Grant Lake Hydroelectric Project (FERC No. 13212)

Aquatic Resources Study – Grant Creek, Alaska
Fisheries Assessment Report

Prepared for
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Acronyms and Abbreviations

ADF&G	Alaska Department of Fish & Game
AEIDC	Arctic Environmental Information Data Center
AUC	area-under-the-curve
AWC	Anadromous Waters Catalog
cfs	cubic feet per second
CIAA	Cook Inlet Aquaculture Association
CPUE	catch per unit effort
DLA	Draft License Application
FERC	Federal Energy Regulatory Commission
FL	fork length
GPS	Global Positioning System
IFIM	Instream Flow Incremental Methodology
KHI	Kenai Hydro, Inc.
KHL	Kenai Hydro, LLC
LA	License Application
LWD	large woody debris
mm	millimeter
MW	megawatt
NAVD 88	North American Vertical Datum of 1988
NGVD 29	National Geodetic Vertical Datum of 1929
NOI	Notice of Intent
PAD	Pre-Application Document
PM&E	protection, mitigation and enhancement
Project	Grant Lake Hydroelectric Project
TWG	Technical Working Group
USGS	U.S. Department of the Interior, Geological Survey
WUA	weighted usable area

Note: Measurements within this document are given in metric units with the exception of Section 1.1 (the description of the proposed project). Measurements within that section are given in English units in order to be consistent with other Grant Creek resource documents.

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Aquatic Resources Study – Grant Creek, Alaska
Fisheries Assessment Report
Grant Lake Hydroelectric Project (FERC No. 13212)

1 INTRODUCTION

On August 6, 2009, Kenai Hydro, LLC (KHL) filed a Pre-Application Document (PAD; KHL 2009), along with a Notice of Intent (NOI) to file an application for an original license, for a combined Grant Lake/Falls Creek Project (Federal Energy Regulatory Commission [FERC] No. 13211/13212 ["Project" or "Grant Lake Project"]) under Part I of the Federal Power Act (FPA). On September 15, 2009, FERC approved the use of the Traditional Licensing Process (TLP) for development of the License Application (LA) 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).

The fish assessment portion of the Aquatic Resources Study Plan (KHL 2013) was designed to address information needs identified in the PAD, during the TLP public comment process, and through early scoping conducted by FERC. This study report 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 (PM&E) measures in the draft and final LAs for the Project.

1.1 Proposed Project Description

The Project is located near the community of Moose Pass in the Kenai Peninsula Borough, approximately 25 miles north of Seward and just east of the Seward Highway. It lies within Section 13 of Township 4 North, Range 1 West; Sections 1, 2, 5, 6, 7, and 18 of Township 4 North, Range 1 East; and Sections 27, 28, 29, 31, 32, 33, 34, 35, and 36 of Township 5 North, Range 1 East, Seward Meridian (U.S. Geological Survey [USGS] Seward B-6 and B-7 Quadrangles).

The proposed Project would be composed of an intake structure at the outlet to Grant Lake, a tunnel, a surge tank, a penstock, and a powerhouse. It would also include a tailrace detention pond, a switchyard with disconnect switch and step-up transformer, and an overhead or underground transmission line. The preferred alternative would use approximately 15,900 acre-feet of water storage during operations between pool elevations of approximately 692 and up to 703 feet North American Vertical Datum of 1988 (NAVD 88)[1].

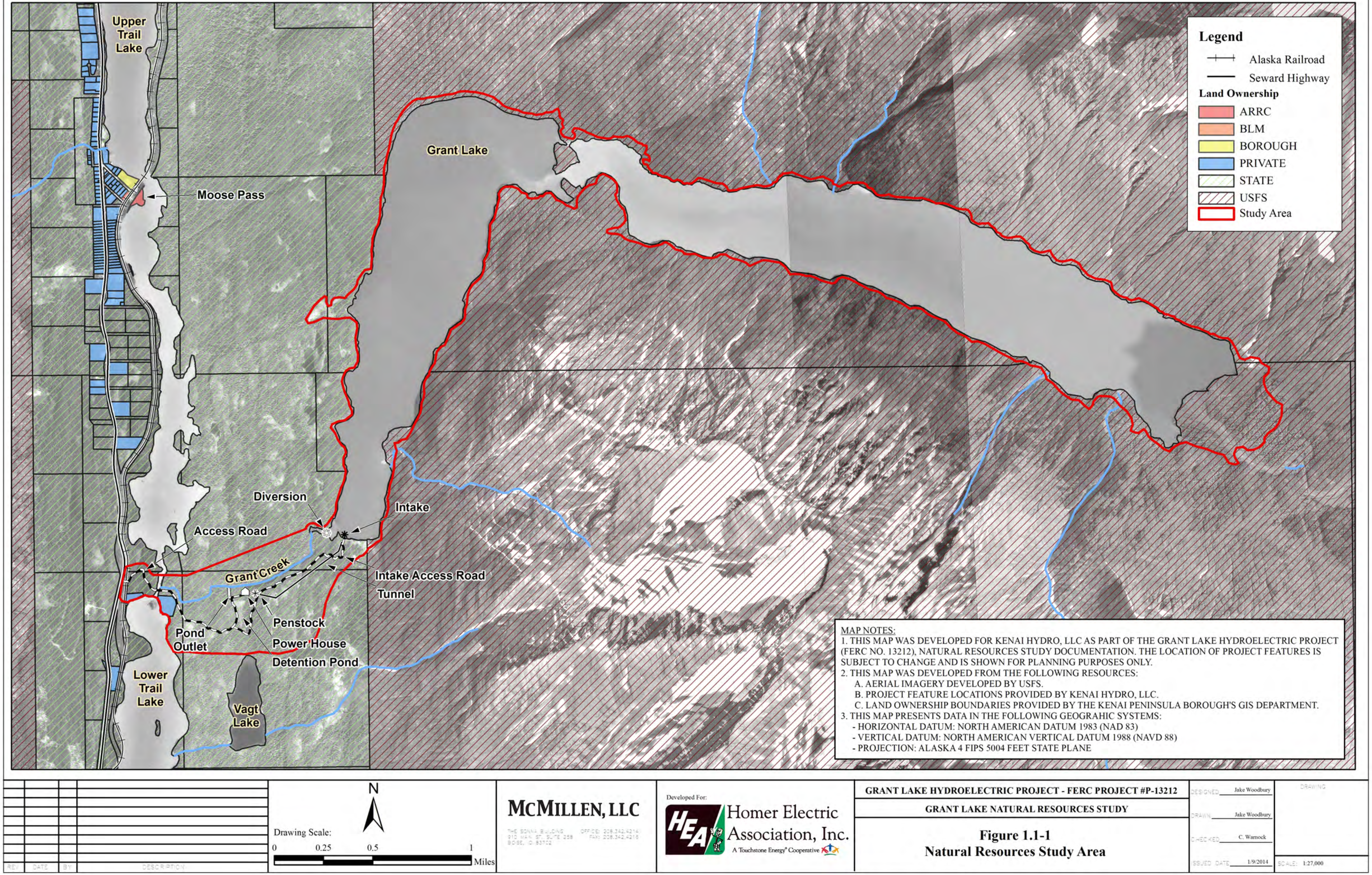
[1] The elevations provided in previous licensing and source documents are referenced to feet mean sea level in NGVD 29 [National Geodetic Vertical Datum of 1929] datum, a historical survey datum. The elevations presented in the Grant Lake natural resources study reports are referenced to feet NAVD 88 datum, which results in an approximate +5-foot conversion to the NGVD 29 elevation values.

An intake structure would be constructed approximately 500 feet east of the natural outlet of Grant Lake. An approximate 3,200-foot-long, 10-foot diameter horseshoe tunnel would convey water from the intake to directly above the powerhouse at about elevation 628 feet NAVD 88. At the outlet to the tunnel a 360-foot-long section of penstock will convey water to the powerhouse located at about elevation 531 feet NAVD 88. An off-stream detention pond will be created to provide a storage reservoir for flows generated during the rare instance when the units being used for emergency spinning reserve are needed to provide full load at maximum ramping rates. The tailrace would be located in order to minimize impacts to fish habitat by returning flows to Grant Creek upstream of the most productive fish habitat.

Two concepts are currently being evaluated for water control at the outlet of Grant Lake. The first option would consist of a natural lake outlet that would provide control of flows out of Grant Lake. A new low level outlet would be constructed on the south side of the natural outlet to release any required environmental flows when the lake is drawdown below the natural outlet level. The outlet works would consist of a 48-inch diameter pipe extending back into Grant Lake, a gate house, regulating gate, controls and associated monitoring equipment. The outlet would discharge into Grant Creek immediately below the natural lake outlet.

In the second option, a concrete gravity diversion structure would be constructed near the outlet of Grant Lake. The gravity diversion structure would raise the pool level by a maximum height of approximately 2 feet (from 703 to 705 feet NAVD 88), and the structure would have an overall width of approximately 120 feet. The center 60 feet of the structure would have an uncontrolled spillway section with a crest elevation at approximately 705 feet NAVD 88. Similar to the first option, a low level outlet would be constructed on the south side of the natural outlet to release any required environmental flows when the lake is drawn down below the natural outlet level. The outlet works would consist of a 48-inch diameter pipe extending back into Grant Lake, a gate house a regulating gate, controls, and associated monitoring equipment. The outlet would discharge into Grant Creek immediately below the diversion structure.

Figure 1.1-1 displays the global natural resources study area for the efforts undertaken in 2013 and 2014 along with the likely location of Project infrastructure and detail related to land ownership in and near the Project area. Further discussions related to specifics of the aforementioned Project infrastructure along with the need and/or feasibility of the diversion dam will take place with stakeholders in 2014 concurrent with the engineering feasibility work for the Project. Refined Project design information will be detailed in both the Draft License Application (DLA) and any other ancillary engineering documents related to Project development. The current design includes two Francis turbine generators with a combined rated capacity of approximately 5.0 megawatts (MW) with a total design flow of 385 cubic feet per second (cfs). Additional information about the Project can be found on the Project website: http://www.kenaihydro.com/index.php.



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MCMILLEN, LLC

Developed For: Homer Electric Association, Inc. A Touchstone Energy® Cooperative

GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT #P-13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 1.1-1
Natural Resources Study Area

DESIGNED: Jake Woodbury
DRAWN: Jake Woodbury
CHECKED: C. Warnock
ISSUED DATE: 1/9/2014
SCALE: 1:27,000
DRAWING

1.2 Overall Goals Identified During Project Scoping

The goals of the study efforts described in this report were to provide baseline information; those data, in conjunction with existing information will be used to develop potential alternative flow regimes, which in turn will be assessed to determine potential Project impacts on aquatic resources. These impact assessments will identify potential protection, mitigation, and enhancement measures to be presented in the draft and final LAs.

The goals of this suite of studies were 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 LA, 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.

1.3 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. In the following sub-sections, Sections 1.3.1 and 1.3.2, we describe the findings from these studies.

1.3.1 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 LA prepared by Kenai Hydro, Inc. (not related to the current Kenai Hydro, LLC; Envirosphere 1987, KHI 1987a, and KHI 1987b).

1.3.1.1 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 (Ebasco 1984; Johnson and Klein 2009). Rearing Chinook, coho and rainbow trout are also present (Ebasco 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 (Ebasco 1984).

Upper Grant Creek is impassable to salmon one mile upstream of the mouth (Johnson and Klein 2009), with most fish habitat 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 (Ebasco 1984). Substrate material is coarse throughout the entire length of the creek due to high water velocity that tends to wash away smaller gravels (Ebasco 1984). Isolated areas of suitable spawning gravels occur in the lower half of the stream (Ebasco 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 (Ebasco 1984).

Ebasco (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) (Ebasco 1984). Spawning coho were not observed (Ebasco 1984) but have been recorded as being present at unknown levels in the stream by the Anadromous Waters Catalog (AWC) published by the Alaska Department of Fish and Game (Johnson and Klein 2009). Maximum counts from intermittent stream surveys by the Alaska Department of Fish & Game (ADF&G) were 76 Chinook (1963) and 324 (1952) sockeye salmon.

1.3.1.2 Grant Lake Fish Resources

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

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, Ebasco 1984), and Grant Lake is not included in the AWC (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 three-spine 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).

1.3.1.3 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 LA 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 LA 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 2009a).

1.3.2 2009 and 2010 Aquatic Resources Studies

The 2009 aquatic resources study program was implemented to assist with the current FERC licensing effort. After collaboration with stakeholders, emphasis was placed on updating existing information, acquiring more complete data 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 after further stakeholder collaboration in an effort to revise the study plans and make them more quantitative in nature.

1.3.2.1 Fish Resources

The 2009 fisheries study (HDR 2009b) 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.

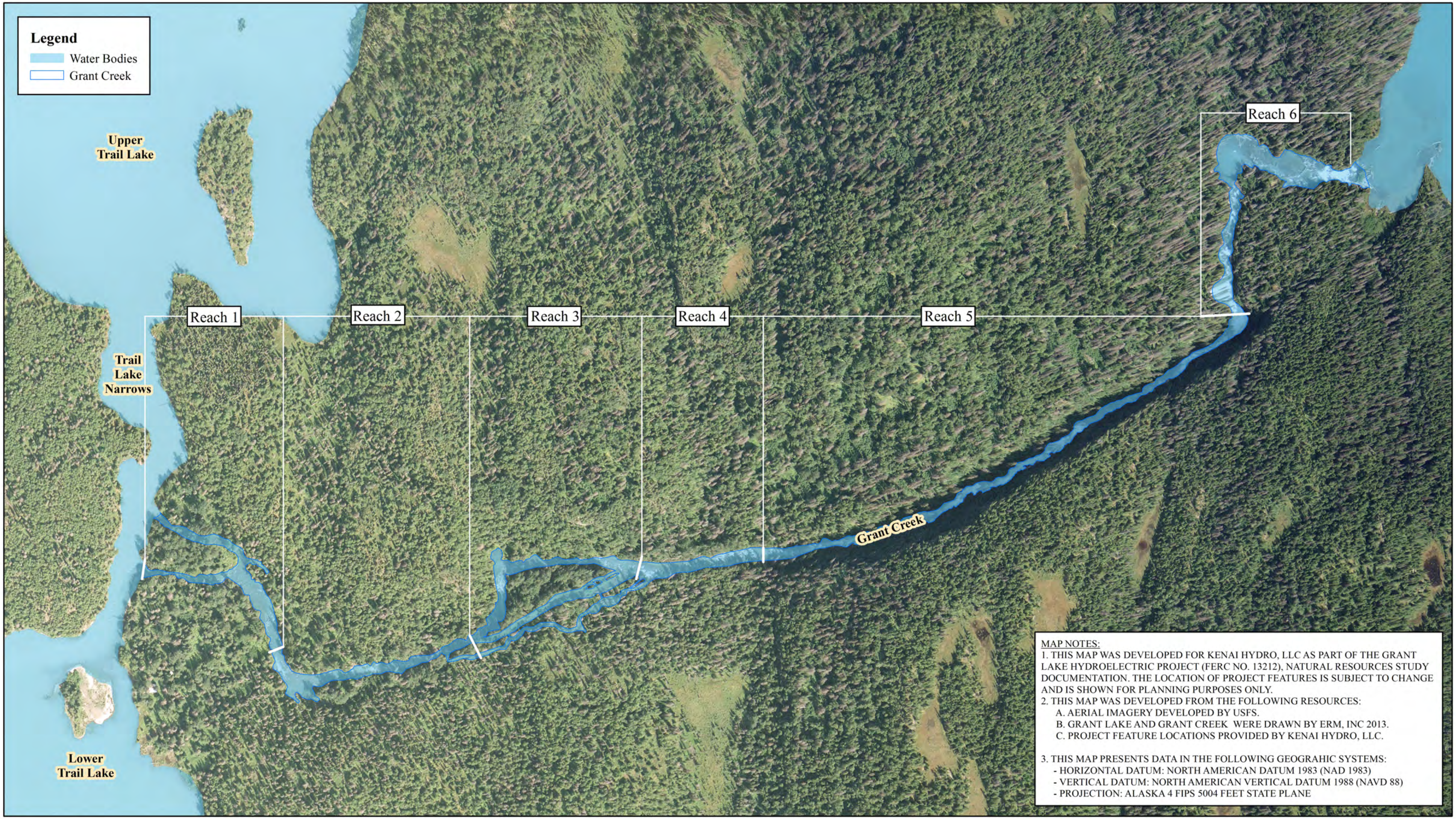
Consistent with studies conducted by AEIDC (1983), Grant Creek was divided into study Reaches 1 through 6 (Figure 1.3-1). Reaches 1 through 4 were roughly equal in length and Reaches 5 and 6 were established based on geomorphologic characteristics (HDR 2009b).

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 0.6 cm. 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 three-spine stickleback. Most salmon captured were young-of-the-year with few larger juveniles present (HDR 2009b).

Relative abundance of larger size resident salmonids (i.e., rainbow trout and Dolly Varden) was determined by calculation of angling CPUE (HDR 2009b). 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 2009b). 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 2009b). 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 2009b). Sampling occurred at nine gill netting sites, 18 electrofishing sites, and 28 minnow trapping sites. Three-spine stickleback was the dominant species in the lake followed by sculpin. No other species of fish was captured (HDR 2009b).



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GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO. 13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 1.3-1
Grant Creek Reaches

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED C. Warnock
ISSUED DATE 3/4/2014

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1.3.2.2 Instream Flow

The collaborative process for a study of "instream flow" effects in Grant Creek was initiated in 2009 (HDR 2009b). The primary goal of the 2009 instream flow study program was to establish a 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 2009b).

As part of the instream flow study, and at the request of the TWG, a sampling event was conducted from June 23-25, 2009 on Grant Creek to characterize the types of aquatic habitats used by resident fish and rearing fish (HDR 2009b). 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 2009b).

1.3.3 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. The field studies conducted in 2013 were 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 micro-habitats 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.
- Fish resources and habitat use of the Trail Lake Narrows at the proposed bridge site.

2 STUDY OBJECTIVES

Study objectives were developed for the 2013 research period based on existing data, and data gaps identified through consultation with the Stakeholders. Most objectives were a continuation of the 2009 and 2010 research effort; while other objectives were the result of additional stakeholder consultation. The objectives encompass adult and juvenile anadromous salmonids, as well as adult and juvenile resident species. The following is a brief description of the 2013 study objectives. The methods employed to achieve these objectives are discussed in detail in Section 4.

2.1 Grant Creek Salmon Spawning Distribution and Abundance

The purpose of this study component was to characterize spawning salmon distribution, run timing, and relative abundance in Grant Creek. This study effort consisted 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 were 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 assess the spawning distribution of Chinook, sockeye, and coho salmon, with emphasis on Reach 5 (Canyon Reach).

2.1.1 Salmon Escapement to Grant Creek – Relative Species Abundance

- Assessment of numbers and species of salmon in Grant Creek.
- Identify key species and critical time periods for environmental assessment.
- Identify 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.
- The primary objective is to obtain a nearly complete count of salmon of each species entering Grant Creek.

2.1.2 Distribution of Spawning Salmon in Grant Creek

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

2.2 Grant Creek Resident and Rearing Fish Abundance and Distribution

The purpose of this study component was 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 consisted 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 meso-habitats in Grant Creek.

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

- Assessment of relative numbers of rainbow trout in Grant Creek.
- Identification of sensitive time periods for environmental assessment.
- Identify important spawning and feeding habitats for general assessment of project impacts.
- Provide input for Project mitigation needs by identifying sensitive stream segments.
- Obtain a count of adult rainbow trout entering Grant Creek during the open water season.
- Determine distribution of trout by tracking radio-tagged fish.

2.2.2 Resident and Rearing Fish Use of Reach 5

- Assessment of rearing fish use of habitats within Reach 5.
- 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.
- Use of an inclined plane trap to monitor outmigrants from Reach 5.

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

- 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.
- Obtain a count of adult rainbow trout, Dolly Varden, and other resident species entering Grant Creek during the open water season.
- Use an inclined plane trap to monitor outmigrants from Reach 5.

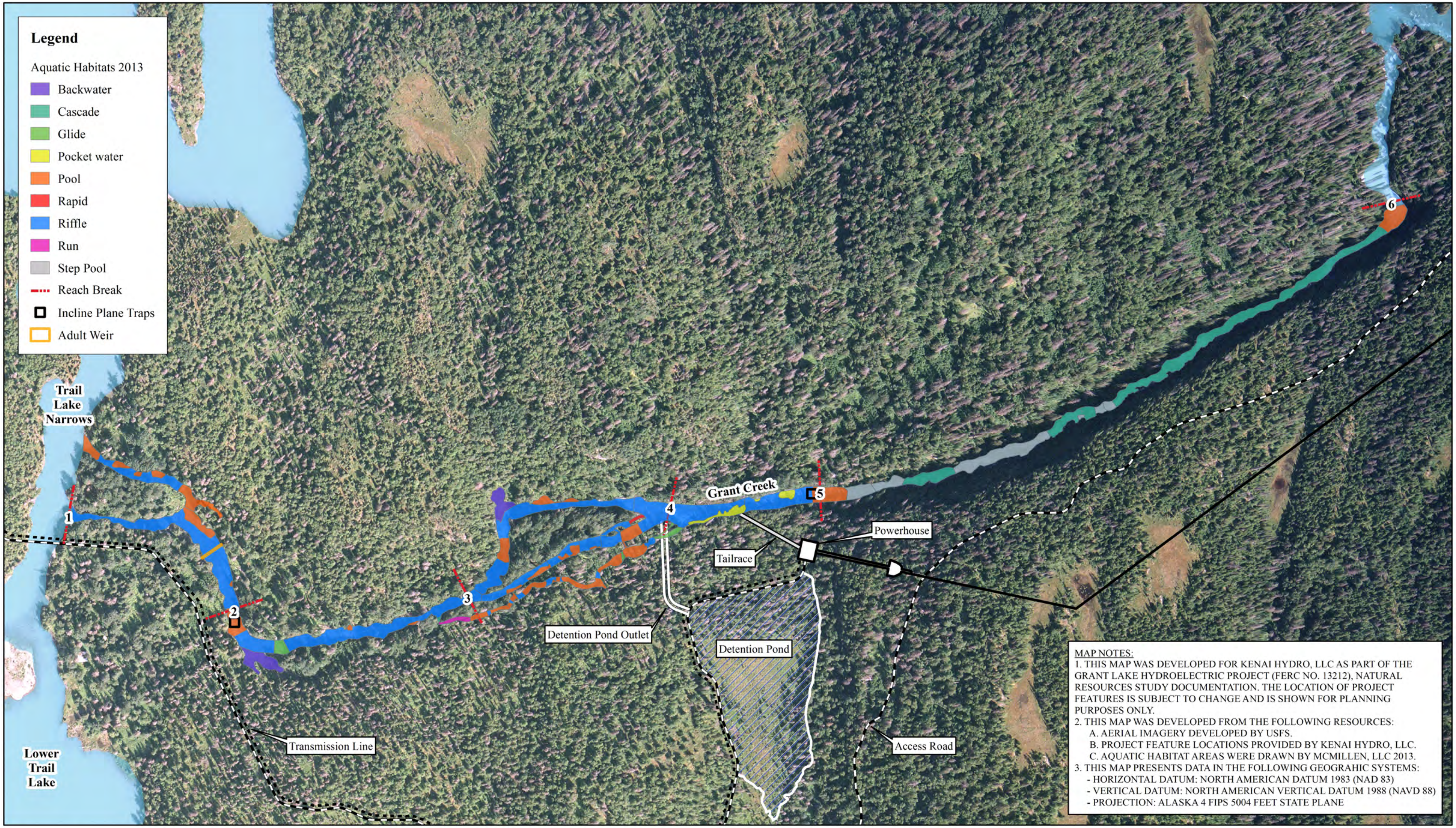
2.3 Trail Lake Narrows Fish and Aquatic Habitats

- Determine 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.

3 STUDY AREA

3.1 Grant Creek

Consistent with studies conducted by AEIDC (1983) and KHL (HDR 2009b), Grant Creek was divided into study Reaches 1 through 6. Reaches 1 through 4 were roughly 0.125 mile each in length and Reaches 5 and 6 were established based on geomorphologic characteristics, and were collectively about 0.5 miles in length (HDR 2009b). Aquatic habitats in reaches 1-5 were documented within the efforts of the IFIM team to help quantify and describe the distribution of habitats in Grant Creek, 2013 (McMillen, LLC 2014; Figure 3.1-1). The material is presented here to describe the study area followed by a brief description of reaches 1-5 on Grant Creek.



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GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Grant Creek Aquatic Habitats
Reaches 1 - 5

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

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1 of 6
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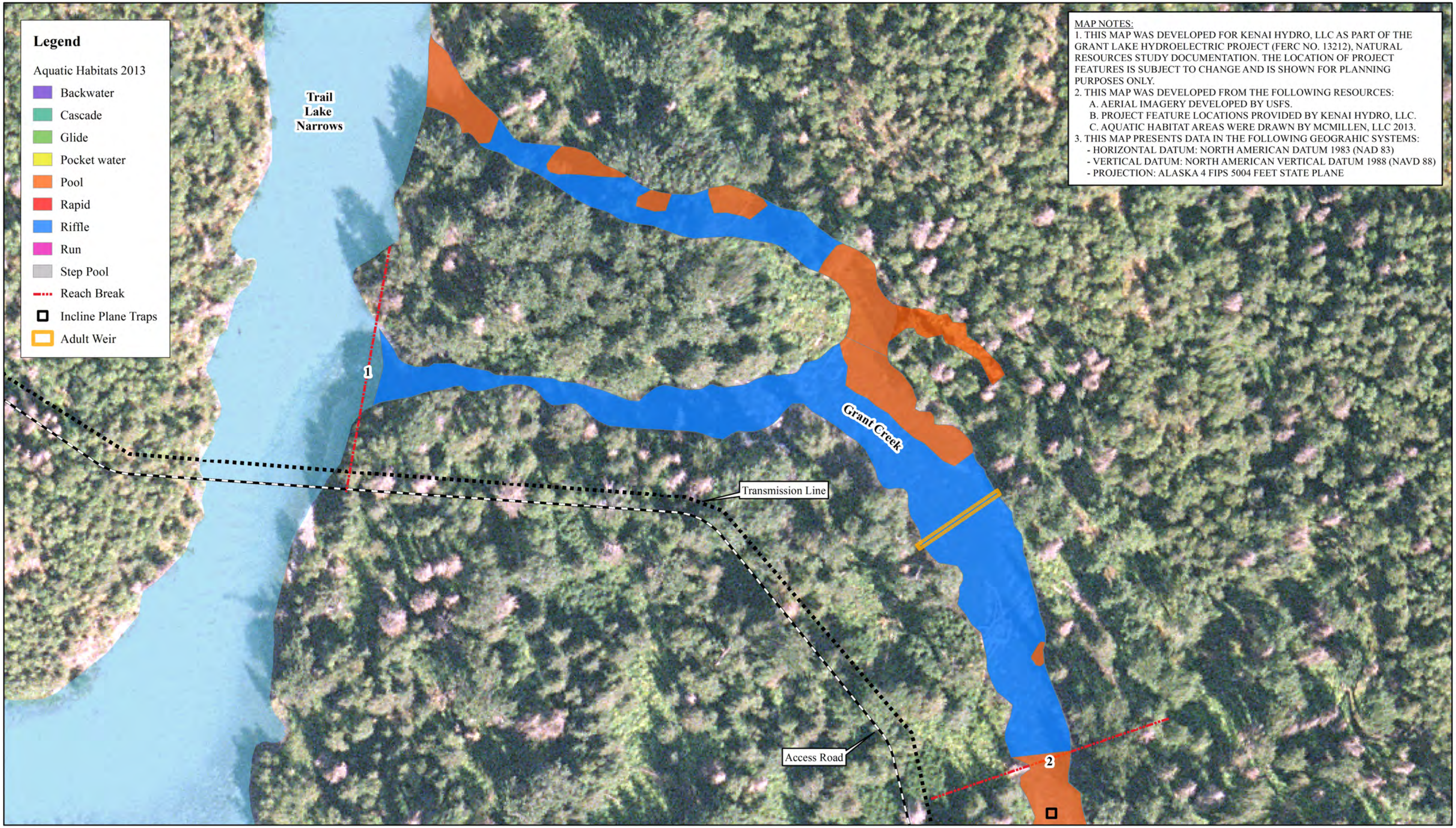

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Grant Creek Aquatic Habitats
Reach 1

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CHECKED: M. Miller
ISSUED DATE: 2/18/2014

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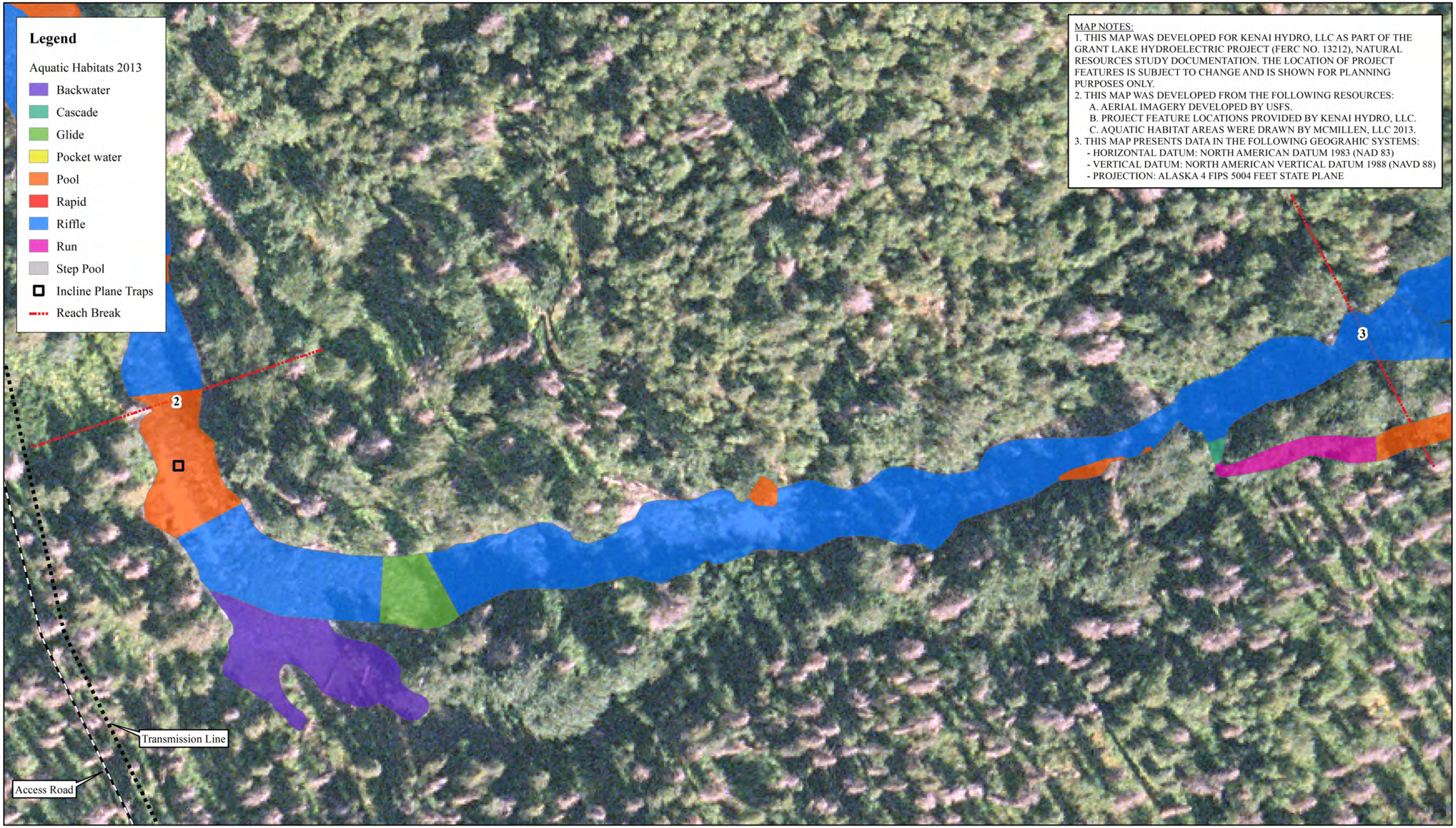

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Grant Creek Aquatic Habitats
Reach 2

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CHECKED: M. Miller
ISSUED DATE: 2/18/2014

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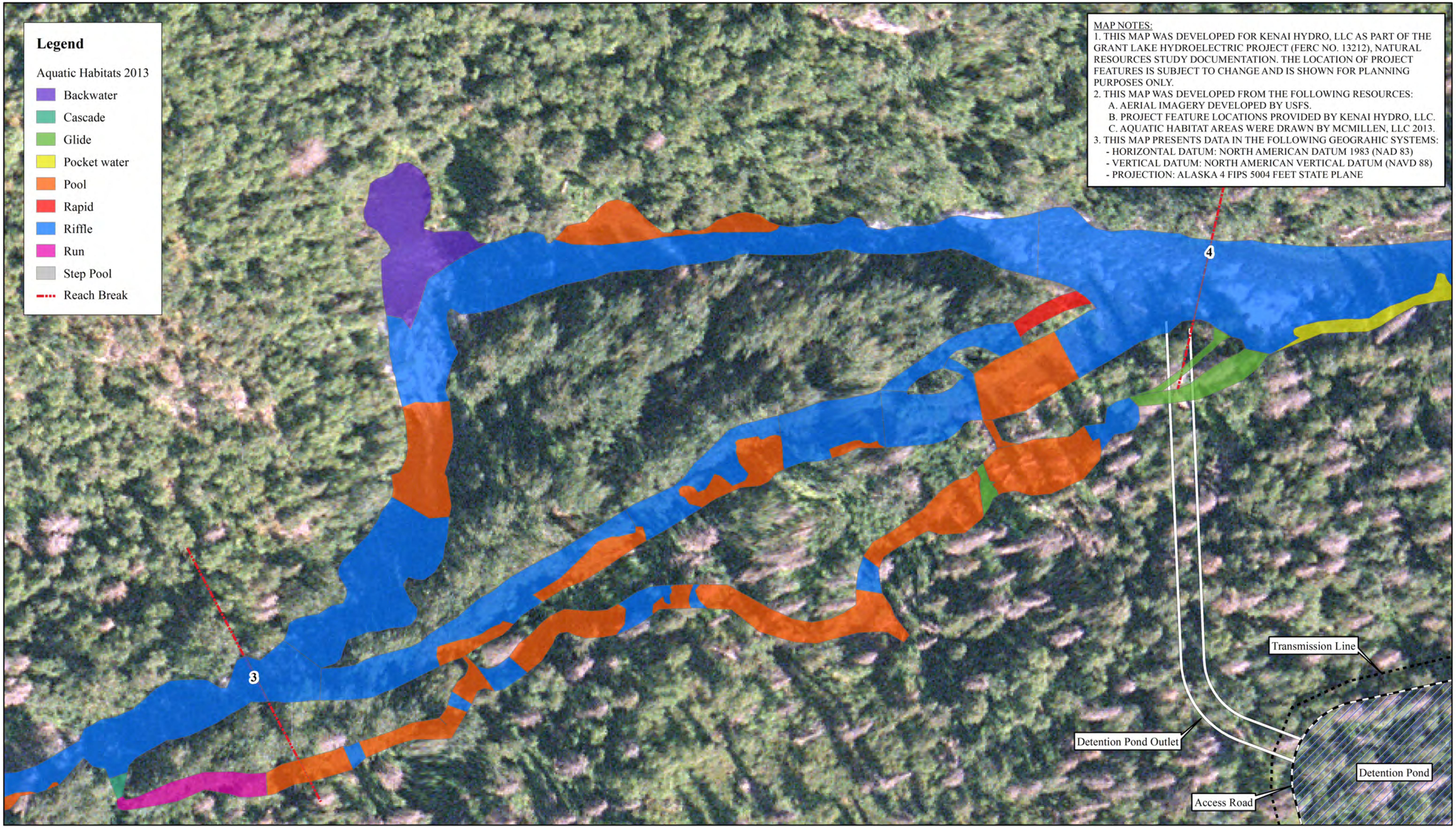

