PEBBLE PROJECT
ENVIRONMENTAL BASELINE STUDIES
2008 STUDY PLAN

CHAPTER 11
FISH AND AQUATIC RESOURCES

DRAFT

2008

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ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
APC	Alaska Peninsula Corporation
APCS	Alaska Peninsula Corporation Services
GPS	global positioning system
HDR	HDR Alaska, Inc.
HSC	habitat suitability criteria
MLE	maximum likelihood estimation
NFK	North Fork Koktuli River
OCH	off-channel habitat
PHABSIM	Physical Habitat Simulation
QA	quality assurance
QC	quality control
R2	R2 Resource Consultants, Inc.
RK	river kilometer
SFK	South Fork Koktuli River
SNTEMP	Stream Network Temperature Model (USFWS)
TWG	technical working group
USGS	U.S. Geological Survey
UT	Upper Talarik Creek
USFWS	U.S. Fish and Wildlife Service
WUA	weighted usable area

11. FISH AND AQUATIC RESOURCES

R2 Resource Consultants, Inc. (R2), and HDR Alaska, Inc. (HDR), will conduct the 2008 baseline study for fish resources in the mine study area. A summary of the tasks for the fish resources study in 2004 through 2008 is provided in Table 11-1. The overall objectives and methods for this fish resources baseline study are the same as those described in the 2007 study plan, except as noted below. The major tasks planned for the 2008 program are described below.

11.1 Study of Fish Use of Overwintering Habitats

There will be no new information collected for fish use of overwintering habitats in 2008.

11.2 Rainbow Trout Telemetry Study in Upper Talarik Creek

11.2.1 Background

Upper Talarik Creek originates in two distinct basins, one to the east and the other to the west of Groundhog Mountain. The creek travels 60 kilometers south to discharge into Iliamna Lake. In addition to providing a subsistence fishery, the creek is one of several Iliamna Lake tributaries that are managed by the Alaska Department of Fish and Game (ADF&G) as a catch-and-release sport fishery for rainbow trout (*Oncorhynchus mykiss*). In addition, Alaska Peninsula Corporation (APC) and Rainbow King Lodge have an exclusive agreement for fishing rainbow trout within APC-owned land in the lower reaches of Upper Talarik Creek.

Several rainbow trout life-history and migration studies have been conducted in and around Iliamna Lake, including studies in the Alagnak River (Meka et al., 2000), Lower Talarik Creek (Russell, 1977), and the Kvichak River (Minard et al., 1992). Meka et al. (2000) identified three life-history strategies exhibited by trout in the Alagnak River system. These strategies vary in the amount of time the trout spend in big river, tributary, and lake environments. As these authors describe, the lake-resident type (adfluvial) trout spend the majority of their time in lakes, with limited forays into lake outlets or inlet tributaries. The lake-river type trout divide their time between mainstem reaches of large rivers, lakes, and tributaries. River type trout reside wholly in larger rivers with no obvious migrations into tributaries or lakes.

Trout movements from Iliamna Lake into the lower reaches of Lower Talarik Creek (which enters Iliamna Lake about 19 kilometers west of Upper Talarik Creek) were described by Russell (1977). Using a stationary weir, Russell documented an upstream spawning migration of adult rainbow trout into Lower Talarik Creek from late April to mid-June, with most fish returning to Iliamna Lake after spawning. A second upstream migration of adult fish occurred in the fall, with fish entering the creek from September to early October.

Results from a mark-and-recapture study conducted on spawning trout in the Kvichak River (Minard et al., 1992) indicated that the adult and subadult rainbow trout congregating on spawning grounds in the

Kvichak River in the spring disperse into Iliamna Lake by June. Furthermore, at least some of these fish were recaptured in the fall in several lake tributaries, including Upper Talarik Creek. Many tagged trout also returned to the Kvichak River in the fall.

Upper Talarik Creek is unlike many other Iliamna Lake tributaries because it is larger and its hydrology is minimally influenced by lakes. For these reasons, it is possible that the migratory patterns of rainbow trout, especially adfluvial or lake-river types, in this creek could be different compared to drainages with more lacustrine influences such as Lower Talarik Creek, Gibraltar Creek, and the Alagnak River. Information on seasonal distributions and migrations related to spawning, feeding, and overwintering of rainbow trout specific to Upper Talarik Creek is limited to a study by Minard et al. (1992), which documented that rainbow trout that were spawning in the Kvichak River entered Upper Talarik Creek in the fall.

