Grant Lake Project
(FERC No. 13212)

Water Resources

Draft Study Plan

Prepared for:
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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
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

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. KHL is planning to file a License Application for the Project in September 2014.

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 Water 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 to present 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 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 Lakes Narrows route would be about 1 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 rout from consideration. The Trail Lakes Narrows route would extend eastward to cross the narrows

between Upper and Lower Trail lakes and then continue eastward to the powerhouse. The Trail Lakes 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 goal of the study effort described in this plan is to provide baseline information, and where applicable, information on alternative flow regimes, which will inform an assessment of potential Project impacts on water resources. The impact assessments and potential protection, mitigation, and enhancement measures will 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 construction and operation (, changes in flow) on Grant Lake and Grant Creek water quality, hydrology, and water temperature.
- Impact of Project construction and operation on water quality, of Lower Trail Lake and Trail Creek.

Specific project objectives and quantitative objectives will be presented below for each individual study component.

3 Existing Information and Need for Information

3.1 *Existing Information*

3.1.1 Pre-2009 Studies

The hydroelectric potential at Grant Lake (Figure 1) has been evaluated several times as a potential power source for the Seward/Kenai Peninsula area. In 1954, R.W. Beck and Associates (cited by APA 1984) conducted a preliminary investigation and concluded that a project was feasible. The U.S. Geological Survey (USGS) conducted geologic investigations of proposed power sites at Cooper, Grant, Ptarmigan, and Crescent Lakes in the 1950s (Plafker 1955). In 1980 CH2M Hill (cited by APA, 1984) prepared a pre-feasibility study for a Grant Lake project and concluded that a project developed at the site would be feasible. The Grant Lake Project was referenced in the 1981 U.S. Army Corps of Engineers (USACE) National Hydroelectric Power Study (USACE 1981). The most extensive study was performed by Ebasco Services, Inc. in 1984 for the Alaska Power Authority (now Alaska Energy Authority; APA 1984). Alternatives evaluated by Ebasco included the diversion of adjacent Falls Creek into Grant Lake to provide additional water for power generation. These investigations have provided hydrological records as follows:

- Historical Grant Creek stream gage data (USGS 15246000) - 11 years of continuous stream gage data from 1947-1958.
- Grant Lake Hydroelectric Project Detailed Feasibility Analysis, by EBASCO, (APA 1984), that includes modeled Falls Creek data.

- Historical Falls Creek discharge data limited to several instantaneous discharge measurements made over various years including 1963-70, 1976, and 2007- 2008.

3.1.2 HDR 2009 and 2010 Water Resources Studies

The 2009 water resources study programs were 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. Hydrology and water quality studies were continued in 2010; however, the study program was halted in July, 2010 because of various Project uncertainties.

Water quality measurements were made and water samples collected in Grant Lake near the proposed Project intake and near the natural outlet of Grant Lake during June and August, 2009 and in June 2010. In-situ parameters were measured at 1-meter depth increments including temperature, pH, dissolved oxygen, conductivity, and oxygen reduction potential. Water quality samples were collected at several depths for laboratory analysis. A string of logging thermistors was installed in the water column near the proposed intake to a depth of 20 meters. Loggers began collecting temperature data at various depths in June 2009 and continued logging throughout the winter. The lake thermistor string was removed for repair in June 2010 and replaced in early July. The Grant Lake thermistor string remains in place but is inactive and no longer being maintained. All other temperature logging instrumentation was removed from the study area in late July 2010.

Water samples were collected at three sampling sites in Grant Creek and one site in Falls Creek in June and August, 2009 and in June, 2010 for laboratory analysis. Temperature data and other in-situ parameters including pH, dissolved oxygen, conductivity, and oxygen reduction potential were also collected. Temperature data loggers were installed at the three water quality sampling sites.

The 2009 hydrology studies included establishing one gage each on Grant Creek (at the original USGS site), and on Falls Creek, establishing temporary benchmark monuments at the gage sites, and relating the elevations of the monuments to the Project datum, installing continuously recording stage and temperature loggers, and collecting instantaneous discharge measurements when stream flows allowed. Water temperature data loggers were also installed in Grant Creek in four locations in run and pool habitat types.

3.2 *Need for additional information*

Early study programs and the 2009-2010 preliminary study program sponsored by KHL have provided a significant amount of background information regarding water resources in the Project area. Additional data will be collected to support the existing record.

Additional water quality field studies will:

- Collect at least one additional set of water chemistry data in Grant Creek and Grant Lake in late summer 2013 to confirm 2009 measurements, complete the seasonal sampling that was initiated in 2010, and better define baseline water quality conditions.

- Continue to collect water temperature data in Grant Creek and Grant Lake to extend the period of record.
- Expand the water quality data collection to incorporate the Trail Lake Narrows access route.

Additional hydrology field studies will:

- Continue discharge measurements at the historical gage station on Grant Creek to validate or calibrate the historical rating curve and extend the period of record. Emphasis will be on medium- and low-flow measurements to fill information gaps.
- Make discharge measurements at Grant Lake outlet and near the proposed powerhouse location during low-flow conditions to attempt to determine if Grant Creek gains or loses water.
- Investigate the fluvial geomorphology of Grant Creek to address issues of material transport in Grant Creek, especially as gravel movement may be related to maintenance of salmon spawning habitat.
- Characterize the erosion potential along the shores of Grant Lake and its tributaries resulting from potential lake impoundment and drawdown scenarios.

