow Trout Abundance, Distribution, and Spawning in Grant Creek

Project-Related Objectives

- Assessment of relative numbers of Rainbow trout in Grant Creek as a whole.
- Identification of sensitive time periods as required for environmental assessment.
- Identification of important spawning and feeding habitats as required for general assessment of Project impacts.
- Provide input for Project mitigation needs by identifying sensitive stream segments.

Quantitative Objectives

- Obtain a count of adult Rainbow trout entering Grant Creek during the open water season. It is understood that some trout will likely escape the weir or be too small to be captured.
- Determine distribution of trout by tracking radio-tagged fish. Ideally, the numbers of radio-tagged fish should be adequate to provide an acceptable representation of the total Grant Creek population.

Angling surveys in 2009 and 2010 documented that modest numbers of adult and sub-adult Rainbow trout were widely distributed in Grant Creek during the open water season and confirmed that some spawning occurs in the creek. Catch-and-recapture numbers in 2010 were too small to allow mark-and-recapture population estimates, and spawning locations remain largely unknown. To obtain more complete information on abundance, distribution, and timing of movements, it is proposed that additional study occur in 2013 that combines angling with possible weir capture of larger fish.

Weir and Angling Study - The weir will be installed in April during low-flow conditions; consequently, it will be in place prior to spring spawning migrations, which typically occur as water temperature approaches 4 ˚C. The final weir design is unknown and picket spacing may be such that most Rainbow trout will be able to bypass the weir. During the spring migration period only, vexar screen of an appropriate mesh size may be secured to the weir to increase the capture efficiency of the weir for rainbow trout. If the weir is effective at catching rainbow trout then the weir will be operated in capture mode during the spawning period, and all trout will be

measured and sexed and their reproductive condition will be assessed if possible. Depending on the effectiveness of the weir at catching trout, additional fish may be captured by angling during the spring and early summer period. During the remainder of the open water season, trout caught in the weir will be counted and representative numbers will be measured. Two-way passage will be the preferred mode of weir operation in the fall when trout are likely to be moving out of Grant Creek.

Radio Telemetry Study - A representative number of mature Rainbow trout will be captured during the early weeks of the spawning migration for surgical implantation of radio transmitters into the abdominal cavity. Capture method will be by weir capture, angling, or a combination of both Surgical methods will generally follow those described by Summerfelt and Smith (1990). Fish within the dominant size range of mature Rainbow trout (500 - 700 mm) will likely weigh 1,800-6,000 grams (Russell, 1977). It is advised that radio tags should not exceed 2 percent of body weight, thus a tag weighing less than about 35 grams would be suitable. The tags will be individually coded allowing identification of specific fish. Forty radio tags will be secured for the Rainbow trout telemetry study.

A fixed radio telemetry receiver will be installed at the reach-break between Reaches 4 and 5 (Figure 2) to detect when fish enter or exit Reach 5. A second fixed-telemetry site will be located downstream of the weir near the Grant Creek confluence (as discussed above). Tracking surveys using a hand-held mobile receiver will be conducted at least weekly, and more frequently when possible during the spawning period. A trail has been established along a safe route on the canyon rim paralleling Reach 5. Once a fish is detected, the crew will use triangulation techniques to identify the fish's position. Locations of the tagged fish will be recorded using GPS coordinates as well as marked on hand-held maps.

Movements of radio-tagged fish will be mapped and analyzed to determine the locations of probable spawning and feeding habitats.

4.5.2 Resident and Rearing Fish Use of Study Reach 5

Project-Related Objectives

- Assessment of rearing fish use of habitats within the high gradient Canyon Reach as required for impact assessment within the portion of Grant Creek that will be most altered by the Project.
- Assessment of the juvenile fish productivity of Reach 5 relative to the remainder of Grant Creek.
- Assessment of the need for mitigation measures within Reach 5.

Quantitative Objectives

- Because of the difficulty in safely accessing much of Reach 5 and the dominant turbulent flow, habitat areas sampled were selected purely on the basis of accessibility and feasibility of sampling. These reconnaissance level investigations are non-quantitative in nature. They provide presence/absence information and relative species abundance data for the sample sites. Statistical analyses are not appropriate under these circumstances.

- Inclined plane traps used for outmigrant monitoring can be expected to capture a percentage of young fish moving downstream. If numbers are sufficiently high, trap efficiency can be calibrated by releasing marked samples of fish, and total outmigration can be estimated. Number of fish in test sample will likely depend on number available from the trap and will need to be determined in the field.

On-site Sampling - During 2009 minnow trap sampling, crews were unable to access Reach 5, except for the first 100 m beyond the reach-break between Reaches 4 and 5 (Figure 2). Most of Reach 5 was also not accessed in the 1980s by previous investigators (AEIDC 1983). High-velocity flows and cascades prevented safe wading of the stream, and steep terrain prevented safe upland access without climbing gear. To assess the presence of juvenile fish in Reach 5, juvenile fish sampling will be expanded to areas not reached in 2009.

An initial reconnaissance of Reach 5 was conducted in late winter 2010 when the creek was frozen and could be accessed on foot at the bottom of the gorge; information was gathered regarding potential summer access points, likely fish habitat, and potential sample sites.

Juvenile fish use of Reach 5 was assessed using the same minnow trapping methods that were employed during 2009, except that special equipment was used to access the creek in Reach 5 in a safe manner. Routine access of Reach 5 during high-flow conditions was accomplished by using roped protection. Sample site locations were based on the ability to safely access this reach from the canyon rim, influenced by the following criteria:

- Safe access via rappel/belay techniques.
- Proximity to safe anchor sites.
- Proximity to likely fish habitats.

Two sampling events were conducted in 2010, May and July. The initially planned September sampling event was not completed. A crew of two set minnow traps in as many locations as possible with 3 to 4 traps each within likely fish habitats, such as plunge pools and eddies. The three sites trapped in 2009 in the lower 300 meters of Reach 5 were also re-sampled, for a total of five sites in Reach 5. Target species were Chinook and coho salmon, Dolly Varden, Rainbow trout, and sculpin. CPUE was defined as the catch per trap-hour.

All sampling sites were marked by a GPS, staked, and flagged for future identification. Habitat characteristics were recorded. Fish captured were identified to species, measured, and released near the point of capture. Salmonid length measurements were based on fork length (tip of the snout to the fork in the tail), and other fish length measurements were based on total length (tip of snout to end of tail).

The procedures described above for the 2010 sampling will be repeated in September to complete the originally planned sampling schedule. Additional sampling techniques including electrofishing, seining, and underwater video may also be employed where feasible. Special effort will be dedicated to determining whether adult Dolly Varden use portions of Reach 5 for spawning. Weir operation, as described in Section 4.3, may provide information on the timing of upstream movements of adult Dolly Varden. If sufficient numbers of spawning condition Dolly Varden are observed, mobile surveys of radio tagged fish will be utilized to identify their final desitnation. Given the historical data associated with Dolly Varden numbers in Grant Creek, HEA believes 10 radio tags will be sufficient for this analysis.