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Figure 3.1-1
Grant Creek Aquatic Habitats
Reach 3

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CHECKED M. Miller
ISSUED DATE 2/18/2014

DRAWING **4 of 6**

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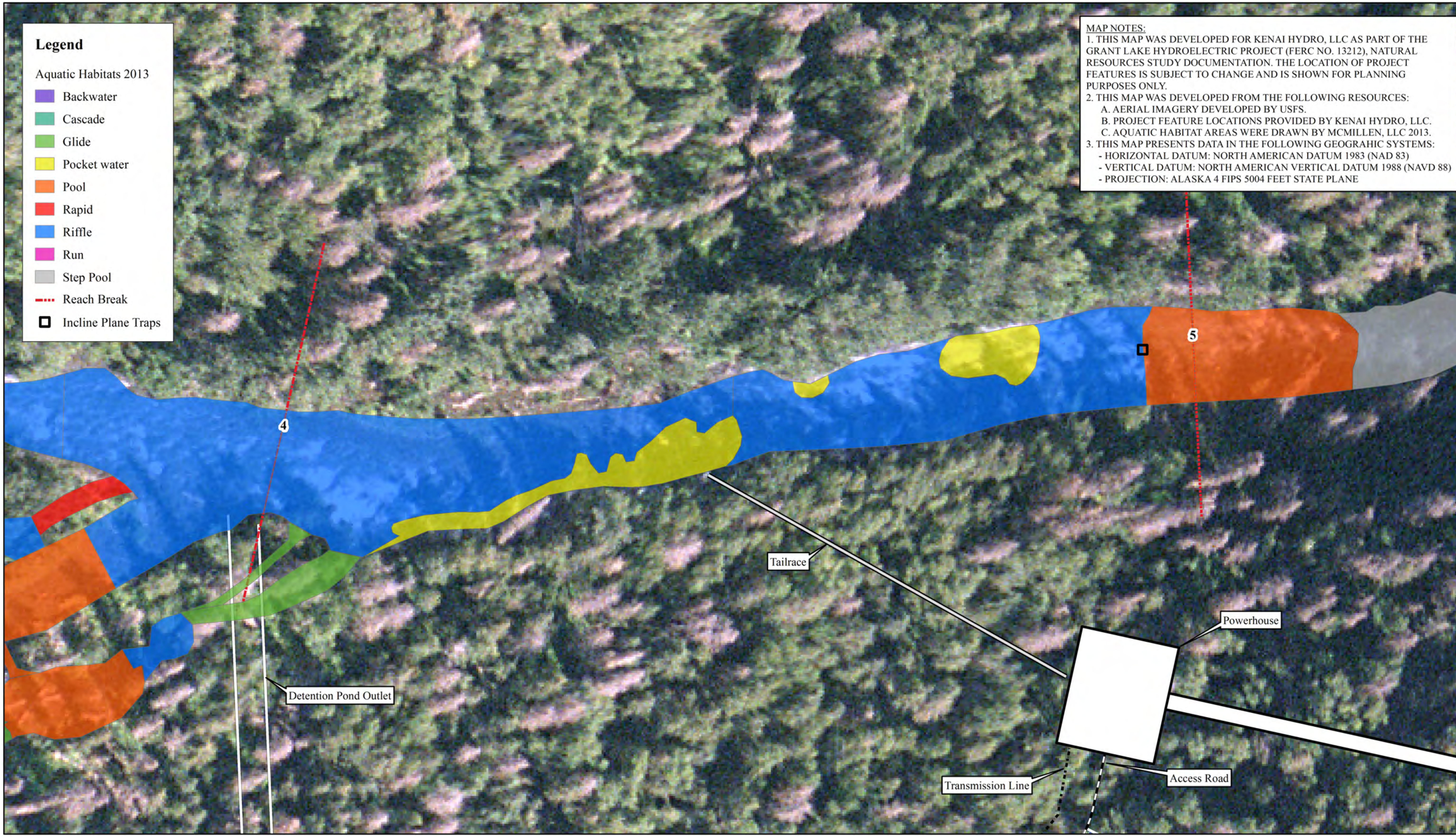

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Grant Creek Aquatic Habitats
Reach 4

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CHECKED: M. Miller
ISSUED DATE: 2/18/2014

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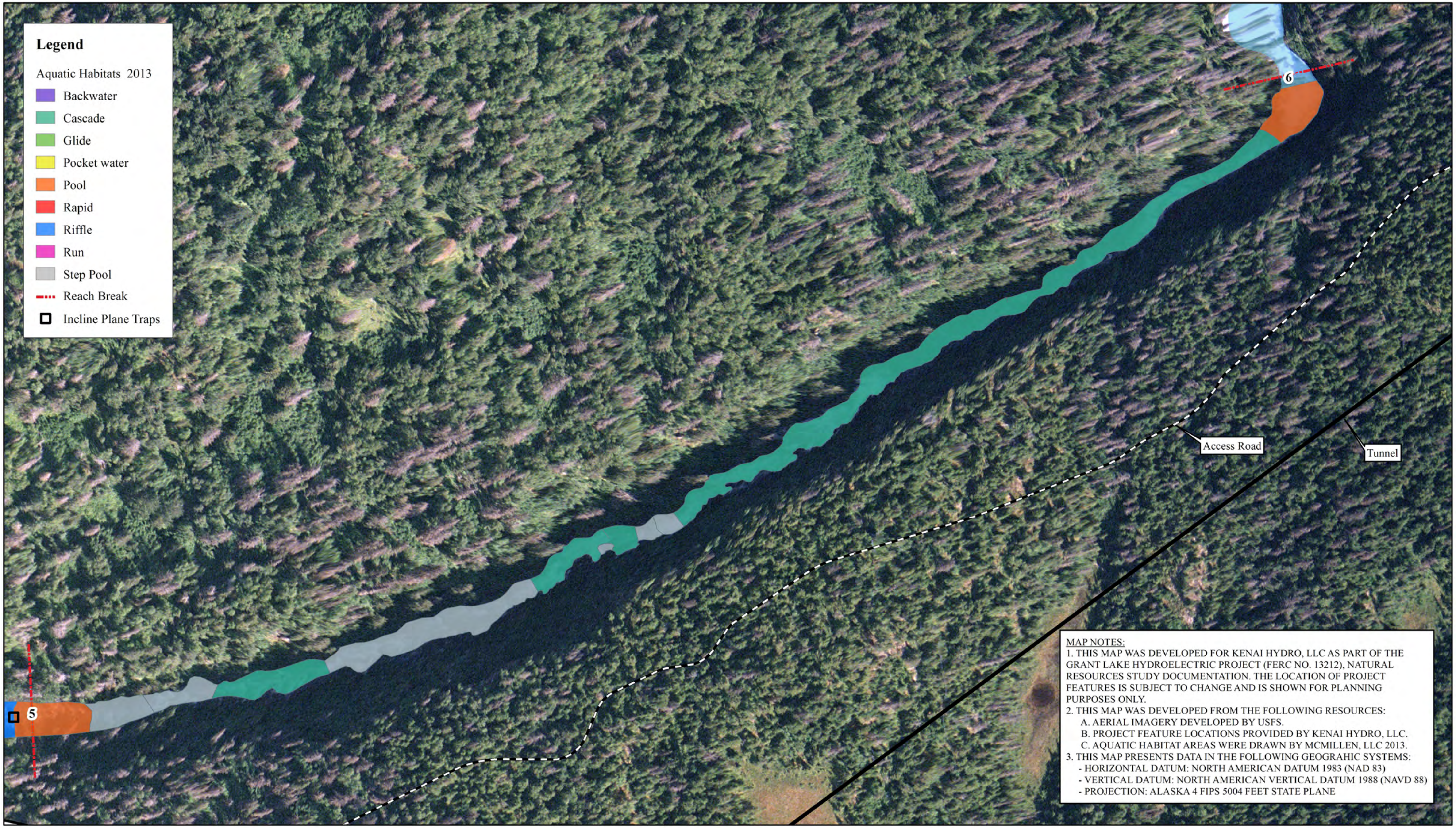

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 3.1-1
Grant Creek Aquatic Habitats
Reach 5

DESIGNED: J. Woodbury
DRAWN: J. Woodbury
CHECKED: M. Miller
ISSUED DATE: 2/18/2014

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SCALE: 1:1,500

Reach 1, which extends approximately 0.125 miles upstream of the confluence of Grant Creek, includes a small distributary off the right bank. The distributary becomes watered when Grant Creek flows exceed 190 cfs (Figure 3.1-2). This channel consists of pools and riffles that provided habitat for juvenile salmonids, as well as some small pockets of spawning gravels. The mainstem portion of Reach 1 includes pool and riffle habitat at lower flows, but becomes more turbulent as flows increase. Reach 1 also contains suitable gravels and cobbles for salmonid spawning. Reach 1 contains some pool habitat for adult salmon staging.

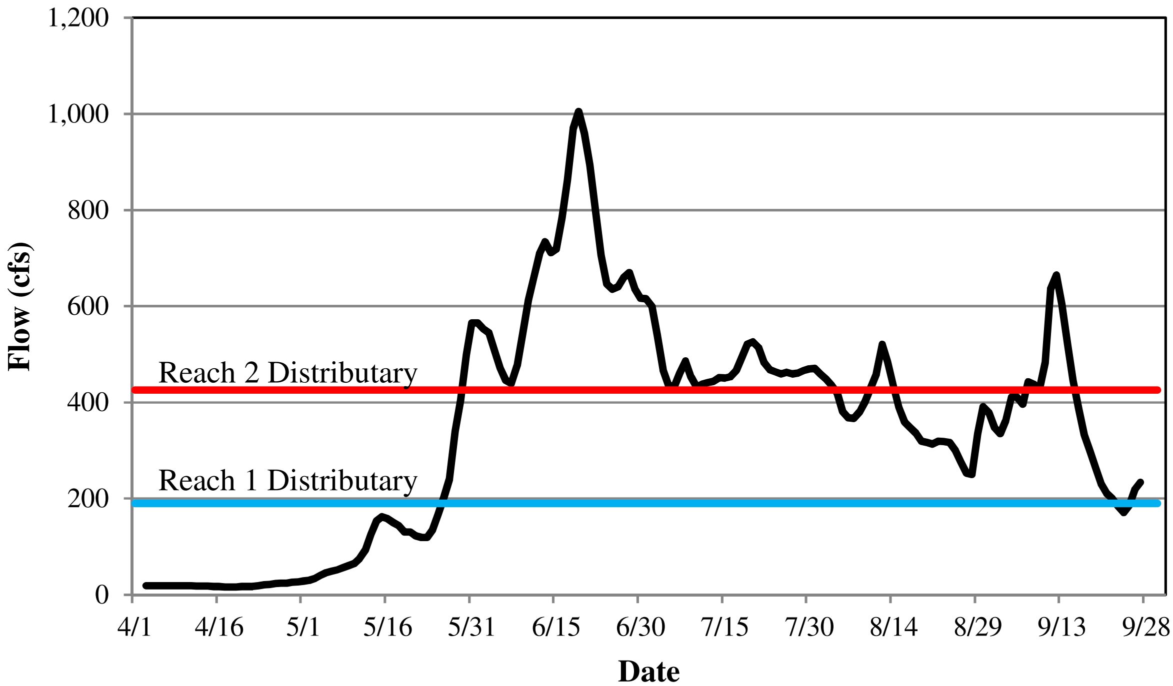


Figure 3.1-2. Grant Creek mean daily flows as measured at the Reach 3 gaging station, 2013. Flows at which the Reach 1 Distributary (190 cfs; blue line) and the Reach 2 Distributary (426 cfs; red line) begin to flow are depicted.

Reach 2 consists primarily of turbulent fast water riffle habitat, but does have some unique features. A small distributary branches from the mainstem just upstream from the Reach 1/2 break on the left bank. This channel flows through a parcel of private property and empties into Lower Trail Lake downstream of the Narrows. During its course, the channel splits into two channels at higher flows, which rejoin downstream. This channel contains a wide variety of habitat, including riffles, pools, glides, etc., and does have some smaller gravel deposits, which would be suitable for resident species spawning (i.e., rainbow trout and Dolly Varden). This channel is only watered when flows within the mainstem of Grant Creek exceed 425 cfs (Figure 3.1-2).

Upstream of this distributary within Reach 2, there are three backwater pools, which vary in size depending on flows. Another pool immediately upstream of the Reach 1/2 break was the location where the downstream incline plane trap was deployed, and contained both juvenile rearing habitat and suitable spawning gravels. These pool habitats were also used for adult salmon resting and staging.

Reach 3 contains the greatest habitat diversity of all reaches within the study area. As with all reaches, the mainstem consists primarily of turbulent fast water riffle habitat at higher flows. In addition to the mainstem, two additional channels exist within Reach 3. Both of these channels branch off the mainstem of Grant Creek on the left bank near the Reach 3/4 break. The larger of the two channels is situated between the mainstem of Grant Creek and the southernmost channel, and is referred to as the “Predominate Side Channel”. This side channel consisted primarily of turbulent fast water riffle habitat, but does include a substantial log jam just downstream of its diversion that creates a dammed pool. The second channel consists of a wide variety of habitat, and includes riffles, glides and pools; this channel is referred to as the “Secondary Side Channel”. Both channels provide rearing and spawning habitat, and become watered as soon as the snow and ice cover melt. In 2013, flow was observed in both channels when Reach 2 and 4 mainstem flows were measured at 17 cfs.

Within the mainstem of Grant Creek, two backwater pools on the right bank provide spawning habitat, adult staging, as well as juvenile rearing habitat. Downstream of those backwater pools, a large scour pool exists, which provides staging and spawning for adult salmon, as well as rearing for juveniles.

Reach 4 consists primarily of turbulent fast water riffle habitat at most flow levels. At higher flows, a small channel diverges off the right bank of the mainstem, and rejoins the mainstem channel downstream. At the upper portion of Reach 4, near the Reach 4/5 break, there is a scour pool. This pool was the location of the upper incline plan trap. While spawning gravel does exist within Reach 4, it is contained primarily in small pockets mainly downstream of large boulders, and along stream margins.

Reach 5, which is approximately 0.5 miles long, consists primarily of turbulent cascade and step pool habitat. During the majority of the study period, it was not possible to access much of Reach 5, and even at lower flows only the lower section of Reach 5 could be sampled. Likewise, access into the upper portion of Reach 5 was problematic. During the September minnow trap sampling period, the area immediately downstream of the falls was assessed using rappelling techniques. However, it was not possible to extend the sampling further downstream than the access point due to dangerous flow conditions.

3.2 Trail Lake Narrows

The Trail Lake Narrows is located between Upper and Lower Trail Lakes, and is where the Grant Creek confluence is located. The Narrows is also the location where the proposed access road will cross the Trail Lake system. Because of the potential impacts associated with the construction of the bridge and subsequent use of the access road on fish residing downstream of the bridge, this location was surveyed in July 2013. The survey area included the Narrows from the downstream edge of the Grant Creek confluence to the lower reaches of the channels flowing to both the right and left of the island located immediately below the Narrows, as well as the downstream shore of the island. Riffle habitat is dominant in this area from the confluence of

Grant Creek to almost the downstream end of the island. This area contains juvenile rearing habitat, spawning habitat and adult salmon staging habitat.

4 METHODS

During the course of the study, a number of methods were employed to accomplish the objectives outlined in Section 2. Juvenile sampling included the daily operation of two juvenile incline plane traps, monthly minnow trapping, snorkeling and beach seining. Adult sampling included the daily operation of an adult picket style weir, weekly radio telemetry tracking, redd surveys, visual surveys and carcass surveys. The remainder of this section will describe how each survey method was conducted, and how the data were used to address each study objective.

4.1 Grant Creek Salmon Spawning Distribution and Abundance

4.1.1 Salmon Escapement to Grant Creek

A weir was placed about 150 meters upstream of the Grant Creek confluence, and was designed, installed, and operated by Cook Inlet Aquaculture Association (CIAA). The weir was an A-frame picket design, which was situated perpendicular to the flow (Figure 4.1-1). One and a half meter long pickets were secured in place by two cross members (top and bottom) that were attached to the upstream side of each A-frame. The cross members contained holes that allowed pickets to be slid down until they rested on the stream bottom. Each picket could be removed for cleaning or the relocation of the adult trapping facilities, which was necessary as flow levels fluctuated. The gap between each picket was about 2.5 cm. Adult traps were placed on both sides of the weir to allow upstream and downstream movement past the weir. A work station and recovery/holding area were placed on the upstream side of the weir for biological sampling.

Figure 4.1-1. The A-frame weir used on Grant Creek to count adult salmon, rainbow trout and Dolly Varden in 2013.

The weir was checked every day, seven days per week by on-site staff living in a man camp on the shore of Grant Creek. Weir operations began on May 23, and the weir operated continuously except for the period from June 18 to June 22 when high flows (>969 cfs) required the removal of numerous pickets to maintain weir integrity. Installation of 3-meter pickets became necessary during high flows and their installation was complete on July 5 to replace shorter pickets first installed. Prior to the installation of the 3-meter pickets, especially during high flow, water and potentially fish could flow over the top of the weir. The weir was removed on October 24. Hourly counts typically occurred between the hours of 0800 and 2100 each day.

Upstream and downstream passage past the weir was compiled hourly and summed to document daily counts. Salmon escapement to Grant Creek was assessed as the sum of the daily counts for net upstream passage. While the operation of the weir provided a daily count of fish by species migrating upstream of the weir, it did not account for the number of fish that migrated into Grant Creek and resided and/or spawned downstream of the weir. To attain an estimate of total escapement within Grant Creek (both up and downstream of the weir), it was necessary to calculate escapement using the Area-Under-the-Curve methodology (Bue et al. 1998).

4.1.1.1 Escapement Estimate: Area-under the Curve (AUC)

There were three components required to estimate salmon escapement (Ê) to Grant Creek using area-under-the-curve methodology. The first component was to conduct systematic visual counts within the study area while salmon were present. The second component was to provide an estimate of the average time an individual salmon remained alive in the study area. This is commonly called stream or survey life ($\hat{S}$). The last component was an estimate of observer efficiency ($\hat{B}$). A secondary objective of this study component was to apply the estimates of stream life and observer efficiency estimated from Grant Creek in 2013 to visual counts in 2009.

To obtain an estimate of total escapement within Grant Creek (both up and downstream of the weir), it was necessary to calculate escapement using the Area-Under-the-Curve methodology (Bue et al. 1998), which is calculated as:

$$\hat{E} = \frac{\hat{A}}{\hat{S}\,\hat{B}}$$

Where:
$\hat{E}$ = is an estimate of Escapement;
$\hat{A}$ = is an estimate of Area-Under-the-Curve;
$\hat{S}$ = is an estimate of Stream Life; and
$\hat{B}$ = is an estimate of Observer Efficiency.

Area-under-the-curve ($\hat{A}$) was estimated using a trapezoidal approximation procedure similar to that described in English et al (1992),

$$\hat{A} = \sum_{i=2}^{n} \frac{(t_i - t_{i-1})(c_i + c_{i-1})}{2}$$

Where: t_i = was the Julian date of the visual survey and
c_i = was the visual count of salmon for the i^{th} survey.

4.1.1.1.1 Stream Life

Stream life was estimated for each species of interest (i.e., Chinook, sockeye, and coho) using Floy tags, radio tags and pooled data. It should be noted that all fish that were tagged with a radio transmitter were also tagged with a Floy tag. The estimate of stream life in this report is defined as the mean length of time between tagging at the weir and the time tags were recovered. The Floy tags used in this study were a T-bar anchor tags (model FD-94 Anchor Tags) that were individually numbered for all fish and colored for each species (Chinook-white, sockeye-yellow, coho-red). The unique number made it possible to calculate the span of time between tagging and the time of recovery. Floy tags were placed near the dorsal fin on the right side of the fish with a needle inserted into the body to anchor the tag (T-bar) through the dorsal fin ray. There were 33 Chinook, 533 sockeye, and 176 coho Floy tagged at the weir.

The radio tags used in this study were Lotek models MCFT2-3A and MCFT2-3B equipped with mortality switches that allowed researchers to identify dead fish. All anadromous salmonids that were radio-tagged were collected at the weir as they migrated upstream. A total of 14 frequencies in the 148 MHz range were used for the three species of anadromous salmonids and the two species of resident salmonids radio-tagged. To minimize the likelihood of signal collision, transmitters with four different burst rates (4.0, 4.5, 5.0, and 5.5 seconds between transmissions) were deployed. The transmitters emitted a different code sequence once the transmitter became stationary for 12 hours, as compared to the normal code sequence. This signal identified dead fish. All anadromous species were gastrically radio-tagged and resident species were surgically implanted with transmitters. Collectively, a total of 145 fish were radio-tagged; 9 Chinook, 65 sockeye, 50 coho, 20 rainbow trout, and 1 Dolly Varden.

4.1.1.1.2 Observer Efficiency

Observer efficiency was estimated from the relationship of visual survey counts to weir counts on Grant Creek. Observer efficiency was estimated by the slope of the linear fit of survey counts regressed against an adjusted weir count. The adjusted weir count was the cumulative weir counts by species on the days of visual surveys corrected for stream life and fish passage on the day of the visual survey. Like Bue (1998), the assumption was that the relationship between the estimated number of live salmon in a creek (independent variable-weir count) and survey counts (dependent variable) was linear, and observers would not see salmon in a creek when none were present (the fitted line passed through the origin).

4.1.1.1.3 Area-Under-the-Curve (Visual Surveys)

Visual surveys were used to document the number of live salmon in Grant Creek to estimate area-under-the-curve. Visual surveys were conducted on Grant Creek from the confluence of Trail Lake Narrows to about one half the way up the canyon in Reach 5. Visual counts in Grant Creek were segregated as counts above the weir and by counts downstream from the weir. Visual surveys were conducted every week (5-10 days) between the hours of 10:00-14:00 hours.

Attempts were made to keep survey conditions fairly uniform by hour of the day, weather, and stream conditions to make sure observer efficiency was not unduly affected. Visual counts were rescheduled if heavy rain, severe wind or stream conditions (flooding) precluded adequate survey conditions. Visual counts were conducted from the beginning of August until the end of the first week of November.

In August, a crew of two biologist wearing polarized sunglasses walked upstream on each bank of Grant Creek (total of 4 observers). The location of all observed fish was recorded on maps, with species and number counted. Later, when flows decreased (i.e., mid-September), it was possible at times to walk within Grant Creek at some locations during surveys.

4.1.1.1.4 Telemetry and Carcass Surveys

Mobile telemetry surveys and carcass surveys were an integral part of estimating escapement to Grant Creek and for collecting biological information. Telemetry surveys were performed twice per week, typically on Mondays and Thursdays. Fish locations were determined using standard triangulation techniques (Eiler 2012). Fish locations were recorded with Global Positioning System (GPS) waypoints and on maps of Grant Creek. During each survey, two receivers were used and the crews split the number of frequencies monitored. Splitting the number of frequencies monitored during a mobile survey helped to expedite the telemetry surveys.

Carcass surveys were performed each week but survey crews sampled fish opportunistically any time they traveled within the study area. At the time of carcass recovery, date, species, sex, location, and tag information were recorded. For females, eggs retained were noted and for all fish the tail was removed and the carcass returned to Grant Creek.

4.1.2 Life History Characteristics

Salmon were counted and sampled at the weir and carcass surveys were conducted to document the life history characteristics of spawning salmon in Grant Creek, 2013. Biological data needed to document run timing, sex ratios, egg retention, age structure, genetic stock identification and size (length and weight) were either collected at the weir or during carcass surveys. All fish counted at the weir were identified to species and enumerate. A subsample of the fish was sampled for specific data collection needs (biological data and tagging).

Run timing was determined by summing the number of fish passed the weir each week of the year. The start, peak and end of a particular salmon run on Grant Creek was simply the week when the first, greatest number and last fish passed the weir, respectively.

The sex ratio of all salmon except sockeye was determined from inspection of nearly 100 percent of the fish past the weir. For sockeye, the sample rate was lower (70 percent) to accommodate the greater abundance of fish at the weir. For anadromous salmon, gender was determined easily with a quick visual assessment of each fish.

Egg retention information was collected on spawned out female carcasses by inspecting the abdominal cavity and counting the number of eggs retained. Average egg retention was assessed by dividing the total number of eggs retained by the number of females assessed. Prespawn mortalities were noted but were presumed to have died before spawning; therefore, they were not included in the estimate.

Salmon collected at the weir were measured from mid-eye to fork length (mm) and weighed (gm) to describe the size of returning salmon to Grant Creek. Mean and standard deviations were generated for each species and gender.

Scale samples for Chinook and coho salmon were taken at the weir and delivered to the ADF&G for age determination. For sockeye salmon, otoliths were extracted from 100 sockeye salmon carcasses to prevent difficulties of age determination associated with scale reabsorption. Sockeye otoliths were delivered to CIAA for age determination. Two methods were used to describe age. The first method describes the total age of the fish (egg-to-spawning adult, i.e., gravel-to-gravel). The second method is termed the "European Method" and identifies the number of winters the fish spent in freshwater before migrating to the ocean as well as the number of winters the fish spent in the ocean. For example, a fish designated as 1.2 spent one winter in freshwater and two in the ocean. A fish designated as 0.3 migrated to the ocean in its first year and spent three winters in the ocean. Fish designated as 0.3 or 1.2 are considered 4-year-old fish, from the same brood year.

The axillary processes from 100 sockeye, 33 Chinook, and 100 coho salmon were removed and placed into vials for genetic analysis of returning salmon to Grant Creek. The tissue samples were delivered to ADF&G. Analysis of these samples is not contained within this report.

4.1.3 Distribution of Spawning Salmon in Grant Creek

The distribution of spawning salmon in Grant Creek was documented during spawning (redd) surveys and radio telemetry surveys. During redd surveys, the location and number of redds were recorded on maps of Grant Creek. For radio telemetry surveys, the location of tagged fish were also noted on maps of Grant Creek. The combination of both survey techniques is useful in defining spawning habitat especially when turbidity precludes observations of spawning in deeper water. The primary goal of these surveys was to identify sensitive spawning habitats in Grant Creek

Redd surveys were conducted weekly during the spawning period, and were similar to visual surveys in that crews hiked along the banks of Grant Creek, and recorded the locations of any redds observed. Given the high turbidity levels in Grant Creek during these surveys, most redds were located by first observing a fish, or observing digging activity. For all redds, the location and species in attendance were noted. At some locations where a large number of redds were constructed (i.e., spawning aggregates), it was difficult to identify individual redds. In such cases, the number of redds was estimated based upon data from past surveys, and the number of females defending redds.

Radio telemetry surveys were also employed to identify spawning locations. As discussed previously, telemetry surveys were conducted twice per week, and triangulation techniques were employed to identify the location of tagged fish. Since males often spawn with more than one female they could reveal multiple spawning locations within the study area. Females typically build and defend a single redd. The goal was to radio-tag three females for each male tagged.

The location of redds and tagged fish were compiled on maps and by reach and habitat type to describe the spawning distribution of salmon in Grant Creek.

4.2 Grant Creek Resident and Rearing Fish Abundance and Distribution

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

As with the anadromous species, the weir was the foundation of rainbow trout research in Grant Creek in 2013. The weir provided the opportunity to enumerate and capture rainbow trout for biological sampling and tagging. Biological sampling included length-weight and scales samples. Radio-tagged fish in turn provided information on spawning distribution and areas of feeding. Weir counts provided information on run timing and abundance. The abundance estimate for rainbow trout was assessed as total count of adult rainbow trout migrating upstream of the weir and run timing was simply the distribution of daily counts of rainbow migrating upstream past the weir.

Adult rainbow captured at the weir were assessed for spawning condition, and if determined to be active spawners and greater than 300 millimeters (mm) in length fork length (FL), they were surgically implanted with a radio-transmitter. Gender and spawning condition for rainbow trout and Dolly Varden was based on professional judgment of morphological characteristics (color, abdomen development, reproductive products, ovipositor extension, kype, etc.). For all fish, scale samples were collected in order to determine age, and each radio-tagged fish was tagged with a uniquely numbered Floy tag. Tagged fish were transported approximately 75 meters upstream, and released into a quiet cove located on the right bank to facilitate recovery. Rainbow trout captured at the weir were supplemented with fish captured through angling. Initially, the intent was to tag a total of 30 rainbow trout and 10 Dolly Varden. However, the weir did not become fully functional until early July when longer pickets were installed to preclude fish passage (both up and downstream) over the weir. Therefore, it was necessary to capture resident fish through angling efforts.

Radio-tagged trout were tracked twice per week for the duration of the study period, and their location at the time of detection was determined using triangulation techniques. Those positions were recorded on maps of the study area.

Redd surveys for rainbow trout were conducted at least once per week following the method described previously for anadromous species. Researchers also checked opportunistically as they were in the study area at least 5 days a week.

4.2.2 Resident and Rearing Fish Use of Reach 5

Due to the nearly vertical walls, steep gradient, and high flows within Reach 5, assessment of resident and rearing fish use of this area was challenging. Sampling techniques that could be conducted throughout the study period included minnow trapping and radio telemetry surveys. Telemetry surveys could be conducted from the top of the canyon wall, which allowed the survey of all of Reach 5. Minnow trapping was limited to the lower and upper portions of Reach

5, with the upper section accessed through rappelling. Snorkeling was conducted early in the study period (April and May), and was limited to the lower third of the canyon. Due to the substrate in Reach 5, which consists primarily of large boulders, beach seining was not conducted within this portion of Grant Creek.

In order to assess the use of Reach 5 by juvenile rearing fish, an incline plane trap was deployed at the Reach 4/5 break to identify and enumerate juvenile salmonids as they migrated downstream and out of Reach 5.

The juvenile incline plane trap was located in a scour pool immediately downstream of the Reach 4/5 break, and was operated seven days per week, 24 hours per day unless either high flows or debris load made operations either ineffective or too dangerous to operate. The trap was cleaned at least twice per day and more frequently when debris became an issue. All fish collected at the trap were removed from the live box using aquarium nets and transferred to a 18.9-liter bucket for transfer to the processing station located on the left bank. Fish were then anesthetized in a mixture of clove oil and water (6 drops of clove oil per 3.8 liters of water), measured (to the nearest millimeter), and weighed (to the nearest tenth of a gram), and then recovered in fresh water. Fish were held until equilibrium was achieved, and were then released into a low flow area within Reach 4 of Grant Creek.

Initially, the study objective was to estimate relative abundance of various salmonid juveniles within Reach 5 using the incline plane trap; that is, if sufficient numbers were captured to conduct efficiency trials of the trap, and in turn use a Petersen equation to estimate overall abundance. However, it was known from previous research (HDR 2009b) that it was unlikely that sufficient numbers of juveniles migrating downstream and out of Reach 5 would be captured to estimate abundance. While marking and release protocols were developed and ready for use, relatively few fish were captured during the study period. Furthermore, due to high flows during the period of May 30 to September 19, trapping operations were terminated due to the risk of the trap breaking free from its moorings, the risk of death and injury to captured fish, poor trapping conditions, and the danger to the field personnel when accessing the trap. As such, the focus of the incline plane trap once it was re-installed was to simply establish presence and enumerate the various species collected in the trap, and to collect weight and length data.

In addition to the incline plane trap, minnow trapping and snorkeling were utilized to determine rearing fish use of Reach 5. Due to the high flows described previously, snorkeling within Reach 5 was only possible in April and in May. Snorkel sites were selected based on likelihood of juvenile rearing. Snorkel sites typically encompassed an entire habitat unit; that is, if the site was within a pool, the entire pool was snorkeled unless the habitat unit exceeded 100 meters in length, in which case a sub-sample of the habitat unit was evaluated. The number of individuals snorkeling a given site was dependent on the size of the snorkel site, but was typically two individuals. All sample sites were measured, which included length and at least one width, and more if the stream width was highly variable. Measurements were used to calculate area to provide a density metric for comparisons between sites and reaches. All fish observed during the snorkel surveys were classified by species and categorized into 20 mm length bins. To ensure accuracy, snorkelers called out data, which was recorded by an individual on shore. Due to the cold water temperatures in April and May (0.5° C in April, and 4.0° C in May), all snorkeling occurred at night since juvenile fish were not active during daylight hours.

Minnow trapping was conducted monthly from April through October. Minnow trap locations throughout the study period were representative of habitats available to rearing salmonids. In some cases, suitable habitat could not be sampled simply due to access (Reach 5). However, during the course of the study, a total of 330 minnow traps were deployed within Grant Creek.

Minnow traps were constructed with 6.4 mm galvanized square wire mesh, and were approximately 40.6 cm long, 22.9 cm wide, with a 2.2 cm entrance at each end of the trap. At the time of deployment, a 16.4 cubic centimeter mass of cured and sterilized salmon eggs was placed in a PVC tube approximately 2.5 cm in diameter and approximately 7.6 cm long, with bait mesh stretched over each end and secured with rubber bands as an attractant. In addition to the bait tube, a river rock was placed into the trap to help weigh it down. The trap was then placed into the desired location parallel to flow, and was secured to shore with a length of parachute cord.

At the time of deployment, characteristics of the site were recorded, which included:

- The minnow trap number (every minnow trap set had a unique and sequential number);
- Habitat type (e.g., turbulent fast water riffle);
- General position within the channel (i.e., right bank, center, or left bank);
- Presence of large or small woody debris, overhead vegetation, or if there was an undercut bank;
- The time the trap was set; and
- The unique GPS waypoint.

Traps typically fished 24 hours before they were processed. At the time of processing, fish were placed into an 18.9-liter bucket for transport from the minnow trap site to the processing station. Fish were placed into a solution of water and clove oil (6 drops per 3.8 liters of water). Once anesthetized, fish were identified to species, and were measured (nearest millimeter) and weighed (to the nearest tenth of a gram). Fish were then placed into a 18.9-liter bucket of fresh water and allowed to recover before being released in the general area of capture.

A fixed-site telemetry station and mobile telemetry surveys were used to assess the use of Reach 5 by adult resident fish. As discussed previously, a total of 20 adult rainbow trout and 1 Dolly Varden were surgically implanted with digitally encoded transmitters. Telemetry surveys occurred twice per week, and were conducted as far upstream into Reach 5 along the left bank as possible. Additional surveys were conducted from the canyon rim from the right bank as necessary. If a tagged fish was detected within Reach 5, it was tracked until its position could be determined using triangulation techniques. In addition to mobile surveys, a fixed-antenna system was installed.

The fixed-antenna system consisted of two underwater antenna arrays, the downstream array at the Reach 4/5 break and the other array approximately 25 meters upstream. Underwater telemetry systems were used in lieu of aerial systems to minimize the likelihood of signal bounce due to the canyon walls, and to reduce the detection range so that fish entry into Reach 5 could be determined. Each array consisted of 4 bared coaxial antennas that were evenly spaced along a steel cable, which was secured to each shoreline and weighted down so that the antennas were on the bottom of Grant Creek. The four antennas were combined with a 4-way combiner, which was then amplified and the signal transmitted via coaxial cable to a Lotek SRX/DSP receiving system. Each antenna array was attenuated so as to balance the system to provide equal signal reception with the transmitter an equidistant from each antenna array (Evans and Stevenson 2012). Each antenna array was monitored independent of the other, so that it was possible to determine when a tagged fish moved upstream into Reach 5, the direction of travel, and when a tagged fish migrated downstream of Reach 5. Each antenna array had a detection range of approximately 15 meters.