4 Methods

The following sections describe the proposed Project's study area and proposed methods for the water quality and temperature, hydrology, and Grant Lake and Grant Creek fluvial geomorphology studies.

4.1 *Study Area*

The Project area is located near the town of Moose Pass, Alaska (pop. 206), approximately 25 miles north of Seward, Alaska (pop. 3,016), just east of the Seward Highway (State Route 9); this highway connects Anchorage (pop. 279,671) to Seward. The Alaska Railroad parallels the route of the Seward Highway and is also adjacent to the Project area. The town of Cooper Landing is located 24 miles to the northwest and is accessible via the Sterling Highway (State Route 1), which connects to the Seward Highway approximately 10 miles northwest of Moose Pass.

Grant Creek is approximately 5,180 feet long (approximately one mile) and flows west from the outlet of Grant Lake to the narrows between Upper and Lower Trail lakes (Figure 1). The Grant Creek watershed is approximately 44 square miles and the watershed contains Grant Lake as well as a portion of the Kenai Mountain Range with glacier capped peaks as high as 5,500 feet. Grant Creek has a mean annual flow of 193 cfs, with an average gradient of 207 feet per mile; its substrate includes cobble and boulder alluvial deposits and gravel shoals (APA 1984). The stream is 25 feet wide on average. In its upper half, the stream passes through a rocky gorge with three substantial waterfalls; in its lower half, the stream becomes less turbulent as it passes over gravel shoals and diminishing boulder substrate (APA 1984). Grant Creek's mobile substrate is comprised of well packed, unsorted broken angular rock, and there is minimal rounded material. Some fines may be found in small eddies and a few backwaters.

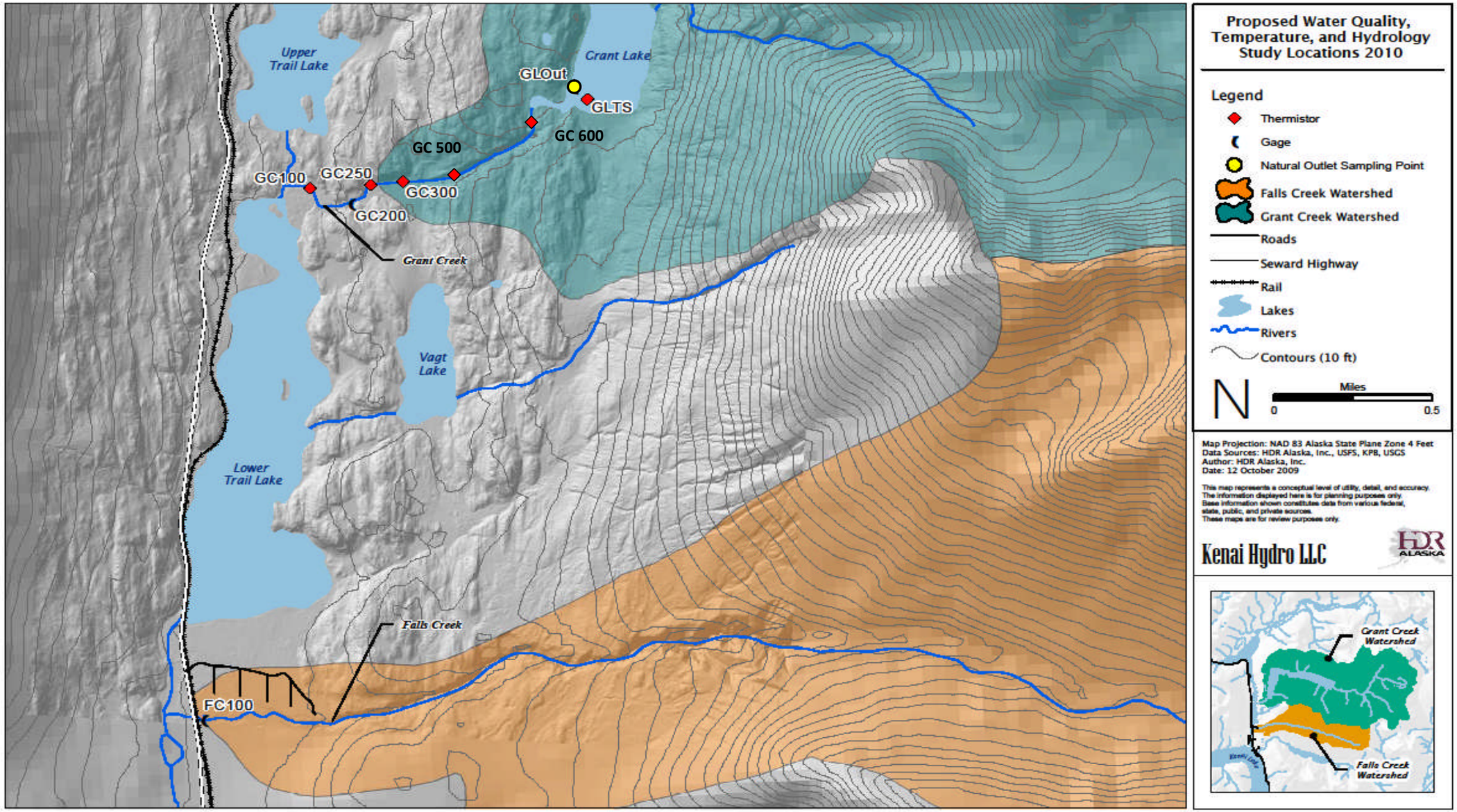

Figure 1. Proposed water quality, temperature, and hydrology study locations.