Outmigrant Monitoring - In addition to the sampling described above, outmigration of juvenile fish from Reach 5 will be monitored in the spring using a small inclined plane trap. The trap will be anchored near the boundary between Reaches 4 and 5, immediately downstream from the proposed Project powerhouse and tailrace outfall. The intent will be to determine the outmigrant contribution of the Canyon Reach (Reach 5) relative to the remainder of Grant Creek. Species of primary interest will be juvenile Chinook, coho, and Sockeye salmon and young-of-the-year Rainbow trout. Sockeye salmon fry are known to move out of Grant Creek within a few weeks of emergence; consequently, the outmigrant trap will need to be installed in early spring at the same time as the counting weir. Young fish entering the trap will be held in a fine mesh live box, which will be monitored at least once per day, more often if large numbers of fish are entrapped. All fish in the trap will be identified to species, counted, and measured (fork length). If substantial numbers of fish are caught, an attempt will be made to calibrate the overall effectiveness of the trap by holding a sample of the trapped fish, marking them with dye, and transporting them for release upstream. The proportion of dyed fish subsequently caught in the trap will provide an indication of the percentage of total outmigrants captured in the trap, thus providing a basis for estimating total outmigrant production from Reach 5. Resident and Rearing Fish Use of Winter Habitats

Project-Related Objectives

- Determine the extent of fish and habitat use of Grant Creek during winter conditions as required for Project environmental assessment.
- Determine the need for winter mitigation measures, especially as related to storage pond release rates.
- Contribute habitat use information for application to instream flow studies.

Quantitative Objectives

- Winter sampling of selected potential habitat use areas will be essentially reconnaissance level efforts and are non-quantitative in nature. They provide presence/absence information and relative species abundance specific to each sample site. In most cases statistical analyses will not be appropriate under these circumstances. Inclined plane traps used for outmigrant monitoring can be expected to capture a percentage of young fish moving downstream. If numbers are sufficiently high, then trap efficiency can be calibrated by releasing marked samples of fish and total outmigration can be estimated. Number of fish in test sample will likely depend on number available from the trap and will need to be determined in the field
- The results of the 2009 snorkel and minnow trapping surveys provided evidence that very few juvenile salmon observed were older than young-of-the-year fish (YOY; i.e., hatched in spring). Based on these results, there is some question as to whether Grant Creek provides favorable overwinter habitat for juvenile s**a**lmon and other species. This study component will assess juvenile salmonid presence in likely overwintering habitats such as open water, springs and seeps, deep pools, and backwater areas.

Likely overwintering habitats will be identified based on existing habitat mapping, knowledge of study area, and 2009 data. Additional areas will be identified based on winter reconnaissance. In addition to likely areas of winter refuge, sampling will also be conducted, where possible, at the locations of the instream flow transects to allow instream flow modeling to include the winter

period. Areas of unfrozen water will be sampled using both minnow traps and backpack electrofisher. In frozen areas where substantial unfrozen water is suspected under the ice, an ice auger will be used to gain access to water under the ice, if necessary. A baited minnow trap or bait container will be lowered into the water along with an underwater video camera. Under-ice conditions will be observed on a monitor. If fish are seen on the monitor, then video will be recorded for later review. Footage will then be analyzed in the office to determine species and age class of any fish attracted to the bait. This one-time sampling event will occur in late winter, before breakup occurs in Grant Creek. The study will likely need to be conducted before break-up in Trail Lake to ensure safe access to Grant Creek.

Spring Outmigration Monitoring - In addition to onsite winter investigations, the outmigration of juvenile fish from Grant Creek will be monitored in the spring to help determine the extent to which juvenile salmon and Rainbow trout overwinter in Grant Creek. Emphasis will be on Chinook and coho salmon smolts. Recently emerged Sockeye salmon fry will likely also be captured in the trap. An inclined plane trap will be installed near the mouth of Grant Creek to intercept juvenile fish moving downstream. The trap will be installed during the low-flow period that immediately precedes spring break-up at the same time that the outmigrant trap is installed below the Canyon Reach. Young fish entering the trap will be held in a fine mesh live box that will be monitored at least once per day, more often if large numbers of fish are trapped. All fish in the trap will be identified to species, counted, and measured (fork length). If substantial numbers of fish are caught, an attempt will be made to calibrate the overall effectiveness of the trap by holding a sample of the trapped fish, marking them with dye, and transporting them for release upstream. The proportion of dyed fish subsequently caught in the trap will provide an indication of the percentage of total outmigrants captured in the trap, thus providing a basis for estimating total outmigrant production from Reach 5. Calibration of the downstream trap may be coordinated with calibration of the upstream trap, using fish trapped upstream and released for downstream capture. Estimated Chinook and coho smolt outmigration numbers based on the trap catch will provide a direct indication of the contribution of Grant Creek overwinter rearing to the Kenai River system and will be compared to catches in the upstream trap to determine the relative contributions of upstream and downstream areas to Chinook and coho production. Numbers of Sockeye salmon fry will provide an indication of hatching success and can also be compared to catches in the upstream trap to determine the relative contributions of upstream and downstream areas to Sockeye production.

4.5.3 Resident and Rearing Fish Use of Open Water Habitats in Lower Grant Creek

Project-Related Objectives

- Assessment of rearing fish use of habitats within lower Grant Creek as required for Project impact assessment.
- Assessment of the juvenile fish productivity of Reaches 1-4 relative to the remainder of Grant Creek.
- Assessment of the need for mitigation measures within Lower Grant Creek.
- Selection of high fish use areas for incorporation in the instream flow study.

Quantitative Objectives

- Sampling of selected potential habitat use areas will be essentially reconnaissance level efforts and are non-quantitative in nature. They provide presence/absence information and relative species abundance specific to each sample site. In most cases statistical analyses will not be appropriate under these circumstances.
- Obtain a count of adult Rainbow trout, Dolly Varden, and other resident species entering Grant Creek during the open water season. Use of the complete count methodology requires no specific statistical analysis.
- Inclined plane traps used for outmigrant monitoring can be expected to capture a percentage of young fish moving downstream. If numbers are sufficiently high, trap efficiency can be calibrated by releasing marked samples of fish and total outmigration can be estimated. Number of fish in test sample will likely depend on number available from the trap and will need to be determined in the field.

Field Sampling - Investigations in spring, summer, and fall of 2009 and in spring of 2010 sampled a variety of slow-water habitats using minnow trapping and snorkeling techniques, identified habitat types most heavily used by rearing fish, and provided significant information regarding relative species abundance. This task continues those investigations with the intent of filling data gaps and sampling a wider variety of habitat types so that the information can be integrated with the habitat mapping information.

In Study Reaches 1-4, sample sites in which catch of juvenile salmon in minnow traps was poor or sample sites in habitats that were underrepresented by sampling in 2009 and 2010 (e.g., low-velocity habitats, backwaters, undercut banks) will be identified in the office and in the field. Each selected habitat area will be sampled using the method most appropriate to the conditions. Methods may include baited minnow traps, snorkeling, electrofishing, and seining Sampling methods for this subcomponent will be similar to those used in Reach 5, with the exception of the method of site determination, which will be based on habitat units. Where possible, minnow trapping sites will also be electrofished or snorkeled to attempt to correct for gear bias of the minnow traps (i.e., document species that may not be captured in the minnow traps). This kind of sampling results in a variety of outputs with varying quantitative value

Electrofishing will not be employed when spawning fish are present within 10 meters of the study site. Instream work will be minimized in the vicinity of spawning fish. Any activity that causes displacement of spawners from spawning areas will be avoided.

Weir Data - The counting weir described in Section 4.3 will be in place throughout the open water season and may allow monitoring of the upstream and possibly downstream movements of larger resident fish throughout the season. The final design of the weir is currently unknown and it may not be effective at catching resident species. The weir may be useful for monitoring the upstream migration of Rainbow trout that occurs coincident with the salmon migration and for observing possible upstream movements of Dolly Varden spawners in the fall. All resident fish passing the weir will be recorded. When the weir is in capture mode, the lengths of all fish will be measured if possible without harming fish or requiring extra effort. As described above, the presence of an obvious pulse of large Dolly Varden will trigger a need for foot surveys to identify spawning locations.