The presence of subsistence and recreational fisheries in the mine study area motivated this program to collect more comprehensive data on adult rainbow trout foraging (summer and fall), overwintering, and spawning migrations (April through June) in Upper Talarik Creek. It is important to understand the life-history patterns of Upper Talarik Creek rainbow trout for several reasons, including the following:

- To provide baseline biological information to be used in the permitting process.
- To inform overall project design.
- To provide information that may assist in determining possible project effects.
- To inform mitigation planning, as needed.

The Pebble Project study, initiated in 2007, investigates the seasonal distribution and migration patterns of the rainbow trout populations foraging and spawning in Upper Talarik Creek. In 2007, the study objectives were to document the seasonal distribution and migrations of adult rainbow trout in the foraging population in Upper Talarik Creek. This population was composed of fish present in Upper Talarik Creek in the late summer and fall, which presumably were in the stream to feed on salmon eggs. It was expected that many of these fish would subsequently returned to Iliamna Lake. It was unknown whether a proportion of this foraging group would spawn in Upper Talarik Creek or elsewhere within the Kvichak River watershed.

Lotek Model SR-M11-35 radio transmitters were chosen to provide information on stream fidelity for both spawning and foraging. Work during 2007 was conducted by HDR fisheries biologists in cooperation with APC, Alaska Peninsula Corporation Services (APCS), and Rainbow King Lodge. The work was done according to the approach described in the 2007 fish and aquatic resources study plan (NDM, 2007). In August and September 2007, radio transmitters were surgically implanted in 38 adult rainbow trout captured from Upper Talarik Creek. Fixed radio telemetry stations were installed near the mouths of Upper Talarik and Lower Talarik creeks to monitor tagged trout entering and exiting these drainages. In addition to the fixed stations, aerial tracking by helicopter was conducted on a weekly basis from September 9 through December 3, 2007, and has continued monthly since February 2008.

11.2.2 Goals and Objectives

In 2007, the ADF&G regional biologist requested that the study be expanded to specifically target the population of rainbow trout spawning in Upper Talarik Creek; thus, in 2008, the study goal is to document the migratory behavior of fish entering Upper Talarik Creek in the late summer and fall to forage (including those fish tagged in 2007) and those entering the creek to spawn, including potential migrations to nearby lakes and/or streams within the Iliamna Lake watershed. In addition, information will be collected on stream fidelity for both spawning (spring) and foraging (fall) incursions.

The specific objectives of the Upper Talarik rainbow trout radio telemetry study in 2008 are as follows:

- Collect and implant 2-year radio transmitters (Lotek Model SR M11-35) in up to 60 post-spawning rainbow trout migrating out of Upper Talarik Creek during a minimum of two capture periods in mid- to late May 2008.
- Conduct aerial radio telemetry surveys monthly in late winter/early spring and in late fall through early spring 2009, twice a month during mid-April through May, and weekly during June through October. The surveys will be conducted throughout the Iliamna Lake watershed to track the seasonal migration patterns of radio-tagged rainbow trout from the Upper Talarik Creek foraging (35 fish) and spawning (up to 60 fish) populations.
- Continually monitor the movements of the radio-tagged fish at Lower Talarik and Upper Talarik creeks with fixed telemetry stations located at each site from mid-April through December 2008.

11.2.3 Study Area

The study area focuses on rainbow trout habitats within the Iliamna Lake watershed downstream to the upper extent of tidal influence in the Kvichak River, with special emphasis on Lower Talarik and Upper Talarik creeks (Figure 11-1). Other tributaries within the study area include Pete Andrews Creek, Middle Talarik Creek, Zhakar Creek, Dennis Creek, Belinda Creek, Chekok Creek, Newhalen River, Knutson River, Pile River, Tazimina River, Iliamna River, Copper River, and Gibraltar River; the shoreline of Iliamna Lake also is included in the study.