4.2 *Field Study Design*

4.2.1 Water Quality and Temperature

Project-Related Objectives

- Obtain baseline water quality data to provide a basis for environmental assessment and allow comparison with future years if needed.
- Obtain baseline information on the seasonal temperature regime to provide input data required for modeling of potential Project impacts to stream temperatures under various operational scenarios.
- Provide input data required for the planning of mitigation measures.

Quantitative Objectives

- Assure that physical measurements and chemical analyses are sufficiently accurate so that impact analyses and Project planning that depend on them will be meaningful. Use of standard methods, instrument calibration, and laboratory quality control per Environmental Protection Agency (EPA) standards will provide adequate assurance.

Water quality studies will be conducted to further document baseline conditions in Grant Lake and Grant Creek throughout the year. Describing the baseline conditions in each of these systems is necessary for understanding how Project operations may affect water quality. Water quality parameters were chosen for analysis based on several factors: parameters sampled in previous studies, parameters that may be affected by land use practices in the Project area, parameters either necessary for aquatic life or that act as nutrients, and the drinking water and aquatic life criteria that have been developed for fresh water in Alaska. Water quality criteria have been established to set limits on how much certain water quality parameters may change due to human activity.

The water quality and temperature study will contain the following subcomponents: baseline water quality studies in Grant Creek and baseline water quality studies in Grant Lake.

Baseline water quality studies in Grant Creek

- Water quality samples will be collected at three sites on Grant Creek (GC100, GC200, and GC300; Figure 1) in August to complete the seasonal sampling initiated in 2010.
- In situ parameters will be collected using an YSI or Hydrolab multi-parameter meter at each Grant Creek location.
- Water samples will be collected for laboratory analysis of the analytes listed in Table 1.
- Temperature data loggers will be re-established at four previously monitored sites on Grant Creek (GC100, GC200, GC250, and GC300) and will be downloaded as necessary.
- Two additional temperature data loggers will be established within the canyon reach of Grant Creek (GC500 and GC600) as well as 2-3 off-channel locations where ground water influence is suspected. The off-channel locations will be selected based on observed utilization by spawning and rearing fish species.

Baseline water quality studies in Grant Lake

- Water quality samples will be collected at two sites in Grant Lake in late summer to complete the seasonal sampling initiated in 2010. Samples will be collected at two depths at the natural outlet site (GLOut) and at three depths at the proposed intake location (GLTS; Figure 1).
- In situ parameters will be measured using an YSI or Hydrolab multi-parameter meter at each site in a vertical transect at one meter increments.
- Water samples will be collected for laboratory analysis of the analytes listed in Table 1.

A thermistor string identical to that used in 2009 will be re-established in late winter/early spring near the proposed intake (GLTS) and will log temperature at ten depths in a vertical transect, continuing the period of record from prior measurements.

Baseline water quality studies in Trail Lake Narrows

- Water quality samples will be collected in Trail lake Narrows at one location about 100 m downstream from the proposed access road bridge site. Samples will be collected at three times during the year, early June (spring runoff), late summer, and September/October (fall runoff). Samples will be collected from the center of the narrows channel.
- Parameters to be analyzed include those in Table 1 plus standard hydrocarbon analytes.

Table 1. Water Quality Analytes.

Parameter	Units
Alkalinity ($CaCO_3$)	mg/L
Total dissolved solids (TDS)	mg/L
Total suspended sediment (TSS)	mg/L
Kjeldahl Nitrogen	mg/L
Nitrate/Nitrite	mg/L
Orthophosphate	mg/L
Total phosphorous	mg/L
Lead	µg/L
Hardness	mg/L
Calcium	mg/L
Magnesium	mg/L
Sodium	mg/L
Potassium	mg/L
Low level mercury	ng/L
Fluoride	mg/L
Chloride	mg/L
Sulfate	mg/L
pH	STD
Temperature	^0C

Dissolved oxygen (DO)	mg/L, %
Specific and Relative Conductivity	mS/cm, µS/cm
Oxygen Reduction Potential (ORP)	mV
Turbidity	NTU

The technique used for collecting water quality samples from Grant Creek (sampling sites GC100, GC200, and GC300; Figure 1) will depend on flow rate and water depth. Depth- and width-integrated sampling with a DH-81 sampler will be conducted when it is necessary to collect water from multiple locations within the cross section of Grant Creek. A DH-81 sample bottle will be used to collect one liter sub-samples, and the sub-samples will be combined in one sampling bucket to integrate water collected across the width of the cross section. Depth integration will be accomplished by gradually lowering and raising the sample bottle within the water column allowing it to fill from different depths. Width-integrated grab samples will be collected when the width of the stream is wide enough to require multiple subsamples across the section, yet it is not deep enough to require depth integration. Laboratory sample bottles will be filled from the bucket when integrated sampling techniques are used. In situations where the creek is too narrow and too shallow to warrant integrated sampling, or when the creek is very well mixed, a single grab sample will be collected. In these cases, grab samples will be collected from the most well mixed portion of the stream and transferred directly into the laboratory sample bottles.