Outmigrant Monitoring - Some rearing fish move out of small streams in the fall into winter rearing areas. Others may remain in the stream through the winter. To better understand the life history of resident and anadromous species in Grant Creek, an inclined plane trap will be employed near the mouth of Grant Creek in the fall to intercept juvenile fish moving downstream. The trap will be installed in mid-September and will continue to operate until about mid-October, depending on fish movements. Young fish entering the trap will be held in a fine mesh live box that will be monitored at least once per day, more often if large numbers of fish are trapped. All fish in the trap will be identified to species, counted, and measured (fork length). If substantial numbers of fish are caught, an attempt will be made to calibrate the overall effectiveness of the trap by holding a sample of the trapped fish, marking them with dye, and transporting them for release upstream. The proportion of dyed fish subsequently caught in the trap will provide an indication of the percentage of total outmigrants captured in the trap, thus providing a basis for estimating total number of fall outmigrants contributed by Grant Creek. Combining the results of the spring and fall outmigration monitoring will provide an indication of the total annual productivity of the creek.

4.6 Grant Creek Aquatic Habitat Mapping

Project-Related Objectives

- Prepare an image of Grant Creek upon which aquatic habitat and fish use information can be superimposed.
- Develop a map of aquatic habitats that will provide a basis for describing the distribution of key habitat types.
- Identify important factors that influence fish use of key habitats for input to the instream flow analysis.

Quantitative Objectives

- Habitat should be identified and mapped with sufficient resolution so that the GIS system can be used to accurately calculate surface areas.

The purpose of this study is to fully delineate and map the aquatic habitats available in Grant Creek, identify important habitats for fish (i.e., rearing and resident fish; spawning salmon), and describe and distinguish the factors that may influence fish use of the key habitats over those habitat units not occupied by fish in Grant Creek.

It should be noted that much of the work described below has been completed including the basic structure of the GIS system and substantial information regarding fish use of various habitat types. The focus of the 2013 work will be to complete the habitat mapping, integrate all of the field data into the georeferenced database, identify data gaps, and conduct limited fieldwork to fill the gaps.

The approach of this study involves three primary phases. During the first phase, the team will spatially synthesize existing aquatic habitat and fish use data generated during various field efforts throughout the 2009 and 2010 field seasons. This exercise will be completed primarily to identify spatial data gaps. In the second phase, the team will then ground-truth habitat data in

the field, collect additional habitat and fish use data in Reaches 1 through 5[3], and incorporate other suitable habitat and fish use data collected in 2010 (e.g., instream flow study, Section 4.7). Finally, the team will analyze the suite of habitats and fish use data to identify important factors affecting the distribution of fish. The primary tasks associated with this approach will be:

- Prepare an office-based aquatic habitat map (i.e., based on habitat observations assembled throughout the 2009 and 2010 field seasons).
- Conduct field surveys to ground-truth the office-based mapping effort and fill spatial data gaps relative to aquatic habitat and fish use in Reaches 1 through 4. Actual collection of fish habitat use information will be accomplished by the resident and rearing tasks and the instream flow task.
- Incorporate aquatic habitat fish use data to identify key rearing, spawning, and feeding habitats for salmon and resident fish and potential overwintering habitats.
- Analyze and identify the factors that may influence fish use of the key habitats over those habitat units not occupied by fish in Grant Creek.

The office-based mapping exercise will incorporate existing habitat data overlain by fish use data into a spatial format, using ArcMap© geographic information system (GIS) software. The initial dataset will include habitat units mapped during a microhabitat fish use reconnaissance study completed in June 2009[4]. The team will also plot locations of salmon spawning activity recorded during 2009 foot surveys and high-use spawning areas identified by historical data (APA 1984). The team will use the preliminary spatial fish habitat information to catalog and identify gaps in coverage.

The team will conduct surveys to ground-truth the preliminary aquatic habitat delineation (i.e., generated through the office-based exercise), redraw mapping boundaries where appropriate and confirm the location of habitat areas that are in need of additional study.. The team will delineate aquatic habitats at the mesohabitat category and subcategory scale, consistent with the approach developed for the 2009 habitat reconnaissance study. Mesohabitat subcategories identified in 2009 included fastwater pools and fastwater riffles, margins with undercut bank, margins without undercut bank, large woody debris dams, margin shelves associated with large wood debris, backwater pools, sloughs, and pockets. Additional subcategory characterizations will be added if deemed necessary. Habitats identified as needing additional study will be investigated further under Task 4.5.4.

Definition of Terms

- As mentioned above, mesohabitat types were identified and mapped in 2009/2010. The following definitions are provided for these habitat types (Overton et al. 1997, unless otherwise noted):Backwater: Pool formed by an eddy along a channel margin downstream from obstructions such as bars, rootwads, or boulders, or resulting from back-flooding upstream from an obstructional blockage. Also, a body of water, the stage

[3] Due to physical access limitations, the field team may be unable to ground-truth aquatic habitats delineated in portions of Reach 5.

[4] The 2009 fish microhabitat use reconnaissance study was initiated to gain insight into the types of habitats that fish occupy in Grant Creek. The team identified discrete microhabitat types and sampled for fish presence at 16 sites in Grant Creek.

of which is controlled by some feature of the channel downstream from the backwater, or in coves or covering low-lying areas and having access to the main body of water.

- Cover: Suspended material covering the land or water; measured as a percentage of the surface area when looking from above.
    - Fish: anything that provides protection from predators or improves adverse conditions of streamflow or seasonal changes in metabolic costs. This may be overhead cover or submerged cover and it may be used for escape, feeding, hiding, or resting.
    - Overhead: Whitewater, surface turbulence, bank vegetation, tree branches, floating logs, or other debris that are touching or are within 0.3m of the water surface.
    - Submerged: Large woody debris, other organic debris, ledges, or aquatic vegetation which are below the water surface.
- Fast water: Habitat types consist of turbulent (cascade, step run, high gradient riffle, and low gradient riffle) and non-turbulent (runs and glides).
- Large Woody Debris: Large pieces of relatively stable woody material located within the bankfull channel and appearing to influence bankfull flows. These are categorized as singles, aggregates, or rootwads.
    - Aggregate: Two or more clumped pieces, each of which qualifies as a single piece.
    - Rootwad: Rootmass or boles attached to a log less than 3 m in length.
- Pocket: Small bed depressions, often less than 30 percent of wetted width, formed around channel obstructions (boulders, logs, irregular bank, jutting peninsulas, and so forth) within fast water habitat types.
- Pool: A habitat type formed by either scour that has carved out a depression in the channel, or a location where the channel has been dammed. Surface velocities may be slow to fast, but subsurface velocities tend to be slow. Pools are characterized by a head crest (upstream break in slop) and a tail crest (downstream break in slope). Types of pool include:
    - Dammed: Pool formed by downstream damming action. Dam pools can be located in main channel (or side channel) or backwaters.
    - Scour: Pool formed by scour action when flowing water impinges against and is diverted by a streambank or channel obstruction (rootwad, woody debris, boulder, bedrock, and so forth). Scour pools may be lateral scour, mid-scour, plunge. Or underscour pools.
        - Lateral scour: A pool formed by the scouring action of the flow as it is directed laterally or obliquely to one side of the stream by a partial

channel obstruction, such as a gravel bar or wing deflector, or by a shift in channel direction.