11.2.4 Methods

11.2.4.1 Fish Tagging

Collection

The intent of this study is to capture post-spawning adult rainbow trout that spawned in Upper Talarik Creek in the spring of 2008. To maximize the chances of collecting post-spawning trout, the fish will be collected from the lower reach of the creek from after the peak to the end of the spawning period. Based on studies in nearby rivers (Meka et al., 2000) and spawning surveys conducted in Upper Talarik Creek in 2007, it is expected that fish collection and tagging will occur from mid-May through late May. Up to 60 post-spawning fish will be chosen for tagging based on physical condition, gender, and size to ensure that the fish weight to tag weight ratio is less than 2 percent (Winter, 1983). A minimum of two capture events are currently planned, depending on the availability of fish. Approximately half of the total fish will be captured during each capture event. Fish selected for tagging will consist of approximately equal numbers of males and females, assuming a 50:50 sex ratio in the post-spawning population.

Study fish will be collected with hooks and lines, tangle nets, beach seines, and/or hoop nets, in order of preference, with the assistance of APC and APCS. Hook-and-line sampling with barbless hooks will be used as the primary collection method because it is the least intrusive, with minimal handling stress on the fish. Angling efforts will generally consist of three to five people fishing within a designated area near a mobile tagging station. Fly rods or spinning gear will be used. Fish will be landed as quickly as possible to minimize stress.

Tangle nets, beach seines, and/or hoop nets will be used if hook-and-line collection does not provide an adequate number of suitable fish per day. Two tangle nets will be available for capturing fish, each approximately 15 meters long and 3 meters feet deep. One net will have a mesh size of approximately 2.5 centimeters, while the other will be larger (more than 8.8 centimeters) to avoid gilling the fish. The most effective tangle net for capturing fish with minimal stress and injury will be used. Beach seining will be considered if it can be accomplished without disrupting actively spawning fish. Hoop nets with leads may also be used to capture trout.

Fish Transport and Holding

Fish will be placed in a transport container and taken to the tagging station immediately after capture. Captured trout will be transported to the tagging station by means of a 1-meter-long “boot” constructed from rubber inner-tube material. The boot will be filled with water, and the fish will be placed in headfirst. The water in the boot will be exchanged with fresh stream water if the transport time to the tagging station exceeds two minutes.

If the surgeons and tagging station are available for immediate tag implantation, the fish will be placed in the anesthesia bath. In the event that a surgery is ongoing at the time of capture, fish will be held in a 1-meter-deep by 1-meter-wide square net pen within the stream. Fish capture will be temporarily suspended if more than two fish per surgeon are being held in the pen.

Transmitter Implantation

The surgery gear will be transported to a tagging station and completely assembled before fish capture begins. Surgeries will be performed by trained surgeons from R2, DeCicco-Alaska, APCS, or ADF&G under the guidance of Mr. Alfred DeCicco of DeCicco-Alaska and Mr. Craig Schwankey of ADF&G. Surgical methods used will be consistent with those used by ADF&G. Prior to tag implantation, a practice surgery session will be held on adult rainbow trout at a local hatchery.

Surgical gloves will be used at all times during all fish-handling procedures to prevent infection or de-scaling. Fish will be carefully transferred from the boot, recovery bath, or holding pen into the anesthesia bath containing ambient stream water and a solution of 1 part clove oil to 9 parts ethanol at a concentration of 50 milligrams per liter of water. For each fish, information including the radio-transmitter frequency and code; the date; capture method; times captured, processed, and released; and the fish’s physical condition, fork length, weight, and gender will be recorded. An example tagging data form is provided in Appendix 11A.

The fish will be removed from the anesthetic and placed on a neoprene-lined surgery cradle sprayed with a water conditioner, such as Polyaqua-stress coat. The water conditioner will be used to minimize scale loss and to maintain the exterior mucous coating on the fish. The fish will be placed ventral side up on the pad, and the gills will be continuously flushed with anesthesia to keep the fish anesthetized during the surgical procedure. After completion of the first suture, the gills will be continually flushed with fresh water.