Grant Lake water samples will be collected from two sampling sites, GLOut and GLTS (Figure 1), using a Niskin bottle sampler. At GLTS, which is approximately 20 meters deep, samples will be collected at three depths: surface, mid-depth or just below the thermocline when present, and from 1 meter above the substrate. GLOut is shallower, approximately 10 meters, and samples will be collected from the surface and mid-depth of the water column. Depths will vary seasonally at the lake sampling sites as the lake level elevation changes.

In situ parameters will be measured in both Grant Creek and Grant Lake using an YSI or Hydrolab multi-parameter meter. Because of uncertainty regarding some of the 2009 instrument data, a second instrument will be deployed for comparison as a quality assurance measure. Bottles and preservatives for all water quality samples for laboratory analysis will be supplied by the analytical laboratory. All in situ water quality measurements will be recorded on a standard water quality study field data form. Water quality samples will be sent to an approved analytical laboratory in Anchorage, Alaska for analysis

Temperature sensors and data loggers were installed at GC100, GC200, GC250, GC300, and GLTS (Figure 1) in 2009. These instruments were removed in mid-summer 2010 and will need to be reinstalled early in the open water season. Two additional temperature data loggers will also be established within the canyon reach of Grant Creek (GC500 and GC600). Temperature measurements will be collected using HOBO Pro V2 continually recording temperature loggers and HOBO U20 Water Level Loggers manufactured by Onset Computer Corporation. The HOBO Pro V2 logging thermistor has an operating range of -40 to 50 ºC, and is accurate to 0.2 ºC over 50 ºC. The HOBO U20 water level logger has a pressure operating range of 0-207 kPA, with a typical error of 0.05 percent, and a temperature operating range of -20 to 50 ºC and is accurate to 0.37 ºC at 20 ºC. Both HOBO units have 64K bytes of memory. Loggers in the lake and in Grant Creek pools at GC100, GC250 and near GC200 will continue to collect temperature

data throughout the year. Water temperature data loggers will be downloaded periodically throughout the ice-free season as conditions permit and in conjunction with other field efforts for the sake of safety and efficiency. Similar to 2009 studies, stream temperature data loggers will be placed within the stream channel in areas expected to remain submerged during all flows. Temperature data loggers will be kept submerged by anchoring them to boulders using stainless steel wire cable. Each temperature data logger will also be anchored (i.e., tree, log, or boulder) along the shoreline. Additional temperature data loggers will be placed at 2-3 selected off channel sites. Site location will be coordinated with the Aquatic Resources study team and will emphasize locations that may be influenced by groundwater. The off-channel locations will be selected based on observed utilization by spawning and rearing fish species. Temperature measurements in Grant Lake are intended to provide a temperature profile of the water column near the proposed intake. Water temperatures in Grant Lake will be measured both instantaneously and continuously using recording data loggers. At both GLOut and GLTS, temperatures will be measured in a vertical transect during water quality sampling events with a YSI or Hydrolab multi-parameter meter using a 20-meter cable calibrated at one meter intervals. The instantaneous water temperature measurements will be used to supplement the continually recorded temperature data. HOBO Pro V2 temperature data loggers will also be used at the proposed intake site on Grant Lake. A thermistor string was installed in 2009 along a vertical transect in this location to a depth of 20 meters. Data loggers were attached to the string at depths of 0.2, 0.5, 1.5, 3, 6, 9, 12, 15, 18 and 19.5 meters. The data loggers recorded temperature at 4-hour intervals. The thermistor string remained in place through the winter of 2009-2010 and was maintained through mid-summer 2010. It remains in place but is inactive and no longer maintained. It will need to be tested and reinstalled or replaced in late winter/early spring to begin a new period of record.

Temperature information will be summarized and arrayed in a format that will allow information to be easily interpreted for impact analysis purposes and facilitate input into a simple temperature model at a later date, if necessary.

4.2.2 Hydrology

Project-Related Objectives

- Continue to obtain baseline hydrologic data to increase the period of record and provide essential information for engineering and environmental assessment.
- Provide stream flow conditions over the full range of flows to provide essential input to instream flow models (see Aquatic Resources Study Plan).
- Determine whether portions of Grant Creek gain or lose water, with emphasis on measurement of accretion in flow that may occur in the Canyon Reach.
- Provide input data required for the planning of mitigation measures.

Quantitative Objectives

- Assure that physical measurements are sufficiently accurate so that impact analyses and Project planning that depend on them will be meaningful. Use of standard methods, instrument calibration, and redundancy will provide adequate assurance. Statistical

analysis of measurement errors will be essential to determine validity of between-reach comparisons.

Hydrology studies will be conducted in order to further document baseline conditions in Grant Lake and Grant Creek throughout the year. Describing the baseline conditions in each of these systems is necessary for understanding how alterations to seasonal flow regimes might affect aquatic resources. Results will be used in conjunction with data collected in 2009, as well as historical data, to support the Instream Flow Study (HDR 2010), the engineering effort, and other related studies. A major goal for proposed study is to validate or calibrate the historical rating curve at GC200 for discharges less than 400 cfs. Another goal is to determine if Grant Creek gains or loses water. To meet these goals, the study will have two components as follows:

Installation of staff gages and continuously recording stream gages

- Installation of staff gage at GC200.
- Installation and seasonal operation of continuously recording stage recorder at GC200.
- Survey staff gages and stage recorders after spring installation and prior to autumn decommissioning.
- Download data loggers bi-monthly.