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

Assessment of use by resident and rearing fish in lower Grant Creek was accomplished with the same suite of techniques as in Reach 5. That is, radio telemetry was used to determine movement and feeding habitat of adult rainbow trout; and juvenile use was assessed using an incline plane trap, minnow trapping, and snorkeling. In addition, beach seining was also used to assess juvenile resident and rearing fish use of Reaches 1-4.

To identify potential feeding and spawning habitat of adult rainbow trout, methods were employed as discussed above. That is, mobile surveys were conducted twice per week, and all locations were determined using triangulation techniques, which were recorded on maps.

The incline plane trap was located within a scour pool immediately upstream of the Reach 1/2 break. The purpose of this trap was to intercept juvenile salmonids migrating downstream within Grant Creek. The intent of deploying two traps; one at the bottom of Reach 5, and the other as close as possible to the Grant Creek confluence was to estimate relative abundance within Reach 5, and the Reach 1-4 sections of Grant Creek separately. As discussed, it was not possible to fish the upper trap for the better portion of the study period, so it was not possible to determine juvenile use of Reaches 1-4 exclusively. However, the continuous operation of the lower trap did allow abundance above that trap (including Reach 5) to be estimated. To do so, it was necessary to conduct efficiency trials of the lower trap. To estimate efficiency, captured juveniles were marked using a Bismark Brown dye solution (0.4 gm/18.9 liters of water) for 30 minutes, and then released upstream of the trap. Recapture rates were then calculated for each species of juveniles. Operation of the incline plane trap was conducted 24 hours per day, seven days per week. The exception to this protocol was when either high flows or debris load made operations either ineffective or too dangerous to operate the trap.

To estimate abundance within Reaches 1-5, we used a season-wide estimator that accounts for trap efficiency, data gaps due to trap outages, and provides estimates of standard error. The season-wide estimator of total juvenile abundance $\left(\overset{*}{N}\right)$ is the sum of estimated abundance when the index counts at the incline plane trap are present $(\tilde{N})$ and during periods when such data are missing $\left(\hat{N}_j\right)$, i.e.,

$$\overset{*}{N} = \tilde{N} + \sum_{j=1}^{k} \hat{N}_j$$

Where:

k = number of missing trap index count events during the season.

A detailed description of the calculations used to estimate juvenile abundance is presented in Appendix 1 (Skalski and Townsend 2014).

Scatter plots and line graphs were used to describe the size and time of emigration for juvenile salmonids captured in the lower incline plane trap on Grant Creek. Fork length (mm) and weight (0.2 grams resolution) of nearly all juvenile fish were taken to document the size of downstream migrants. The date of capture documented the time of emigration and helped to identify periods of downstream migration and movement. The size and time of emigration provided some insight into the basic life history of juvenile fish in Grant Creek.

Minnow trapping and snorkeling were conducted as described in Section 4.2.2, and will therefore not be discussed here. Beach seining was also employed within several sites in Reaches 1-4. However, due to the large and irregular substrate, seining was only partially effective and was abandoned as a means to sample juvenile fish in Grant Creek. Numbers of fish captured with beach seining are not reported for Grant Creek because of limited success. Beach seining was successfully used in the Trail Lake Narrows in areas of smaller substrate.

4.3 Trail Lake Narrows Fish and Aquatic Habitats

The Trail Lake Narrows was sampled to determine species diversity and relative abundance. The Narrows was sampled from the downstream margin of the Grant Creek confluence to the downstream margin of the island immediately below the Narrows, and included both channels on each side of the island. Angling was the only means of assessing adult salmonid (rainbow and Dolly Varden) presence, and was conducted during a single day in July. A total of seven angling stations were used and were selected to represent the area of potential impact associated with the installation and use of an access road into the Study Area. On July 17, 2013, two personnel fished each angling station for 30 minutes, and recorded both fish captured, and fish that were hooked but not landed. Captured fish were identified as to species, and length (mm) and weight (grams to the nearest tenth of a gram) were recorded. For fish that were hooked but not landed, species and an estimate of length were noted when possible.

To assess juvenile presence and relative abundance, minnow trapping and beach seining were used in the Trail Lake Narrows area. Snorkeling was not possible because of high turbidity (i.e., poor visibility). Over the course of a week, a total of 52 minnow traps were deployed (13 set locations with a total of 4 traps per set). As with all minnow trapping efforts, traps fished for about 24 hours, and a description of the location was recorded. Beach seining occurred the night of July 23 and a total of three sites were seined. Three seines were composited at each location and typically occurred where fine gravel and sand were present. Beach seining was based on the methodology described in Hahn et al. (2007). A 15.2-m long, 0.6-cm mesh beach seine with a bottom lead line and an upper cork line was used. One crew member would wade into the water at the selected site with the net attached to a 1.5-m pole, all the time keeping the bottom of the net on the stream bottom. The second individual would unspool netting from the stream edge from a second 1.5-m pole in order to keep it somewhat taught as the first individual encompassed the desired area. Once the sample area had been enclosed, both individuals moved towards each other along the bank margin trapping fish within the seine. Fish from minnow traps and beach seines were transferred to an 18.9-L bucket where they were anesthetized in a clove oil solution (6 drops per 3.8 L of water). Fish were enumerated by species, measured (to the nearest millimeter), weighed (to the nearest tenth of a gram) and then allowed to recover in a bucket of fresh water. Once equilibrium was achieved, fish were released back into the general area of capture.

5 RESULTS

In the sections that follow, the results of field collection efforts accomplished on Grant Creek in 2013 are presented.

5.1 Grant Creek Salmon Spawning Distribution and Abundance

To assess the abundance and distribution of spawning salmon, fish were enumerated at the weir to estimate spawning escapement, while redd surveys and radio telemetry surveys documented the distribution of spawning.

5.1.1 Salmon Escapement to Grant Creek – Relative Species Abundance

As discussed in Section 4.1.1, a weir was placed in Reach 1 of Grant Creek to intercept, count and sample adult salmonids migrating upstream. Daily fish counts were used to estimate run timing and provided an overall estimate of escapement to Grant Creek. Some fish intercepted at the weir were sampled to obtain estimates of age structure, length, weight, and to secure genetics samples for the ADF&G. The weir also allowed researchers to Floy tag and radio tag adult salmonids. Genetic samples were delivered to ADF&G but those analyses will not be presented in this report.

5.1.1.1 Weir Count

There were 1,439 salmon that passed upstream of the weir on Grant Creek while 52 of those salmon passed back downstream of the weir for a net passage of 1,387 salmon (Table 5.1-1). Sockeye salmon were the dominant run of salmon entering Grant Creek with 1,117 counted above the weir. There were 10 pink, 23 Chinook and 237 coho salmon counted above the weir. The net passage of salmon across the weir does not include salmon that entered and potentially spawned in Grant Creek downstream from the weir.

In the next section, total spawning escapement was assessed using area-under-the-curve methodology to provide total spawning escapement to Grant Creek in 2013.

Table 5.1-1. Upstream, downstream and net passage of pink, Chinook, sockeye and coho salmon across the weir in Grant Creek, 2013.

Species	Upstream Passage	Downstream Passage	Net Passage
Pink Salmon	12	2	10
Chinook Salmon	35	12	23
Sockeye Salmon	1,153	36	1,117
Coho Salmon	239	2	237
Total	1,439	52	1,387

5.1.1.2 Escapement Estimate: Area under the curve (AUC)

Several different surveys (i.e., visual, telemetry and carcass) were performed on Grant Creek to estimate escapement with the area under the curve methodology (Bue 1998). The information documents estimates for stream life, observer efficiency, and escapement for 2013 and 2009 (recalibrated count).

5.1.1.2.1 Stream Life

Stream life was estimated as the mean of the pooled recovery of Floy tagged and radio tagged salmon in Grant Creek. The pooled information was used because radio tags alone did not adequately cover the entire passage distribution of fish across the weir. Tag schedules for the salmon migration to Grant Creek were based on visual surveys conducted in 2009 for Chinook and sockeye. In 2009, the peak visual counts for Chinook and sockeye occurred the third week of August and second week of September, respectively. Peak counts of Chinook and sockeye occurred 1-2 weeks earlier in 2013. There was little information on the run timing of coho salmon. The pooled data provided a better estimate of stream life particularly for fish earlier in the run for sockeye and later in the run for coho salmon.

Stream life estimates are provided for pooled data, radio tags only and Floy tags only. Mean stream life for the pooled data for Chinook, sockeye and coho salmon was 11 days, 14 days and 16 days, respectively (Table 5.1-2). Stream life was different for the two tags employed, but the mean stream life from radio tags was consistently 4-6 days less than that estimated from Floy tags.

Table 5.1-2. Stream life estimates for the combined recovery of Floy tagged and radio tagged Chinook, sockeye and coho salmon in Grant Creek, 2013.

Species	Tagged	Recovered	Percent Recovered	Stream Life Mean	SD	Min	Max
Combined Recovery							
Chinook	33	14	42	11	6.2	4	22
Sockeye	533	195	37	14	5.9	2	30
Coho	176	77	44	16	5.9	1	37
Radio Tags Only							
Chinook	9	7	78	8	3.9	4	14
Sockeye	65	40	62	9	2.6	2	15
Coho	50	32	64	14	4.6	1	22
Floy Tags Only							
Chinook	33	7	21	13	7.5	4	22
Sockeye	533	155	33	15	5.8	4	30
Coho	176	45	26	18	6.3	8	37

5.1.1.2.2 Observer Efficiency

Observer efficiency was estimated from the relationship of visual survey counts to weir counts on Grant Creek. Because salmon die periodically throughout the spawning season, an adjustment was made to the cumulative weir count to adjust for mortality. The mean stream life estimated from salmon in Grant Creek was applied to the cumulative count to account for mortality. The count was also adjusted to correct for fish passage on the date and time of the visual survey.

By way of example, on August 29 the cumulative weir count for sockeye salmon passed the weir was 720 fish (Table 5.1-3). To adjust the cumulative weir count on that date for stream life, we subtracted the cumulative weir count of sockeye that had passed the weir 14 days prior (August 15). The cumulative count of sockeye 14 days prior was 15 fish. The adjusted count was 705 fish (720-15=705). The weir count was also adjusted by 99 fish on the date of the visual survey because those fish had not passed the weir by the time the visual survey was conducted. The final adjusted weir count equaled 606 sockeye (705-99=606). During the visual survey on August 29, 442 sockeye were observed above the weir on Grant Creek. Therefore, the observer efficiency for the August 29 visual survey for sockeye was 72.9 percent (442/606).

Table 5.1-3. Cumulative weir counts for sockeye adjusted for a stream life of 14 days and for fish passage at the weir on dates of visual surveys.

Date	Cumulative Weir Count	Adjusted for Stream Life (14 days)	Fish passage adjusted for time of day	Adjusted Weir Count	Visual Counts
8/2/2013	0	0	0	0	0
8/9/2013	8	0	0	8	2
8/16/2013	15	5	4	6	3
8/23/2013	169	8	35	126	85
8/29/2013	720	15	99	606	442
9/6/2013	1,021	244	13	764	543
9/16/2013	1,115	933	1	181	211
9/21/2013	1,115	1,061	0	54	52
9/28/2013	1,115	1,111	0	4	2
10/4/2013	1,116	1,115	0	1	0
10/10/2013	1,117	1,115	0	3	1

During visual surveys, observers typically underestimated the number of live salmon in Grant Creek. The plots of visual counts to adjusted weir counts revealed strong linear relationships for salmon in Grant Creek (Figure 5.1-1). Observer efficiency (slope of the line) was 0.60 for Chinook, 0.72 for sockeye, and 0.75 for coho. The trend in observer efficiency for salmon in Grant Creek fit our general expectations. For Chinook, we expected the lowest observer efficiency because they remained in deeper, faster waters during higher flows making them the most difficult to observe. In general, sockeye remained near the stream banks in shallower water making them easier to see than Chinook. For coho salmon, observations during stream surveys were more favorable because of reduced flow and better water clarity.

Stream life and observer efficiency estimates for salmon in Grant Creek were used to estimate total escapement to Grant Creek and as a comparison to the weir count. Stream life and observer efficiency estimates were also applied to calculations of area-under-the-curve estimates for Chinook and sockeye provided in the 2009 escapement (HDR 2009b). In the 2009 escapement estimates, outside literature sources and professional judgment were used to estimate both stream life and observer efficiency. No escapement estimates for coho in Grant Creek were provided in 2009.

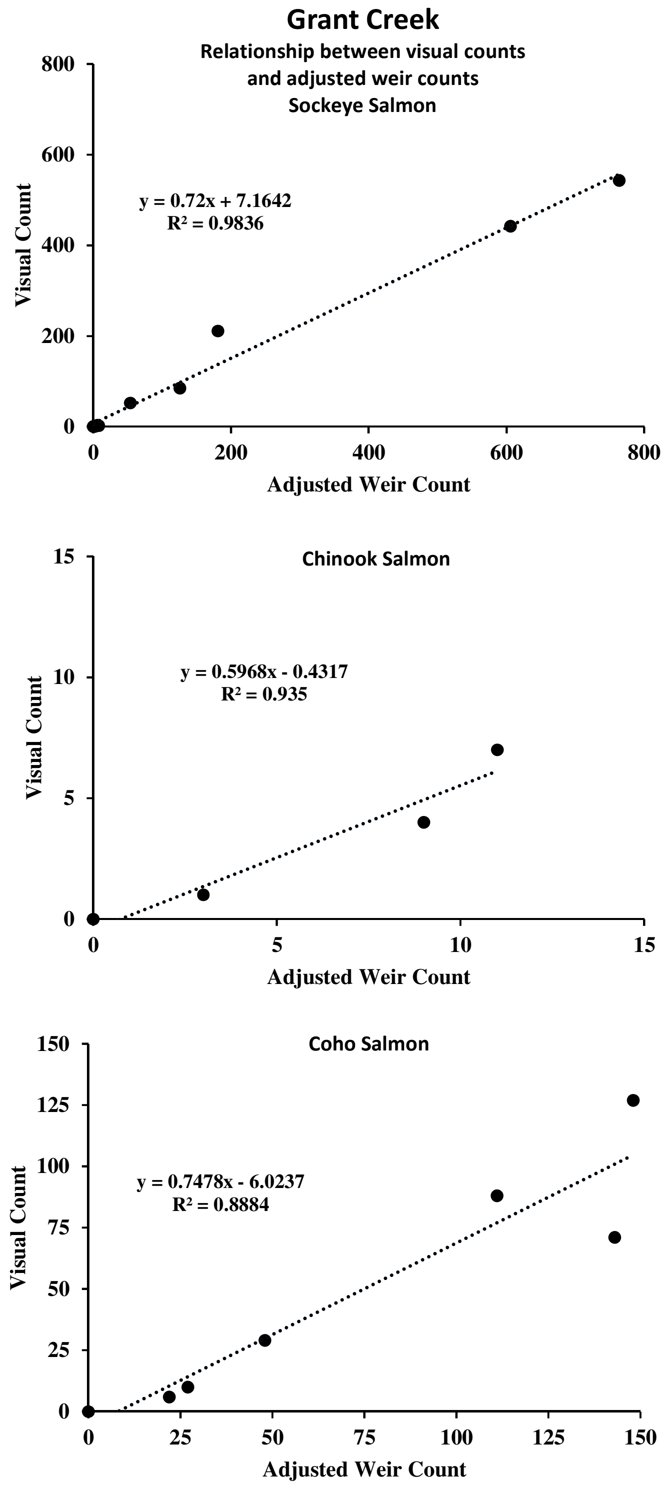


Figure 5.1-1. Observer efficiency relationships for sockeye, Chinook and coho salmon in Grant Creek, 2013.

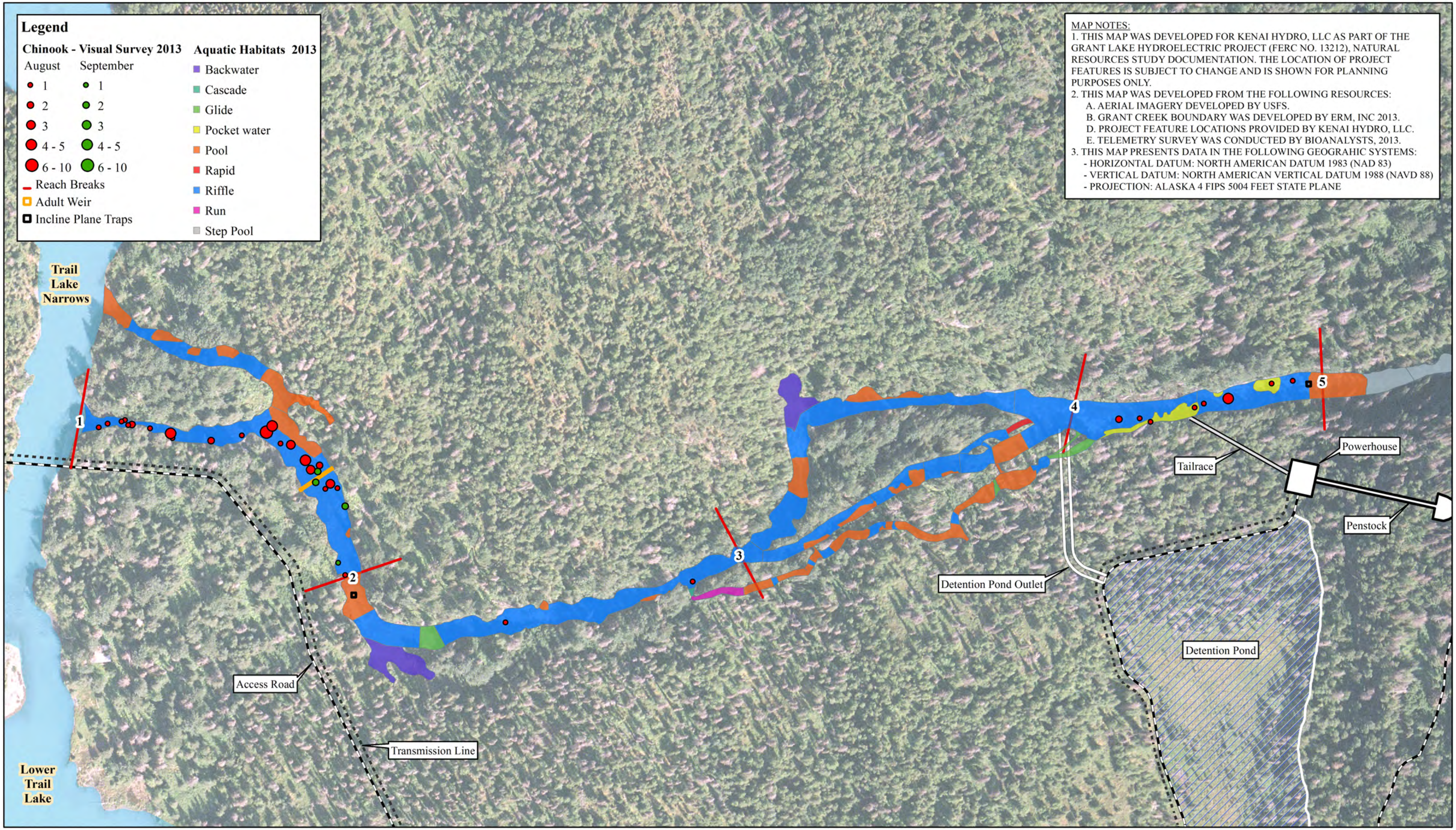
5.1.1.2.3 Estimated Escapement: AUC

In this section, two escapement estimates are provided for Grant Creek based on visual counts. The first estimate is the estimated escapement above the weir and the second estimate is for the entire stream. Visual counts were conducted from the beginning of August until the end of the first week of November (Table 5.1-4; Figures 5.1-2, 5.1-3 and 5.1-4). Visual counts were separated as "below weir" and "above weir" during each survey to make direct comparisons to the total escapement above the weir. Plots of area-under-the-curve estimated for Chinook, sockeye and coho salmon are presented in Figure 5.1-5.

Peak visual counts (above the weir) for Chinook, sockeye and coho salmon occurred on August 28, September 6 and October 10, 2013, respectively. It should also be noted that three coho were observed on the last visual survey on November 7. It was assumed that by the next week no coho would be observed in Grant Creek and if there were any remaining fish it would have a minor effect on AUC estimates.

Table 5.1-4. Visual counts of sockeye, Chinook and coho salmon above and below the weir in Grant Creek, 2013.

Date	Day of Year	Sockeye		Chinook		Coho	
		Below Weir	Above Weir	Below Weir	Above Weir	Below Weir	Above Weir
8/2/2013	214	0	0	0	0	0	0
8/9/2013	221	0	2	0	0	0	0
8/16/2013	228	8	3	14	1	0	0
8/23/2013	235	43	85	22	6	0	0
8/29/2013	241	59	442	19	11	0	0
9/6/2013	249	45	543	2	4	0	0
9/16/2013	259	12	211	0	0	0	6
9/21/2013	264	10	52	0	0	0	10
9/28/2013	271	0	2	0	0	14	29
10/4/2013	277	0	0	0	0	7	71
10/10/2013	283	0	1	0	0	8	127
10/18/2013	291	0	0	0	0	4	88
10/24/2013	297	0	0	0	0	3	63
11/1/2013	305	0	0	0	0	2	12
11/7/2013	311	0	0	0	0	1	2



REV	DATE	BY	DESCRIPTION

N

Drawing Scale: 0 100 200 400 Feet

MCMILLEN, LLC
1401 SHORELINE DRIVE BOISE, ID 83702
OFFICE: 208.342.4214 FAX: 208.342.4216

Developed For: Homer Electric Association, Inc. A Touchstone Energy Cooperative

GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO. 13212

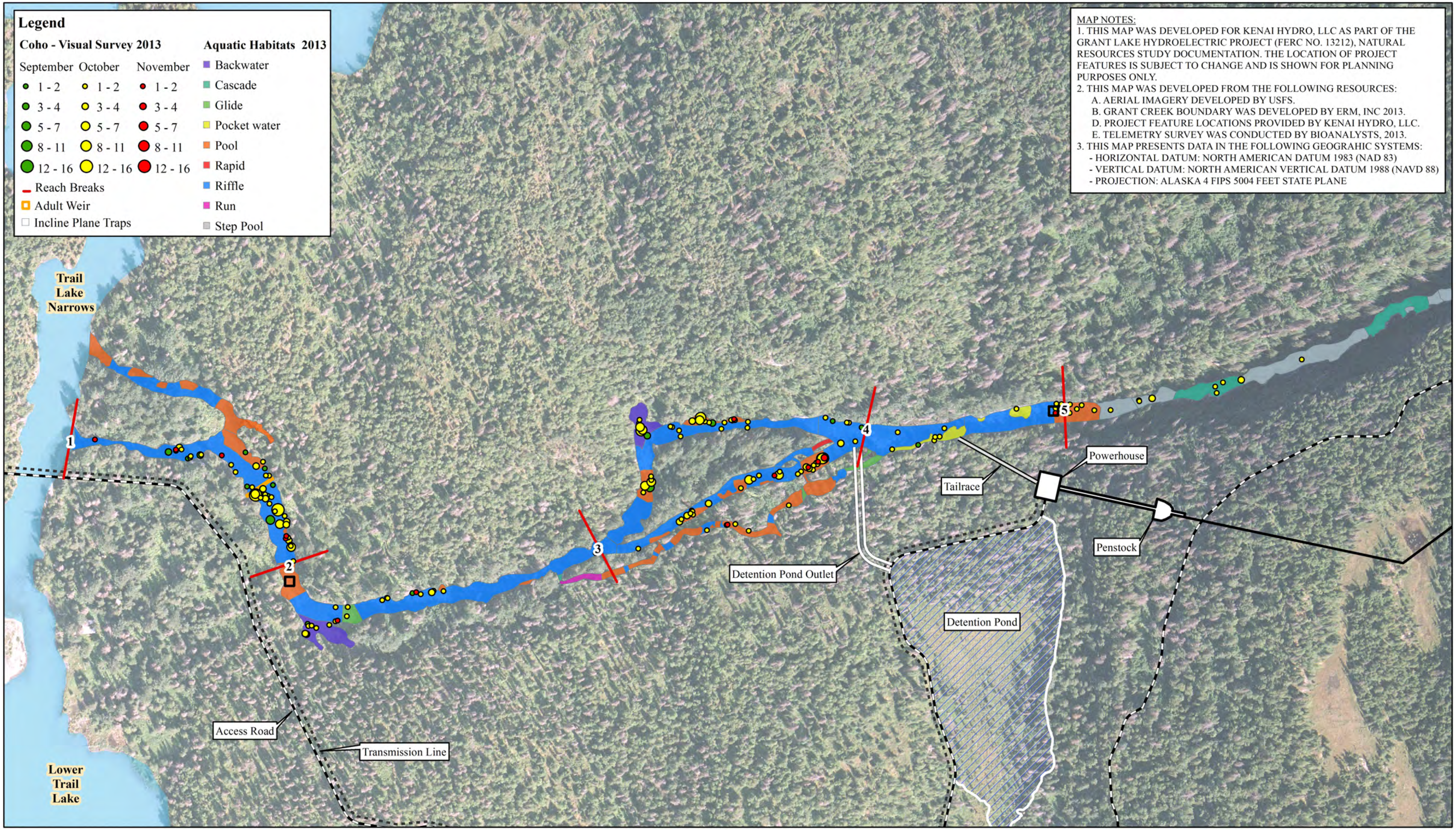
GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.1-2
Visual Surveys
Chinook Salmon

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

DRAWING 1 of 1

SCALE: 1:2,000



REV	DATE	BY	DESCRIPTION

N

Drawing Scale: 0 100 200 400 Feet

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GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO.13212

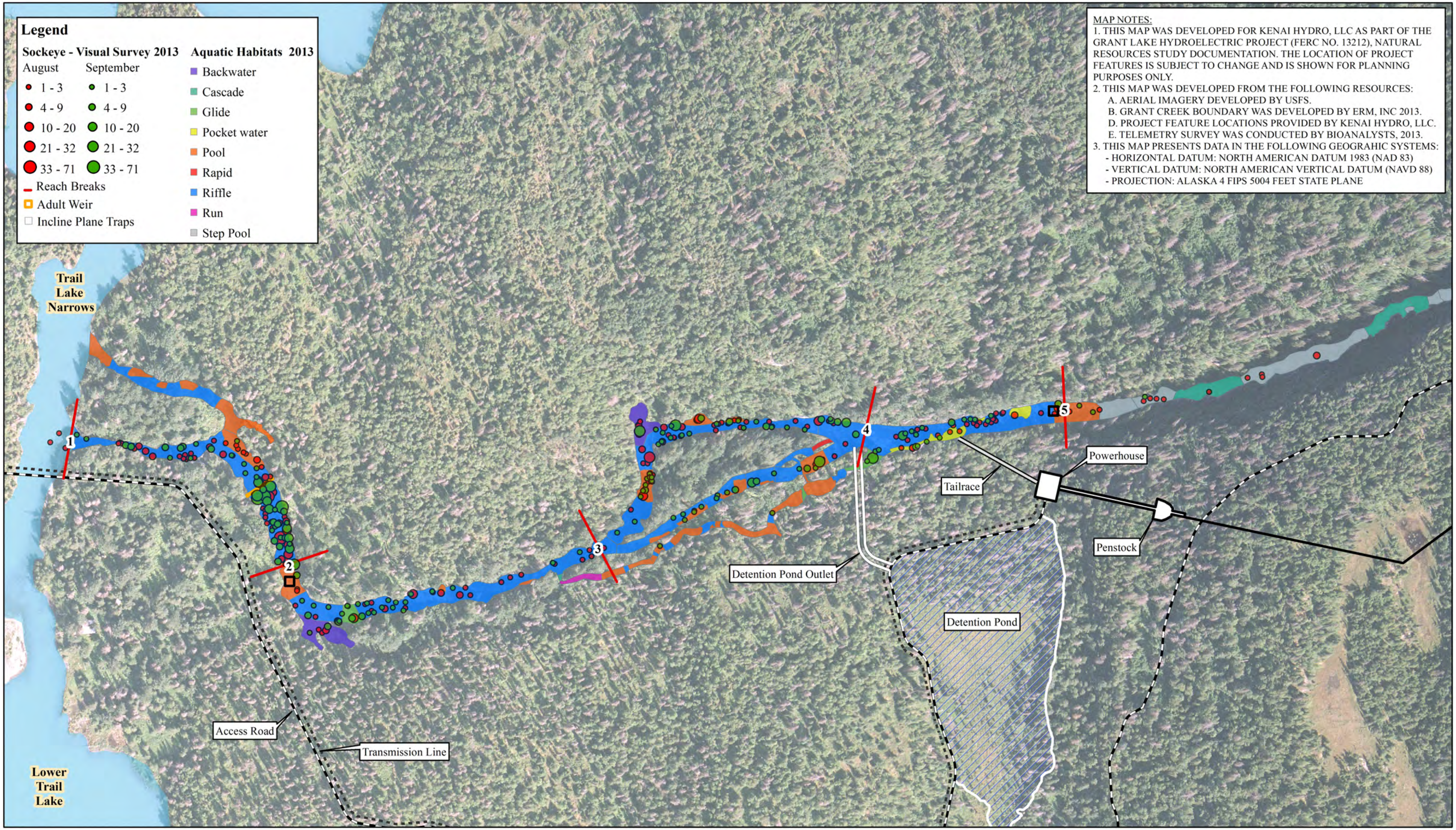
GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.1-3
Visual Surveys
Coho Salmon

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

DRAWING 1 of 1

SCALE: 1:2,500



REV	DATE	BY	DESCRIPTION

N

Drawing Scale:
0 100 200 400 Feet

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.1-4
Visual Surveys
Sockeye Salmon

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

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1 of 1

SCALE: 1:2,500

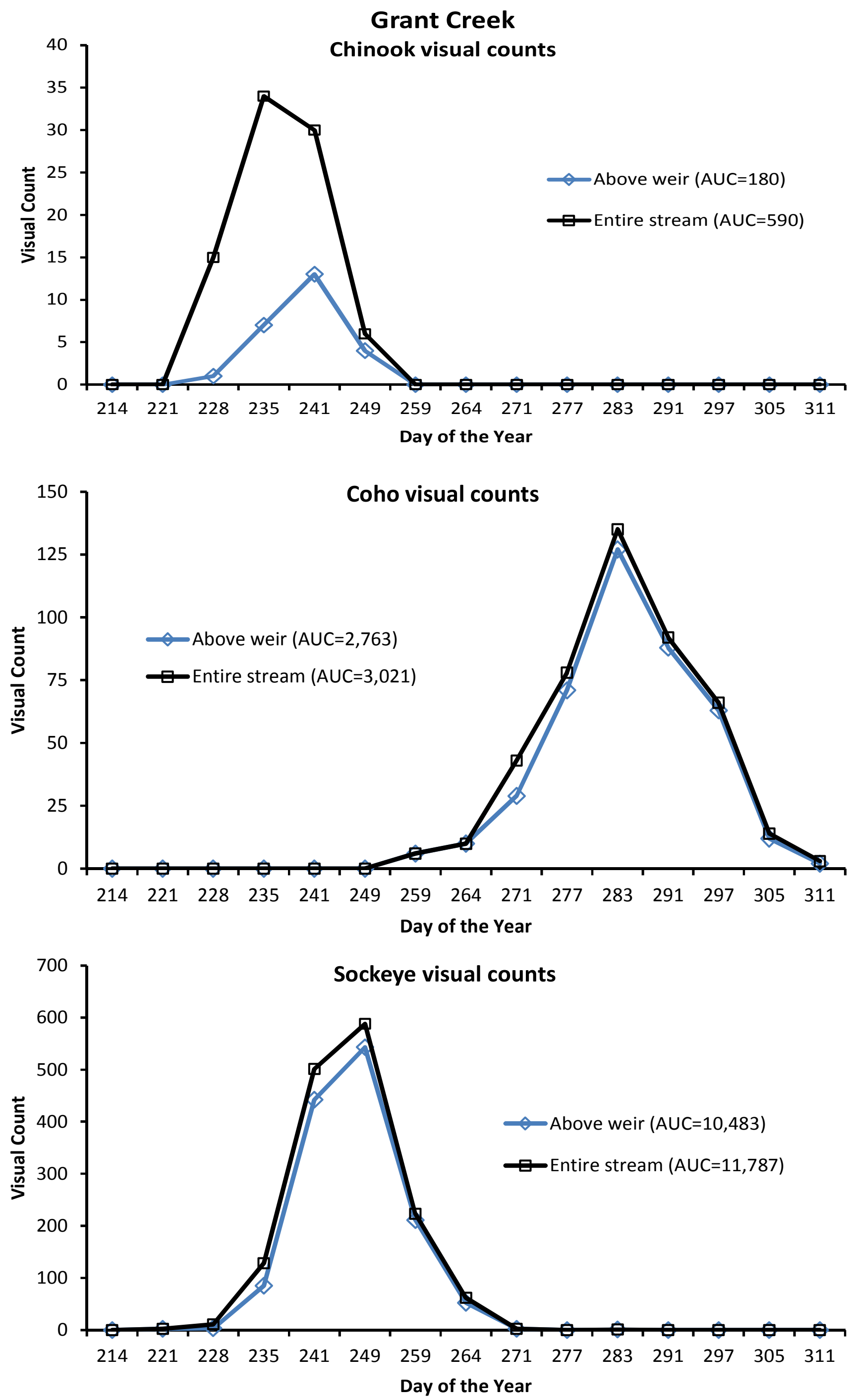

Figure 5.1-5. Plots of visual counts used to estimate area-under-the-curve for Chinook, sockeye and coho salmon in Grant Creek, 2013.

Estimates of escapement above the weir based on visual counts (AUC) were within ±12 percent of the weir counts (Table 5.1-5). Escapement estimates for the entire stream were 90 Chinook, 1,169 sockeye and 252 coho salmon.

Table 5.1-5. Escapement estimates for salmon in Grant Creek at the weir and estimated from area-under-the curve with stream life and observer efficiency

			Escapement Estimates 2013			Escapement Estimate 2009	
Species	Stream Life (s)	Observer Efficiency (v)	Weir Count	Above Weir (AUC)	Entire Stream (AUC)	Estimate	Adjusted
Pink	---	---	10	---	---	---	---
Chinook	11	0.60	23	27 (112%)	90 (391%)	231	148
Sockeye	14	0.72	1,117	1,040 (93%)	1,169 (105%)	6,293	2,705
Coho	16	0.75	237	231 (97%)	252 (106%)	---	---

The area-under-the-curve estimates for sockeye and coho salmon for the entire stream add an additional 52 sockeye and 15 coho salmon to the weir count. These additional fish downstream from the weir fit within our expectation of the number of spawning fish for both sockeye and coho salmon. However, the difference in the Chinook weir count (23 fish) and the estimate for the entire stream (90 fish) implies that 67 additional Chinook spawned downstream of the weir. That estimate appears to be too high because we did not observed that much more additional spawning activity below the weir. Given the level of movement (downstream) for Chinook across the weir, it is likely that the Chinook observed during visual counts downstream of the weir may have spawned in the Trail Lake Narrows or elsewhere. That is, our visual surveys counted fish that moved into lower Grant Creek but did not remain there to spawn, which inflated the number of fish in Grant Creek downstream of the weir. We offer two arguments in support of this conclusion:

1. There were 35 Chinook that crossed upstream of the weir and 12 fish migrated back downstream. That equates to about 34 percent fallback rate. The percent of fallback for sockeye (3 percent) and coho (<1 percent) was much lower.
2. There were three Chinook salmon redds observed downstream of the weir. There were 3 redds counted above the weir with an escapement of 23 fish, which equates to about 7.6 fish per redd above the weir. There were 67 additional fish estimated by AUC downstream of the weir and only three redds.