  - Mid-channel scour: A pool formed by the scouring action of the flow as it is directed toward the middle of the channel by a partial channel obstruction.
  - Plunge: A pool formed by scourimg action from vertically falling water.
  - Underscour: A pool formed by scouring under an obstruction, such as a log. Sometimes called an upsurge pool

- Riffle: Shallow rapids where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but where standing waves are absent.
- Side Channel: A lateral channel with an axis of flow roughly parallel to the mainstem and which is fed by water from the mainstem; a braid of a river with flow appreciably lower than the main channel.
- Slow water: Habitat types consist of dammed (main and backwater) and scour (lateral, mid-channel, plunge, and underscour).
- Stream Margin: edge of the wetted perimeter.
- Undercut bank: A bank that has its base cut away at least 5 cm by the water or has been artificially made and overhangs directly above the water surface.

The team will identify key fish habitats in Grant Creek, based on observed fish use. This will be accomplished by analyzing the microhabitat fish use data collected in support of this study, data collected in support of the instream flow study (see Section 4.7), and data collected in 2009 during the reconnaissance study (HDR 2009a). These data will be incorporated into the spatial dataset. Other fish use habitat datasets (e.g., foot surveys, telemetry surveys, electrofishing) will be considered when developing key habitat designations. Surface areas of habitat types will be calculated as needed using the capability of the GIS software.

4.7 Grant Creek Instream Flow Study

Project-Related Objectives

- Assist impact analysis by modeling changes in key types of fish habitat relative to potential changes in stream flow.
- Provide a basis for planning Project instream flow mitigation measures.
- Provide a starting point for stream flow discussion.

Quantitative Objectives

- Provide supportable predictions of fish habitat availability in lower Grant Creek under various stream flow scenarios for key species and life history stages.

The Grant Creek instream flow study approach to be applied to lower Grant Creek Reaches 1-4 was collaboratively developed based on input from the Instream Flow Technical Working Group (TWG). Public meetings of the TWG were held in April and September 2009, and a conference

call was held in May 2009; input and suggestions were solicited during these meetings and also through email and phone communications with the TWG and TWG members.

The selected instream flow study approach emphasizes a detailed study of utilized habitat types and addresses the desire of the TWG to examine how important individual habitat units may be affected by changes in flow due to the operation of the Project. Rather than applying a typical habitat study that generalizes mesohabitat units in a study reach, this approach uses several techniques to tie physical microhabitat to flow and timing, and applies *in situ* knowledge of fish habitat use in Grant Creek as tools to determine potential effects of the Project.

For an instream flow study in Grant Creek, an integrated effort provides a cost-effective way of obtaining information that most directly answers the questions the TWG members have regarding the effects of the Project on fish habitat in Grant Creek. The approach includes:

1. A series of single transect analyses, with each transect going through a known fish use area such as high-use spawning or rearing areas.
2. Fish studies that help identify microhabitat factors that affect fish use within each key habitat type.
3. Monitoring temperature and flows at multiple locations on Grant Creek in conjunction with the Water Resources study program to establish baseline stream flow and temperature changes.

These three components will be integrated and analyzed to determine effects of different flow regimes on several factors that are important in the life stages of Grant Creek resident and anadromous fish.

It is important to understand that a significant portion of the work described below has been completed. Specific study sites within high-use habitat types were selected, and transects were established at 18 locations including survey data and complete measurements of transect geometry. Depth, velocity, water surface elevation, discharge, substrate, and cover were measured at the transects during low and medium flow conditions. Incomplete data regarding microhabitat habitat suitability have been collected at various locations.

4.7.1 Habitat Availability

The purpose of the habitat availability component of the instream flow study is to measure available habitat at proposed mesohabitat sites as a function of discharge (Table 1). Available habitat will be correlated to results of the Habitat Utilization Study described below (Section 4.7.2). This information will be cross-referenced with historic hydrographs, recent hydrologic data, and potential flow scenarios in Grant Creek to determine discrete time periods when the habitat unit may be available for its designated use.

Table 1. Proposed mesohabitat assessment sites.

Kenai Hydro - Grant Creek Instream Flow Transect Summary

	Transect #	Channel Type	Fish Habitat Site	Notes
1	100	Rearing Distributary	R1FH11	Linear transect, slow water
2	110	Rearing Distributary	R1FH12	Linear transect, slow water, LWD
3	120	Spawning Main	-	Spawning riffle
4	130	Rearing Main	R1FH05	Main channel fast water, Side chnnl, small mid channel bar, vegetated, LWD upstream
5	140	Rearing Main	R1FH05	Main channel fast water, Side chnnl, small mid channel bar, vegetated, LWD upstream
6	150	Rearing Main	R1FH13	Woody debris LB LUS, fast water main channel
7	160	Rearing Main	R1FH13	Woody debris LB LUS, fast water main channel
8	200	Rearing Main	R1FH06	Backwater lobe
9	210	Rearing Main	R2FH10	Small tertiary channel
10	220	Rearing Main	R2FH10	Main channel, Fast water, undercut bank on RB
11	230	Rearing Main	R2FH10	Main channel, Fast water, undercut bank on RB, surveyed across island to backwater pool
12	300	Rearing Main	-	Backwater lobe
13	310	Spawning Main	R3FH14	Backwater, low vels , main channel fast deep
14	320	Rearing Secondary	R3FH09	LWD, Secondary channel and spawning
15	330	Rearing Secondary and Tertiary	R3FH09	LWD, Secondary channel, spawning and Tertiary channel.
16	400	Rearing Main	R3FH16	Small side channel, cobble/gravel bar - no veg, very deep undercut bank
17	410	Rearing Main	R3FH16	Small side channel, cobble/gravel bar - no veg
18	430	Spawning Main	R5FH15	Pool, deep fast, LWD upstream, shallow slow margin shelf

Channel Type	Count	Percent
Rearing Distributary	2	11.1%
Rearing Secondary or Tertiary	2	11.1%
Spawning Main	3	16.7%
Rearing Main	11	61.1%
Total	18	

Cross section geometry, substrate, cover, and hydraulic data will be measured at each transect using techniques developed for the Physical Habitat Simulation (PHABSIM) method. Application of PHABSIM techniques on Grant Creek is different from most other studies because transects are selected on important habitat units with known fish use, as opposed to a standard PHABSIM that attempts to represent all habitat units regardless of unique importance or known fish use. Collected data will enable several analyses including:

- Changes in the availability of microhabitat (depth, velocity, substrate, and cover) across a transect or at specific cells or groups of cells along the transect as a function of discharge.
- Lateral connectivity of main channel flow with side-channel, off-channel, or undercut bank habitats as a function of flow.
- Egg incubation effective habitat analysis.

Transects will be oriented across the selected habitat unit to best capture the average condition of interest in that unit, such as spawning or rearing potential. Headpins, tailpins, and a temporary benchmark will be set at each transect. Survey instrument and photo points will be established and marked. Each transect site will be fixed using a handheld GPS. Habitat unit cross sectional profiles will be surveyed using standard differential survey techniques. Cross section survey

points will divide the profile into 1 - 3 foot cells. Dominant and subdominant substrate and cover will be recorded within each cell.

Water surface elevations at each transect will be measured using a survey instrument at 3 - 4 discharges ranging from a low flow of approximately 50 cfs to a high flow of approximately 200 – 300 cfs. Mean column velocities will be measured within each cell at a high flow of 170 - 200 cfs, or the highest possible flow within practical and safety limitations. If feasible and safe to do, an additional water surface elevation will be taken above the high flow in order to extend the range of flows for the model. Numerous photos from established photopoints will be taken at each of the 3 - 4 flow levels.