Measure Instantaneous discharge

- Make discharge measurements using the wading method for low flows.
- Make discharge measurements from a boat attached to a tensioned line or the use of an Acoustic Doppler Channel Profiler (ADCP) for medium flows.
- Salt dilution or wading method for determining gaining and losing characteristics during low-flow conditions, with emphasis on accretion within Reach 5 (Canyon Reach).

4.2.2.1 Stream Gage Installation (Continuously Recording Data Logger)

Following guidelines from previously permitted installation activities in 2009, a stream gage will consist of a staff gage and a continuous stage (CQ) data logger, each anchored individually to the stream bank and near the shoreline to avoid catching floating debris. The data loggers used for this project will be a USGS-approved bubbler/pressure transducer system manufactured by Design Analysis Associates, Inc with an accuracy of 0.02%. . These data loggers accurately record pressure, which will be related to water surface elevation of the staff gage. The data loggers will be set to record water depth at 15-minute intervals.

Each staff gage will be mounted vertically in the stream channel to measure water depth for the full range of flow conditions. The data loggers will be housed in a shoreline enclosure with the bubbler line protected in conduit and 2”galvanized pipe within the wetted channel.

The staff gage and logger installation will be placed far enough apart that the minor flow disturbances from one will not affect the other. Figure 2 shows multiple views of the data logger, bubbler line, and staff gage, installation. Grant Creek will have one stream gage at GC200 (Figure 1). Project construction equipment will be limited to a battery powered roto-hammer, hand-held post driver, and small hand tools for assembly.

Figure 2. Examples of Design Analysis data logger, bubbler line and staff gage installation.

During field visits, manual readings of the staff gages and the time will be recorded. These manual staff gage readings will be compared with the stage values provided by the data logger during the same time interval. If either of the instruments moves, the movement will be detected by comparing the two gage readings. If movement is indicated, the gage will be resurveyed, and a mathematical adjustment will be applied to the data.

A differential survey will be performed for each of the data loggers and associated staff gages following installation in the spring and prior to decommissioning in the fall. Cross sections at these locations will be surveyed once per year during low-flow conditions. As noted above, an additional differential survey may be performed if elevation movement is observed while the data loggers are in place (i.e., during ice-free months). Multiple temporary benchmarks (TBMs) at each stream gage location will provide differential vertical datum checks for the gage equipment to monitor movement. The Grant Creek stream gage is tied into the elevation of the historical USGS gage and this elevation will be confirmed at installation.

Data loggers will be operated during ice free months. The schedule for these installations is dependent on individual site conditions (e.g., ice cover and water level). Installation of stream gauging equipment will begin as soon as practicable. All installed equipment will actively collect data as long as technical personnel can safely access the site.

Each stream gage will be revisited at least bi-monthly through mid-October and on a monthly basis until site conditions limit safe access. During site follow-up visits the field team will download data from the data logger and take a manual stream discharge measurement when flows permit.

4.2.2.2 Instantaneous Discharge Measurements

Collecting instantaneous discharge data from Grant Creek may require various methods depending upon seasonal variations in flow conditions. It is not possible to wade Grant Creek during high and medium summer flows, which are common in Grant Creek. Potential instantaneous discharge measurement methods will include:

- Current meter method: Wading method (low-flow events on Grant Creek).
- Current meter method: Boat or ADCP method (medium-flow events on Grant Creek).
- Salt dilution method (low flows on Grant Creek).

Regardless of the method used, all instantaneous discharge measurements will yield comparable results and will follow field procedures laid out in Rantz et al (1982). Each stream gage site will be visited at least monthly, and instantaneous discharge measurements will be taken until freeze-up as stream conditions permit, to collect data to validate or calibrate the rating curve. Measurements at other sites within the Grant Creek drainage will be conducted as those sites are determined, and when stream conditions permit

Wading Method - When using the wading method, a Marsh McBirney or Swoffer current meter will be used for taking instantaneous discharge measurements. Measurements will be taken by using a top-setting wading rod with the current meter. During higher or fast-water conditions, the boat method will be employed to obtain discharge measurements.

Procedures for taking discharge measurements using a current meter in ice-free conditions are outlined below.

1. Visually check wading rod and current meter for damage. Repair damage to equipment and replace batteries as necessary.
2. Calibrate the current meter at the start of each field event according to manufacture protocols.
3. Anchor survey measuring tape tautly across the stream perpendicular to the direction of stream flow and attach it on either side of the stream with the low numbers of the tape on the left side of the stream. Calculate the width of the entire stream cross section.
4. Determine the spacing of the vertical partial sections (referred to as "verticals"). This is typically accomplished by splitting the entire stream cross section into approximately 25 to 35 verticals. The number of verticals will be based on an estimated distribution of the discharge across the entire cross section. At locations with narrow stream cross sections, a smaller number of verticals may be used. Space the verticals to meet the USGS objective that no vertical partial section should contain more than 10 percent of the total discharge. The ideal measurement is one in which no partial section contains more than 5 percent of the total discharge. Equal widths of verticals across the entire cross section are not recommended unless the discharge is well distributed. Widths of the vertical partial sections should become less as depths and/or velocities become greater (USDOI, 1969). Water column depth readings will be taken at each vertical.
5. The person wading in the stream will call out the location of the first vertical with respect to the surveyor's tape to the person on shore who is recording data (data recorder). The station or vertical location is recorded on the Kenai Hydro LCC hydrology field form (see example field forms at the end of this document) to the nearest 0.1 feet and the closest spacing for any velocity measurement will be 0.20 feet.
6. Using the wading rod, the person wading in the stream will, if possible, measure water depth at that vertical to the nearest 0.05 foot. The wading person will call out this depth

reading to the data recorder and adjust the height of the current meter on the top-set wading rod according to the depth at that vertical. For water columns less than or equal to 2.5 feet deep, a single measurement of velocity at 60 percent of the water column height from the stream bottom will be recorded. If the water is more than 2.5 feet deep, measurements should be made at 20 and 80 percent of the water-column height.