A more realistic estimate of total escapement to Grant Creek for Chinook salmon is 46 fish (6 redds x 7.6 fish/redd = 46 fish).

In 2009, the estimated escapement using area under the curve methodology was 231 Chinook and 6,293 sockeye salmon (HDR 2009b). Recalibrating those counts by stream life and observer efficiency from 2013 adjusted those counts to 148 Chinook and 2,705 sockeye salmon (Table 5.1-5).

5.1.2 Life History Characteristics

Adult salmon were counted and subsampled at the weir to describe life history characteristic of the spawning population. The information documents the run timing, size and age structure of returning salmon to Grant Creek.

5.1.2.1 Run Timing

Run timing for adult salmon to Grant Creek extended over a 13 week period beginning at the end of July and finishing near the end of October. Chinook and pink salmon both entered Grant Creek over a four week period (Table 5.1-6). Pink salmon passed the weir on Grant Creek from the first week of August to the end of August. Chinook salmon passed the weir from the second week of August through the first week of September. Peak passage for pink and Chinook salmon occurred on week 32 and 33, respectively. The adult migration for sockeye occurred over a ten week period beginning the last week of July with a peak at the end of August and the second week of October. Two individual sockeye extended the run timing an additional three weeks after the majority of the run was complete. Coho salmon began entering Grant Creek the second week of September, peaked the first week of October and ended the last week of October when the weir was removed (October 24).

Table 5.1-6. Run timing by week of the year for pink, Chinook, sockeye and coho salmon assessed at the weir on Grant Creek, 2013.

Week of Year	Dates	Pink	Chinook	Sockeye	Coho
31	Jul 28- Aug 03	0	0	5	0
32	Aug 04 - Aug 10	6	0	3	0
33	Aug 11- Aug 17	2	11	16	0
34	Aug 18 - Aug 24	1	3	220	0
35	Aug 25 - Aug 31	1	7	601	0
36	Sep 01 - Sep 07	0	2	201	0
37	Sep 08 - Sep 14	0	0	65	16
38	Sep 15 - Sep 21	0	0	4	17
39	Sep 22 - Sep 28	0	0	0	40
40	Sep 29 - Oct 05	0	0	1	96
41	Oct 06 - Oct 12	0	0	1	42
42	Oct 13 - Oct 19	0	0	0	21
43	Oct 20 - Oct 26	0	0	0	1
	Total	**10**	**23**	**1,117**	**237**

5.1.2.2 Size (length and weight)

Length and weight measurements were collected at the weir to describe the size of returning salmon to Grant Creek (Table 5.1-7). Female Chinook salmon were larger than males (mean length and weight). Male and female sockeye were similar with males slightly heavier and longer than females. For coho salmon, the size of males and females was similar. On average, male coho salmon tended to be heavier than females but females were on average longer than males. For pink salmon, males tended to be longer and heavier than females.

Table 5.1-7. Mean, maximum, and minimum length and weight of Chinook, sockeye and coho salmon measured at the weir on Grant Creek, 2013.

		Length cm (mid-eye to fork)					Weight (kg)				
Species	**Sex**	**Mean**	**SD**	**Max**	**Min**	**Number**	**Mean**	**SD**	**Max**	**Min**	**Number**
Chinook	F	88	5.8	98	81	6	10.4	2.6	14.5	7.6	6
	M	71	13.7	104	38	27	5.9	3.8	16.4	0.6	27
Coho	F	59	4.0	68	45	116	3.3	0.7	5.0	1.4	116
	M	58	4.3	67	45	116	3.5	1.0	6.5	1.5	116
Sockeye	F	54	3.5	60	42	415	2.6	0.5	3.8	1.0	415
	M	55	4.6	77	33	361	3.0	0.7	4.9	0.5	360
Pink	F	42	2.3	46	39	9	1.0	0.2	1.3	0.8	9
	M	45	3.8	51	40	6	1.3	0.4	2.1	0.9	6

Note: Samples size for fish measured may include some fish that past upstream of the weir and subsequently passed back downstream.

5.1.2.3 Age Structure

In this section, information is reported on the length-and-age-at-return and freshwater life history for Chinook, coho and sockeye salmon. For Chinook and coho salmon, scale samples were collected at the weir and for sockeye, otoliths were extracted from carcasses and used for age determination. Length measurements were from mid-eye to fork of the caudal fin.

Chinook salmon returned to Grant Creek at 3 to 6 years of age with most (84 percent) returning as 4 and 5-year old fish (Table 5.1-8). Three year old fish made up about 4 percent and 6-year old fish made up about 3 percent of the fish sampled. The age structure of male and female Chinook salmon differed slightly with one male returning at three years of age. Coho salmon returned at three to five years of age with most (90 percent) returning as 4-year old fish. Three year old fish made up about 4 percent and 5-year old fish made up about 7 percent of the fish sampled. The age structure of male and female coho salmon was similar in age-at-return with slightly more male fish returning at five years of age than females. Sockeye salmon returned at four to six years of age with most (95 percent) returning as 5-year old fish. Female sockeye returned as 4 and 5 year old fish. Males returned as 4, 5 and 6-year old fish.

Table 5.1-8. Age-at-return for coho, Chinook and sockeye salmon sampled in Grant Creek, 2013.

Sex	Total Age								Total
	Age-3		Age-4		Age-5		Age-6		
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	
Chinook Salmon									
Female	0	0.0	0	0.0	4	80.0	1	20.0	5
Male	1	5.0	12	60.0	5	25.0	2	10.0	20
Total	1	4.0	12	48.0	9	36.0	3	12.0	25
Coho Salmon									
Female	3	3.5	78	91.8	4	4.7	0	0.0	85
Male	3	3.6	73	88.0	7	8.4	0	0.0	83
Total	6	3.6	151	89.9	11	6.5	0	0.0	168
Sockeye Salmon									
Female	0	0.0	3	5.9	48	94.1	0	0.0	51
Male	0	0.0	0	0.0	47	95.9	2	4.1	49
Total	0	0.0	3	3.0	95	95.0	2	2.0	100

In general, mean length increased with age for returning salmon to Grant Creek. Mean length increased the most for Chinook between 3 and 4-year old fish (Table 5.1-9). For Chinook salmon, females were larger than males at 5-year old fish but as 6-year old fish. Female coho salmon were slightly larger than males as 4-year old fish, smaller as 3-year old fish and the same as 5-year old fish. Like Chinook, mean length increased the most for coho between 3 and 4-year old fish. For sockeye salmon, males tended to be larger than females and the largest increase in mean size was between 4 and 5-year old fish.

Table 5.1-9. Length-at-age for returning coho salmon sampled at the Grant Creek weir in 2013. Length (cm) was measured from mid-eye to the fork of the caudal fin.

Sex	Age-3		Age-4		Age-5		Age-6	
	No.	Mean Length (cm)	No.	Mean Length (cm)	No.	Mean Length (cm)	No.	Mean Length (cm)
Chinook Salmon								
Female	0	---	0	---	4	86.0	1	97.5
Male	1	37.5	12	65.1	5	77.0	2	100.3
Total	1	37.5	12	65.1	9	81.0	3	99.4
Coho Salmon								
Female	3	52.1	78	59.0	4	60.3	0	---
Male	3	60.6	73	58.4	7	60.3	0	---
Total	6	56.4	151	58.7	11	60.3	0	---
Sockeye Salmon								
Female	0	---	3	48.6	48	56.1	0	---
Male	0	---	0	---	47	57.1	2	58.1
Total	0	---	3	48.6	95	56.6	2	58.1

The European method of age designation documents the general freshwater life history for adult salmon returning to Grant Creek. For Chinook, all fish spent 1 winter (1.x) in freshwater before migrating to the ocean (Table 5.1-10). The amount of time that coho spent in freshwater varied the most of returning salmon. Most (88 percent) coho salmon spent two winters (2.x) in freshwater while about 2 percent migrated to the ocean in their first year of life (0.x). Coho salmon that had spent one winter in freshwater (1.x) made up 4 percent and fish that spent 3 winters (3.x) in freshwater made up about 6 percent. Most (97 percent) adult sockeye returning to Grant Creek spent one year in freshwater (1.x) before migrating to the ocean. A few (3 percent) sockeye remained in freshwater for two years (2.x) before they migrated to the ocean.

Table 5.1-10. General freshwater life history of Chinook, coho and sockeye salmon returning to Grant Creek, 2013.

	0.x		1.x		2.x		3.x		
Species	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**	**No.**	**Percent**	**Total**
Chinook	0	0	25	100	0	0	0	0	25
Coho	3	2	7	4	148	88	10	6	168
Sockeye	0	0	97	97	3	3	0	0	100

Notes:
European Age Designation
0.x = Juvenile fish migrated to the ocean in its first year of life (no freshwater annulus).
1.x = Juvenile fish migrated to the ocean in its second year of life (one winter in freshwater).
2.x = Juvenile fish migrated to the ocean in its third year of life (two winters in freshwater).
3.x = Juvenile fish migrated to the ocean in its fourth year of life (three winters in freshwater).

5.1.2.4 Egg Voidance

Female carcasses were examined to describe spawner success (egg retention). Table 5.1-11 presents the number of carcasses recovered, mean egg retention and the number of females assessed.

Table 5.1-11. Number of Chinook, sockeye, pink, and coho salmon recovered during carcass surveys on Grant Creek, 2013.

Species	Females	Males	Total Recovered	Mean Egg Retention	Number Females Assessed
Chinook	5	10	15	255	5
Coho	28	35	63	289	28
Pink	8	3	11	100	2
Sockeye	266	218	484	81	257

5.1.3 Distribution of Spawning Salmon in Grant Creek

The distribution of spawning salmon in Grant Creek was investigated by conducting redd surveys and mobile telemetry surveys. Redd surveys were conducted at least once a week during the spawning period to document the location, number, and time of redd construction in Grant Creek. Documenting the number of redds in Grant Creek was at times hampered by stream flow, turbidity and mass spawning. Mobile surveys documented the locations of tagged fish during the course of the spawning period, which aided in documenting important spawning locations and resting pools. Both surveys were used together to help identify sensitive time periods and habitats for salmon reproduction.

The following pages document the locations where redds were observed and where radio tagged salmon were documented.

Pink, Chinook, sockeye and coho salmon spawned in Grant Creek during the summer and fall of 2013 (Figures 5.1-6 through 5.1-9). The number of new redds observed during each week of the study period was documented by week of the year (1-52). As expected, the distribution of redds closely follows the distribution of visual detections (Figures 5.1-2 through 5.1-4) and mobile telemetry surveys (Figures 5.1-10 through 5.1-12).

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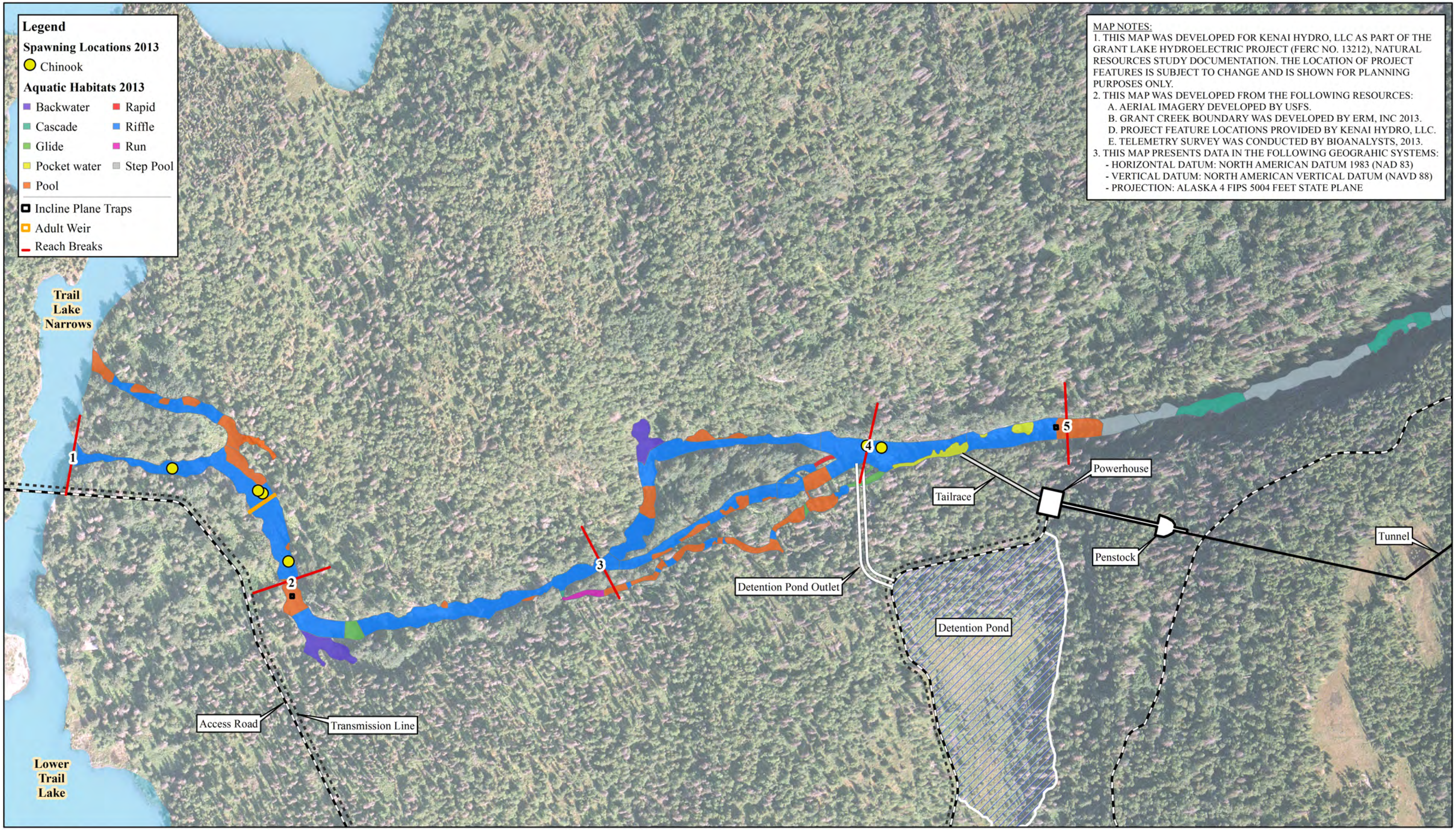

REV	DATE	BY	DESCRIPTION

N

Drawing Scale:
0 100 200 400 Feet

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1401 SHORELINE DRIVE BOISE, ID 83702
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Figure 5.1-6
Spawning Locations
Chinook Salmon

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/25/2014

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1 of 1

SCALE: 1:2,500

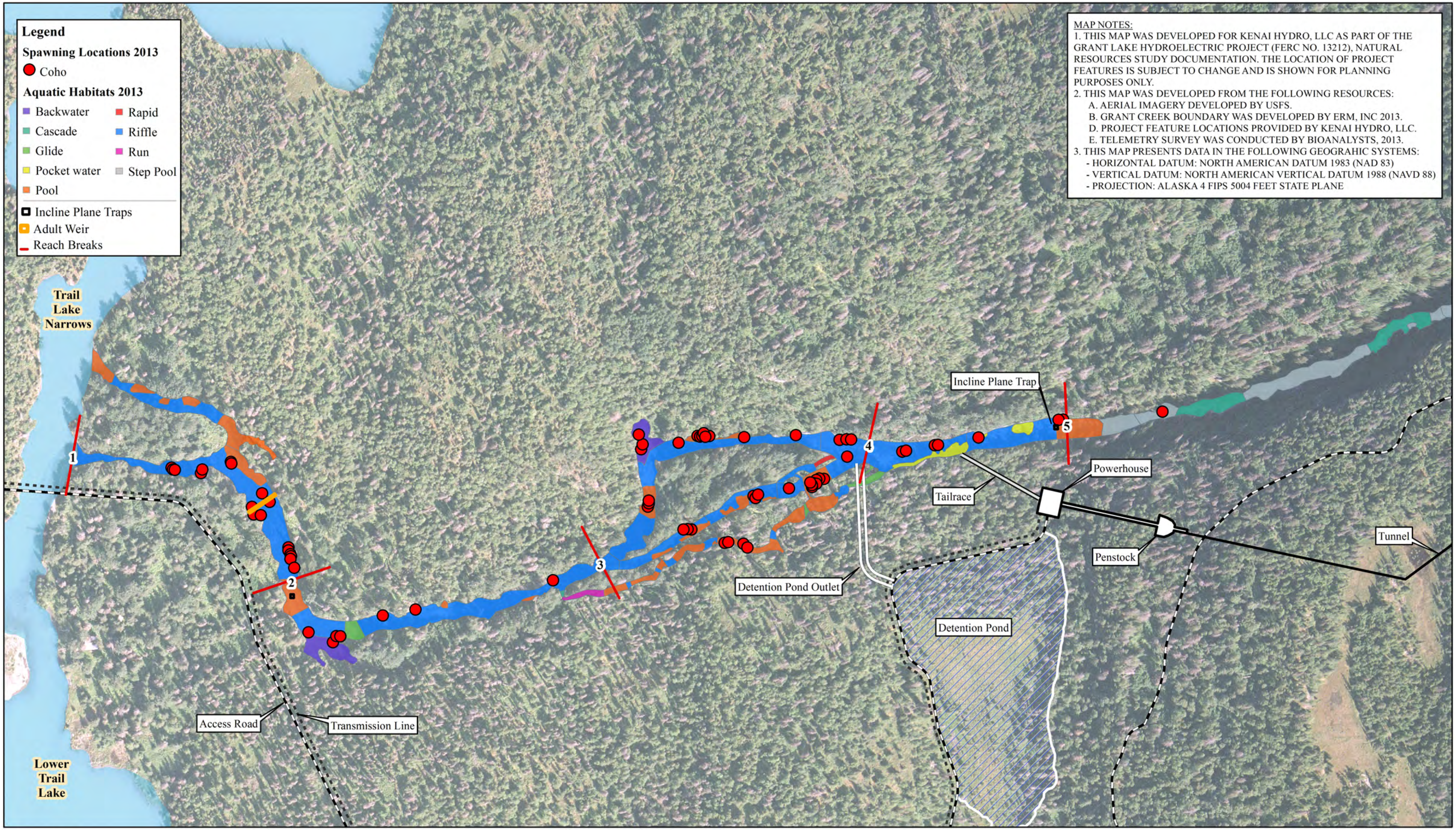

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Figure 5.1-7
Spawning Locations
Coho Salmon

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ISSUED DATE 2/25/2014

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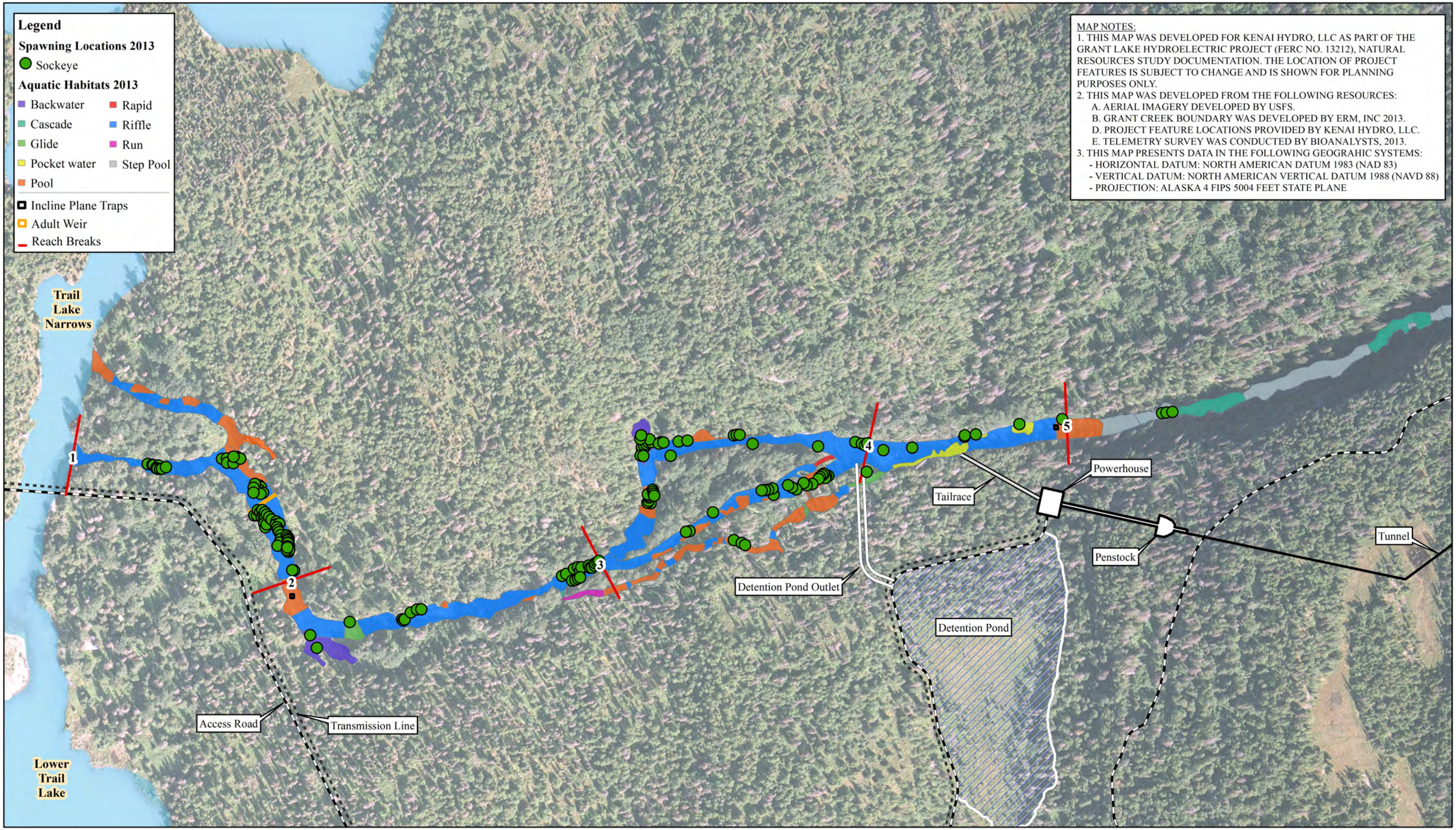

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Figure 5.1-8
Spawning Locations
Sockeye Salmon

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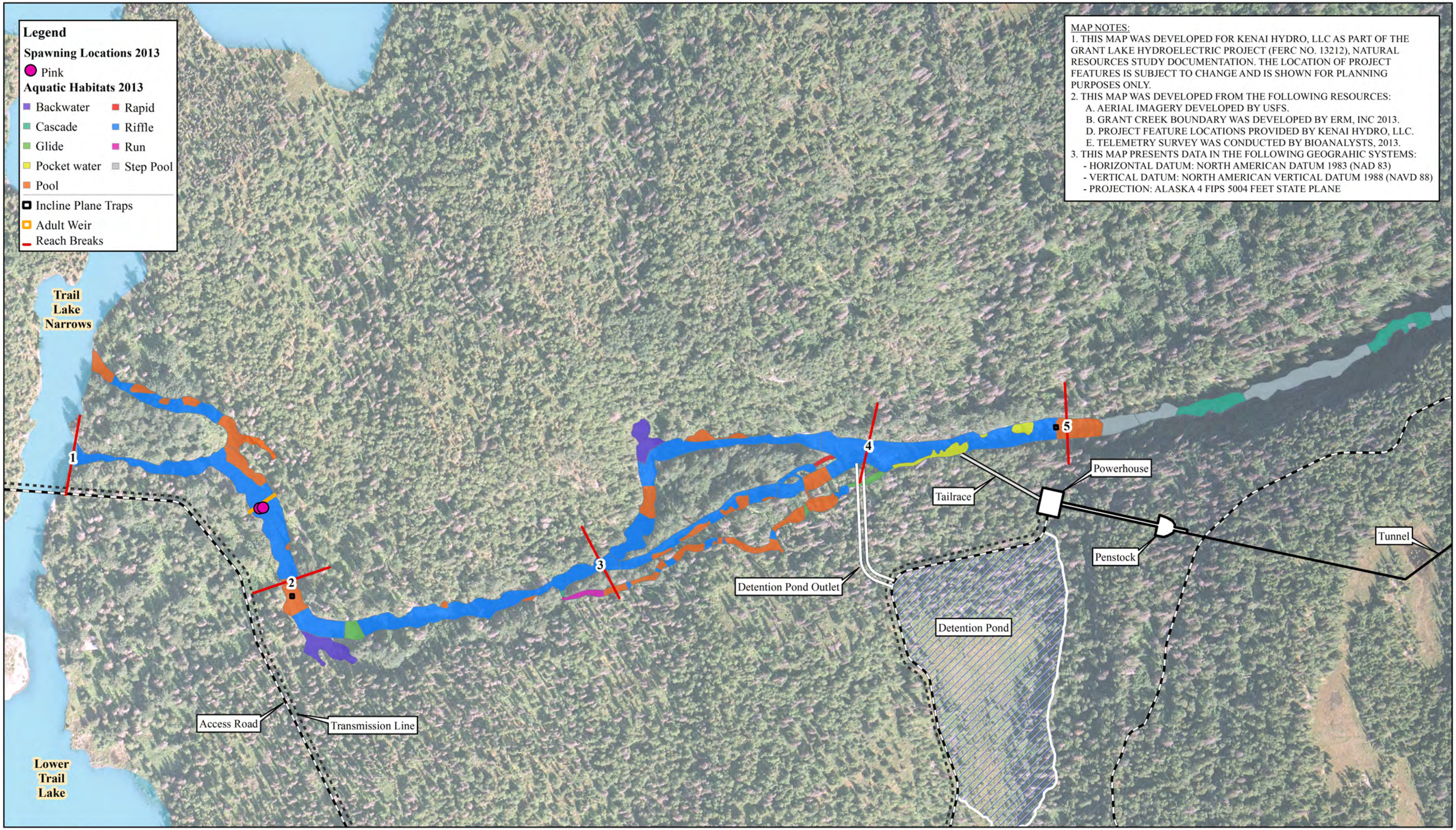

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Figure 5.1-9
Spawning Locations
Pink Salmon

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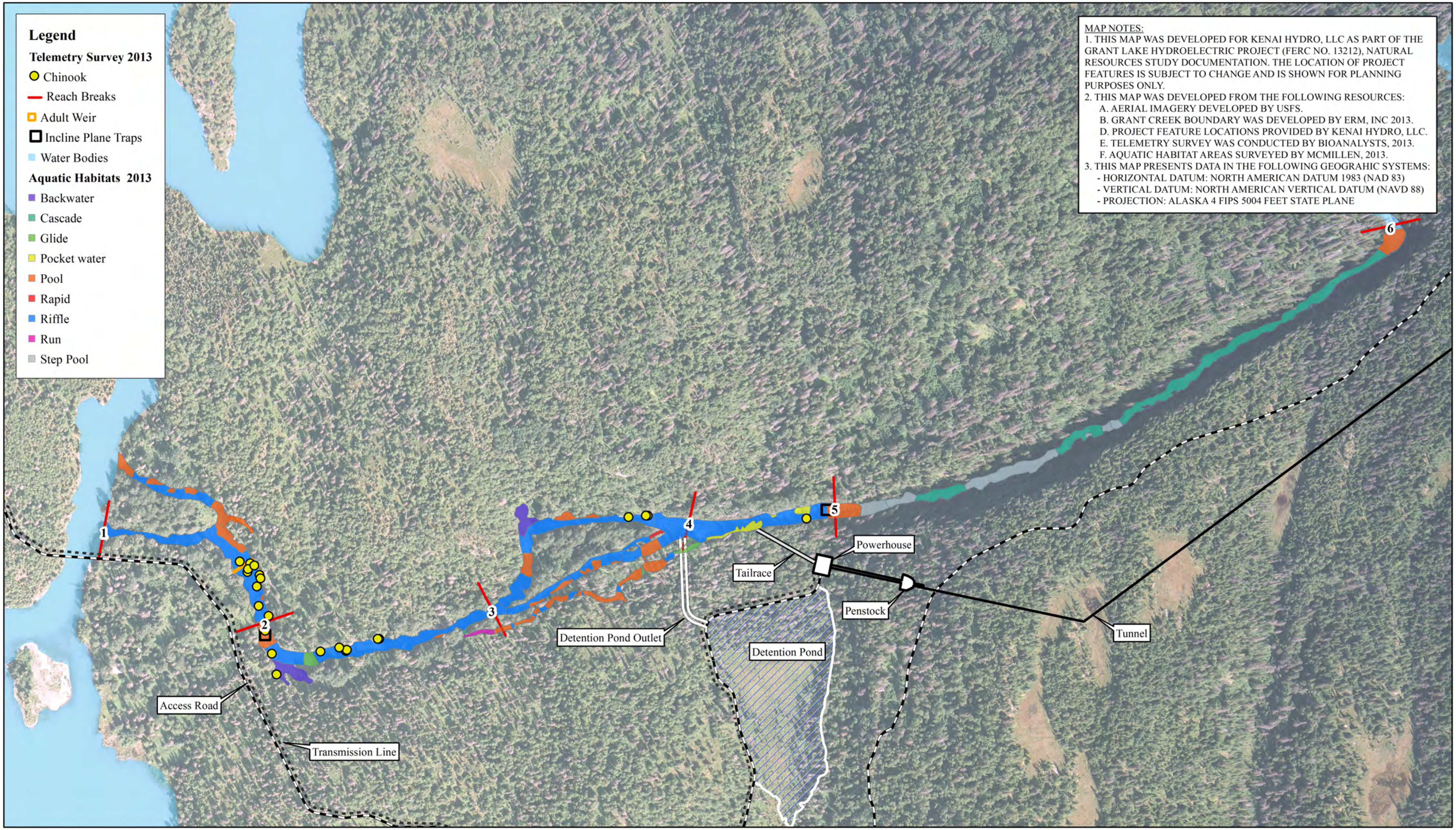

REV	DATE	BY	DESCRIPTION

N

Drawing Scale:
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GRANT LAKE NATURAL RESOURCES STUDY

Figures 5.1-10
Telemetry Survey Data
Chinook Salmon

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED J. Stevenson
ISSUED DATE 2/25/2014

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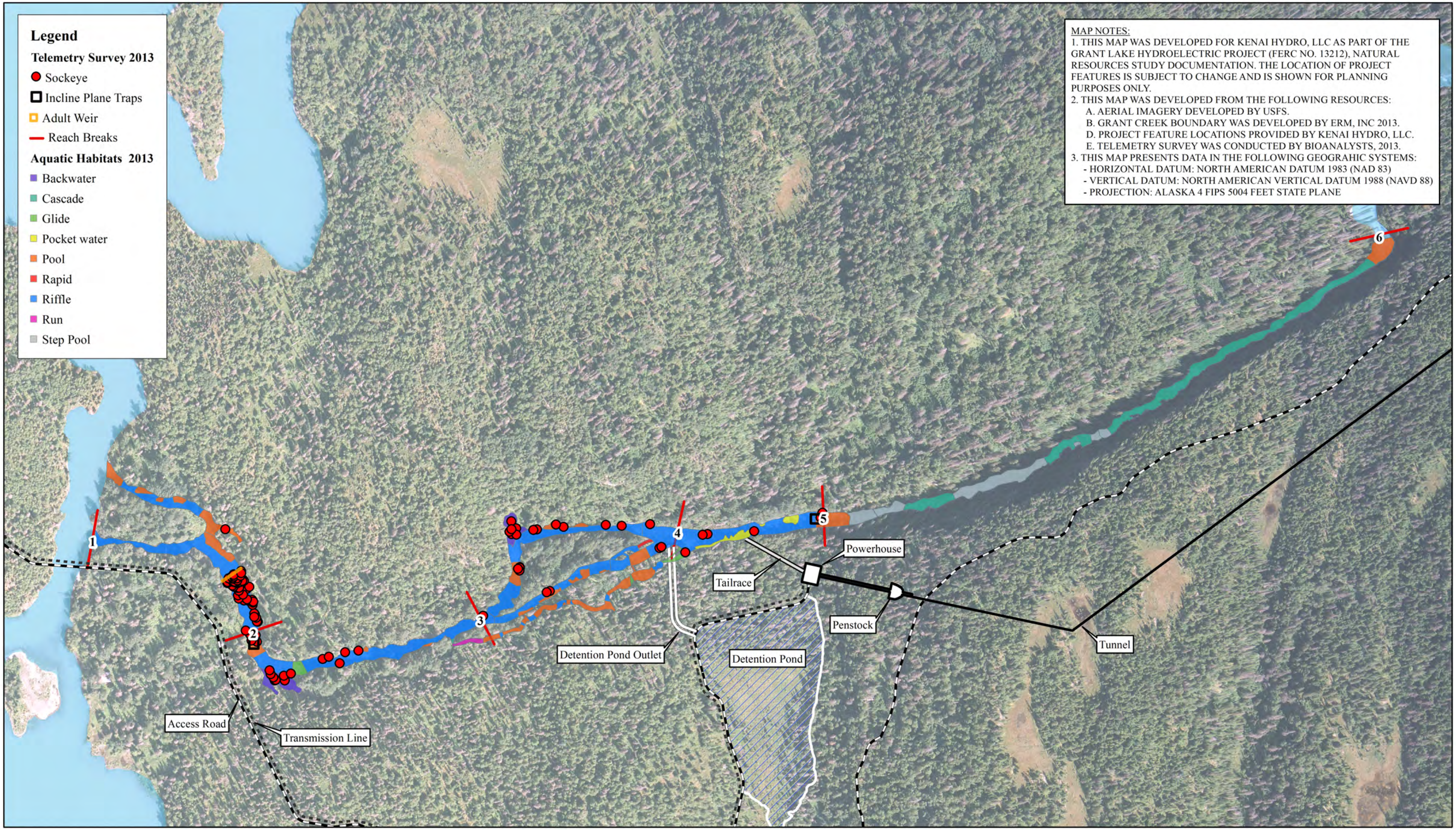
1 of 1

SCALE: 1:3,400



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GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.1-11
Telemetry Survey Data
Sockeye Salmon

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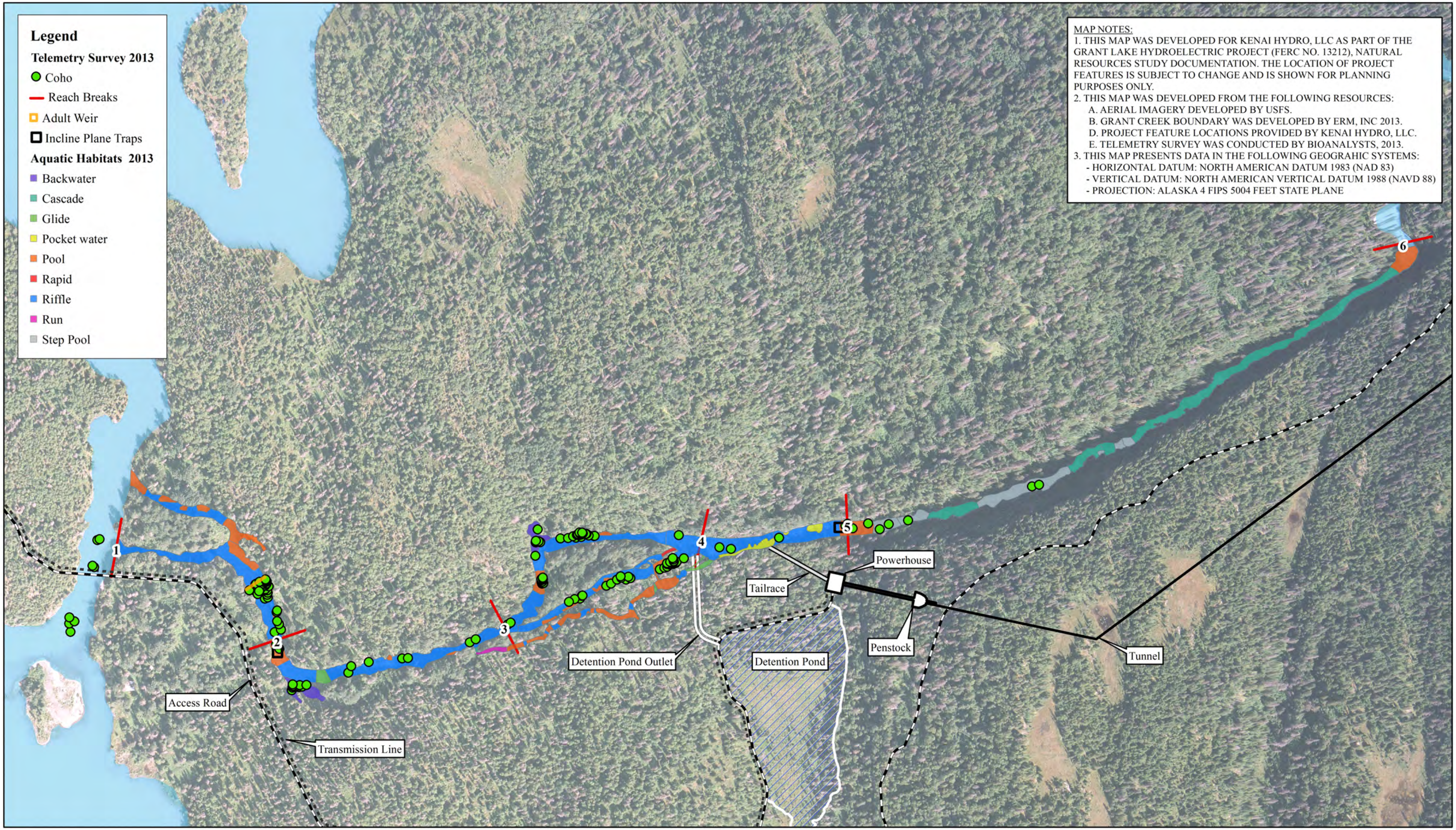

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.1-12
Telemetry Survey Data
Coho Salmon

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CHECKED J. Stevenson
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1 of 1

SCALE: 1:3,400

5.1.3.1 Time of Spawning

Salmon began building redds the first week of August and ended spawning activity at the end of October (Table 5.1-12). Pink salmon began spawning in early August with only two redds constructed near the weir in Reach 1. Chinook salmon began spawning in mid-August and built six redds in a three week period. Sockeye began spawning at the end of August building 308 redds within the first two weeks. By the third week (week 37) new redds and old redds could not be distinguished in the mass spawning aggregates. Spawning activity (active digging) was observed until the last week of September. Coho began spawning the first week of October and were complete at the end of the month constructing 72 redds in Grant Creek.