Proposed cross sections (Table 1) were located during a site visit 24 September 2009. The locations were set based on presence of physical microhabitat (i.e., undercut bank, overhead cover, bedrock outcrops, and pocket water) and observations of fish during the site visit and during snorkeling studies. The site locations will be refined and measured during spring, summer, and early fall. These transects, approved by the TWG and placed in the field during 2010, are shown in Figure 3.

Incubation Analysis

The incubation analysis is proposed to follow methodologies previously conducted for hydropower projects, such as Sullivan Creek is E. Washington (EESC 2009), which modeled the effects on incubating bull trout eggs (*Salvelinus confluentus*) as flows receded.

The Applicant proposes to use the following data in order to conduct the incubation analysis;

- Select calibrated and approved transects from the Grant Lake instream flow study that represent spawning habitat.
- Use the Habitat Suitability Index (HSI) curves developed for the project
- Bed elevation from each transect
- Stage at given flows (from the HYDSIM sub module of RHABSIM)

KHL will use RHABSIM (Riverine Habitat Simulation System) by Thomas R. Payne and Associates (Arcata, CA) to produce Weighted Usable Area (WUA) curves for target species spawning. One of the options available in the program is the ability to evaluate WUA on a cell-by-cell basis along each transect at a variety of flows.

WUA for an individual cell is calculated as:

S (depth) * *S* (velocity) * *S* (substrate) * the area cell represents,

where *S* = the suitability index for depth, velocity, and substrate, respectively. A value of 1.0 for each suitability index is optimum, while a value of 0.0 indicates no value for that particular variable. For this analysis, KHL will model existing substrate as reflected in the hydraulic models developed from site-specific transect data.

Value of Spawning Habitat

There are several options for evaluating spawning habitat. One method is to analyze the impacts on all spawning habitat, regardless of its combined suitability values; this method. Another method, which has been used, is to protect the better quality spawning habitat. As a result, only those cells with a combined suitability value of 0.25 or greater (e.g., *S* (depth) * *S* (velocity) * *S* (substrate)) are evaluated. This methodology has been used previously with McMillen staff and WDFW and WDOE personnel (Hal Beecher and Brad Caldwell) when examining spawning habitat and protection of incubating eggs. If the suitability value was $\geq$ 0.25, the area of that cell was counted; if the combined suitability value was < 0.25, the area of that cell was given a value of 0.00.

Criteria for Protection of Incubating Eggs

The criteria used in this analysis is that the depth of water over a particular cell that is included as spawning habitat has to be at least 0.1 ft or greater (1.2 inches). The analysis conducted to determine the WUA value is:

- The water surface elevation for the transect is calculated (from submodule HYDSIM of RHABSIM) for each modeled flow
- For each modeled flow, the depth of the water over that cell is calculated by subtracting the bed elevation of the cell from the calculated water surface elevation
- If the depth of water over the cell is $\geq$ 0.1 ft, the WUA for that cell was used and added to the total
- If the depth of water over the cell is < 0.1 ft, a value of 0.0 was used
- Flows can be modeled down from the spawning flows in 10 cfs increments (or whatever is deemed appropriate by the TWG)
- Analysis is continued to incubation flows of 10 cfs (or whatever is deemed appropriate by the TWG).

The level of protection afforded incubating eggs is then calculated as the percentage of spawning habitat still covered with at least 0.1 ft of water at a given incubation flow. The following ranges can be used to evaluate level of protection.

Protection (%) of incubating eggs	Range
100%	100%
90%	86 – 99%
80%	76 – 85%
70%	70- 75%

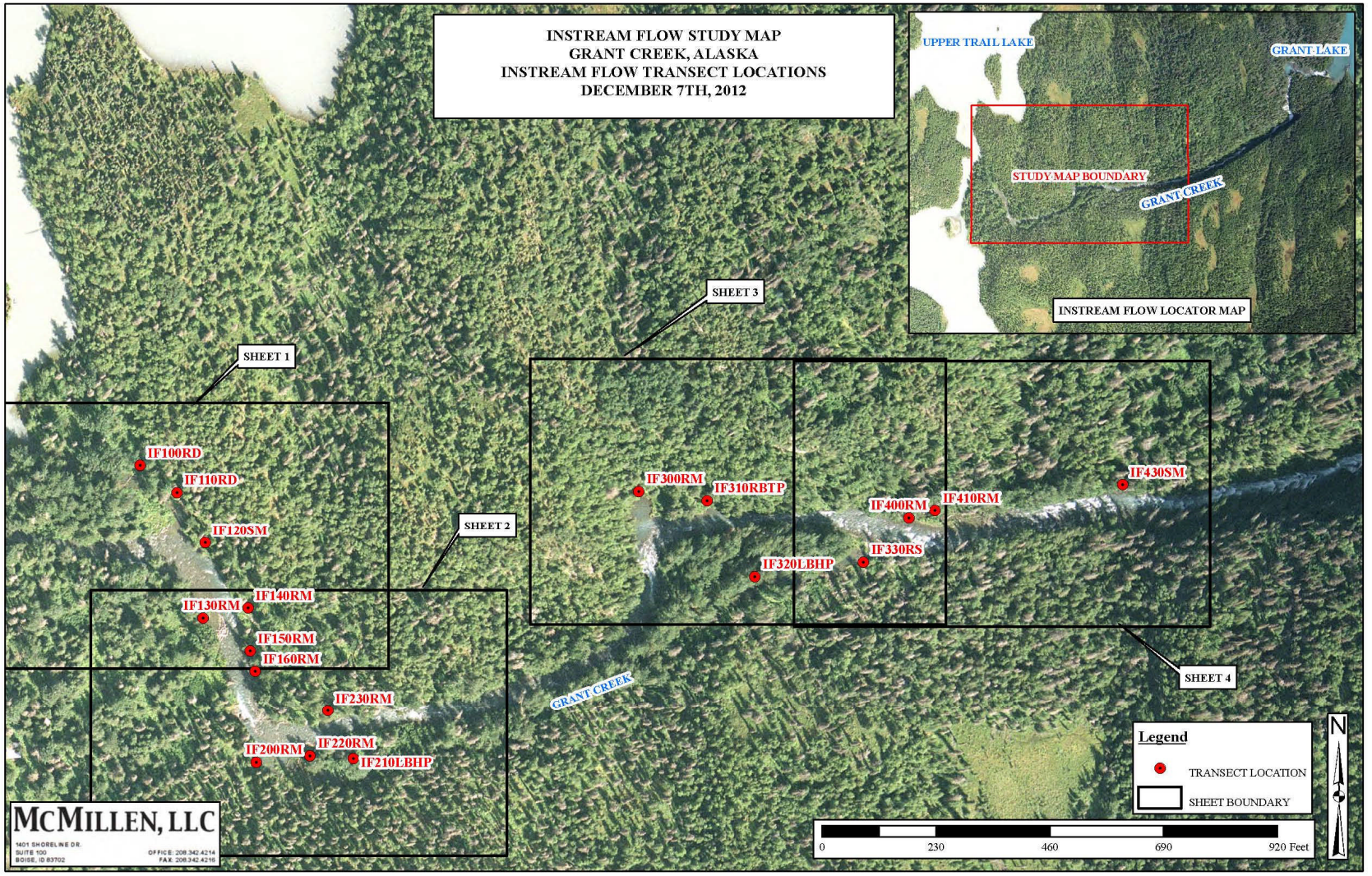

Figure 3. Location of Grant Creek Instream flow transects.