Other disinfection and sterilization procedures used for the surgical equipment will follow the procedures described in Summerfelt and Smith (1990). All instruments will be soaked in a sterilizing antiseptic bath for at least 10 minutes and then rinsed in a 0.1-percent saline solution prior to surgery. Two sets of surgical instruments will be alternately employed so that one set is being disinfected in the sterilization solution for 10 minutes while the other is being used. Tags will be soaked in an iodine solution and rinsed in alcohol prior to insertion. All sutures will be individually sterile packed.

A 2- to 3-centimeter-long incision will be made lateral to and parallel to the mid-ventral line and anterior to the pelvic girdle. Care will be taken to barely penetrate the peritoneum; a probe will be used to complete the opening so that internal organs are not inadvertently cut. A 14-gage intravenous catheter needle will be used to guide the transmitter antenna through the body wall. The needle will be inserted 10 to 15 millimeters posterior and slightly dorsal to the origin of the pelvic fins. A grooved director will be placed in the incision to protect the internal organs. The needle will be guided along the grooved director from the point of entry and out through the incision.

The transmitter will be inserted into the abdominal cavity by first threading the antenna through the incision end of the needle. Both the antenna and the catheter will be gently pulled posterior while the transmitter is simultaneously inserted into the body cavity. The catheter will then be removed. The position of the transmitter will be adjusted by gently pulling on the antenna until the transmitter rests horizontally in the body cavity slightly posterior to the incision.

The incision will be closed with two to three simple non-absorbable monofilament sutures evenly spaced along the incision (Summerfelt and Smith, 1990). To prevent infection, a small amount of adhesive veterinary glue will be placed over the incision and the antenna location. The fish will then be placed into the recovery bath containing ambient stream water.

All fish treated with anesthesia will be marked with a 5-centimeter green T-bar anchor tag, individually numbered and labeled “Not For Human Consumption. Call R2 at 907-771-4090.” Anchor tags will be inserted just below the dorsal fin at an acute angle so that the tag lies next to the body when the fish is swimming. Care will be taken to place the tag behind the pterygiophores to prevent excessive tag loss (Guy et al., 1996). The insertion of anchor tags will occur in the anesthesia bath prior to surgery to decrease exposure times.

Pelvic auxiliary process samples will be collected and preserved in ethanol at the request of ADF&G for the purpose of genetics research. While in the recovery bath, scale samples also will be collected from midway between the dorsal fin and the caudal peduncle, in an area just above the lateral line, by using a single scraping motion with a clean scalpel. The scales will be placed in scale envelopes and labeled with an identifying number unique to each sample.

Post-surgery recovery will occur in 1-meter-deep by 1-meter-wide covered net pens set in the creek. Fish will be monitored, and the time when equilibrium is regained will be noted. The fish will be released in calm water after approximately 20 to 30 minutes of observation.

Information on the fish, the capture site and environmental conditions, the surgical procedures, and the transmitter will be recorded on field data forms (Appendix 11A).

Radio Transmitters

The pulse-coded radio transmitters used in this study are Model SR M11-35 tags developed and manufactured by Lotek Wireless Fish and Wildlife Monitoring of Ontario, Canada. The transmitters are 11 millimeters in diameter by 61 millimeters long with a 1- millimeter by 43- millimeter Teflon-coated antenna. The radio transmitters weigh 11.5 grams in air. To reduce the chance of signal interference, the group of transmitters operates on two separate frequencies (150.340 and 150.580) and has two different burst rates (5.0 seconds and 5.5 seconds) on each frequency. The expected battery life of these transmitters is 829 days, with a minimum manufacturer warranty life of 616 days. The transmitters are equipped with a motion sensor designed to signal after being stationary for 24 consecutive hours to indicate possible mortality or a shed tag.

11.2.4.2 Tracking

Fixed Telemetry Stations

Radio receivers will be installed at the fixed telemetry stations positioned at the mouths of Upper Talarik and Lower Talarik creeks in early April 2008, prior to fish tagging, to provide continuous monitoring of transmitter movements as fish enter and exit the creeks throughout 2008. The Lower Talarik Creek fixed station is located on state-owned property near the mouth of the creek at latitude N 59.62245 and longitude W 155.53061. The Upper Talarik Creek telemetry station is installed on APC-owned property approximately 1.5 miles from the mouth at latitude N 59.65534 and longitude W 155.20165. The fixed tower locations are identified in Figure 11.1-2 of the 2007 study plan (NDM, 2007).