7. The person wading will stand downstream of the survey measuring tape, facing upstream and holding the wading rod vertical in the water with the current meter facing directly into the current. The wading person should stand to the side, rather than directly behind the meter, to avoid influencing velocity readings. Occasionally flow at a vertical may not be perpendicular to the tape due to a rock upstream or other flow restrictions. If the obstruction cannot be cleared and the flow is more than 20 degrees off perpendicular, the person in the stream should orient the meter directly into the flow and call out the angle of flow with respect to perpendicular. A correction will be applied to the velocity measurement from the vertical when calculating the discharge.
8. The person wading will observe visual output of velocity measurements at each vertical. Velocity measurements will be made for 30 seconds, and velocity will be recorded. The time interval will be noted on the data sheet. In the event of extreme weather or flow conditions, a minimum of 30 seconds may be used for velocity measurements.
9. The person recording data will record this and other appropriate information on the field form.
10. Repeat above procedure at each vertical.

Boat or ADCP Method - When stream flows are high and swift and wading is not a safe option, a boat may be used as a stable platform from which to measure discharge. If a boat is used, it will be tethered to a tensioned safety line securely fastened to either side of the stream. The hydrographer will use the current meter with the standard top-set wading rod as described above, except work will be done from the boat. A range finder may be used to determine vertical spacing along the cross section. Conditions may require that the tethered boat and hydrographer be conveyed across the stream cross section manually by safety line operators on either bank. If velocities are so high that it becomes difficult to hold the wading rod still, a suspended weight may be used to weight the current meter to allow for velocity measurements. If appropriate for the conditions, an ADCP mounted to a River Cat trimaran can be ferried across the channel as described above to measure depth and velocity verticals. The use of an ADCP would represent a viable and safer option than standard current meter techniques via wading or boat techniques.

Salt Dilution Method - The measurement of accretion in the Canyon Reach (Reach 5) will likely involve very small differences and therefore will be conducted at a low flow time of the year (late March) The salt dilution method may be most appropriate for this task because of safety and accuracy issues. Hydrological measurements using the current meter method in upstream portions of Grant Creek have been extremely difficult and unsafe due to the high velocities, turbulent flow, and hazards such as waterfalls and strainers. Data collected with the salt dilution method are comparable to the current-meter method typically used for these data collection efforts when field conditions allow.

The salt dilution method is a standard USGS method used to measure stream discharge. The basic premise is to introduce a known amount of salt at one point in the stream and measure the conductivity (i.e., concentration) wave as it passes a point downstream where it is completely mixed in the flow. Stream flow is calculated from the area under the resulting conductivity curve. The salt dilution method uses common table salt (NaCl) as a tracer to measure discharge without the use of a current meter. Salt is preferred as a tracer over other known tracers because it is non-toxic to aquatic organisms at the concentrations and exposure times associated with the measurements. It is also inexpensive, easily obtained, and convenient to work with. Field measurements can be made with a conductivity meter read by a data logger.

It is recognized that there is a likelihood that flow differences between upstream and downstream measurements will be too small to be detected within the range of error inherent in the method. Nevertheless, the data are considered valuable from the project permitting standpoint regardless of outcome.

4.2.3 Grant Lake and Grant Creek Fluvial Geomorphology

The Grant Lake and Grant Creek Fluvial Geomorphology study consists of two study components: a Grant Lake shoreline erosion inventory and comparison and a Grant Creek spawning substrate recruitment assessment.

Project-Related Objectives

- Provide a basis for predicting and assessing potential lake shore erosion in Grant Lake as a result of proposed reservoir operation.
- Provide a basis for predicting and assessing potential changes to material movement, sedimentation, and gravel recruitment that may occur in Grant Creek with changes in flow, especially as related to the long-term maintenance of fish spawning substrate.
- Provide a basis for predicting and assessing potential changes to material movement, sedimentation, and gravel recruitment that may occur in Grant Creek with changes in flow, especially as related to the long-term maintenance of fish spawning substrate.
- Provide input data required for the planning of mitigation measures.

Quantitative Objectives

- The proposed Grant Lake shore erosion study is a semi-quantitative inventory of shoreline conditions that might affect erosion potential that will permit comparison with conditions at existing operating reservoirs. Conclusions will combine objective criteria with professional judgment.
- The Grant Creek spawning substrate study will combine quantitative and qualitative elements. Bulk samples will be of sufficient size to be statistically representative using standard methods. The validity of sediment transport equations and their attendant assumptions will be discussed in light of project requirements.

4.2.3.1 Grant Lake shore erosion study

- Summarize existing topographic, soils, and geology data of potential erosion features.
- Compile and analyze local wind intensity and direction data.
- Map high wave areas on Grant Lake.

- Conduct a boat-based GIS-enabled lake shore inventory.
- Conduct data analysis and QA/QC.
- Produce a technical memorandum.