Table 5.1-12. Number of new redds constructed in Grant Creek by week of the year for pink, Chinook, sockeye and coho salmon in 2013. A designation of "MS" (Mass Spawning) means that new redds and old redds for could not be distinguished in the mass spawning aggregates.

Week	Dates	Species				Total
		Pink	Chinook	Sockeye	Coho	
31	Jul 28 - Aug 03	0	0	0	0	**0**
32	Aug 04 - Aug 10	2	0	0	0	**2**
33	Aug 11 - Aug 17	0	0	0	0	**0**
34	Aug 18 - Aug 24	0	1	0	0	**1**
35	Aug 25 - Aug 31	0	3	200	0	**203**
36	Sep 01 - Sep 07	0	2	108	0	**110**
37	Sep 08 - Sep 14	0	0	MS	0	**0**
38	Sep 15 - Sep 21	0	0	MS	0	**0**
39	Sep 22 - Sep 28	0	0	MS	0	**0**
40	Sep 29 - Oct 05	0	0	0	5	**5**
41	Oct 06 - Oct 12	0	0	0	47	**47**
42	Oct 13 - Oct 19	0	0	0	13	**13**
43	Oct 20 - Oct 26	0	0	0	6	**6**
44	Oct 27 - Nov 02	0	0	0	1	**1**
45	Nov 03 - Nov 09	0	0	0	0	**0**
	Total	**2**	**6**	**308**	**72**	**388**

5.1.3.2 Spawning Distribution

The distribution of spawning salmon in Grant Creek was document with both redd surveys and mobile telemetry surveys. The distribution of salmon redds was concentrated (95 percent) within Reaches 1-3 of Grant Creek (Table 5.1-13). Sockeye and coho salmon spawned in every reach of Grant Creek while Chinook only spawned in Reach 1, 3 and 4. The spawning locations of sockeye and coho salmon often overlapped in several locations in reaches 1 and 3. Pink salmon only spawned in Reach 1. There was less spawning in Reach 2 (15 percent), Reach 4 (4 percent) and Reach 5 (1 percent). Spawning only occurred in a few locations in Reaches 4 and 5.

Table 5.1-13. Number and proportion of redds counted in each reach of Grant Creek for pink, Chinook, sockeye and coho salmon in 2013.

Reach	Species				Total	Proportion
	Pink	Chinook	Sockeye	Coho		
1	2	4	144	18	**168**	**0.433**
2	0	0	52	7	**59**	**0.152**
3	0	1	102	38	**141**	**0.363**
4	0	1	7	7	**15**	**0.039**
5	0	0	3	2	**5**	**0.013**
Total	**2**	**6**	**308**	**72**	**388**	**1.000**

Radio telemetry tracking occurred throughout the spawning period for Chinook, sockeye and coho salmon. Radio tracking was used to determine the distribution of salmon within Grant Creek (Figures 5.1-10 through 5.1-12). Those distributions likely include migration (wandering), spawning and resting (pools) behaviors within Grant Creek.

Of the nine Chinook that were radio-tagged, seven were detected within Reach 1, three within Reach 2, none in reaches 3 and 4, and five within Reach 5 (Table 5.1-14). While five Chinook were detected within Reach 5, no redds were associated with these detections nor were any Chinook redds observed in Reach 5. In reaches 3 and 4 there were no unique fish detections but at least two redds were observed in those reaches. In Reach 2 there were 3 fish detected but no redds were observed in that reach. In Reach 1 there were 7 fish detected and 4 redds observed.

Table 5.1-14. The number of unique detections of radio-tagged adult salmon by species and reach within Grant Creek.

Reach	Chinook (n = 9)	Sockeye (n = 65)	Coho (n = 50)	Total	Proportion
1	7	48	40	95	**0.41**
2	3	14	12	29	**0.13**
3	0	18	30	48	**0.21**
4	0	3	6	9	**0.04**
5	5	20	26	51	**0.22**
Total	**15**	**103**	**114**	**232**	**1.00**

Unique detections by reach for sockeye more closely resemble observed redds by reach as presented in Table 5.1-13. Of the 65 radio-tagged sockeye, 48 were detected in Reach 1, 14 in Reach 2, 18 in Reach 3, 3 in Reach 4, and 20 in Reach 5 (Table 5.1-14). There were 20 sockeye detected in Reach 5 and at least 3 redds were observed. In reach 3 there were 18 sockeye detected and 102 redds were observed. In Reach 2 there were 14 fish detected and 52 redds observed. Reach 1 had 48 fish detected and there were 144 redds observed in this reach.

Of the 50 coho salmon radio-tagged, 40, 12, 30, 6, and 26 tagged fish were observed in reaches 1-5, respectively (Table 5.1-14). Coho were detected in all reaches of Grant Creek and indeed spawned in all reaches of Grant Creek like sockeye salmon. The majority of coho salmon were detected in Reaches 1 and 3 and these were the areas where most of the spawning occurred.

Clearly, detection of radio tagged fish helped describe the distribution of salmon entering Grant Creek, but it did not always indicate that spawning occurred. However, most fish appeared to be closely associated with either spawning areas or resting pools. The proportion of redds observed in Grant Creek was similar to the proportion of fish detected within each reaches. Reach 5 was the most notable divergence with several fish detected in the lower portion of reach 5 but few redds identified in this reach. The number of radio tagged detections in that reach may indicate exploratory behavior and/or the inability to detect redds in the lower section of reach 5.

5.1.3.3 Spawning Habitat

In Grant Creek, most redds were located in the mainstem areas, but also occurred in side channels and backwater areas (Table 5.1-15). Sockeye and coho both spawned in mainstem, side channel and backwater areas while pink and Chinook only spawned in mainstem areas. In mainstem areas, spawning usually occurred along the stream margins or in areas protected from the main current. Chinook were the exception, building redds mid-channel within the stronger current. In side channels, salmon spawned throughout the width of the channel and in backwater areas, salmon usually selected locations close to the mainstem where suitable stream velocity and substrate were present.

Table 5.1-15. Location of salmon redds within different channel areas of Grant Creek.

Species	Backwater Areas	Mainstem Areas	Side Channel Areas	Total
Chinook	0	6	0	**6**
Coho	4	49	19	**72**
Pink	0	2	0	**2**
Sockeye	27	239	42	**308**
Total	**31**	**296**	**61**	**388**

The majority of redds in Grant Creek were located in riffle (71 percent) and pool (19 percent) habitat (Table 5.1-16). In Reach 1, spawning for pink, sockeye and coho salmon most often occurred in riffle and pool habitat along the stream margins in the mainstem areas away from the thalweg and the highest stream velocities. Chinook spawned only in riffle habitat most often mid-channel where higher velocity and larger spawning substrates occurred. In Reach 2, most spawning occurred in mainstem riffle habitat along the stream margins for sockeye and coho salmon. Irregularities along the stream margin (large woody debris [LWD], bedrock, boulders) of riffle habitat created areas of lower velocity and suitable spawning substrate. Sockeye and coho also spawned in the stream margins of some pool habitat (lateral scour pool) of Reach 2. In Reach 3, most spawning occurred in pool habitat in mainstem (scour pools) and side channel areas (dammed pools). One large backwater area (pool habitat) was also used by sockeye and coho salmon. In Reach 4, spawning occurred in mostly riffle habitat along the stream margins of the right bank. Spawning also occurred along the left bank in pocket water (riffles w/ pockets) formed by velocity breaks such as boulders or tree roots that allowed spawning gravels to accumulate. In Reach 5, spawning occurred in step pool habitat along the stream margins often behind large boulders or bedrock outcroppings (velocity breaks) where gravels and cobbles accumulated.

Table 5.1-16. Location of pink, Chinook, sockeye and coho salmon redds within reaches and aquatic habitats of Grant Creek. A designation of "NA" means that the habitat type was not available in that reach of Grant Creek.

Species	Reach - Area	Riffle	Pool	Back -water	Step Pool	Glide	Pocket Water	Total
Pink	1 - Mainstem	2						2
	2 - Mainstem							
	3 - Mainstem							
	3 - Predominate Side Channel							
	3 - Secondary Side Channel							
	4 - Mainstem							
	5 - Mainstem							
Chinook	1 - Mainstem	4						4
	2 - Mainstem							
	3 - Mainstem	1						1
	3 - Predominate Side Channel							
	3 - Secondary Side Channel							
	4 - Mainstem	1						1
	5 - Mainstem							
Sockeye	1 - Mainstem	129	15					144
	2 - Mainstem	47		4		1		52
	3 - Mainstem	18	19	23				60
	3 - Predominate Side Channel	27	11			1		39
	3 - Secondary Side Channel		3					3
	4 - Mainstem	6	1					7
	5 - Mainstem				3			3
Coho	1 - Mainstem	15	3					18
	2 - Mainstem	6		1				7
	3 - Mainstem	6	10	3				19
	3 - Predominate Side Channel	7	8					15
	3 - Secondary Side Channel	1	3					4
	4 - Mainstem	5	2					7
	5 - Mainstem				2			2
	Total:	**275**	**75**	**31**	**5**	**2**	**0**	**388**
	Proportion:	**0.71**	**0.19**	**0.08**	**0.01**	**0.01**	**0.00**	**1.00**

The majority of radio tagged salmon were detected in riffle (62 percent) and pool (24 percent) habitat (Table 5.1-17). The proportion of detections in aquatic habitats of Grant Creek follows the distribution of redds. The slightly higher detection rate of fish in pools may be a related to staging and resting behavior as well as spawning. Backwater areas along the mainstem also appeared to be important spawning areas. In general, close inspection of maps that depict redd locations and detections of tagged fish show a cluster of activity in mainstem riffle areas near pool habitat.

Table 5.1-17. Number of detections for radio tagged Chinook, sockeye, and coho salmon in aquatic habitats of Grant Creek, 2013.

Species	Reach	Riffle	Pool	Back-water	Step Pool	Glide	Pocket Water	Total
Chinook	1 - Mainstem	10						10
	2 - Mainstem	6	2	2				10
	3 - Mainstem		2	1				3
	3 - Predominate Side Channel							0
	3 - Secondary Side Channel							0
	4 - Mainstem							0
	5 - Mainstem				1			1
Sockeye	1 - Mainstem	49	2					51
	2 - Mainstem	6	4	7				17
	3 - Mainstem	9	7	4				20
	3 - Predominate Side Channel	4						4
	3 - Secondary Side Channel							0
	4 - Mainstem	3						3
	5 - Mainstem							0
Coho	1 - Mainstem	57	1					58
	2 - Mainstem	6	3	10				19
	3 - Mainstem	12	27	7				46
	3 - Predominate Side Channel	6	14					20
	3 - Secondary Side Channel					1		1
	4 - Mainstem	3	3					6
	5 - Mainstem		2		4			6
	Total:	**171**	**67**	**31**	**5**	**1**	**0**	**275**
	Proportion:	**0.62**	**0.24**	**0.11**	**0.02**	**<0.01**	**0.00**	**1.00**

5.2 Grant Creek Resident and Rearing Fish Abundance and Distribution

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

A weir was placed in Reach 1 of Grant Creek to intercept, count and sample adult salmonids migrating upstream. Daily fish counts were used to estimate run timing and provided an overall estimate of escapement to Grant Creek. Dolly Varden and rainbow trout were intercepted at the weir to help facilitate radio tagging. Fish captured at the weir that were radio-tagged were also Floy-tagged.

The migration period for rainbow trout lasted 6 weeks from May 24 to June 29 and resulted in the capture of 13 adult rainbow trout (Table 5.2-1). The abundance of adult rainbow trout in Grant Creek based on weir counts may be biased low. This conclusion is based on the observation of two radio tagged rainbow trout, which were released upstream of the weir in June and were subsequently captured downstream from the weir in July while angling. Neither of these fish were captured and released downstream of the weir. Later, both of these fish were detected upstream of the weir; again without being captured at the weir.

Table 5.2-1. Weekly passage of rainbow trout and Dolly Varden across the weir in Grant Creek, 2013.

Week of the Year	Dates	Rainbow Trout	Dolly Varden
21	May 19 - May 25	3	0
22	May 26 - Jun 01	1	0
23	Jun 02 - Jun 08	1	0
24	Jun 09 - Jun 15	1	0
25	Jun 16 - Jun 22	3	0
26	Jun 23 - Jun 29	4	0
27	Jun 30 - Jul 06	0	0
28	Jul 07 - Jul 13	0	0
29	Jul 14 - Jul 20	0	0
30	Jul 21 - Jul 27	0	0
31	Jul 28- Aug 03	0	0
32	Aug 04 - Aug 10	0	0
33	Aug 11- Aug 17	0	0
34	Aug 18 - Aug 24	0	1
35	Aug 25 - Aug 31	0	4
36	Sep 01 - Sep 07	0	6
37	Sep 08 - Sep 14	0	3
38	Sep 15 - Sep 21	0	0
39	Sep 22 - Sep 28	0	0
40	Sep 29 - Oct 05	0	0
41	Oct 06 - Oct 12	0	0
42	Oct 13 - Oct 19	0	0
43	Oct 20 - Oct 26	0	0
	Total	13	14

The relatively low abundance of rainbow trout passing the weir might be attributed to the date the weir was placed into Grant Creek. Some adult rainbow trout may have moved upstream into Grant Creek before the weir was in place. Angling was initiated to help capture fish for radio tagging. Within the first two weeks, 16 adult sized (>300 mm FL) rainbow trout were tagged. Many of these fish were captured upstream of the weir. In July two observers in dry suits and snorkel gear inspected the weir and found no obvious areas of entry from mid-channel to the left bank. The right bank undercut could not be inspected and is suspected to have been large enough to provide some supplementary passage to rainbow trout.

The migration period for Dolly Varden lasted 4 weeks from August 18 to September 14, with the capture of 14 Dolly Varden (Table 5.2-1). Only one Dolly Varden was large enough for tagging, and which appeared to be in spawning condition. Angling efforts in Grant Creek proved unsuccessful to capture adult Dolly Varden for tagging.

5.2.2 Resident and Rearing Fish Use of Reach 5

To monitor fish use of upper Grant Creek, adult rainbow trout were surgically implanted with radio tags to monitor their movements and use of Reach 5. A total of 20 adult rainbow trout were radio-tagged, and included a portion of the fish collected at the weir, and a number of fish captured above the weir using angling techniques. Minnow traps and snorkel surveys were also used to assess the relative abundance of juvenile fish in upper Grant Creek.

Of the 20 adult rainbow trout that were surgically implanted with radio-transmitters, three males and one female were detected within Reach 5 subsequent to their release. All four were detected by the underwater antenna arrays located at the Reach 4/5 break. Because there were two antenna arrays located approximately 30 meters apart, and they were monitored individually, it was possible to determine when the tagged fish approached the Reach 4/5 break, and when they migrated past that point and into Reach 5. Likewise, it was possible to determine the direction of travel, and when a tagged fish migrated downstream and out of Reach 5. Of the four radio-tagged fish that entered Reach 5, two were also detected during mobile surveys of the "Canyon Reach" (Reach 5), providing a more detailed assessment of their positions.

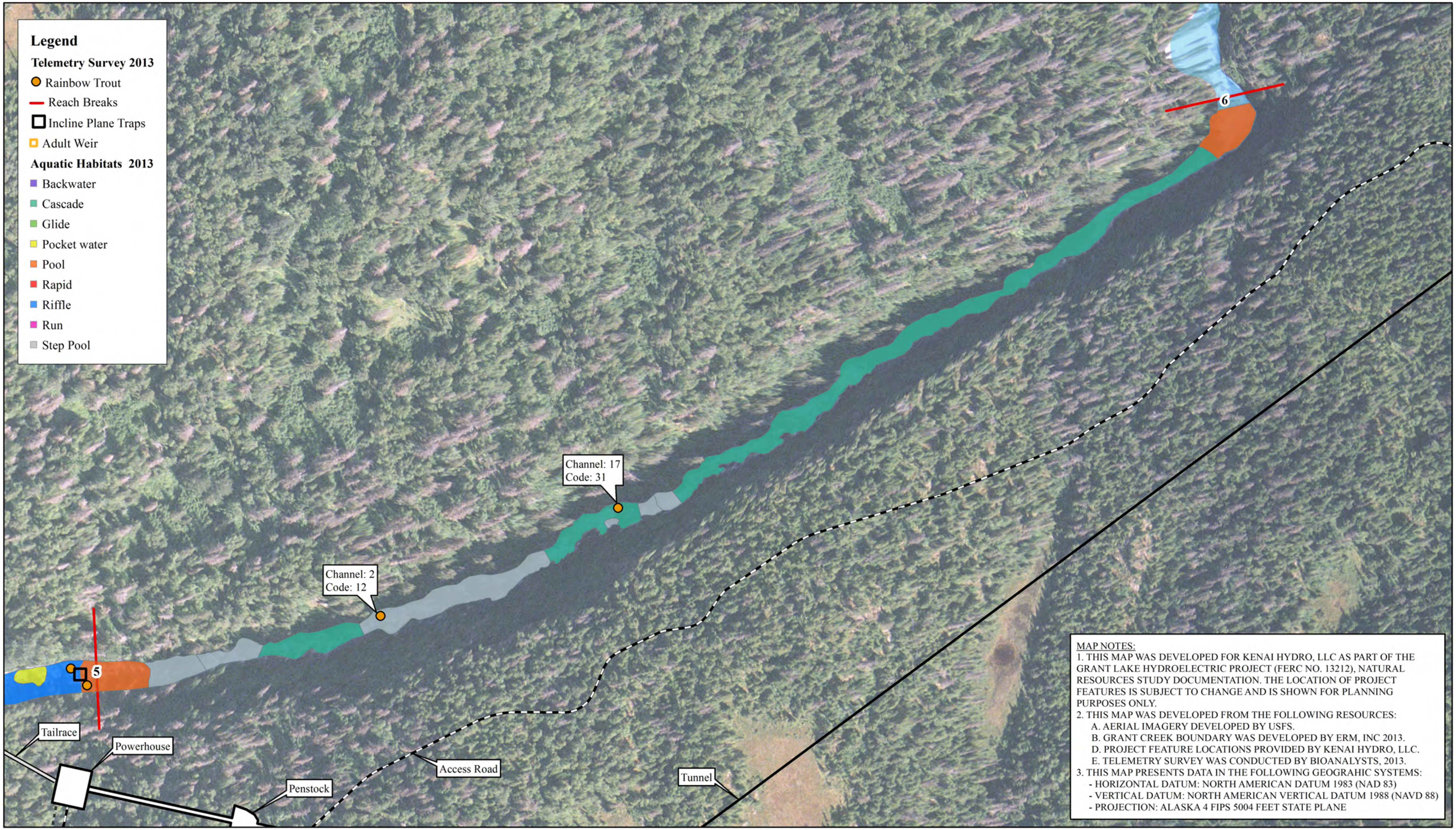
On average, it took 9.9 days after tagging and release for the four fish to migrate upstream through Grant Creek and be detected by the antenna array located at the Reach 4/5 break (median of 6.6 days; range of 2.0 to 24.4 days; Table 5.2-2). Three of the four fish made a single foray into Reach 5, spending on average 0.27 days within Reach 5. The fourth fish, a male, made three different forays into Reach 5; the first lasting 4.35 days, the second 0.72 days, and the last foray lasting 0.75 days, each venture into Reach 5 being separated by about 6 hours.

Table 5.2-2. The travel time and length of residence of radio-tagged rainbow trout detected in Reach 5 of Grant Creek.

<table>
<tr><th>Fish I.D. (Channel/Code)</th><th>Sex</th><th>Travel Time from Release to Reach 4/5 Break (days)</th><th>Length of Time within Reach 5 (days)</th></tr>
<tr><td>2/12</td><td>Female</td><td>6.12</td><td>0.80</td></tr>
<tr><td>2/19</td><td>Male</td><td>24.37</td><td>0.01</td></tr>
<tr><td rowspan="3">17/31</td><td rowspan="3">Male</td><td rowspan="3">2.00</td><td>4.35</td></tr>
<tr><td>0.72</td></tr>
<tr><td>0.75</td></tr>
<tr><td>17/46</td><td>Male</td><td>7.05</td><td>0.01</td></tr>
</table>

The tagged female (Fish I.D. 2/12) spent 0.80 days in Reach 5, and was detected at the time of a mobile telemetry survey. During this survey, this fish migrated upstream to a point approximately 135 meters above the Reach 4/5 break (Figure 5.2-1). The location where this fish was detected was further scrutinized at the time of the telemetry survey, and its position was determined using a bared-coaxial underwater antenna, which allows accuracy on the order of 3 meters or less.

The radio-tagged male (Fish I.D. 17/31), which made multiple forays into Reach 5, spent the most time in Reach 5, and migrated the farthest upstream of the Reach 4/5 break (about 250 meters; Figure 5.2-1). Its location was ascertained during a mobile survey where its position was triangulated from the top of the canyon rim from the right bank. As such it was not possible to collect any information as to the specific location (i.e., habitat type, substrate, etc.).



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Drawing Scale: 0 50 100 200 Feet

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.2-1
Telemetry Survey Data
Rainbow Trout - Reach 5

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED J. Stevenson
ISSUED DATE 2/25/2014

DRAWING 1 of 1

SCALE: 1:1,675

Minnow trapping and snorkeling were used in upper Grant Creek (Reach 5 only) from April through October to document species diversity, relative abundance, and distribution. Over the course of the study, there were 57 individual minnow traps (effort=1,318 hours) placed in different locations capturing 205 fish in upper Grant Creek (Table 5.2-3; Figure 5.2-2). Snorkeling was only conducted in April and May when stream flows and water clarity allowed. Three step pools were snorkeled in April and two were snorkeled in May identifying 16 fish in upper Grant Creek.

Table 5.2-3. Number of minnow traps, total effort, and number of fish captured in Reach 5 of Grant Creek from April through October 2013.

Upper Grant Creek Minnow Trapping				
Reach	**Number of Traps**	**Total Effort (days)**	**Total Effort (hrs)**	**Number of Fish**
5	57	54.9	1,318	205

Dolly Varden and rainbow trout were the most numerous fish captured in minnow traps followed by Chinook, sculpins sp. and coho (Table 5.2-4). Juvenile Dolly Varden comprised half of the fish captured in minnow traps.

Table 5.2-4. Number, proportion and CPUE of fish caught in Reach 5 of Grant Creek with minnow traps from April through October 2013.

Upper Grant Creek Minnow Trapping			
Species	**Number**	**Proportion**	**CPUE (fish/hr)**
Chinook	31	0.15	0.024
Coho	5	0.02	0.004
Dolly Varden	102	0.50	0.077
Rainbow Trout	48	0.23	0.036
Sculpin sp.	19	0.09	0.014
Grand Total	**205**	**1.00**	**0.156**

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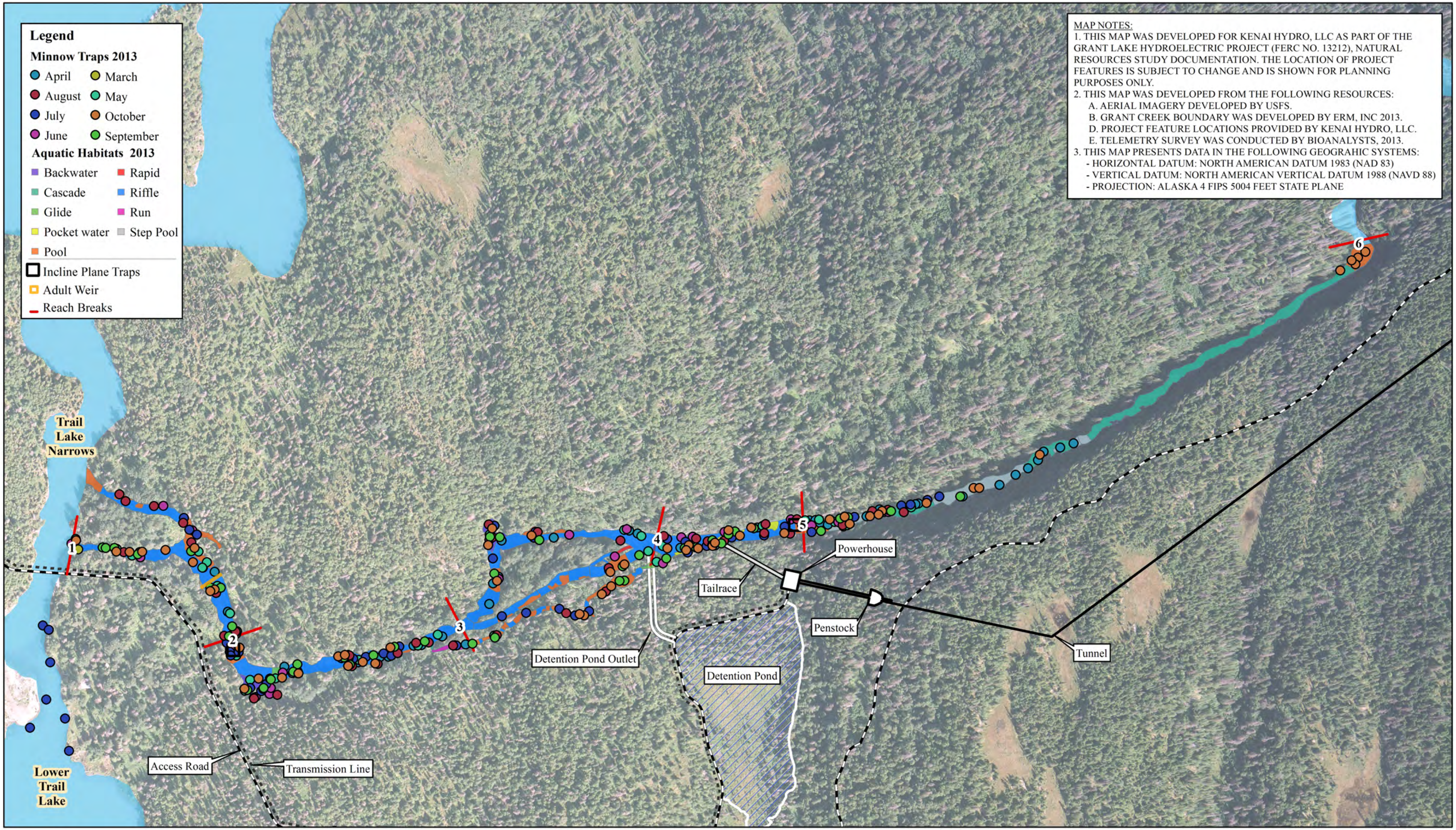

REV	DATE	BY	DESCRIPTION

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Drawing Scale:
0 150 300 600 Feet

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GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.2-2
Minnow Trap Observations
By Month

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

DRAWING
1 of 1

SCALE: 1:3,400

The relative abundance of fish observed in Reach 5 of Grant Creek varied over time (Table 5.2-5). Repeated minnow trap sampling from April through October in upper Grant Creek showed that relative abundance was lowest in May and increased to September (Figure 5.2-3; Table 5.2-5). In general, peak abundance (catch) occurred from June through October. CPUE for juvenile Chinook increased from April to a peak in September and declined in October (Figure 5.2-3). Juvenile Chinook varied in size from 68-118 mm FL. CPUE for juvenile coho salmon peaked in September and fish ranged in size from 60-95 mm FL. For Dolly Varden, the greatest CPUE occurred in August but was fairly stable during the summer (June-August). The size range of Dolly Varden captured in upper Grant Creek varied from 71-151 mm FL. Catch of juvenile rainbow trout peaked in September and October (Table 5.2-5). Rainbow trout captured in upper Grant Creek varied from 54-143 mm FL. No fish were captured in the plunge pool downstream from the anadromous fish barrier in September when peak catch rates were generally highest for most other species (except Dolly Varden).

Table 5.2-5. Number of fish captured in minnow traps by month for upper Grant Creek from April through October 2013.

Month	Number						
	Chinook	**Coho**	**Dolly Varden**	**Rainbow Trout**	**Sculpin sp.**	**Three-spine Stickleback**	**Total**
APR	2	0	1	5	0	0	8
MAY	1	0	1	4	0	0	6
JUN	0	0	18	1	0	0	19
JUL	1	0	23	3	1	0	28
AUG	1	1	20	4	3	0	29
SEP	18	4	17	16	5	0	60
OCT	8	0	22	15	10	0	55
Total	31	5	102	48	19	0	205

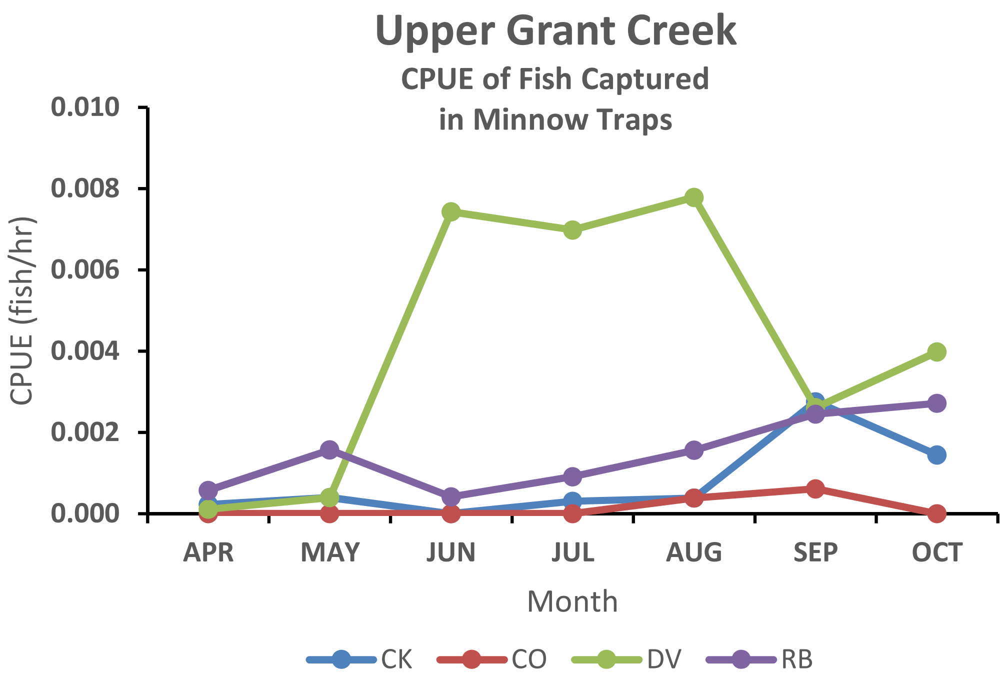

Figure 5.2-3. Catch-per-unit-effort (CPUE) for juvenile Chinook, coho, Dolly Varden and rainbow trout from minnow trapping in upper Grant Creek from April through October, 2013.

Night time snorkel surveys in April and May within Reach 5 of Grant Creek documented 7 rainbow trout in April and 9 rainbow trout in May. These fish were observed in step pool habitat and varied in size from 60-280 mm FL.

The upper incline plane trap was installed within a scour pool, which was located immediately downstream of the Reach 4/5 break. Trap installation was completed on April 28, and the trap was permanently removed on October 16. The trap was operated 24 hours per day, seven days per week with a number of exceptions. Due to few fish being captured, the trap was not operated the first three weekends of the study (May 4 and 5; May 11 and 12; and May 18 and 19). As Grant Creek flows increased, the trap became increasingly problematic to operate. In addition to high debris loads, the water velocity entering the trap was approaching 1 meter per second, with large rolling waves. This caused flow entering the trap to surge, making it difficult to optimize the trap settings. Efforts were made to reposition the trap within the pool; however there was little flexibility in adjustment within the pool due to boulders. Towards the end of May, velocities had reached a point where it was difficult to access the trap, and the level of risk to personnel had become unacceptable. Therefore, on May 30 the trap was taken out of operation, and on June 1 the trap was moved to a position along the left bank and the trap was secured. It wasn’t until September 19 that flow subsided to a point where the trap could be moved into fishing position, and trapping operations re-initiated.

During the juvenile migration, problems associated with the lower incline plane trap located at the Reach 1/2 break became apparent. Juvenile salmonid fry were being observed along flooded areas of Grant Creek, yet none of these fry-sized fish were being observed in the incline plane trap live box. Through ad hoc investigations, it was determined that the mesh size on the live box, as well as the incline plane of the trap was too large, which allowed juvenile fish to escape the trap. Modifications were made to both the incline plane and the live box; since the upper incline plane trap located at the Reach 4/5 break was constructed identically to the lower trap, alterations were made to it as well.