4.7.2 Habitat Utilization

The purpose of the habitat utilization component is to learn what meso- and microhabitat factors the fish in Grant Creek occupy to assess whether the Project would have an effect on instream habitat. To maximize the knowledge of habitat selection factors for fish in Grant Creek, observations will be made at the locations of the transects as described in the previous section.

Fish spawning and rearing microhabitat values will be recorded at programmatically-selected sites in Reaches 1 through 4. Measured microhabitat use parameters will vary by habitat units. During the TWG meeting on September 23, the following table (Table 2) was developed with input from TWG members.

Table 2. Parameters used in the habitat utilization study.

Habitat use function by life history	Habitat use parameters to measure
Salmon rearing	Depth, velocity, cover, wetted perimeter, habitat connectivity
Salmon spawning	Substrate, depth, velocity, temperature
Rainbow trout spawning	Substrate, depth, velocity, temperature
Incubation	Depth, wetted perimeter, temperature
Resident rearing and spawning	Salmon rearing will be used as a surrogate

Information relating to site-specific habitat suitability criteria (HSC) will be developed from these data and used in combination with HSC available in the existing literature and professional judgment to determine final HSC to be used in modeling. Development of final HSC will occur as a collaborative effort with the Instream Flow TWG. HSC will be combined with the transect measurements and mesohabitat characterizations to model changes in habitat as a function of discharge.

Habitat use data collection will be similar to the sampling approach developed in 2009,as described in the 2009 baseline study report (HDR 2009) and existing data files furnished by KHL. However, the field effort may be expanded to include multiple sampling events at varying flow regimes, as discussed below. The primary tasks associated with this approach are to:

- Identify and describe discrete mesohabitat sample areas within each sample site, based on habitat factors observed.
- Record fish species presence (or absence) within each mesohabitat sample area.

The field team established 16 sample sites in Grant Creek in June 2009. The sample sites comprise habitats expected to contain high densities of juvenile fish (i.e., backwater areas; along stream margins) as well as those not necessarily expected to contain high numbers of rearing fish (i.e., fast water near the thalweg). As a result, the team identified a number of key habitats for rearing and resident fish. The instream flow team considered the key habitats identified through the June 2009 effort and in September 2009 established cross-sections at these locations (as discussed above). The field team will sample mesohabitats associated with the selected transects. Most transects are co-located with at least one mesohabitat unit sampled in June 2009. Additional sample sites will be established if deemed necessary.

Sites will be divided into discrete mesohabitat sample areas based on habitat characteristics observed within the stream segment sampled. In 2009, the field team identified the following mesohabitat sample areas: fast water pool, fast water riffle, margin with undercut bank, margin without undercut bank, large woody debris dam, and margin shelf associated with large wood debris, backwater pools, pockets, and sloughs, and "other" channels (i.e., distributary, secondary, tertiary). One sample site may be composed of multiple mesohabitat categories. Additional mesohabitat categories will be added if encountered. Mesohabitat factors taken into consideration will include:

- Location relative to the main channel (i.e., stream margin; mid-channel; backwater slough; backwater pocket).
- Depth and flow regimes (i.e., shallow fast, shallow slow, deep fast, deep slow).
- Presence of cover (i.e., no cover; velocity; instream cover).
- Type of instream cover when present (i.e., undercut bank; woody debris; overhanging vegetation; submerged vegetation; substrate).

The field team will record fish presence (or absence) within discrete mesohabitat sample areas, so that fish presence (or fish absence) can be correlated with the microhabitat characteristics present (or absent) at each location sampled.

The team will rely on snorkeling as the primary method to document fish presence (or absence) within each mesohabitat sample area. Electrofishing will be used primarily to confirm species identification and calibrate fish length estimates. Electrofishing will be used in lieu of snorkeling, if conditions preclude the effective use of snorkeling (i.e., shallow conditions). Each fish observed during snorkeling will be identified to species and its fork length will be estimated using 20 mm size intervals.

Within rearing habitats and near stream margins, the field team will record dominant and subdominant types of cover for each separate observed group of fish. Stream depth will be recorded using a wading rod at locations of observed fish use, and fish nose depth will be estimated by the snorkeler. Mean column velocities and velocity at the fish location will be recorded using a Price-AA or Swoffer current meter attached to a USGS top-setting or standard wading rod. Water temperature will be recorded at each station, ideally mid-column and at or near the location of observed fish.

In areas of observed spawning use, high stream depth and velocity may preclude field staff from measuring all microhabitat parameters. When possible, depth and velocity will be recorded as described above. Dominant and subdominant types of substrate size will be recorded by visual estimate using categories as described in Table 3. When direct measurements are not possible, depth at the spawning habitat will be visually estimated, and a GPS point will be taken and the habitat area described. The field team will revisit spawning habitat areas in the fall when flows allow wading, and will record dominant and subdominant types of substrate types immediately outside the redd perimeter for each observed redd. In all cases, surface water temperature will be measured near mid-column in a well-mixed area near the location of the observed redd.

Table 3. Substrate size classes used on Grant Creek instream flow study.

Substrate Type	Size (inches)
Organics, vegetation	--
Clay, silt (fines)	<0.002
Sand (coarse)	0.002 - 0.07
Small gravel	0.07- 0.30
Medium gravel	0.30 – 1.25
Large gravel	1.25 – 2.5
Small cobble	2.5 – 5.0
Large cobble	5.0 – 10.0
Boulder	>10.0
Bedrock	--

4.7.3 Integration with Flow and Temperature Monitoring

Grant Creek flow and temperature studies for 2010 are described in the Water Resources Study Plan (HDR 2009c). Specifically, continuous flow and temperature monitoring stations that were set in 2009 will be continued and/or reestablished. The instream flow study relies on integration of the collected data, described in the previous sections, with the data collected per the Water Resources Study Plan. The data loggers will be downloaded at regular intervals to contribute to analysis during the field season.

4.7.4 Analysis Methods

Field data collected as described above will permit both empirical analysis and habitat modeling as a function of flow.

A number of different graphs can be provided and may include the "wetted perimeter versus flow" relationship, a static cross section of the channel showing substrate distribution and water surface at any flow, and/or a dynamic Excel graphic. A static example of the dynamic graphic is shown below in Figure 4. Changing the value in the "Discharge Window" will adjust the water level up or down corresponding to the stage/discharge formula imbedded in the worksheet. Wetted perimeter and average depth values in the lower right also change with the assigned discharge. Values such as percent of change in wetted perimeter can be easily added to the graphic. This type of dynamic graphic can be provided for any transect, as appropriate.