The purpose of the Grant Lake shore erosion inventory will be to characterize the erosion potential along the shores of Grant Lake and its tributaries resulting from potential lake impoundment and drawdown scenarios. A boat-based inventory will be conducted for areas of current erosion and potential erosion along the shoreline of Grant Lake. Location data, site characteristics, and photos will be collected using GIS mapping techniques. The Grant Lake data will be compared to Cooper Lake shore erosion data (HDR, 2004) and other reservoir conditions as applicable to allow for the general prediction and identification of possible erosion issues under an impoundment and drawdown scenario.

4.2.3.2 Grant Creek spawning substrate recruitment study

The purpose of the Grant Creek spawning gravel recruitment study will be to assess the existing processes that control the supply of substrate suitable for spawning in Grant Creek and to assess potential changes to substrate composition under the potential scenario of a partially dewatered canyon reach and altered seasonal flow regime.

A three-phase work plan is proposed to accomplish the above objectives: (1) assessment of the substrate at existing spawning areas including aspects of embeddedness and substrate size composition, (2) quantification of material transport conditions under the existing and projected flow regimes, and (3) qualitative geomorphic assessment of existing sediment supply conditions. General methodology and scope will be similar to that employed by Inter-Fluve, Inc. (2004) on Cooper Creek related to relicensing of the Cooper lake Hydroelectric Project.

For Phase 1: Standard methods, including Wolman pebble counts and embeddedness indices, will be employed to characterize existing surface spawning gravels conditions. Woman pebble count (frequency-by-numbers) methods will be determined based on field conditions, but will likely include a grid-type method using 100-stone counts. The grid spacing will be determined by field conditions, but should not affect the final results assuming that the sediment deposit is isotropic in the horizontal directions.

The embeddedness sampling will include measurements of approximately 50 stones of surface substrate of a particle size range that falls within the range of spawning substrate sizes for species using Grant Creek. A qualitative discussion of potential changes in embeddedness under management scenarios will be conducted. Both Wolman pebble count and embeddedness measurements could be used for future monitoring to evaluate potential changes following management scenarios.

Bulk samples (frequency by volume) of subsurface stream margin and gravel bar substrate will be obtained at select study sites to assure statistically significant samples utilizing methods consistent to those discussed in Church *et al* 1987. Grain-size distribution will be determined for each bulk sample by conducting field sieves and hand measurement for the larger grain material and removing the finer-grained sediment for measurement at a laboratory facility. Because of

the large grain sizes present at the site, it is infeasible to remove the full sample for laboratory measurement.

Approximately 10 sampling sites will be established for Phase 1 measurements in the documented spawning reach (Reaches 1-4 downstream of the canyon). Based on field conditions, the sampling sites will be established at or near locations of the established Instream Flow monitoring sites to the extent feasible in order to integrate the Instream Flow modeling outputs into the sediment transport equation(s) (See Phase 2 below). Based upon professional judgment, additional sampling sites may be established depending upon field conditions and substrate changes within the study reach. These sampling sites will be spatially referenced for potential future monitoring.

For Phase 2: Sediment transport analyses will combine existing hydrological information, 2013 measurements of hydraulic characteristics at select sites (integrating the Instream Flow modeling outputs to the extent possible), and utilize incipient motion particle size analysis to determine the threshold of mobility for particles of various sizes for a given hydraulic condition predicted under existing conditions and a proposed management scenario. Existing incipient motion equation(s) and literature-referenced calibration estimates will be used and the equation(s) will be selected and applied based on field conditions and professional judgment. Rationale as to the assumptions integrated into the equations and a qualitative discussion of the reliability model outcomes will be documented. Field measured surface and subsurface (bulk sample and Wolman pebble counts) particle sizes, field measured channel geometry, and instream flow modeling outputs collected as part of the IFIM study under Task will be used as input to the selected sediment transport equation(s).

For Phase 3: Qualitative geomorphic assessment of the sediment supply for Grant Creek will be based on detailed observations of the Grant Lake watershed, known geological conditions, and professional interpretation of observed geomorphic processes to interpret and discuss potential impacts to the future supply of substrate to the spawning reach in Grant Creek (Reaches 1-4) and anticipated channel response.

5 Agency Resource Management Goals

Stated resource agency management goals resulting from coordination include:

- Alaska Department of Fish and Game published Our Wealth Maintained: A Strategy for Conserving Alaska's Diverse Wildlife and Fish Resources in 2006. The Strategy is intended to integrate new conservation methods with existing wildlife management and research programs. Maintaining diversity of wildlife (including fish) is the main goal of the Strategy.
- The Kenai River Special Management Area (KRSMA) is managed under Alaska Department of Natural Resources. The area includes public lands and waters that contribute to sustaining Kenai River's fish resources.
- The Revised Land and Resource Management Plan for the Chugach National Forest developed by the United States Forest Service lists multiple goals based around maintaining and/or improving fish habitat within the National Forest.
- The Kenai River Comprehensive Management Plan, managed by the Alaska Department of Natural Resources, is the basis for management of state lands within KRSMA.
- The Alaska Department of Fish and Game published Aquatic Resources Implementation Plan for Alaska's Comprehensive Wildlife Conservation Strategy (CWCS) in 2007. The goal of the CWCS is to conserve the diversity of Alaska's fish and wildlife resources, focusing on species and habitats of greatest concern.