As discussed in the Methods Section, a goal of the study was to estimate abundance of juvenile fish within Grant Creek, and to partition that estimate into two sections; Reach 5, and Reaches 1-4. An estimate of abundance at the lower incline plane trap would represent all of Grant Creek; that is, from the trap upstream to the waterfall at the top of Reach 5. To partition that estimate into the two sections, it is then necessary to get an estimate of abundance for just Reach 5. Given that the upper incline plane trap was inoperable during much of the juvenile migration due to high flows, the collection of adequate numbers of fish to estimate trap efficiency at the upper trap was not possible. As such, results for the upper incline plane trap, which are presented below only include actual counts of fish collected at the trap, and results for the lower incline plane trap presented in Section 5.2.3 include abundance estimates that are for all of Grant Creek.

During the operation of the upper incline plane trap, a total of 172 fish were processed. Of those, there were 8 Chinook, 1 coho, 7 Dolly Varden, 5 rainbow trout, 19 sculpin, and 132 sticklebacks. Due to the low numbers of species of interest, no fish were marked to assess trap efficiency.

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

To monitor fish use of lower Grant Creek, adult rainbow trout were surgically implanted with radio tags to monitor their movements. Minnow traps and snorkel surveys were also used to assess the relative abundance of juvenile fish in upper Grant Creek.

During the period of May 24 to July 11, a total of 20 adult rainbow trout were surgically implanted with radio-transmitters; one in May, six in June, and 13 in July (Table 5.2-6). Of those 20 fish, 8 were female, 11 were male, and the sex of one other was undetermined. The age of adult rainbow trout (>300 mm) varied from three to seven years old, which is similar to what has been observed in the Upper Kenai River (Hayes and Hasbrouck 1996). The mean weight was 543.5 grams (range of 252.6 to 1,571.2 grams), and the mean length was 358.4 mm, with a range of 300 to 500 mm (Figure 5.2-4).

Table 5.2-6. The date of tagging, transmitter coding, capture method, sex, weight and length of 20 adult rainbow trout tagging in Grant Creek, Alaska 2013.

Date	Channel	Code	Capture Method	Sex	Age	Weight (g)	Length (mm)
24-May-13	2	11	Angling	Unknown	---	462.6	343
6-Jun-13	17	31	Weir	Male	3	1571.2	500
15-Jun-13	2	17	Weir	Male	3	767.4	402
17-Jun-13	17	44	Weir	Female	6	548.2	357
17-Jun-13	2	12	Weir	Female	3	969.4	431
25-Jun-13	17	32	Angling	Female	7	406.2	345
28-Jun-13	2	18	Angling	Female	3	334.0	309
1-Jul-13	2	21	Angling	Female	3	634.0	382
1-Jul-13	17	25	Angling	Male	6	252.6	304
3-Jul-13	2	22	Angling	Male	7	269.2	309
3-Jul-13	17	45	Angling	Male	4	457.8	348
3-Jul-13	17	26	Angling	Male	4	551.6	373
4-Jul-13	2	13	Angling	Female	3	535.4	357
5-Jul-13	17	33	Angling	Female	3	724.8	411
5-Jul-13	2	19	Angling	Male	3	398.2	329
7-Jul-13	17	46	Angling	Male	3	582.6	385
9-Jul-13	17	37	Angling	Female	3	314.4	318
10-Jul-13	17	38	Angling	Male	5	487.2	335
11-Jul-13	2	23	Angling	Male	3	284.2	300
11-Jul-13	17	27	Angling	Male	3	318.0	329
					Mean	**543.5**	**358.4**

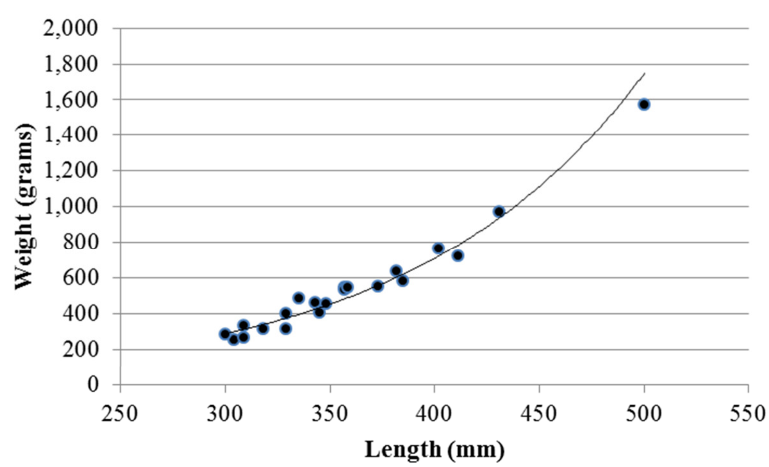

Figure 5.2-4. The length-weight relationship of radio-tagged adult rainbow trout in Grant Creek, 2013.

During the course of the study, all 20 fish were detected at some time by one of the fixed-telemetry stations located at the Reach 4/5 break and near the confluence of Grant Creek, or during one of the mobile telemetry surveys. Of those, four fish were detected within Reach 5 (see Section 5.2.2), while 17 fish were detected at the lower site.

During the course of 37 mobile surveys, a total of 198 contacts were made with radio-tagged adult rainbow trout within Reaches 1-4 of Grant Creek; 124 contacts in Reach 1, 40 in Reach 2, 31 in Reach 3, and 3 in Reach 4 (Figure 5.2-5). Of the 20 radio-tagged fish, 18 were detected during mobile surveys. The other two fish that were not detected during mobile surveys were detected shortly after tagging (three to six hours) by the fixed-telemetry array downstream of the weir as the fish migrated downstream and exited Grant Creek into the Trail Lake Narrows.

Mobile detections of rainbow trout can be assessed by their location within a reach (i.e., mainstem, backwater areas, and side-channels) and habitat type. Of the 124 detections within Reach 1, all were located within the mainstem, with 23 fish locations noted within pools, and 101 fish locations within riffle habitat (Table 5.2-7). A total of 40 detections occurred within the Reach 2 mainstem, with 19 fish locations within pool habitat, 13 in riffle habitat, and 8 within backwater areas. Within the Reach 3 mainstem, 9 detections were observed in pool habitat and 11 in riffle habitat. Within the Reach 3 Predominant Side Channel, three detections were observed in pool habitat and 11 detections within riffle habitat, and three detections were recorded in the Reach 3 Secondary Channel within pool habitat. Finally, a total of three detections were observed in the Reach 4 mainstem; with 1 detection in each of the pool, riffle, and pocket water habitats.

Table 5.2-7. Habitat use by location based on mobile telemetry surveys for radio-tagged rainbow trout in Grant Creek, AK, 2014.

Reach - Area	Riffle	Pool	Back-Water	Step Pool	Glide	Pocket-Water	Total
1 - Mainstem	101	23					**124**
2 - Mainstem	13	19	**8**				**40**
3 – Mainstem	11	9					**20**
3 – Predominant Side Channel	5	3					**8**
3 – Secondary Side Channel		3					**3**
4 - Mainstem	1	1				**1**	**3**
Total	**131**	**58**	**8**	**0**	**0**	**1**	**198**

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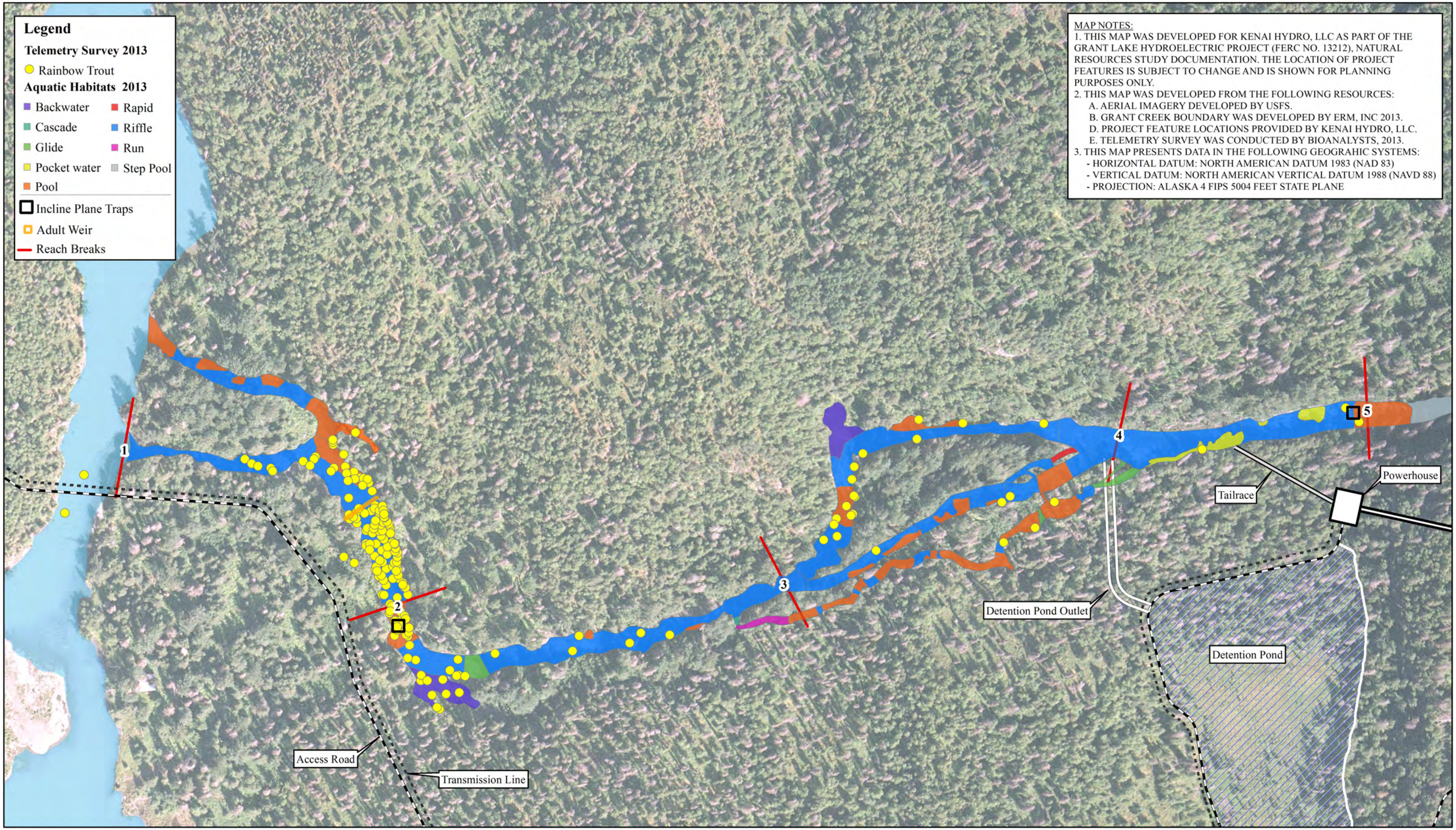

REV	DATE	BY	DESCRIPTION

N

Drawing Scale:
0 75 150 300 Feet

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GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO.13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.2-5
Telemetry Survey Data
Rainbow Trout Reaches 1 - 4

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED J. Stevenson
ISSUED DATE 2/25/2014

DRAWING
1 of 1

SCALE: 1:2,000

Furthermore, of the 20 radio-tagged rainbow trout, all 20 were detected at some point within Reach 1 (either by the fixed telemetry station or during mobile surveys). Fourteen of the twenty tagged rainbow were also detected in reaches two and three, three in Reach 4, and as discussed previously, four in Reach 5 (Table 5.2-8). The tagged Dolly Varden was not detected at any time after release.

Table 5.2-8. The number of radio-tagged rainbow trout and Dolly Varden detected by reach within Grant Creek, Alaska 2013.

Reach	Rainbow (n = 20)	Dolly Varden (n = 1)
1	20	0
2	14	0
3	14	0
4	3	0
5	4	0

The detections of fish in Reach 1 and 2 occurred throughout the period radio-tagged rainbow trout were detected within Grant Creek (May 25 through October 17), whereas detections in Reach 3 occurred primarily shortly after tagging (June 20 through August 15); and the single detection in Reach 4 occurred on June 28. As discussed in Section 5.2.2.1, no rainbow trout redds were observed in Grant Creek in 2013. However, due to the poor water clarity and high flows, that was not unexpected. Detections primarily in Reach 3 shortly after tagging, coupled with suitable pockets of gravel at the locations of detection may suggest that rainbow trout spawning possibly occurred in Reach 3; including both the mainstem of Grant Creek and the secondary channel. The location of detections in Reach 3 for rainbow trout correspond with the location of observed redds for both sockeye and coho. And while spawning substrates for the three species varies to some degree, the observations for Chinook, sockeye, and coho indicate that due to the limited amount of spawning gravel in Grant Creek, the fish will spawn in what visually appears to be marginal spawning habitat. However, it should be noted that observations of radio-tagged rainbow in Reach 3 may well have been due to tagged fish taking advantage of feeding opportunities at those locations.

As can be seen in Figure 5.2-5, the majority of rainbow trout detections were in Reach 1 and to a lesser extent, the lower portion of Reach 2. These areas were also where the greatest concentration of sockeye and coho spawned. Detections of rainbow trout in these areas occurred throughout the tracking period and toward the end of the study. Near the end of the study period, these areas were the only locations where tagged rainbow resided. These factors indicate that while it is possible that some rainbow spawned within this area, fish likely resided within this area to take advantage of feeding opportunities.

Review of the last date of detection by either mobile surveys or the fixed-site telemetry system provides an opportunity to determine the date of exodus from Grant Creek. Mobile telemetry surveys continued until tagged fish were no longer detected in Grant Creek, which included tagged Chinook, sockeye, and coho. The last telemetry survey was conducted on October 29; however, the date of last detection for rainbow trout during a mobile survey in Grant Creek was on October 17. Some fish were detected later than October 17 by the fixed-site telemetry system near the confluence; but these detections were likely the result of tagged fish travelling downstream and exiting Grant Creek into the Trail Lake Narrows. For 18 tagged rainbow trout, the mean and median date of last detection in Grant Creek was September 1, with the earliest date of exodus being June 17, and the latest date being October 26 (Table 5.2-9). Two additional fish appear to have expired during the study period. The transmitter of one fish (Fish I.D. 2/17) was tracked to the general area under a bald eagle nest along the left bank (looking downstream) of Reach 1 shortly after being tagged. While the transmitter was never recovered, its position remained constant over the course of several months. The transmitter of a second fish (Fish I.D. 17/31), which had been detected in Reach 5 numerous times, was recovered on shore near a log jam near the top of the secondary channel in Reach 3. The transmitter antenna had a number of kinks that appeared to be due to bite marks.

Table 5.2-9. The date of last detection for 18 radio-tagged adult rainbow trout in Grant Creek, Alaska, 2013.

Channel	Code	Last Date of Detection
2	11	23-Oct-13
2	12	13-Jul-13
2	13	9-Sep-13
2	18	28-Jun-13
2	19	30-Jul-13
2	21	17-Oct-13
2	22	26-Oct-13
2	23	27-Jul-13
17	25	17-Oct-13
17	26	25-Aug-13
17	27	17-Aug-13
17	32	2-Oct-13
17	33	1-Oct-13
17	37	17-Oct-13
17	38	5-Aug-13
17	44	17-Jun-13
17	45	19-Oct-13
17	46	16-Jul-13
	Mean:	1-Sep-13
	Median:	1-Sep-13
	Min:	17-Jun-13
	Max:	26-Oct-13

A single Dolly Varden female was surgically implanted with a transmitter on September 10, and weighed 1,844 grams and was 545 mm FL. This fish was not detected during any mobile surveys, and was never detected by one of the fixed-telemetry sites. Given the extensive telemetry surveying of Grant Creek, it is likely that the transmitter either failed after release, or the fish was captured by a predator that removed the carcass from the study area. Subsequent efforts to trap additional Dolly Varden at the weir and through angling proved unsuccessful.

Minnow trapping was used in lower Grant Creek (Reaches 1-4) from April through October to document species diversity, relative abundance, and distribution. Minnow trapping was also conducted to help establish important or sensitive juvenile rearing habitat. Over the course of the study there were 273 individual minnow traps (effort=6,137 hours) placed in different locations describing fish in distinct reaches, channel locations, and habitat units. Over 3,468 fish were captured, measured and weighed to describe baseline conditions in lower Grant Creek (Table 5.2-10). The following section discusses the results of this effort from a broad scale (reach) to a more focused habitat unit basis. The assumption is that CPUE at the reach, channel and habitat unit scale are a good indicator of relative abundance, distribution and fish-habitat associations.

Table 5.2-10. Number of minnow traps, total effort, and number of fish captured in lower Grant Creek from April through October 2013.

Lower Grant Creek Minnow Trapping				
Reach	**Number of Traps**	**Total Effort (days)**	**Total Effort (hrs)**	**Number of Fish**
1	63	60.6	1,454.4	899
2	77	72.1	1,713.6	819
3	69	63.6	1,567.2	1,187
4	64	59.4	1,404.0	560
Total	**273**	**255.7**	**6,139.2**	**3,465**

In lower Grant Creek, relative abundance of fish caught in minnow traps expressed as both CPUE and proportion of total catch was highest in Reach 3 followed by Reach 1, Reach 2, and then Reach 4 (Table 5.2-11). The CPUE in the lower gradient reaches (1-4) of Grant Creek were more than two times the CPUE observed in the higher gradient section of Reach 5 (Table 5.2-11). This information indicates that juvenile fish were most abundant in lower Grant Creek and in particular, Reach 3.

Table 5.2-11. Number, proportion, and CPUE for fish caught in Lower Grant Creek from April through October of 2013.

Reach	Number of Fish	Proportion	CPUE (fish/hr)
1	899	0.26	0.62
2	819	0.24	0.48
3	1,187	0.34	0.76
4	560	0.16	0.40
Total	**3,465**	**1.00**	**0.56**

Juvenile Chinook and Dolly Varden were the most numerous fish captured in minnow traps on Grant Creek followed by rainbow trout, coho, sculpins sp. and three-spine sticklebacks (Table 5.2-12). Few juvenile sockeye were captured in minnow traps in either Grant Creek (no fish) or Trail Lakes Narrows (1 fish) and is likely related to their early life history and behavior. That is, shortly after emergence sockeye generally tend to migrate into lakes as fry where they feed and grow (Burgner 1991). The size of post-emergent sockeye fry in Grant Creek would likely have been too small (<40 mm FL) to effectively capture in Grant Creek. Also, the period of exposure to minnow trapping would have also been very brief before they emigrated from Grant Creek.

Table 5.2-12. Number, proportion and CPUE of fish caught in lower Grant Creek with minnow traps from April through October, 2013.

Lower Grant Creek Minnow Trapping			
Species	**Number**	**Proportion**	**CPUE (fish/hr)**
Chinook	1,244	0.359	0.20
Dolly Varden	1,142	0.330	0.19
Coho	420	0.121	0.07
Rainbow Trout	397	0.115	0.06
Sculpin sp.	258	0.074	0.04
Three-spine Stickleback	4	0.001	0.00
Grand Total	**3,465**	**1.000**	**0.56**

The relative abundance of fish observed in Grant Creek varied over time. Repeated minnow trap sampling from April through October in lower Grant Creek showed that relative abundance increased from fairly low levels in April and May representing late winter and early spring stream conditions to much higher levels in late spring, summer and fall (June-October) (Figure 5.2-6; Table 5.2-13). In general, peak abundance (catch) occurred during the summer. CPUE for juvenile Chinook increased from April to a peak in September and declined in October (Figure 5.2-6). Recently emerged Chinook fry (<50 mm FL) were first noted in minnow traps in June but fry of this size were also noted in July and August. Juvenile Chinook varied in size from 45-110 mm FL. CPUE for juvenile coho salmon increased steadily from May to a peak in August and declined in September and October (Figure 5.2-6). Recently emerged coho fry (<50 mm FL) were first noted in minnow traps in July but fry of this size were also noted in August, September (1-fish) and October (1-fish). Juvenile coho varied in size from 42-106 mm FL. For Dolly Varden, the greatest CPUE occurred in June and remained fairly stable in summer and fall. No Dolly Varden less than 50 mm FL was captured in minnow traps. Dolly Varden varied in size from 52-165 mm FL. Catch of juvenile rainbow trout decreased from April to June and remained relatively low into July and August. In September and October there was a noticeable increase in juvenile rainbow trout. Small rainbow trout fry (<50 mm FL) were noted in April (1-fish), May (2-fish) and June (1-fish). However, the majority of small rainbow trout fry were observed in September and October. Rainbow trout varied in size from 43-146 mm FL.

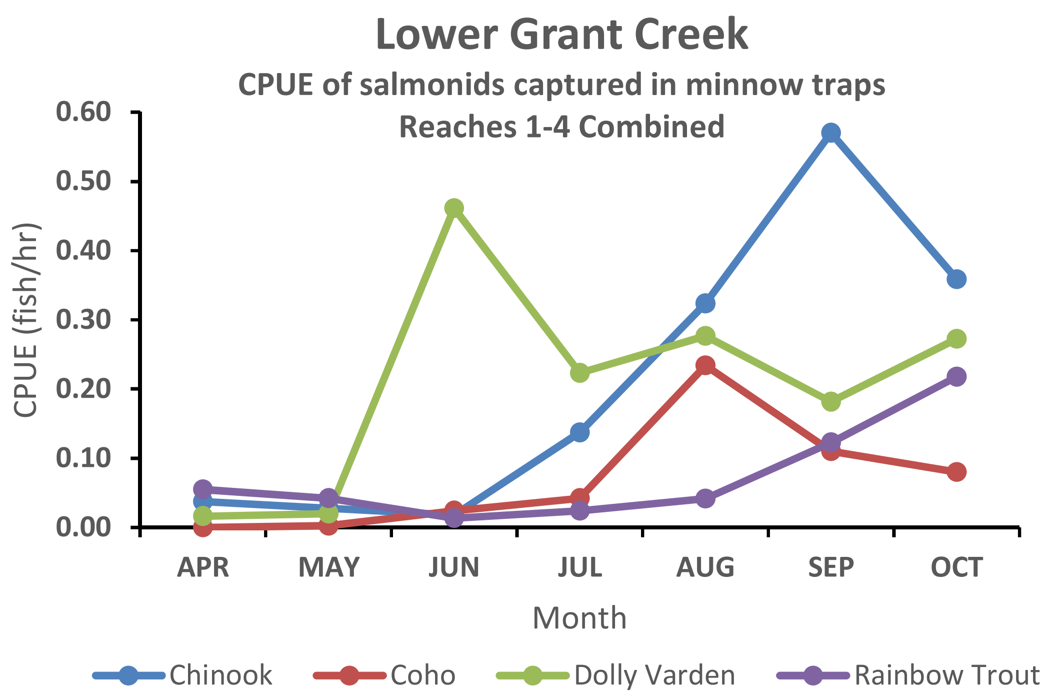

Figure 5.2-6. CPUE for juvenile Chinook, coho, Dolly Varden and rainbow trout from minnow trapping in lower Grant Creek from April through October, 2013.

Table 5.2-13. Numbers of fish collected from minnow trapping in lower Grant Creek from April through October 2013.

Fish Species	Month							
	Apr	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Total**
Chinook	33	24	15	120	280	484	288	1,244
Coho	0	2	20	37	202	93	66	420
Dolly Varden	14	17	371	174	220	143	203	1,142
Rainbow Trout	46	34	10	18	32	92	165	397
Sculpin sp.	19	7	35	40	50	29	78	258
Three-spine Stickleback	0	0	1	1	2	0	0	4
Total	**112**	**84**	**452**	**390**	**786**	**841**	**800**	**3,465**

Most of the patterns of change in fish abundance and CPUE over time is likely the result of new recruits (age-0 fish) that become available for capture (>40 mm FL) in minnow traps post emergence in spring (Chinook and coho) or summer (rainbow trout). What is less apparent is the increase in abundance of Dolly Varden, which is likely explained in part, by new recruits but also habitats that became available (side channels) as flows increased. The low catch of most fish during April and May does not appear to be a bias in sampling method and comports well with snorkel observations at those times.

Most fish that occur in Grant Creek were present in all reaches of lower Grant Creek (Table 5.2-14). No juvenile sockeye or arctic grayling were captured in lower Grant Creek. There were a few three-spine sticklebacks captured in lower Grant Creek (reaches 1 and 3). The number of Chinook and Dolly Varden captured in lower Grant Creek was similar as was the number of coho and rainbow trout.

Table 5.2-14. Number of fish captured in minnow traps in different reaches of lower Grant Creek from April through October 2013.

Fish Species	Lower Grant Creek Reaches (Number)				Total
	1	2	3	4	
Chinook	370	351	390	133	**1,244**
Coho	89	116	176	39	**420**
Dolly Varden	306	150	418	268	**1,142**
Rainbow Trout	75	115	126	81	**397**
Sculpin sp.	57	87	75	39	**258**
Three-spine Stickleback	2	0	2	0	**4**
Total	**899**	**819**	**1,187**	**560**	**3,465**

In lower Grant Creek, CPUE was highest (0.758 fish/hr.) in reach 3 for all fish except sculpins (Table 5.2-15). CPUE for juvenile Chinook was similar in reaches 1 and 2, but for coho the capture rate was nearly twice as high in Reach 3 as other reaches. For rainbow trout, capture rates were fairly uniform in all reaches of lower Grant Creek. Similar to Chinook, Dolly Varden had the highest capture rates in reaches 1 and 3. Unlike Chinook, Dolly Varden had a higher capture rate in Reach 4 than in Reach 2. In lower Grant Creek the capture rates for sculpins was fairly uniform across all reaches. The capture rates presented for lower Grant Creek indicate that there may be some channel or habitat characteristics within different reaches preferred by some fish species.

Table 5.2-15. CPUE for fish captured in minnow traps in different reaches of lower Grant Creek from April through October 2013.

Fish Species	Lower Grant Creek Reaches (CPUE)				Total
	1	2	3	4	
Chinook	0.254	0.203	0.256	0.093	**0.203**
Coho	0.061	0.067	0.115	0.027	**0.068**
Dolly Varden	0.210	0.087	0.274	0.188	**0.186**
Rainbow Trout	0.052	0.066	0.083	0.057	**0.065**
Sculpin sp.	0.039	0.050	0.049	0.027	**0.042**
Three-spine Stickleback	0.001	0.000	0.001	0.000	**0.001**
Total	**0.618**	**0.473**	**0.778**	**0.393**	**0.564**

Capture rates were assessed for juvenile fish in lower Grant Creek by location within the active channel and habitat unit. Channel descriptors were used to describe the location of three broad categories: side channels areas, backwater areas or mainstem areas.

In lower Grant Creek, CPUE was highest in side channel areas followed by backwater areas and then locations within the main stream channel (mainstem) (Figure 5.2-7). Side channels occur mostly in Reaches 1 and 3 and backwater areas occur only in Reaches 2 and 3. Aquatic habitats are discussed in more detail in the Instream Flow Study, Final Report (KHL 2014a).

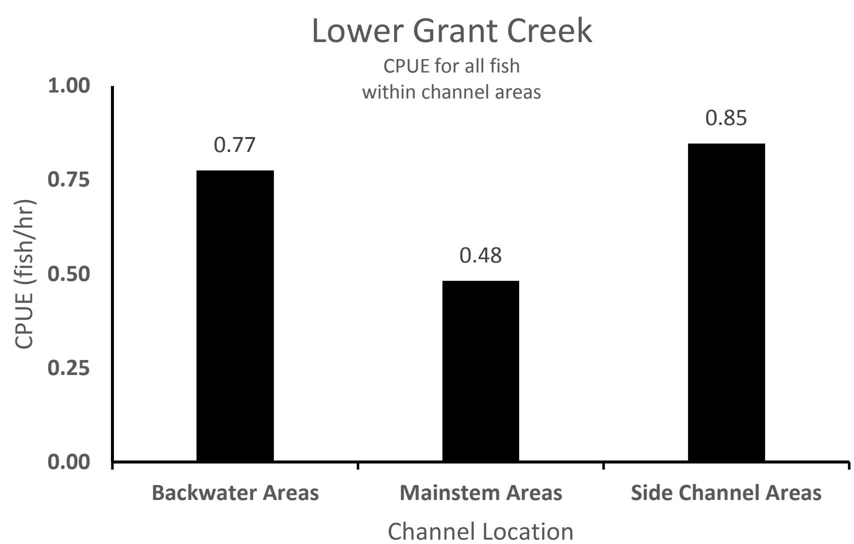

Figure 5.2-7. CPUE for fish captured in minnow traps placed in backwater, side channel and mainstem areas of lower Grant Creek from April through October 2013.

Capture rates for salmonids varied within channel types on lower Grant Creek (Figure 5.2-8). For juvenile Chinook and coho, capture rates were highest in backwater areas while Dolly Varden and rainbow trout CPUE was the highest in side channels. Mainstem areas dominated by riffle habitat had the lowest CPUE for juvenile Chinook and coho. Dolly Varden had the lowest capture rates in backwater areas and rainbow trout capture rates were the same in both mainstem and backwater areas.

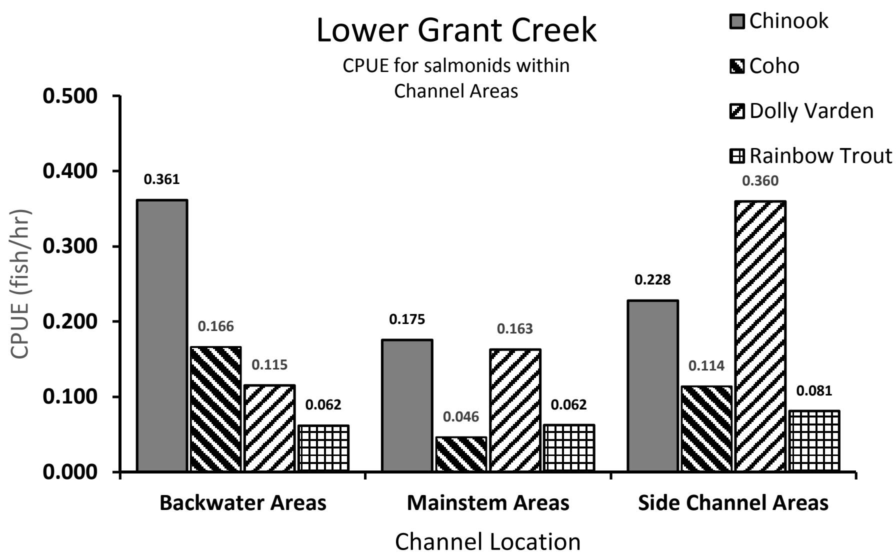

Figure 5.2-8. CPUE for salmonids captured in minnow traps placed in backwater, side channel and mainstem areas of lower Grant Creek from April through October 2013.

In lower Grant Creek, CPUE for salmonids varied by species and habitat unit type (Figure 5.2-9). Catch rates for juvenile Chinook were nearly equal between pools and glides and the least in riffles and pocket water. For coho, the catch rate was highest in pools followed by riffles. No coho were captured in glides. Catch rates for Dolly Varden were highest in glides and runs and lowest in riffle habitat. Juvenile rainbow trout had the highest catch rates in glides and pocket water and was the least in pool habitat. The high catch rates in glide and run habitats are somewhat counterintuitive with basic habitat preferences for most juvenile salmonids. Both of these habitat types were rare in lower Grant Creek.

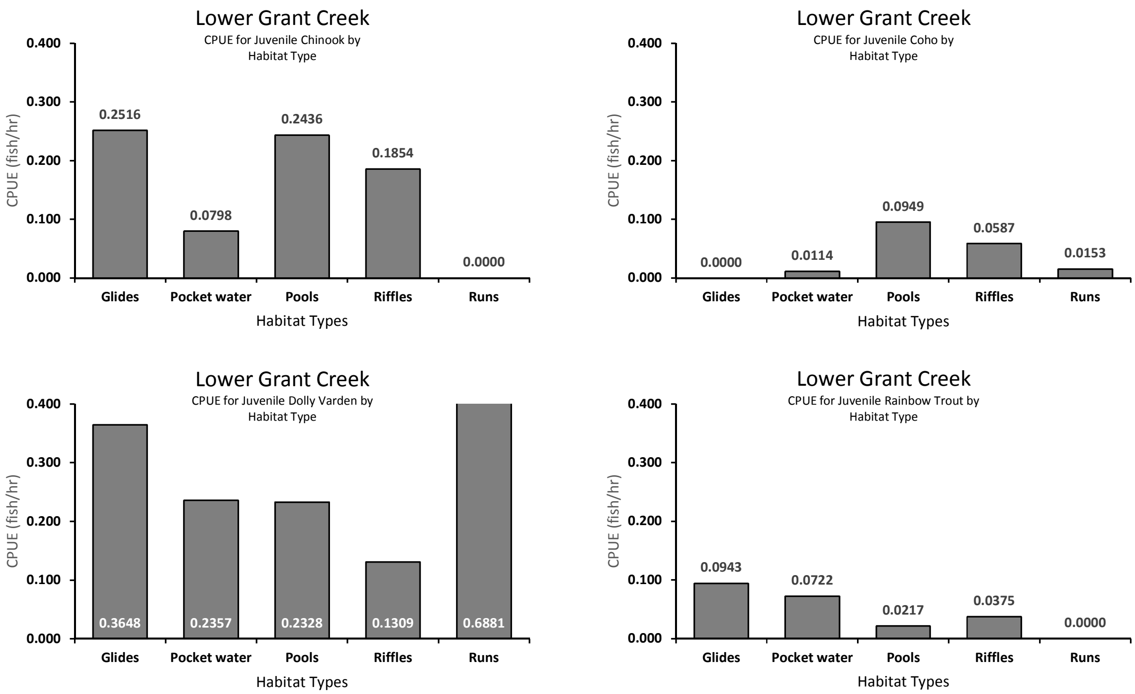

Figure 5.2-9. CPUE for salmonids captured in minnow traps placed in different habitat unit types of lower Grant Creek from April through October, 2013.

Minnow trapping in lower Grant Creek showed that salmonids were present in all reaches of lower Grant Creek with the highest catch rate (0.778 fish/hr) noted in Reach 3. Reach 3 contained all channel types (mainstem, backwater and side channels), which increases both channel and habitat diversity compared to other reaches. The capture rates of salmonids in lower Grant Creek indicate that side channel and backwater areas are important rearing areas (Figure 5.2-7). In particular, catch rates for juvenile Chinook, coho and Dolly Varden were highest in these channel locations likely because large woody debris or greater depth and/or lower velocities provided good juvenile rearing habitat (Figure 5.2-8). Juvenile coho and Chinook tend to prefer large, deep pools with abundant cover (McMahon 1983; Raleigh et al. 1986). Capture rates for rainbow trout were much more even by reach, channel and habitat designation. Rainbow trout, as generalist, appear to have similar requirements for abundant cover but depth (pool habitat) may be less important (Raleigh et al. 1984).

Nighttime snorkeling was used in both April and May to assess species diversity, distribution and relative abundance of fish in lower Grant Creek. From June through October, the water was too turbid to snorkel effectively. In April, low flows (18 cfs) and cold water (0.5-1.5°C) were the prevailing stream conditions. In May, both flow (150 cfs) and water temperature (4.0°C) had increased. These conditions are a good approximation of winter and early spring stream conditions in lower Grant Creek.