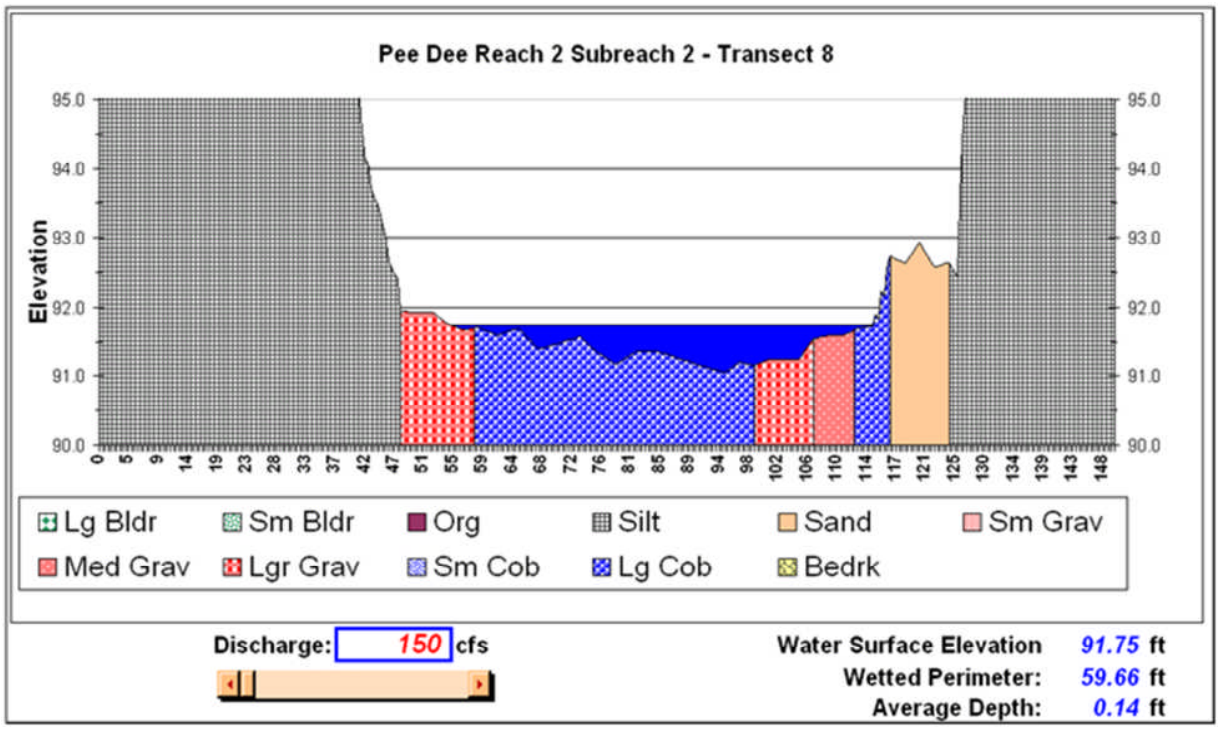

Figure 4. Example of a Channel/Flow Response cross sectional profile.

Collected data will also permit the application of the PHABSIM model for evaluation of changes in suitable habitat at select transects as a function of flow (Bovee et al. 1998). Site-specific habitat suitability will be developed from observations of microhabitat use by fish. A commercial version of PHABSIM, known as Riverine Habitat Simulation (RHABSIM), will be used.

4.7.5 Reach 5 (Canyon Reach) Analysis

The proposed Grant Lake Hydroelectric Project would necessitate a major reduction in the flow of the portion of Grant Creek upstream from the proposed powerhouse (Reach 5). Because of the extreme flow reduction and the very high gradient of the creek in this reach, standard instream flow analysis methods are not applicable or appropriate. It is expected that available post-Project habitats will be limited to pools that contain sufficient water to support fish.

A simplified modeling effort will be employed to obtain insight into the effects that small changes in flow might have on pool depth, pool connectivity, and fish passage availability. Physical measurements will be conducted at selected step pools including basic cross section, surface area, and depth of downstream control (to determine minimum pool depth at very low flow).Connectivity of the various pools and channels will be measured and assessed using the Oregon Method (Thompson 1972). After 10 years of research on depth and velocity in streams in Oregon, Thompson concluded that the depth over "the shallow bars most critical of adult passage" was the feature that determined the likelihood of successful migration. Thompson recommends a minimum depth of 0.6 feet for large trout and 0.8 feet for Chinook salmon to achieve successful passage. The "Oregon Method" as it is now commonly called, concludes that

the passage flow is adequate when the depth criteria is met on at least 25 percent of the transect width and on at least a 10 percent continuous portion. Transect data will be collected to determine where connectivity meets this criteria and where it does not based on the three flows described above.

Connectivity will be assessed concurrently with the instream flow study being conducted downstream in Reaches 1 – 4, at the same flows, provided data can be collected safely. Photo documentation will be included in the connectivity analyses. Documentation will include transect measurements delineating each pool that is measured at each of the flow levels evaluated.

4.7.6 Instream Flow Modeling

Input from the instream flow analyses will be used to model the effects on fish habitat under various flow regimes and will examine the habitat and energy trade-offs associated with a range of scenarios.

4.8 Baseline Studies of Benthic Macroinvertebrates in Grant Creek

Project-Related Objectives

- Provide a reliable measure of baseline stream productivity that can be compared from year to year and with other stream systems.
- Provide some indication of the relative "health" of the Grant Creek ecosystem by employing standard measures that are readily comparable to other Alaska stream systems.

Quantitative Objectives

- Standard methods will be used that require replicate samples within uniform riffle habitat areas to minimize the effect of between sample variability. Five replicates are generally recommended for initial sampling. An analysis of variance will be employed to determine adequacy for baseline use.

Benthic macroinvertebrates inhabit every wetted habitat within a stream system. The various genera of aquatic macroinvertebrates feed on multiple trophic levels ranging from primary consumers to predators. They are the primary food source for many fish species, so the abundance of macroinvertebrates can directly affect fish populations. Benthic macroinvertebrates also serve a role in understanding long-term water quality trends within a stream system. Many benthic macroinvertebrate genera have been assigned "biotic index" values that rate their relative tolerance for environmental stress (e.g., organic pollution or sedimentation). Assigned biotic index values can be used to calculate an average score for a stream system.

Benthic macroinvertebrate samples will be collected at two stations on Grant Creek (GC 100 and GC 300) in August using the Surber sampling method. This technique is used to accurately characterize population density and taxa richness in a single habitat within a stream system and allows comparison between seasons and/or years.

Five replicate samples will be collected at each station. Each sample is collected from within the same riffle/run area of the stream. A specialized net is placed in the riffle/run, which defines a 1 ft^2 area that is then thoroughly examined for invertebrates by kicking, scrubbing, and moving

substrate and allowing the invertebrates to wash downstream into the net. The contents of the net will be emptied into a sample jar and preserved with 70 percent ethyl alcohol.

Macroinvertebrates will be sorted from substrate material in the laboratory, identified to genus (except for Chironomidae), and counted. Data analyses will include a variety of standard metrics including taxa abundance, taxa diversity, percent dominance, and percent EPT (Ephemeroptera, Plecoptera, Trichoptera).

4.9 Baseline Studies of Periphyton in Grant Creek

Project-Related Objectives

- Provide a reliable measure of baseline stream productivity that can be compared from year to year and with other stream systems.
- Provide some indication of the relative "health" of the Grant Creek ecosystem by employing standard measures that are readily comparable to other Alaska stream systems.

Quantitative Objectives

- Standard methods will be used that require replicate samples to minimize the effect of between-sample variability. Ten replicates are recommended for initial sampling. An analysis of variance will be employed to determine adequacy for baseline use.

Periphyton are single-celled algae that typically grow on rocky substrates in streams and rivers. Periphyton will be collected to assess chlorophyll *a* concentration, representing primary productivity, in Grant Creek. Many genera of benthic macroinvertebrates and some fishes depend on periphyton as their primary food source. Chlorophyll *a* concentration also can provide an indication of stream condition.