6 Project Nexus

The proposed Grant Lake Project may have potential impacts on water resources within Grant Creek, Grant Lake, and Trail Lake Narrows. The studies described above are intended to provide sufficient information regarding the nature of the existing water resources such that these potential impacts can be adequately assessed. The impact assessments will be presented in the study report and be used to inform the development of protection, mitigation, and enhancement measures to be proposed in the draft and final license applications.

6.1 *Water Quality and Temperature*

Water quality samples will be collected using standard methods approved by the EPA. Sampling equipment will be cleaned and decontaminated between each sampling site/event. Sample frequency during open-water months may vary depending on the needs of the project. The HOBO Pro V2 logging thermistor has an operating range of -40 to 50 ºC, and is accurate to 0.2 ºC over 50 ºC. The HOBO U20 water level logger has a pressure operating range of 0-207 kPA, with a typical error of 0.05 percent, and a temperature operating range of -20 to 50 ºC and is accurate to 0.37 ºC at 20 ºC. Both HOBO units have 64K bytes of memory.

6.2 *Hydrology*

Hydrology studies, including the installation and operation of surface water elevation data loggers, and instantaneous discharge measurement methods will be conducted using standard methods as described by Rantz et al (1982). These methods have been developed, standardized, and are in use by the USGS specifically for measuring stream discharges throughout the nation.

6.3 *Grant Lake and Grant Creek Fluvial Geomorphology*

The Grant Lake shoreline erosion study is designed to be a reconnaissance-level effort that relies on existing geologic and soils data, hydrologic data, and meteorological data as well as professional experience and judgment to produce a meaningful description of processes and implications for potential Project impacts. The Grant Creek spawning substrate recruitment study combines standard quantitative measures of sediment transport with qualitative analyses. Both studies will incorporate methods used in previous studies (e.g. HDR 2004 and Inter-Fluve 2004).

7 Consistency with Generally Accepted Practices

7.1 *Water Quality and Temperature*

Water quality samples will be collected using standard methods approved by the EPA. Sampling equipment will be cleaned and decontaminated between each sampling site/event. Sample frequency during open-water months may vary depending on the needs of the project. The HOBO Pro V2 logging thermistor has an operating range of -40 to 50 ºC, and is accurate to 0.2 ºC over 50 ºC. The HOBO U20 water level logger has a pressure operating range of 0-207 kPA, with a typical error of 0.05 percent, and a temperature operating range of -20 to 50 ºC and is accurate to 0.37 ºC at 20 ºC. Both HOBO units have 64K bytes of memory.

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8 Schedule for Conducting the Study

8.1 *Water Quality and Temperature*

- April 2013 - One-day field event to deploy temperature loggers in Grant Creek (main channel reaches only)

- June 2013 - Four-day field event to deploy thermistor string in Grant Lake, download Grant Creek thermistors, collect water quality samples at Trail Lake Narrows.

- August 2013 - Three-day field event to collect water quality samples at Grant Lake, Grant Creek, and Trail Lake Narrows; one day of preparation, download thermistors, potentially deploy off-channel thermistors.
- September/October 2013 - Three-day field event to collect water quality samples at Trail Lake Narrows, download thermistors at Grant Lake and Grant Creek
- November/December 2013 - Two-day field event to download thermistors at Grant Lake (if possible) and Grant Creek.
- February 2014 - Complete QA/QC on all data, complete data processing and analysis.

Baseline water quality studies in Grant Lake

- Water quality samples will be collected at two sites in Grant Lake in late summer to complete the seasonal sampling initiated in 2010. Samples will be collected at two depths at the natural outlet site (GLOut) and at three depths at the proposed intake location (GLTS; Figure 1).

Baseline water quality studies in Grant Creek

- Water quality samples will be collected at three sites on Grant Creek (GC100, GC200, and GC300; Figure 1) in August to complete the seasonal sampling initiated in 2010.

Baseline water quality studies in Trail Lake Narrows

- Water quality samples will be collected in Trail lake Narrows at one location about 100 m downstream from the proposed access road bridge site. Samples will be collected at three times during the year, early June (spring runoff), late summer, and September/October (fall runoff). Samples will be collected from the center of the narrows channel.

8.2 *Hydrology*

- April 2013 - Prepare equipment and materials for tensioned line and cataraft.
- April-May 2013 - Set up tension line and cataraft; conduct gaining/loosing determination IQ measurements; install gages and data loggers on Grant, make up to two IQ measurements on Grant Creek. These measurements could also be made during autumn low-flow conditions.
- June 2013 - Make one IQ measurement on Grant Creek, conditions permitting.
- July 2013 - Download data loggers in conjunction with other field efforts.

- August 2013 - Make up to one IQ measurement on Grant Creek.
- September 2013 - Make up to one IQ measurement on Grant Creek.
- October 2013 - Make up to two IQ measurements on Grant Creek, download data loggers, and decommission gages.
- February 2014 - Complete QA/QC on all data, complete data processing and analysis.

8.3 *Grant Lake and Grant Creek Fluvial Geomorphology*

- May 2013 - Prepare and conduct spawning gravel reconnaissance field visit during spring low-flow conditions.
- July 2013 - Prepare for lake shore erosion inventory field event.
- August 2013 - Conduct Cooper Lake calibration site visit and Grant Lake shore erosion inventory.
- September 2013 - Process and analyze lake shore erosion data.

9 Provisions for Technical Review

KHL will provide updates and study products for review by the Water 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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