In mid-April, most salmonids were observed in pool habitat available in the mainstem and backwater areas of lower Grant Creek (Table 5.2-16). The highest fish density (fish/100 m^2) occurred in backwater areas available in Reach 3. Backwater areas in Reach 2 were frozen over and inaccessible to snorkeling. Riffle habitat had the lowest fish densities in lower Grant Creek. Side channel habitat was covered in snow and ice and was not available for sampling via night time snorkel surveys. Pool habitat (mainstem and backwater) that occurs in lower Grant Creek provides important overwinter habitat.

Table 5.2-16. Number and density of salmonids observed during night time snorkel surveys in lower Grant Creek in April 2013.

Month	Channel	Habitat	Species				Total	Total Area Sampled (m^2)	Fish Density (fish/100 m^2)
			Chinook	Coho	Dolly Varden	Rainbow Trout			
April	Mainstem	Glide	23	0	2	17	**42**	933.2	4.50
		Pool	202	0	15	140	**357**	7,192.6	4.96
		Riffle	5	0	2	32	**39**	8,462.5	0.46
	Backwater	Pool	46	1	1	35	**83**	793.6	10.46
		Total	**276**	**1**	**20**	**224**	**521**	**17,381.9**	**3.00**

Juvenile Chinook were the most abundant fish observed in lower Grant Creek followed by rainbow trout, Dolly Varden, and coho. Almost all juvenile Chinook observed were within the size range of 60-80 mm FL (Table 5.2-17). A few juvenile Chinook (4 fish) were in observed in the 80-100 mm FL size class. All juvenile Chinook observed in April are likely age-1 fish that overwintered in mostly pool habitats of lower Grant Creek. No juvenile Chinook fry (< 40 mm) or age-0 fish were observed in April. Rainbow trout varied in size from about 40-180 mm FL. Most were observed within the size class of 100-120 mm FL. It is reasonable to assume that several age classes overwintered in pool habitat of lower Grant Creek. There were few Dolly Varden and a single coho observed in lower Grant Creek in April. Dolly Varden varied in size from 40-160 mm FL and the single coho that was observed was within the 40-60 mm size class. There were probably several age classes of Dolly Varden overwintering in lower Grant Creek. Night time snorkel observations appear to comport well with minnow trapping that occurred in April. Juvenile Chinook and rainbow trout were the most abundant salmonids observed in April while Dolly Varden and coho were less abundant.

Table 5.2-17. Abundance of salmonids observed in 20-mm increments during night time snorkels surveys in lower Grant Creek in April and May 2013.

Month	Species	Size Classes (20-mm FL increments)									Total
		40 (20-40)	60 (40-60)	80 (60-80)	100 (80-100)	120 (100-120)	140 (120-140)	160 (140-160)	180 (160-180)	>180	
April	Chinook	0	0	272	4	0	0	0	0	0	**276**
	Coho	0	1	0	0	0	0	0	0	0	**1**
	Dolly Varden	0	1	4	11	3	0	1	0	0	**20**
	Rainbow Trout	1	17	31	56	73	32	11	3	0	**224**
	Total	**1**	**19**	**307**	**71**	**76**	**32**	**12**	**3**	**0**	**521**
May	Chinook	0	2	161	42	0	0	0	0	0	**205**
	Coho	0	4	7	1	0	0	0	0	0	**12**
	Dolly Varden	0	0	0	1	2	2	0	0	0	**5**
	Rainbow Trout	0	7	1	9	55	48	20	17	21	**178**
	Total	**0**	**13**	**169**	**53**	**57**	**50**	**20**	**17**	**21**	**400**

In mid-May, as flows and temperature increased most salmonids were still observed in pool habitat available in the mainstem, backwater, and side channel areas of lower Grant Creek (Table 5.2-18). Chinook and rainbow trout were still the most abundant fish observed in lower Grant Creek in May. There were a few Dolly Varden and coho observed. Pools in backwater areas had the highest fish density while riffles in the mainstem areas had the lowest fish density. Interestingly, riffle habitat in side channels had the second highest fish density in May. Glide habitat (non-turbulent fast water) classified in April had become turbulent and less glide-like with increased flows in May.

Table 5.2-18. Number and density of salmonids observed during night time snorkel surveys in lower Grant Creek in May 2013.

Month	Channel	Habitat	Species				Total	Total Area Sampled (m^2)	Fish Density (fish/100 m^2)
			Chinook	Coho	Dolly Varden	Rainbow Trout			
May	Mainstem	Pool	98	1	2	99	**200**	6,138.6	3.26
		Riffle	0	0	0	2	**2**	1,226.3	0.16
	S. Channel	Pool	6	0	1	34	**41**	1,137.1	3.61
		Riffle	7	1	0	22	**30**	676.1	4.44
	Backwater	Pool	94	10	2	21	**127**	1,111.4	11.43
May Total			**205**	**12**	**5**	**178**	**400**	**10,289.5**	**3.89**

Three different size classes of juvenile Chinook were observed in lower Grant Creek (Table 5.2-17). The 40-60 mm FL (2-fish) likely represent recent emerged age-0 fish while Chinook greater than 60 mm FL (203-fish) represent age-1 juvenile Chinook. Chinook emergence had probably started in May. In May, the range in coho size was similar to Chinook but with fewer fish. Coho emergence may have also begun in May. Rainbow trout varied in size from about 40 mm to greater than 180 mm FL. Most (161-fish) were observed within the size classes greater than 100 mm FL. From April to May, there was an increase in the number of larger rainbow trout in lower Grant Creek. Some of the shift in abundance of larger rainbow trout might be explained by growth but it is likely that feeding and spawning opportunities were bringing larger fish into Grant Creek. The number of Dolly Varden observed from April to May decreased and there were fewer small fish observed. The low abundance of Dolly Varden observed by both snorkeling and minnow trapping in winter and early spring might suggest that the higher abundance of Dolly Varden observed later in the year might be the result of both new recruitment and immigration into lower Grant Creek.

The lower incline plane trap was installed on April 30, 2013 and was in operation until October 16, 2013. The trap typically operated 24 hours per day, seven days per week, with few exceptions. The trap was not fished the first two weekends of operation (May 4-5 and May 11-12) since few fish were being captured by the trap. Trapping operations were suspended on three occasions: June 18-23 due to high flows that created safety issues for crews accessing the trap as well as an influx of debris due to bank flooding; September 11-15, also due to high flows and debris; and October 14 due to wind storms that resulted in an excessive amount of leaf litter in the trap. In each of these cases, trap operation was compromised during the period leading up to the time of outage. Throughout the study, the incline plane trap was checked and cleaned at least twice per day, and more frequently when necessary. During the period leading up to the June 18-23 outage, personnel remained on site 24 hours per day, and the trap was checked and cleaned approximately every 3 to 4 hours. During other periods of high debris load, CIAA staff assisted in the maintenance of the trap by checking and cleaning it typically at 2200 hours and 0200 hours.

As the juvenile migration progressed, it became apparent due to the absence of sockeye fry being captured that the incline plane trap was either not capturing fry sized fish, or it was not retaining them in the live box once captured. Salmonid fry were being observed along the margins of Grant Creek where the foot trails had been flooded. However, few fry sized fish were captured in the trap, nor were they being captured in the minnow traps. Both the incline plane trap's live box and the minnow traps were constructed with 0.6 cm square mesh. Through a series of tests, it became apparent that fry sized fish could escape the incline plane and minnow traps once entrained. As such, both incline plane traps were modified by installing 0.3 cm mesh in critical areas, and installing aluminum flashing around the bottom of the live box to create a sanctuary for captured fish. After these modifications, some fry sized fish were captured in the trap; albeit probably after the majority of the sockeye fry migrated into the Trail Lakes system.

In addition to trap outages and the initial poor efficiency in capturing fry sized fish, another complicating factor hindered the trapping of juvenile fish at the incline plane trap as they migrated out of Grant Creek. Upstream of the incline plane trap, located on the left bank is a distributary that at higher flows becomes watered, and which juvenile fish can migrate downstream bypassing the incline plane trap. This channel begins to overflow at approximately 426 cfs, and meanders in a southeasterly direction and eventually dumps directly into Lower Trail Lake without reconnecting to Grant Creek. During periods of flow, this channel was sampled using minnow traps, and contained a relatively high density of juvenile salmonids, suggesting its use as a migratory corridor. Because of this distributary, it was necessary to assess the need to block the juvenile migration into two periods; a period of relatively lower flow (≤ 425 cfs) when the distributary was "dry", and a period of higher flow (≥ 426 cfs), when the distributary was "wet". Furthermore, it was necessary to calculate trap efficiency for each species separately for each flow period in order to estimate juvenile abundance within Grant Creek. Based on the season-wide estimator described in Section 4.2.3, we calculated trap efficiencies for the lower incline plane trap. Estimation of abundance assumes that all fish used to estimate trap efficiency were active migrants; that there was no mortality between the release location and the incline plane trap; and that the marked fish behaved as the natural population would, that is, they distributed naturally within Grant Creek. To meet these requirements, the release location was selected based on guidelines described in Volkhardt, et al. (2007).

As can be seen in Table 5.2-19, ample numbers of Chinook, coho, and Dolly Varden were released to provide a season wide estimate of trap efficiency. However, collectively only 12 sockeye were released, with no recoveries. As such, it is not possible to get an abundance estimate for sockeye in Grant Creek. Likewise, only 13 rainbow trout were marked and released, with a single recovery. For rainbow, it is also not possible to estimate Grant Creek abundance. An additional point of interest is that during periods of higher flow, when migrating juveniles had the opportunity to utilize the upstream distributary, the capture efficiency was actually higher than when the channel was dry. This seems counter intuitive; however, this observation is consistent across all species. While undoubtedly a portion of the outmigrating salmonids were diverted into the distributary, the higher flows may have improved conditions that diverted juvenile fish that did not enter the distributary into the trap, resulting in higher trap efficiencies for all species.

Table 5.2-19. The number of fish released and recovered by species for the two flow blocks and their corresponding trap efficiencies.

Species	Low Flow Condition		High Flow Condition		Trap Efficiency	
	Release	Recapture	Release	Recapture	Low	High
Chinook	380	45	68	10	0.118	0.147
Coho	169	19	110	13	0.112	0.118
Sockeye	3	0	9	0	0.000	0.000
Dolly Varden	248	2	571	41	0.008	0.072
Rainbow Trout	8	0	5	1	0.000	0.200

To determine whether it was necessary to block the data into the high and low flow periods, a test of homogeneity based on a chi-square test of 1 degree freedom using a 2 x 2 contingency table was performed:

	High	**Low**
Caught	r_1	r_2
Not caught	$R_1 - r_1$	$R_2 - r_2$

Where:

R = the total number of fish released during trap efficiency trials; and
r = the number of *R* recaptured at the trap.

The tests of homogeneity during high and low flow conditions found no difference for Chinook and coho salmon; however, there was a flow effect for Dolly Varden. Therefore, a single estimate of trap efficiency was used to estimate abundance for Chinook and coho (0.123 and 0.115, respectively), whereas two seasonal estimates of trap efficiency were used for Dolly Varden (0.008 during the low flow period, and 0.072 during the high flow period).

Since there were a few data gaps due to the incline plane trap being down during high flow and debris conditions, missing days of data were extrapolated based on the calculations described in Appendix 1. The following table presents estimates of abundance for Chinook, coho, and Dolly Varden in Grant Creek, which represents all of Grant Creek upstream of the lower incline plane trap, including Reach 5 (Table 5.2-20).

Table 5.2-20. The number of juvenile migrants by species captured within the lower incline plane trap, and corresponding abundance estimates and standard errors based on capture efficiencies in Grant Creek.

Statistic	Chinook	Coho	Dolly Varden		
			Low Flow	**High Flow**	**Total**
Observed n	577	360	296	673	
Est. N	4,797.6	3,164.9	36,766.0	9,665.2	46,431.2
S.E. N	603.2	546.2	25,979.5	1,470.9	26,021.1

These values should be considered as estimates for parr sized fish only. That is, until the early part of July the incline plane trap was ineffective at catching fry sized fish (≤ 50 mm). By the time the incline plane trap had been fixed, the majority of fry sized fish (i.e., sockeye fry) had already migrated out of Grant Creek.

While an estimate of abundance for Dolly Varden is included, this species exhibits a different life history compared to Chinook, coho, or sockeye. Chinook and coho typically emigrate as both sub-yearlings and yearlings while sockeye migrate out shortly after emergence as sub-yearlings. Dolly Varden on the other hand may rear in small spawning streams for up to 4 years. As such, for Dolly Varden only a small portion of each year class were likely sampled, excluding of course sub-yearlings, which would not have been captured in the trap until after it had been modified. As a final note, the abundance estimates are for the geographical area from the Grant Creek Falls to the lower incline plane trap; which excludes approximately 210 meters from the trap to the Grant Creek confluence. This latter portion of Grant Creek has the highest density of observed spawning for all species of salmonids in Grant Creek; for which the progeny of these spawners would not be captured by the incline plane trap.

Based on fish size and time of sampling at the lower incline plane trap it is clear that juvenile salmonids of multiple age classes over-wintered in Grant Creek (Figure 5.2-10). For juvenile

Chinook, most fish were in the 80 mm range beginning about May 15. These fish are yearling Chinook that have overwintered in Grant Creek. This observation is supported by snorkel surveys conducted in April and May where juvenile Chinook (age-1) were commonly observed. Later, from June to the beginning of August, there appears to be two predominant size classes of juvenile Chinook captured in the trap. The larger individuals of the migration were in the 100-110 mm size class and represent yearling fish. The smaller individuals were around 50-80 mm, which would be consistent with sub-yearling fish. Later, in mid-August, there is a broad distribution of size for juvenile Chinook, and indicates a dominant subyearling migration with fewer yearling fish migrating out of Grant Creek.

For coho salmon juveniles, very few individuals were captured in the trap until the latter part of July (Figure 5.2-10). The fish that were captured earlier in the migration (end of May) however, were in the 60 mm range, and were likely over-wintering yearling fish. Later (early July through early September), coho juveniles ranged in size of 50-100 mm, and likely represent both sub-yearling and yearling fish. From these data, it appears that there were a few coho that over-wintered in Grant Creek. This observation is supported by few juvenile coho being observed during snorkel surveys in April and May.

For rainbow trout, based on the size distribution it appears that multiple year classes were captured early during the spring migration (i.e., mid-May to early June). As spring spawners, rainbow trout fry emerge in the summer, and due to cold water temperatures they do not grow substantially during the winter months. In Figure 5.2-10, it appears that there are at least two size classes of fish captured at the lower incline plane trap in the spring. There were individuals in the 50 mm size range that had overwintered in Grant Creek emerging the previous summer (brood year 2012). In the spring, there were also individuals in the 80-120 size range that likely emerged two years ago (i.e., brood year 2011). In the fall, rainbow trout had a similar size range indicating age-0 fish had recently emerged in the summer of 2013 and some individuals the previous year (age-1+).

For Dolly Varden, juveniles in the range of 80-110 mm were captured beginning mid-May. This indicates substantial over-wintering for Dolly Varden juveniles, which was substantiated with snorkel surveys in April and May. The abundance of migrating Dolly Varden was greatest in July and likely represents multiple age classes.

Collectively, a total of 3,942 fish were processed at the lower incline plane trap (this total does not include extrapolated numbers to account for trap outages); and includes 577 Chinook, 360 coho, 22 sockeye, 969 Dolly Varden, 36 rainbow trout, 833 sculpin (both slimy and coast range), 1,089 three-spine stickleback, and 56 round whitefish. Figure 5.2-11 shows the emigration period of Chinook, coho, and Dolly Varden, respectively. Sockeye have not been included in this analysis as the majority of sockeye migrating out of Grant Creek were likely not captured at the trap due to deficiencies associated with the trap prior to the early July retrofitting and the small size and likely rapid outmigration of sockeye to the Trail Lake system.

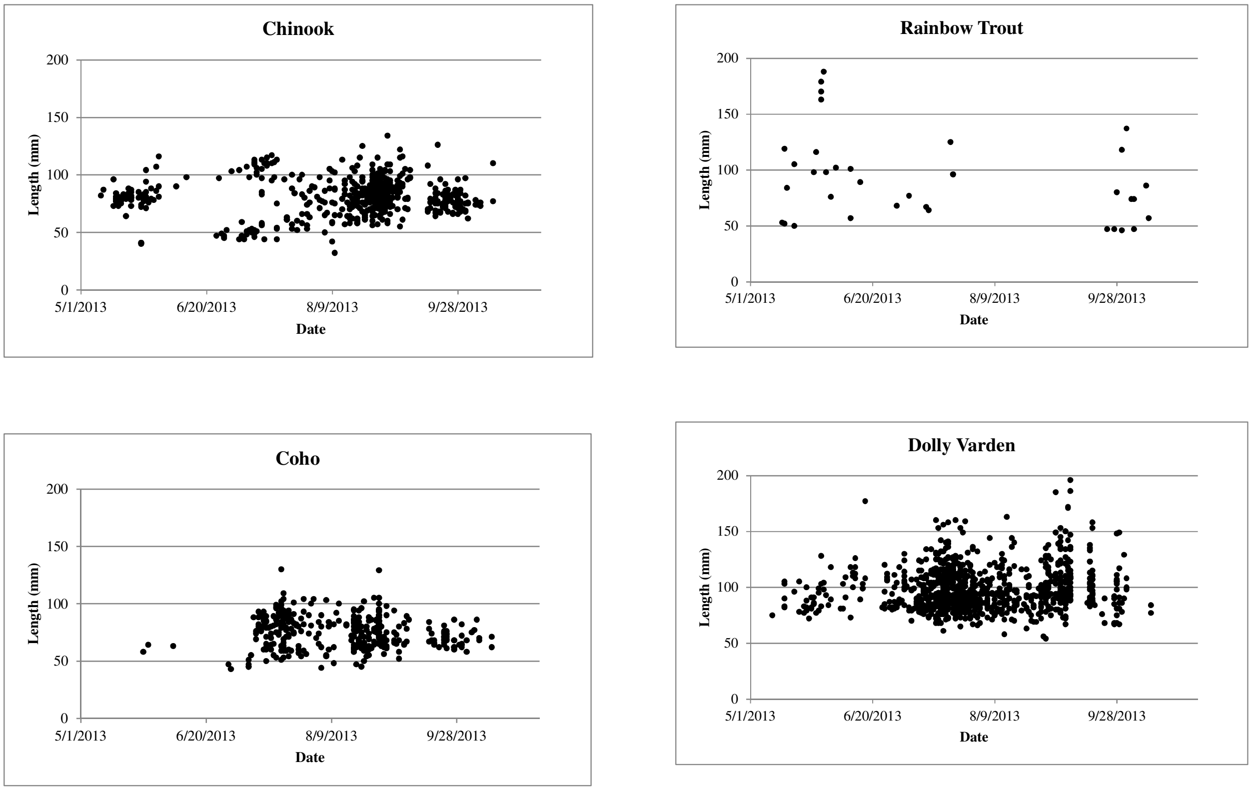

Figure 5.2-10. The distribution of size by date for Chinook, coho, rainbow trout, and Dolly Varden captured in the lower incline plane trap, Grant Creek, Alaska 2013.

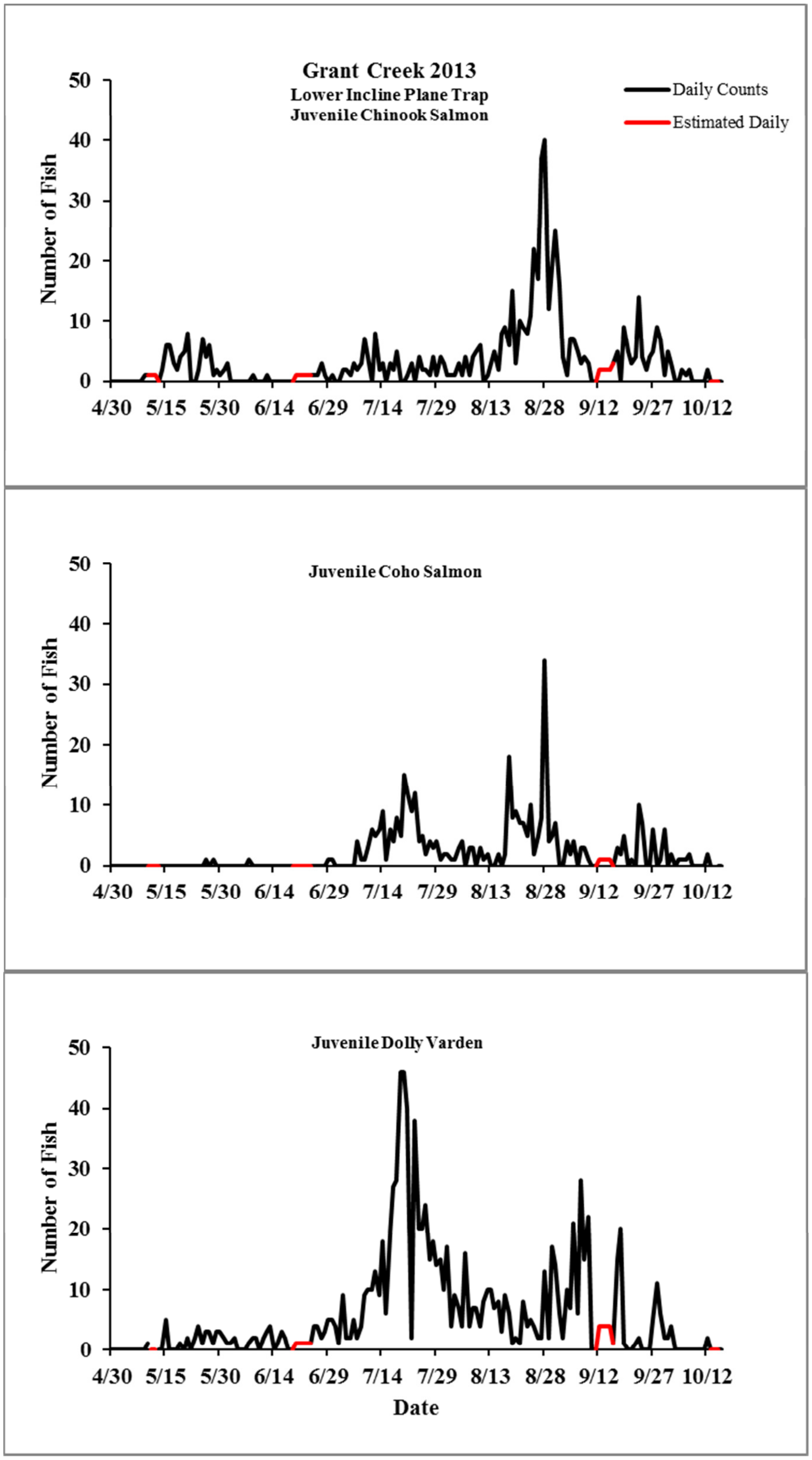

Figure 5.2-11. Emigration timing for Chinook, coho, and Dolly Varden juveniles at the Lower Incline Plane Trap in Grant Creek, Alaska, 2013. Estimated or extrapolated values are highlighted red.

5.3 Trail Lake Narrows Fish and Aquatic Habitats

The Trail Lake Narrows was sampled in July to assess species diversity and relative abundance. Minnow trapping, beach seining and angling were employed to describe baseline conditions in an area of potential impact associated with the installation and use of an access road into the Project Area (Figure 5.3-1). Minnow traps were set in 13 locations with a total fishing effort of 1,133 hours capturing 381 fish (Table 5.3-1).

Table 5.3-1. Number of minnow traps, total effort, number of fish captured and CPUE in the Trail Lake Narrows in July 2013.

Lower Grant Creek Minnow Trapping					
Reach	**Number of Traps**	**Total Effort (days)**	**Total Effort (hrs.)**	**Number of Fish**	**CPUE (fish/hr.)**
Trail Lake Narrow	52	47.2	1,133	381	0.34

Juvenile Chinook and three-spine sticklebacks were the most numerous fish captured in minnow traps followed by coho, Dolly Varden, sculpins sp., rainbow trout and sockeye (Table 5.3-2). CPUE for Chinook and coho was lower in the Trail Lake Narrows than Reaches 1-4 of Grant Creek but greater than Reach 5 of Grant Creek. CPUE for Dolly Varden and rainbow trout in the Trail Lake Narrows was less than all reaches of Grant Creek. Juvenile Chinook captured in minnow traps in July varied in size from 45-121 mm FL indicating that both age-0 and age-1 fish were present. Coho varied in size from 45-97 mm FL. The size range for coho also suggests that age-0 and age-1 fish resided in the Trail Lake Narrows. Rainbow trout varied in size from 63-71 mm FL. Dolly Varden varied in size from 57-184 mm FL, which likely represents several age classes.

Table 5.3-2. Number, proportion and CPUE of fish caught in the Trail Lake Narrows with minnow traps in July 2013.

Lower Grant Creek Minnow Trapping			
Species	**Number**	**Proportion**	**CPUE (fish/hr)**
Chinook	108	0.283	0.095
Dolly Varden	52	0.136	0.046
Coho	62	0.163	0.055
Rainbow Trout	4	0.010	0.004
Sockeye	1	0.003	0.001
Sculpin sp.	38	0.100	0.034
Three-spine Stickleback	116	0.304	0.102
Grand Total	**381**	**1.000**	**0.336**

REV	DATE	BY	DESCRIPTION

N

Drawing Scale: 0 25 50 100 Feet

MCMILLEN, LLC
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OFFICE: 208.342.4214
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Developed For:
Homer Electric Association, Inc.
A Touchstone Energy® Cooperative

GRANT LAKE HYDROELECTRIC PROJECT - FERC PROJECT NO.13212

GRANT LAKE NATURAL RESOURCES STUDY

Figure 5.3-1
Minnow Traps & Angling Locations

DESIGNED J. Woodbury
DRAWN J. Woodbury
CHECKED M. Miller
ISSUED DATE 2/18/2014

DRAWING
1 of 1

SCALE: 1:900

Beach seining was employed at night in three locations where lower velocities and small substrates were conducive to this sampling method. Juvenile Chinook were the most abundant fish captured in beach seines followed by round whitefish and sculpins (Table5.3-3). Other species made up less than five percent of the catch and no coho were captured using beach seining.

Table 5.3-3. Number and proportion of catch for fish seined in beach areas of the Trail Lake Narrows in July 2013.

Species	Abundance	Proportion
Chinook	100	0.58
Dolly Varden	2	0.01
Rainbow Trout	2	0.01
Sculpin sp.	27	0.16
Sockeye	4	0.02
Three-spine Stickleback	5	0.03
Round Whitefish	33	0.19
Total	**173**	**1.00**

Seven angling stations were used to capture fish within the Trail Lake Narrows area (Table 5.3-4). Single, barbless hooks on spinners were used, which allowed the expeditious release of adult salmon (Chinook, sockeye or pink) that were known to be in the area. However, no adult salmon were captured. There was a total of 13 adult trout/char that were hooked, with five of those fish being captured (effort=1 hr./station) for a CPUE of 0.7 fish/hr. Fish that were identified as salmonids were fish that came off the hook close enough to the angler to be identified (4fish). Some fish came off the hook much closer to the angler and species and an estimate of length could be provided (4fish). Five fish were captured and measured for length and weight before release.

Adult salmon, rainbow trout and Dolly Varden occur in the Trail Lakes Narrows area, which is also an upstream migration corridor for fish destined to spawn in Grant Creek and all other tributaries of upper Trail Lake. Likewise, this area is also a downstream migration corridor for salmonid production upstream. Dolly Varden and rainbow trout probably reside in the area taking advantage of juvenile salmon that migrate through or reside in this area. Juvenile Chinook were the most numerous fish captured with minnow traps and beach seines.

Spawning may also occur in this area; depressions (redds) were observed in suitable spawning gravels and sockeye carcasses were recovered in the area that had not been previously sampled. The redds could only be observed after water levels had resided in October.

Table 5.3-4. Angling station and number and size and weight of rainbow trout and Dolly Varden observed in July 2013.

Station	Species	Length (mm FL)	Weight (g)
1	Rainbow Trout	343	424.2
	Rainbow Trout	299	241.8
	Dolly Varden	180	NA
	Dolly Varden	160	NA
	Salmonid	NA	NA
2	Dolly Varden	240	NA
	Rainbow Trout	301	294.0
	Salmonid	NA	NA
3	Salmonid	NA	NA
	Salmonid	NA	NA
4	Dolly Varden	268	191.0
5	No Fish	-	-
6	Rainbow Trout	381	523.8
	Rainbow Trout	220	NA
7	No Fish	-	-

6 CONCLUSIONS

In the section that follows, we summarize the results of fisheries research conducted on Grant Creek in 2013, and describe potential areas of sensitivity that may be affected by hydroelectric development and systems operation.

6.1 Summary of Grant Creek Research

6.1.1 Anadromous Adult Salmonids

Escapement - The key species of adult salmon returning to Grant Creek include pink, Chinook, sockeye and coho salmon. Sockeye salmon were the dominant run entering Grant Creek with 1,117 fish counted above the weir. There were also 10 pink, 23 Chinook and 237 coho salmon counted above the weir. Estimates of salmon escapement based on visual counts (AUC) were within ±12 percent of the weir counts for returning salmon. The estimated escapement based on visual counts for the entire stream were 90 Chinook, 1,169 sockeye and 252 coho salmon.

The estimates for sockeye and coho appeared to be reasonable based on the spawning activity observed below the weir. However, the difference in the Chinook weir count (23 fish) and the estimate for the entire stream (90 fish) implied that 67 additional Chinook spawned downstream of the weir. That estimate appears to be high based on the spawning activity observed below the weir. An estimate of 46 Chinook is a more realistic estimate based on the fish per redd ratio of 7.6 fish/redd that was observed above the weir in 2013.

Run Timing – The period of adult salmon migration into Grant Creek occurs from the end of July and extends over a 13 week period to near the end of October. Pink salmon passed the weir on Grant Creek from the first week of August to the end of August. Chinook salmon passed the weir from the second week of August through the first week of September. Peak passage for pink and Chinook salmon occurred during the weeks of August 4 and August 11, respectively. The adult migration for sockeye occurred over a ten week period from the last week of July to the second week of October. Peak passage for sockeye occurred at the end of August. Coho salmon began entering Grant Creek the second week of September, peaked the first week of October and ended the last week of October. Run timing for Chinook and sockeye in 2013 was at least 1 week earlier than observed in 2009 (HDR 2009b). The sensitive time period based on run timing for adult salmon extends from the last week of July to the last week of October.

Spawning Timing and Distribution – The period of salmon spawning activity in Grant Creek extends over 13 weeks from first week of August to end of October. Pink salmon began spawning in early August with two redds constructed in Reach 1 of Grant Creek. Pink salmon were not observed in Grant Creek during 2009 visual surveys (HDR 2009b). Chinook salmon began spawning in mid-August and built six redds in a three week period. Sockeye began spawning at the end of August building 308 redds within the first two weeks. Sockeye spawning activity was noted until the last week of September. Coho began spawning the first week of October and were complete at the end of the month constructing 72 redds in Grant Creek. The sensitive time period for adult salmon based on spawning was from the first week of August to the end of October.

The majority (95 percent) of critical spawning habitat was concentrated within Reaches 1-3 of Grant Creek. Most (62 percent) documented redds were located in the mainstem areas primarily within riffle (62 percent) and pool (13 percent) habitats. Spawning also occurred in side channels (16 percent) and backwater areas (8 percent). In Reach 1, spawning for pink, sockeye and coho salmon most often occurred in riffle and pool habitat along the stream margins in the mainstem areas away from the thalweg and the highest stream velocities. Chinook spawned only in riffle habitat most often mid-channel where higher velocity and larger spawning substrates occurred. In Reach 2, most spawning occurred in mainstem riffle habitat along the stream margins for sockeye and coho salmon. Irregularities along the stream margin of riffle habitat created areas of lower velocity and suitable spawning substrate. Sockeye and coho also spawned in the stream margins of some pool habitat of Reach 2. In Reach 3, most spawning occurred in pool habitat in mainstem and side channel areas. One large backwater area was also used by sockeye and coho salmon. Spawning activity in Reach 4 was fairly low (4 percent) but did occur in riffle habitat along the stream margins of the right bank. Spawning also occurred along the left bank in pocket water. Spawning in Reach 5 was also low (1 percent) and occurred along the stream margins in step pool habitat in the lower end of the reach.

6.1.2 Resident Adult Salmonids

Run Timing and Abundance – Rainbow trout and Dolly Varden are identified as key species migrating into Grant Creek. The period of migration for rainbow trout lasted 6 weeks from the end of May to the end of June. The weir was not operational at the start of May, which could extend the period of migration by at least three weeks. There were 13 adult rainbow trout that passed the weir on Grant Creek. The abundance estimate is probably low considering the lack of coverage early in the season and based on undocumented passage of previously tagged fish. The migration period for Dolly Varden lasted 4 weeks from mid-August to mid-September. There were 14 Dolly Varden that passed the weir on Grant Creek.

Spawning Distribution - Of the 20 adult rainbow trout that were surgically implanted with radio transmitters, three males and one female were detected within Reach 5 subsequent to their release. Based on radio telemetry mobile surveys and detections by the fixed-site system at the Reach 4/5 break, it does not appear that any of the radio-tagged rainbow trout spawned within Reach 5. However, while no redds or adult rainbow trout were observed during surveys of Reach 5, given the poor water clarity, the probability of spotting live fish or redds was extremely low. Furthermore, no rainbow trout redds were observed anywhere within Grant Creek in 2013. The fact that suitable gravel exists in Reach 5 to support rainbow spawning, and the fact that rainbow trout fry were captured in minnow traps within Reach 5 strongly suggests that spawning does occur within this portion of Grant Creek; to what extent, however, is unknown.

It should be noted that it is possible that many of the tagged rainbow trout were not in spawning condition. The original intent was to have the weir operational on May 1, as rainbow will begin their spawning migration when stream temperatures reach about 4° C. However, due to a variety of factors, including high flows and the undercut bank discussed in Section 4.1.1, the weir was not fully functional until early July. Prior to that time, it is highly likely that a proportion of the rainbow trout that migrated past the weir was not intercepted, and therefore a proportion of the spawning population was missed.

The detections of fish in Reach 1 and 2 occurred throughout the period radio-tagged rainbow trout were detected within Grant Creek (May 25 through October 17), whereas detections in Reach 3 occurred primarily shortly after tagging (June 20 through August 15); and the single detection in Reach 4 occurred on June 28. As discussed in Section 5.2.2.1, no rainbow trout redds were observed in Grant Creek in 2013. However, due to the poor water clarity and high flows, that was not unexpected. Detections primarily in Reach 3 shortly after tagging, coupled with suitable pockets of gravel at the locations of detection suggest that it is possible that rainbow trout spawned in Reach 3; including both the mainstem of Grant Creek and the secondary channel. The location of detections in Reach 3 for rainbow trout correspond with the location of observed redds for both sockeye and coho. And while spawning substrates for the three species varies to some degree, the observations for Chinook, sockeye and coho indicate that due to the limited amount of spawning gravel in Grant Creek, the fish will spawn in what visually appears to be marginal spawning habitat. However, it should be noted that observations of radio-tagged rainbow in Reach 3 may well have been due to tagged fish taking advantage of feeding opportunities at those locations.

Feeding Distribution - Mobile detections of rainbow trout can be further scrutinized as to location by reach (i.e., mainstem, backwater areas and side-channels) and habitat type. Of the 124 detections within Reach 1, all were located within the mainstem, with 23 detections within pools and 101 detections within riffle habitat. A total of 40 detections occurred within the Reach 2 mainstem, with 19 detections within pool habitat, 13 in riffle habitat and 8 detections within backwater areas. Within the Reach 3 mainstem, 9 detections were observed in pool habitat and 11 in riffle habitat. Within the Reach 3 Predominant Side Channel, three detections were observed in pool habitat and 11 detections within riffle habitat, and three detections were recorded in the Reach 3 Secondary Channel within pool habitat. Finally, a total of three detections were observed in the Reach 4 mainstem; with 1 detection in each of pool, riffle and pocket water habitat.