Periphyton will be collected by isolating a space of known area on a rock and collecting the algae from the space. This material is then sent to a laboratory to be analyzed for chlorophyll *a* content. Collection procedures will be as follows:

- Periphyton samples will be collected in August at two stream locations within Grant Creek (GC 100 and GC 300).
- Ten periphyton samples will be removed from a defined area on large gravel or cobble collected from the stream substrate.
- The material scrubbed from the rocks will be rinsed and then filtered onto glass fiber filters, preserved, and then frozen.
- The filters will be sent to a laboratory to assess chlorophyll *a* content.

4.10 Trail Lake Narrows Fish and Aquatic Habitats

Project Related Objectives

- Determine the extent of fish use in the vicinity of the proposed access road bridge crossing of Trail Lake Narrows in order to minimize impact to aquatic resources potentially resulting from bridge design, construction timing, and construction methodology.
- Determine habitat use to optimize bridge location and design.

Quantitative Objectives

- The study will primarily be descriptive with some semi-quantitative fish sampling using catch per unit effort or standardized observations. Statistical analysis will not generally be applicable but catch methods will employ standard techniques allowing comparison with other bodies of water.

Field investigations will be conducted in the late July – early August period in the Trail Lake Narrows with emphasis placed on the vicinity of the proposed bridge site. Methods to be employed will include minnow trapping, beach seining, and snorkeling. Water clarity may be too poor for snorkeling to be effective. Use of stream bank habitats by juvenile Chinook and coho salmon will be a primary focus. It is expected that minnow trapping will be the most effective technique for juvenile captures.

Fish habitats within a cross section of the narrows will be subjectively described and will include a discussion of fish and habitat use.

5 Agency Resource Management Goals

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:

- 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 regulates the construction of fishways and dams. State regulations relating to fish resources are generally administered by ADF&G. 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:
- Magnuson-Stevens Fishery Conservation and Management Act (PL 104-267) provides federal protection to “those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity.” NOAA’s National Marine Fishery Service (NOAA Fisheries) is responsible for designating Essential Fish Habitat (EFH). In the case of anadromous fish streams (principally salmon), NOAA Fisheries has designated the 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 Alaska Dept. of Fish and Game, Div. of Sport Fish.
- Our Wealth Maintained: A Strategy for Conserving Alaska’s Diverse Wildlife and Fish Resources. Prepared by Alaska Department of Fish and Game, Juneau, Alaska. xviii+824 pp.
- Kenai River Comprehensive Management Plan. Prepared by Alaska Department of Natural Resources, Division of Land and Division of Parks and Outdoor Recreation; in

conjunction with Alaska Department of Fish and Game, Habitat and Restoration Division; Kenai Peninsula Borough.

- Kenai Peninsula Borough Comprehensive Plan. Prepared by KPB Planning Department. In 2005. Soldotna, Alaska.
- Kenai Peninsula Borough Coastal Zone Management Plan. Prepared by the Kenai Peninsula Borough Coastal Management Program and LaRoche and Associates. 2008. Kenai Peninsula Borough. Soldotna, Alaska.
- Kenai River Special Management Area (KRSMA), ADNR.
- Final Environmental Impact Statement and the Revised Land and Resource Management Plan for the Chugach National Forest, Chapter 3 Environment and Effects. Prepared by the U.S. Forest Service, 2002.

6 Project Nexus

The proposed Project may have a number of potential impacts on aquatic resources within Grant Creek and Grant Lake. The studies described above are intended to provide sufficient information regarding the nature of the existing aquatic resources such that these potential impacts can be adequately assessed. Each study component is specifically designed to help evaluate potential impacts in the study report. The impact assessments will be presented in the study report, and will be used to inform the development of protection, mitigation, and enhancement measures to be proposed in the draft and final license applications. Some of the direct and indirect Project effects that could impact aquatic resources are itemized below:

- Alteration of the streamflow and temperature regime (depending on the depth of water withdrawal in Grant Lake) in Grant Creek as the result of potential Project operation could affect spawning and rearing habitat for anadromous fish species and habitat for all life stages of resident fish species, depending on the timing and magnitude of flow alteration.
- Changes in water surface elevations in Grant Lake would likely affect aquatic biota in littoral areas, including fish, macroinvertebrates, and macrophytes; the timing and magnitude of lake level changes would dictate the level of effects (the proposed lake level changes would range from 2 feet above to 11 feet below the natural lake elevation of approximately 698 feet). Areas of shoreline wetlands could also be affected.
- Any dredging of Grant Lake in the vicinity of the proposed intake structure could result in short-term impacts on benthic macroinvertebrate populations in the area.
- Water temperatures in Grant Lake could be influenced by operation of the proposed Project, depending on the depth of water withdrawal.

7 Consistency with Generally Accepted Practices

Sampling methodology for Grant Creek and Grant Lake was designed in consultation with the public, resource agency scientists, and members of the Instream Flow TWG. Quality control of all study plans is maintained by using established methods used elsewhere to assess similar potential resource impacts and are reviewed by outside expert scientific reviewers. Methods

proposed herein (use of foot surveys, minnow trapping, angling, block and removal techniques, and radio telemetry) are generally-accepted practices for assessing fish resources.

The instream flow approach, as a whole, is custom-designed for Grant Creek and its unique hydrology, geomorphology, and fish resources. However, each component of the study is a well-known and accepted technique for study application in the field. The integration of these components is accomplished through post-processing and analysis of results.

Macroinvertebrates will be collected using the sampling method described by Eaton et al. (1998). Surber sampling is a preferred method of the USGS and ADF&G. Periphyton will be collected using methods from Eaton et al. (1998).

8 Schedule for Conducting the Study

- May-October 2012 – Re-engage stakeholders and conduct any tasks deemed beneficial in 2012.
- October 2012 – Apply for winter sampling permits.
- February-March 2013 – Conduct winter fish sampling.
- January 2013 (or earlier if any work to be done in 2012) – Apply for fish resources sampling permits, secure field equipment, telemetry tags, telemetry receivers, traps etc., exploration of Reach 5, instream flow transect measurements.
- Mid-April - May 2013 – Begin Rainbow trout survey, juvenile fish habitat use sampling, instream flow habitat suitability measurements.
- June 2013 – Complete Rainbow trout survey, data entry and QC for field data, habitat map GIS work.
- July 2013 – Juvenile fish habitat use sampling, instream flow habitat suitability measurements, instream flow water surface elevation measurements, Trail Lake Narrows assessment, data entry and QC for field data.
- August 2013 – Begin foot surveys for spawning salmon, capture and radio tag Chinook salmon, habitat use snorkel surveys, data entry and QC for field data.
- September 2013 – Continue foot surveys for spawning salmon, tracking radio tagged Chinook salmon, juvenile fish habitat use sampling, instream flow habitat suitability measurements, instream flow water surface measurements, data entry and QC for field data.
- October 2013 – Continue foot surveys for spawning salmon, continue tracking radio tagged salmon, complete field work and demobilize field equipment, data entry and QC for field data.
- November 2013 – Continue foot surveys for spawning salmon, complete data entry and QC for field data, begin development of draft baseline study reports.
- January 2014 – Complete instream flow modeling.
- January 2014 – Complete draft study report for internal review.

9 Provisions for Technical Review

KHL will provide updates and study products for review by the Aquatic Resources Work Group during the licensing process.

- December 2012 – Issue final study plan to Work Group
- April through June 2013 – Start of Study Season [varies by study area].
- Fall 2013 – Work Group update on field activities.
- April 2014 – Distribute draft study report.
- April 2014 – Work Group meeting call to discuss comments on draft study report.
- May 2014 – Distribute final study report.
- September 2014 – File Draft License Application.
- January 2015 – File Final License Application.

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