Furthermore, of the 20 radio-tagged rainbow trout, all 20 were detected at some point within Reach 1 (either by the fixed telemetry station or during mobile surveys). Fourteen of the twenty tagged rainbow were also detected in reaches two and three, three in Reach 4, and as discussed previously, four in Reach 5. The tagged Dolly Varden was not detected at any time after release.

The majority of rainbow trout detections were in Reach 1 and to a lesser extent, the lower portion of Reach 2. These areas were also where the greatest concentration of sockeye and coho spawned. Detections of rainbow trout in these areas occurred throughout the tracking period and toward the end of the study. Near the end of the study period, these areas were the only locations where tagged rainbow resided. These factors indicate that while it is possible that some rainbow spawned within this area, fish likely resided within this area to take advantage of feeding opportunities.

6.1.3 Juvenile Salmonids

Grant Creek Juvenile Abundance and Emigration – There was a total of 4,798 Chinook, 3,165 coho and 46,431 Dolly Varden juveniles that were estimated to have migrated out of Grant Creek in 2013. These estimates represent Reaches 1-5 upstream of the lower incline plane trap and only includes parr sized fish. The trap was modified in early July to capture fry-sized fish (<50 mm), but it was likely too late to capture the majority of fry sized fish (i.e., sockeye, Chinook and fry) as they likely already migrated out of Grant Creek. For juvenile Chinook, emigration from Grant Creek peaked in mid-to-late August and again in September. A smaller peak occurred in May as age-1 fish emigrated from Grant Creek. Juvenile emigration for coho also peaked in mid-to-late August and in mid-to-late July. Juvenile emigration for Dolly Varden peaked in July and again in late August-early September.

Use of Reach 5 – Reach 5 of Grant Creek provides some juvenile rearing habitat but it is low in comparison to Reaches 1-4. The predominance of cascade habitat in Reach 5 likely influences the amount of juvenile habitat. Minnow trapping in step pool and pool habitat conducted in Reach 5 of Grant Creek from April through October captured 205 fish. Juvenile rearing habitat in Reach 5 occurs for Chinook, coho, rainbow trout, Dolly Varden and sculpin sp. Dolly Varden were the most numerous fish observed. The CPUE for all fish in Reach 5 was low (0.16 fish/hr) relative to Reaches 1-4 (0.56 fish/hr). Juvenile rearing habitat consisted mostly of step pool habitat and stream margins during most of the year. Snorkeling conducted in April and May documented that a few (16 fish) rainbow trout (60-280 mm fork length) rear in Reach 5 during winter and early spring.

No estimate of abundance in Reach 5 was obtained with the upper incline plane trap. Due to extreme flow conditions, trapping at this location was terminated. Trap operation resumed on September 19. Due to extremely high seasonal flows, it is unlikely that any emigrant trapping method (incline or screw trap) will produce the estimates of interest from Reach 5.

During the operation of the upper incline plane trap, a total of 172 fish were processed. Of those, there were 8 Chinook, 1 coho, 7 Dolly Varden, 5 rainbow trout, 19 sculpin and 132 sticklebacks. Due to the low numbers of species of interest, no fish were marked to assess trap efficiency, and therefore no estimates of abundance are available.

Use of Reaches 1-4 – Reaches 1-4 of Grant Creek provide the majority of juvenile rearing habitat in Grant Creek. Minnow trapping from April through October captured 3,468 fish. Relative abundance of fish caught in minnow traps expressed as both CPUE and proportion of total catch was highest in Reach 3 followed by Reach 1, Reach 2 and then Reach 4. Reach 3 contained the greatest diversity of habitats with pools and riffles represented in many areas (side channels, backwater areas and mainstem).

Snorkel surveys in mid-April demonstrated that Chinook, coho, rainbow trout and Dolly Varden overwinter in Reaches 1-4 on Grant Creek. In winter, most salmonids were observed in pool habitat available in the mainstem and backwater areas of lower Grant Creek (Reaches 1-4). The highest fish density (10.5 fish/100 m^2) occurred in backwater areas available in Reach 3. Riffle habitat had the lowest fish densities (0.5 fish/100 m^2). Side channel habitat was covered in snow and ice and was not available for sampling via night time snorkel surveys. Pool habitat (mainstem and backwater) that occurs in Reaches 1-4 of Grant Creek provides important overwinter habitat.

In Reaches 1-4 of Grant Creek juvenile Chinook and Dolly Varden were the most numerous fish captured followed by rainbow trout, coho, sculpins sp. and three spine sticklebacks. Repeated sampling showed that relative abundance increased from fairly low levels in April and May representing late winter and early spring stream conditions to much higher levels in late spring, summer and fall (June-October).

Recently emerged Chinook fry (<50 mm FL) were first noted in minnow traps in June but fry of this size were also noted in July and August. Juvenile Chinook varied in size from 45-110 mm fork length. Recently emerged coho fry (<50 mm FL) were first noted in minnow traps in July but fry of this size were also noted in August, September (1-fish) and October (1-fish). Juvenile coho varied in size from 42-106 mm FL. For Dolly Varden, the greatest CPUE occurred in June and remained fairly stable in summer and fall. No Dolly Varden less than 50 mm FL were captured in minnow traps. Dolly Varden varied in size from 52-165 mm FL. Catch of juvenile rainbow trout decreased from April to June and remained relatively low into July and August. In September and October there was a noticeable increase in juvenile rainbow trout. Small rainbow trout fry (<50 mm FL) were noted in April (1-fish), May (2-fish) and June (1-fish). However, the majority of small rainbow trout fry were observed in September and October. Rainbow trout varied in size from 43-146 mm FL.

The highest CPUE in Reaches 1-4 of Grant Creek occurred in side channel areas followed by backwater areas and then locations within the main stream channel. Side channels occur mostly in Reaches 1 and 3 and backwater areas occur only in Reaches 2 and 3. For juvenile Chinook and coho, capture rates were highest in backwater areas while Dolly Varden and rainbow trout CPUE was the highest in side channels. Mainstem areas dominated by riffle habitat had the lowest CPUE for juvenile Chinook and coho.

In Reaches 1-4 of Grant Creek, CPUE for salmonids varied by species and habitat unit type. Catch rates for juvenile Chinook were nearly equal between pools and glides and the least in riffles and pocket water. For coho, the catch rate was highest in pools followed by riffles. No coho were captured in glides. Catch rates for Dolly Varden were highest in glides and runs and lowest in riffle habitat. Juvenile rainbow trout had the highest catch rates in glides and pocket water and was the least in pool habitat.

Minnow trapping in lower Grant Creek showed that salmonids were present in all reaches of Grant Creek with the highest catch rate (0.78 fish/hr.) noted in Reach 3. Reach 3 contained all channel types (mainstem, backwater and side channels), which increases both channel and habitat diversity compared to other reaches. The capture rates for salmonids in Reaches 1-4 of lower Grant Creek indicate that side channel and backwater areas are important juvenile rearing areas.

6.1.4 Trail Lake Narrows

Adult salmon, rainbow trout and Dolly Varden occur in the Trail Lakes Narrows area. The Trail Lake Narrows area is an upstream migration corridor for fish destined to spawn in Grant Creek and all other tributaries of upper Trail Lake. Likewise, this area is also a downstream migration corridor for salmonid production upstream. Dolly Varden and rainbow trout probably reside in the area taking advantage of juvenile salmon that migrate through or reside in this area. This area may also provide spawning and resting areas for adult salmon. Redds in suitable spawning gravels and sockeye carcasses were found that had not been sampled. Chinook and coho salmon may spawn in this area as well.

Juvenile Chinook and three-spine sticklebacks were the most numerous fish captured in minnow traps followed by coho, Dolly Varden, sculpins sp., rainbow trout and sockeye. CPUE for Chinook and coho was lower in the Trail Lake Narrows than Reaches 1-4 of Grant Creek but greater than Reach 5. Juvenile Chinook captured in minnow traps in July varied in size from 45-121 mm FL indicating that both age-0 and age-1 fish were present. Coho varied in size from 45-97 mm FL. The size range for coho also suggests that age-0 and age-1+ fish were present in the Trail Lake Narrows. Rainbow trout varied in size from 63-71 mm FL. Dolly Varden varied in size from 57-184 mm FL with several age classes represented.

6.2 Potential Impacts Associated with the Construction and Operation of a Grant Creek Dam

This section summarizes potential impacts associated with the construction of the proposed Project. It should be noted that this summary is not intended to replace a detailed analysis of expected impacts using integrated Physical Habitat Simulation System (PHABSIM) results at a later date. It does, however, address perceived flow modification impacts based on operations as currently proposed for an average water year. Some potential impacts associated with the Project are not addressed in this section but will be more fully addressed in the DLA. Those potential impacts are:

- Gravel Recruitment – see Geomorphology Report (KHL 2014b);

- Temperature Variances – see Water Quality, Temperature and Hydrology Report (KHL 2014c);
- Outfall Design and Location; and
- Established Minimum Flows, Operational Scenarios and Ramping Rates.

The following assumptions were used to assess potential impacts:

- During the months of December through April, the powerhouse would generally be operated at a low level; that is, the smallest unit operating at sub-maximum capacity with a minimum flow condition (unknown level) established in the bypass segment of Reach 5;
- During the month of May, the lake level would be maintained, the minimum flow condition would be maintained through Reach 5, and the remainder of Grant Creek would be primarily operated as run-of-river. Therefore, the amount of flow through the powerhouse would be equal to the balance of run-of-river flow minus the Reach 5 minimum flow barring unforeseen circumstances such as higher or lower than normal run-off during this period;
- During June and July, the powerhouse would be operated at peak capacity with minimum flow conditions through Reach 5; and
- During the period of August through November, the system would be primarily operated in a run-of-river mode (based on current hydrology); that is, there would be a minimum flow condition within Reach 5, and the surplus would be ran through the powerhouse.

It should be noted that some variability still exists and that engineering feasibility work is currently underway to accurately refine the operating regime and fully specify infrastructural and operational parameters. This finalized work, after collaboration with stakeholders, will be fully documented in the Draft and Final LAs.

The operations described above would likely result in lower flows within Reach 5 throughout the year, with the period of December through April least impacted, and with the period of May through November lower relative to historic levels depending on minimum flow constraints. In June and July, once Grant Lake is refilled, flows within Reach 5 will increase but they will again be lower than historic levels.

Within Reaches 1-4 during the period of December through April, flows are expected to exceed historic levels, with the exception of December. For the months of May through November, excluding June and July, flows through Reaches 1-4 will follow run-of-river regimes (historic levels). In June and July, flows within Reaches 1-4 will decrease relative to historic levels until Grant Lake is refilled. Once the lake is refilled, flow levels within Grant Creek will return to run-of-river levels. As an additional note, it is likely that operations, in general, will sustain high flows for longer periods permitting the more consistent connection of side channel habitats.

6.2.1 Reach 5

6.2.1.1 Egg Incubation

A decrease in flows during the incubation period would result in more exposure of the channel bed and bank within Reach 5. The degree to which this will negatively affect salmonid incubation is unknown. However, given the nature of the canyon reach, which consists of nearly vertical walls, channel morphology may limit channel bed and bank exposure. Only 1 percent of the documented spawning that occurred in Grant Creek was in Reach 5.

Project operations are expected to result in decreased sediment transport through Reach 5 due to lower flows. This will decrease gravel recruitment to the stream including Reaches 1-4 (KHL 2014b). These alterations within Reach 5 may have the potential to negatively impact both resident and anadromous salmonid species.

6.2.1.2 Adult Spawning

Project operations may have varied impacts to spawning adult salmon and resident fish. With lower flows, some areas suitable for spawning may no longer be available to spawning salmonids, with a net loss in suitable spawning habitat. Proposed operations of the Project will likely result in more stable flows during spawning for both anadromous and resident species, which will likely have a neutral to slightly positive effect (reduced scour).

6.2.1.3 Juvenile Rearing

Decreased winter flows will likely have no net impact on rearing juveniles within Reach 5. The canyon reach is primarily cascade (57 percent), step pool (29 percent) and pool (14 percent) habitat, which provides ample rearing habitat at current winter flow conditions. However, a decrease in summer flows (and velocities) may increase juvenile habitat during that period of time. Natural flow conditions during high flow periods result in extremely high velocities within the canyon reach, resulting in a loss of suitable habitat (lower velocity areas) for juveniles. A decrease in flows may result in more juvenile habitat relative to current conditions.

6.2.2 Reaches 1-4

Hydrological impacts to Reaches 1 through 4 based on the Project operations described in the previous section are expected to result in an increase in the annual instream baseline flow (i.e., January through April); run-of-river operations in May; decreased flows in June and July until Grant Lake is refilled, at which time flows would revert to run-of-river; run-of-river flows August through November; and a slight decrease in flows in December.

These hydraulic conditions may result in the Reach 3 side channels being open throughout the winter. While current flows within Grant Creek are sufficient to maintain flow within these channels, they become snowed over. Higher flows may be sufficient to keep that from occurring.

The Reach 2 distributary would likely begin to flow later in the summer than it does under current conditions within an average water year, and would become watered once Grant Lake refilled during the June-July period. As flows for the period of August through November will likely be operated in a run-of-river mode, the Reach 2 distributary will dry up as it currently does in an average water year; that is, sometime in August.

Given the lower flows necessary to maintain flow within the Reach 1 distributary (109 cfs), it would remain watered during the period of May through November (based on an average water year).

6.2.2.1 Egg Incubation

The proposed operations would likely have a positive effect on incubating eggs within the mainstem of Grant Creek for anadromous species; particularly in areas that dewater or have minimum sub-surface flows during winter months (e.g., margins where fish have spawned, near the left bank upstream of the weir, etc.). This assumes of course, that baseline flows will be maintained at a high enough level relative to the natural conditions to keep these areas watered. To what extent survival will be increased is unknown at this time.

Likewise, increased late fall, winter and early spring baseline flow will likely benefit incubating eggs within the Reach 3 Predominant and Secondary side channels. Both of these channels begin to flow as soon as the snow and ice melt, but intra-gravel conditions during winter incubation are unknown. However, any increased flows during this period would likely improve incubation survival, assuming that flow is maintained within these channels during the incubation period. Again, to what extent is unknown.

For the Reach 2 distributary, there will likely be no net change in egg incubation. Under both current and potential hydrological conditions, that distributary is not watered continuously during the spawning/incubation period for either resident or anadromous salmonids. As such, there are no eggs incubating within this distributary.

Likewise, it is unlikely that there would be any net change to the Reach 1 distributary regarding egg incubation. No spawning was observed in this distributary despite flows occurring throughout most of the period of spawning observed in Grant Creek. This channel does not have substrate conducive to salmonid spawning, and therefore no change would be expected.

6.2.2.2 Adult Spawning

During the period of anadromous salmonid spawning within the mainstem of Grant Creek (August through October), the proposed operating scenario would result in run-of-river conditions. Therefore, no impact is anticipated. For resident species, which likely spawn in May and the first half of June, flow will likely be the same as natural conditions in May, and somewhat less in early June due to the refilling of Grant Lake. As the flow alterations in early June are relatively minor, no impact would be expected.

During anadromous and resident spawning in the Reach 3 side channels, flows are expected to be run-of-river (as described in the preceding paragraph). As such, no benefit or negative impact would be expected.

During stream surveys in 2013 of the Reach 2 distributary, no spawning of resident or anadromous species was documented. While this channel will likely be dewatered for a greater period of time relative to natural conditions, it does not occur during the anadromous spawning period. And while resident species could spawn within this channel, under natural conditions redds would become dewatered and developing embryos would die. As such, no change impacts or benefits would be expected for resident spawning.

6.2.2.3 Juvenile Rearing

Within the mainstem of Grant Creek, under proposed operations flows would increase during winter months, decrease slightly in June and July and follow run-of-river flows in May and August through November. In winter, modest increases in flow may result in an increase of juvenile over-winter rearing habitat. In general, weighted usable area (WUA) for juveniles increases at the lower end of the flow regime in Grant Creek with increases in flow (KHL 2014a). During June and July when flows are somewhat decreased, it may result in more juvenile habitat being maintained. That is, under high flow conditions, some juvenile habitat becomes more turbulent with greater velocity, which decreases available juvenile habitat. It should be noted however, that when flows increase dramatically, the margins of Grant Creek begin to flood, which provide excellent habitat for juvenile salmonids, especially young of the year. Given these scenarios, it is not possible to determine what impact may be expected without further IFIM analysis. That is, general trends in WUA for fry tend to increase with flow in some areas while for other areas WUA decreases.

As discussed above, it is possible that higher winter flows may result in the Reach 3 side channels being open during winter months. Should this occur, it would make a large amount of over winter habitat available to rearing juveniles. Given the quality of these side channels, this would certainly increase juvenile overwinter habitat. During the spring, summer and fall periods, the available habitat would not likely change much, if at all. Therefore, no impact or benefit would be expected.

For the Reach 2 distributary, the altered flow regimes would likely result in that channel being dewatered for a greater period of time relative to natural conditions, and would likely occur during the June/July period. This alteration would result in the loss of a substantial amount of juvenile rearing habitat that is currently utilized by both anadromous and resident species. To what extent this alteration would have on juvenile fish is unknown.

The Reach 1 distributary should remain watered similarly under the altered conditions relative to natural conditions. As such, no impact or benefit would be anticipated.

6.2.3 Global Issues

The discussion presented in the preceding sections is based on one possible operating scenario. Issues and perceived impacts may change depending on refinements to that scenario. As that scenario is refined, aquatic impacts will be refined accordingly and will be further detailed in the DLA. While only mentioned briefly in the previous section, minimizing impacts associated with ramping rates, temperature variances and gravel recruitment should be considered during the Project design phase and when developing Project operations. Establishment of minimum flow requirements, both in Reach 5 and lower Grant Creek, as well as outfall design should be considered as the Project is more fully developed. Ongoing efforts in the Aquatic Resources Working Group will help refine potential impacts, which will assist in development of PM&E measures and preparation of the DLA.

In this section there is a brief discussion of some aspects of Project operation that may be addressed in the DLA as operational scenarios are fully developed. For example, the rate in which Project flows are ramped up, and especially decreased can result in stranding and mortality of juvenile salmonids. Stranding has the potential to isolate fish in areas of the river channel where predators or increased water temperatures can cause mortality. Typically, smaller juvenile fish are the most vulnerable to potential stranding because of their habitat preference and poor swimming ability. The incidence of stranding for juvenile fish is affected by river channel configuration, time of day, substrate type and water temperature among other factors.

Seasonal temperature variances may occur in winter and early spring as warmer water from Grant Lake is bypassed through the project downstream to Grant Creek (KHL 2014c). Temperature changes as small as 2°C can affect the rate of egg development during the incubation period, thus effecting time of hatching and emergence (Scannell 1992). Accelerated development leading to early emergence can have several disadvantages such as decreased foraging ability or emergence before suitable prey species are available and increased susceptibility to predation (Scannell 1992).

A reduction in gravel recruitment to Grant Creek is likely to diminish the quantity and quality of spawning habitat in Grant Creek (KHL 2014b). As discussed in KHL (201b), these impacts are likely to occur incrementally over time, and are typically measured in years and decades as the result of flow bypassed around the canyon reach. The canyon area of Grant Creek (Reaches 5 and 6) is the primary source of sediment recruitment.

7 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

In this section, variances that occurred from the FERC-approved study plan are discussed.

The upper incline trap had to be taken out of operation because of dangerous working conditions and potential loss/destruction of equipment. Due to extremely high seasonal flows, it is unlikely that any emigrant trapping method (incline or screw trap) will produce the estimates of interest from Reach 5.

For the lower incline plane trap, the size of mesh used on the incline plane and more importantly the live box did not allow for capture and retention of small age-0 fish (<50 mm). No estimate of fry size fish is provided. The estimate provided in this report is largely for parr and smolt sized emigrants from Grant Creek. Modifications to the trap were completed in mid-July to improve trap efficiency but this was probably too late for most of the smaller age-0 emigrants.

The weir was placed in Grant Creek in late May, which may have been too late to assess total abundance and run timing for adult rainbow trout. The location of the weir may have also been an issue. The weir was placed across a stream channel with an undercut bank that likely allowed rainbow trout to move both upstream and downstream of the weir. In July, when the weir was inspected, measures were taken to close the gap with additional pickets. Unfortunately, this was too late for the rainbow trout migration period. As a result, angling was used to secure rainbow trout for tagging. Most of the fish captured and tagged from angling occurred in July, which is likely past the spawning period. As such, it was not possible to identify areas of rainbow trout spawning within Grant Creek. Natural high flows during the upstream migration of adult rainbow trout make accurate data collection related to this component of Grant Creek research an annual issue.

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Appendix 1: Estimating Salmonid Outmigrant Abundance at Grant Creek

Estimating Salmonid Outmigrant Abundance at Grant Creek

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Introduction

The purpose of this analysis is to estimate the outmigrant abundance of salmonid species at Grant Creek in 2013. An incline plane trap was used to obtain a daily index count, which could then be adjusted for trap collection efficiency. This analysis estimates outmigrant abundance of Chinook salmon, coho salmon, and Dolly Varden over the outmigration season. The estimation process accounts for missing index data and provides standard error calculations. We also report the number of rainbow trout and sockeye captured at the incline plane trap but no estimates of their abundance are provided. Sample sizes were too small for reliable estimates of rainbow trout and sockeye salmon.

Study Design

A single incline plane trap was located downstream from an overflow channel along Grant Creek (Figure 1). That trap provided daily or near daily index counts of captured fish by species. Above the trap and overflow channel, periodic calibration releases were performed (Figure 1) to estimate the trap efficiency of the include lane. The calibration releases actually estimate the joint probability of a fish staying in Grant Creek and being detected (i.e., captured) by the incline plane trap. Similarly, the fish at the trap also represent fish that stayed in Grant Creek and were captured at the trap. Hence, the migrant abundance estimated is the number of juveniles present at the location of the efficiency releases. The overflow channel on Grant Creek became active at a flow ≥426 cfs and potentially directed fish past the incline plane trap during the three periods 30 May-3 August, 10-14 August, and 7-15 September.

Statistical Methods

Season-Wide Estimator

The season-wide estimator of total juvenile abundance $\left(\overset{*}{N}\right)$ is the sum of estimated abundance when the index counts at the incline plane trap are present $(\tilde{N})$ and during periods when such data are missing $\left(\hat{N}_j\right)$, i.e.,

$$\overset{*}{N} = \tilde{N} + \sum_{j=1}^{k} \hat{N}_j$$

where k = number of missing trap index count events during the season.

Specifically, the estimate of total migrant abundance can be written as follows:

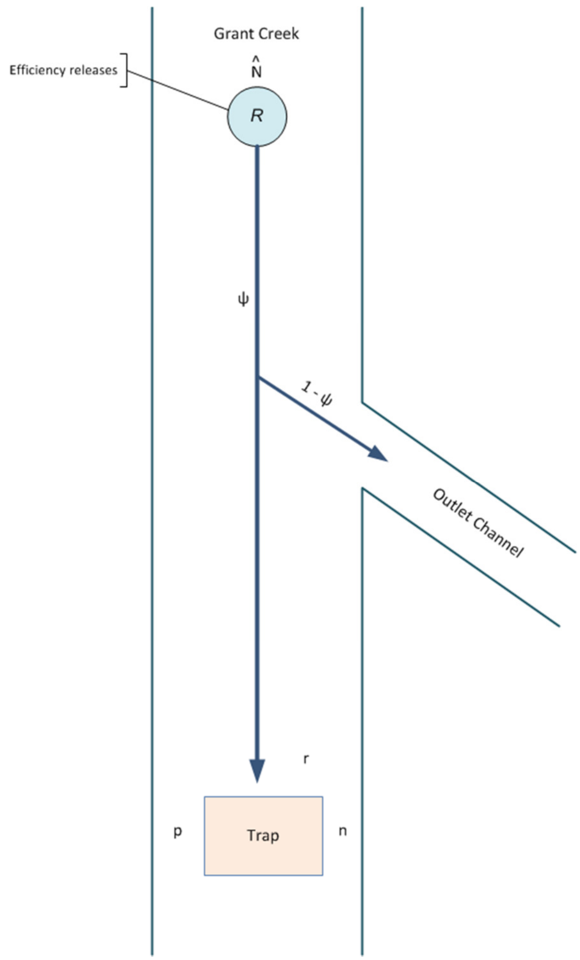

Figure 1. Schematic of migrant abundance $(\hat{N})$ estimation process including trap efficiency releases (*R*), downstream recovery numbers (*r)*, the probability of capture at the trap (*p*), probability a migrant remains in the river (ψ), and the number of fish caught in the trap (*n*). As such, $E(n) = N\psi p$ and $E(r) = R\psi p$, permitting abundance estimation as $\hat{N} = n/(r/R)$.

$$\overset{*}{N} = \frac{n}{\left(\frac{r}{R}\right)} + \sum_{j=1}^{k}\left[\frac{\left[\frac{n_{ji-2} + n_{ji-1} + n_{ji+1} + n_{ji+2}}{4}\right]d_j}{\left(\frac{r}{R}\right)}\right] \qquad (0)$$

where

n = total index count at incline plane during periods of operations,

R = total number of fish released during trap efficiency trials,

r = number of *R* recaptured at trap,

n_{ji-1} = number of index fish caught one day prior to the *j*th data gap (*j* = 1, …, *k*),

n_{ji-2} = number of index fish caught two days prior to the *j*th data gap (*j* = 1, …, *k*),

n_{ji+1} = number of index fish caught one day after the *j*th data gap (*j* = 1, …, *k*),

n_{ji+2} = number of index fish caught two days after the *j*th data gap (*j* = 1, …, *k*),

K = number of data gaps in incline plane index counts.

$$\mathrm{Var}\left(\overset{*}{N}\right) = \mathrm{Var}\left(\tilde{N}\right) + \sum_{j=1}^{k}\mathrm{Var}\left(\hat{N}_j\right) \qquad (0)$$

Estimator (1) and variance (2) were stratified for high and low flow seasons for two fish stocks where detection efficiencies were significantly different between periods.

In the case where there are missing index counts, the sampling process has three sources of variance as follows:

1. Binomial sampling $n \sim \mathrm{Bin}(N, p)$.
2. Estimator of the missing value by $\hat{n}$.
3. Estimator of the trap efficiency using the efficiency releases.

The overall variance during these missing data events can be calculated in stages as follows:

$$\mathrm{Var}\left(\hat{N}_j\right) = \mathrm{Var}_1\left[E_2\left[E_3\left(\frac{\hat{n}}{\hat{p}}\middle|1,2\right)\right] + E_1\left[\mathrm{Var}_2\left[E_3\left(\frac{\hat{n}}{\hat{p}}\middle|1,2\right)\right]\right] + E_1\left[E_2\left[\mathrm{Var}_3\left(\frac{\hat{n}}{\hat{p}}\middle|1,2\right)\right]\right]\right]$$

where 1, 2, and 3 refer to the sampling stages listed above. Then

$$\begin{aligned}
\operatorname{Var}\left(\hat{N}_j\right) &\approx \operatorname{Var}_1\left[E_2\left(\frac{\hat{n}}{p}\middle|1\right)\right]+E_1\left[\operatorname{Var}_2\left(\frac{\hat{n}}{p}\middle|1\right)\right]+E_1\left[E_2\left(\frac{\hat{n}^2\operatorname{Var}\left(\hat{p}\right)}{p^4}\right)\right] \\
&= \operatorname{Var}_1\left[\frac{n}{p}\right]+E_1\left[\frac{1}{p^2}\operatorname{Var}\left(\hat{n}\right)\right]+E_1\left[\frac{\operatorname{Var}\left(\hat{p}\right)}{p^4}\left(\operatorname{Var}\left(\hat{n}\right)+E\left(\hat{n}\right)^2\right)\right] \\
&= \frac{N_j p\left(1-p\right)}{p^2}+\frac{\operatorname{Var}\left(\hat{n}\right)}{p^2}+\frac{\operatorname{Var}\left(\hat{p}\right)}{p^4}\left(\operatorname{Var}\left(\hat{n}\right)+E_1\left(n^2\right)\right)
\end{aligned}$$

$$\operatorname{Var}\left(\hat{N}_j\right)=\frac{N_j\left(1-p\right)}{p}+\frac{\operatorname{Var}\left(\hat{n}\right)}{p^2}+\frac{\operatorname{Var}\left(\hat{p}\right)}{p^4}\left(\operatorname{Var}\left(\hat{n}\right)+\left(N_j p\left(1-p\right)+N_j^2 p^2\right)\right) \tag{0}$$

where

$\hat{n}_j=\left(\frac{n_{ji-2}+n_{ji-1}+n_{ji+1}+n_{ji+2}}{4}\right)d$ = estimate of missing index data,

d = duration of data gap,

$\operatorname{Var}\left(\hat{n}\right)=\frac{s_n^2 d^2}{4}$,

$\hat{p}=\frac{r}{R}$ = estimate of trap efficiency,

$\operatorname{Var}\left(\hat{p}\right)=\frac{\hat{p}\left(1-\hat{p}\right)}{R}=\frac{\left(\frac{r}{R}\right)\left(1-\frac{r}{R}\right)}{R}$, and

$\hat{N}_j=\frac{\hat{n}_j}{\hat{p}}$ = abundance estimate for *j*th period.

In the case where the index count (*n*) is available, the variance of the estimate of fish abundance $\left(\tilde{N}\right)$ is estimated by

$$\tilde{N}=\frac{n}{\hat{p}}$$

and has two sources of variance:

1. Binomial sampling $n \sim \operatorname{Bin}\left(N_j p\right)$.
2. Estimate of the trap efficiency using the efficiency releases.

The overall variance during these time period can be calculated in stages as follows:

$$
\begin{aligned}
\mathrm{Var}\left(\tilde{N}\right) &= \mathrm{Var}\left(\frac{n}{\hat{p}}\right) \\
&= \mathrm{Var}_n\left[E_p\left(\frac{n}{\hat{p}}\middle| n\right)\right] + E_n\left[\mathrm{Var}_p\left(\frac{n}{\hat{p}}\middle| n\right)\right] \\
&\approx \mathrm{Var}_n\left[\frac{n}{p}\right] + E_n\left[n^2\mathrm{Var}\left(\frac{1}{\hat{p}}\right)\right] \\
&= \mathrm{Var}_n\left[\frac{n}{p}\right] + E_n\left[n^2\frac{\mathrm{Var}\left(\hat{p}\right)}{p^4}\right] \\
&= \frac{Np\left(1-p\right)}{p^2} + \frac{\mathrm{Var}\left(\hat{p}\right)}{p^4}\left[\mathrm{Var}\left(n\right) + E\left(n\right)^2\right] \\
&= \frac{N\left(1-p\right)}{p} + \frac{\mathrm{Var}\left(\hat{p}\right)}{p^4}\left[Np\left(1-p\right) + N^2p^2\right] \\
&= \frac{N\left(1-p\right)}{p} + \frac{p\left(1-p\right)}{p^4R}\left[Np\left(1-p\right) + N^2p^2\right]
\end{aligned}
$$

$$
\mathrm{Var}\left(\tilde{N}\right) = \frac{N\left(1-p\right)}{p} + \frac{N\left(1-p\right)^2}{p^2R} + \frac{N^2\left(1-p\right)}{pR} \tag{4}
$$

where

$$
\hat{p} = \frac{r}{R},
$$

$$
\tilde{N} = \frac{nR}{r}.
$$

Test of Homogeneous Trap Efficiency

A test of homogeneous trap efficiency between high and low flow periods was performed using a 2 × 2 contingency table of the form

	High	Low
Caught	r_1	r_2
Not caught	$R_1 - r_1$	$R_2 - r_2$

A test of homogeneity was based on a chi-square test of 1 degree of freedom.

Results

Raw counts of the total number of individuals captured at the incline trap per species ranged from 36 to 969 (Table 1). Efficiency release sizes were too small to convert counts to absolute abundance for rainbow trout and sockeye salmon. Tests of homogeneous trap efficiency during low and high river flow conditions found no difference for Chinook salmon and coho salmon but a flow effect for Dolly Varden (Table 2). Hence, a single estimate of trap collection efficiency was used in the estimation of outmigration abundance for Chinook salmon and coho salmon, while two seasonal values were used for Dolly Varden (Table 2).

The incline trap study estimated juvenile abundance in Grant Creek at the site of the calibration (i.e., trap efficiency) releases. For Chinook salmon, total outmigration was estimated to be $\hat{N}$ = 4,797.7 (95% confidence interval = (3,615.4–5,980.0)). For coho salmon, total outmigration was estimated to be $\hat{N}$ = 3,164.9 (95% CI = (2,094.3– 4,235.5)). The seasonally stratified estimate of total outmigration abundance for Dolly Varden was estimated to be 46,431.2 (95% CI = (-4,570.2–97,432.6)) (Table 2).

Two factors contributed to high standard errors associated with the total abundance estimates. The first was the highly variable daily count on either side of the three "data gaps" observed during the study. Though only 2- 4 days long (a total of 10 days, approximately 7% of the study), these gaps contributed abundance estimates with large associated variance. The greater issue was the low detection efficiencies, which especially affected the Dolly Varden abundance estimate, as its expansion factor during the low flow period was approximately 12 times that of the other species at the trap.

Table 1. Number of juvenile salmonids caught by species at the incline plane trap during the 2013 outmigration at Grant Creek.

Species	Count (*n*)
Chinook salmon	577
Coho salmon	360
Dolly Varden	969
Rainbow trout	36
Sockeye salmon	22

Table 2. Summary of trap efficiency release numbers (*R)* and number of smolts recaptured (*r)* under high and low flow conditions for three species of salmonids. Chi-square tests of homogeneity (df = 1) were performed comparing low and high flow recovery information.

	Low Flow Condition		High Flow Condition		Trap Efficiency			Test for Trap Efficiency Difference	
Species	Release	Recapture	Release	Recapture	Low	High	Combined	χ^{2*}	p
CK	380	45	68	10	0.118	0.147	0.123	0.2136	0.6440
CO	169	19	110	13	0.112	0.118	0.115	0.0000	1.0000
DV	248	2	571	41	0.008	0.072		12.8685	0.0003

*Estimated with Yates continuity correction

Table 3. Estimates of total outmigrant abundance through Grant Creek. Estimates separated by periods with daily index counts and with gaps in the index count. In the case of Dolly Varden, the estimation was also stratified by low- and high-flow trap efficiency periods.

			Dolly Varden		
	Chinook	Coho	Low Flow	High Flow	Total
Observed n	577	360	296	673	
Est. N	4,699.9	3,138.8	36,704.0	9,372.8	46,076.8
Var N	361,252.8	297,453.8	674,913,300.0	2,112,700.0	677,026,000.0
SE N	601.0	545.4	25,979.1	1,453.5	26,019.7
Gap n	12.0	3.0	0.5	21.0	
Est N	97.7	26.2	62.0	292.5	354.5
Var N	2,538.3	929.5	20,981.3	50,786.1	71,767.4
SE N	50.4	30.5	144.8	225.4	267.9
Total					
Est N	4,797.7	3,164.9	36,766.0	9,665.2	46,431.2
Var N	363,791.1	298,383.3	674,934,281.3	2,163,486.1	677,097,767.4
SE N	603.2	546.2	25,979.5	1,470.9	26,021.1