Each station will contain a Lotek SRX600 data-logging radio receiver powered by a 12-volt external battery system and will be equipped with two 4-element Yagi antennas oriented to indicate upstream and downstream direction of travel. Both installations will be tested to determine the range of detection and will be checked for several weeks prior to the first tagging event.

With the assistance of APC, the fixed stations will be visited approximately once every 10 days to retrieve data and to perform battery maintenance. A logbook will be stored at each station to document the status of the equipment, data downloads, and battery changes.

Mobile Tracking

Aerial surveys will be conducted by fixed-wing plane and/or helicopter, depending on weather conditions and availability. Surveys will occur once a month during the winter and early spring (February through mid-April) when the fish are less active. As the fish begin to move and the 2008 post-spawning fish are tagged, aerial surveys will be conducted every two weeks (mid-April through May). The survey frequency will increase to once a week from June through October while the fish are most active and salmon runs are returning to Iliamna Lake tributaries. From late fall through early spring 2009, aerial surveys will occur approximately once a month.

A Lotek SRX600 receiver with an externally mounted H antenna (helicopter) or two 4-element Yagi antennas (fixed-wing plane) will be used to conduct the aerial surveys. In addition to the data retrieved from the receiver, mobile tracking data will be recorded on field data forms during aerial surveys. At each detection, the stream condition, habitat, and presence of spawning salmon will be noted. A logbook of aerial tracking events also will be maintained. Appendix 11A includes a typical field form for recording aerial survey tracking data.

11.2.4.3 Data Analysis

All of the survey data will be combined into a single database. ArcInfo software will be used to display and analyze the distances and directions of fish movements at the completion of the study. The distance each radio-tagged fish traveled from the Upper Talarik Creek release site will be calculated. The data will be explored to determine and allow documentation of evident patterns of seasonal migration timing and geographical migration.

11.3 Salmon Escapement Study

Aerial surveys to count spawning salmon will be conducted on the three primary streams in the mine study area (i.e., North Fork Koktuli River, South Fork Koktuli River, Upper Talarik Creek) to estimate spawning-salmon escapement. Escapement estimates for each species will be developed using the area-under-the-curve method. Observer efficiency will be calculated to help improve escapement estimates. Salmon escapement study activities in 2008 represent a continuation of work initiated in 2004.

11.3.1 Objectives

The objectives of the 2008 salmon escapement study are as follows:

- Obtain estimates of timing and escapement of salmon by species through direct observation.
- Calculate observer efficiency by comparing observer counts and counts made from video tapes of selected “calibration” reaches of streams.
- Document spawning distribution by species.

11.3.2 Survey Areas

Aerial surveys will cover the entire length of the main channel of the North Fork Koktuli River (NFK), South Fork Koktuli River (SFK), and Upper Talarik Creek (UT). Aerial survey areas are depicted on Figure 11-2.

11.3.3 Methods

11.3.3.1 Aerial Surveys

Spawning surveys will be conducted from a helicopter flying at a low altitude (typically less than 500 feet) at ground speeds between 5 and 20 knots. Surveys will cover the entire length of the mainstem of each of the three rivers that is accessible to anadromous salmon. In the SFK, if upstream migration is prevented by intermittent flow conditions, surveys will end at the upstream end of the continuously wetted channel. Weather permitting, aerial surveys will be repeated at five-day intervals from July 1 to approximately October 31, 2008. In the event that weather conditions or helicopter availability prevents completion of a scheduled survey, the survey will be completed on the next possible day.

Two qualified observers will conduct each survey when overlapping runs of different species occur; a single observer will conduct surveys when runs do not overlap. Each observer will concentrate on one or two species. When two observers are recording counts for one species, the individual counts will be averaged for use in subsequent escapement models. All observers will wear polarized sunglasses.

Survey results will be recorded by species. Adult fish will be counted as individuals. If large numbers of fish are encountered in a single area, fish will be summed by groups of fish—i.e., clusters of 5, 10, 20, 50, 100, or 1000 fish, as appropriate—and an estimated count will be generated. Estimates of fish may also be generated if observation of individual fish is impaired by environmental conditions (weather, flow/turbidity, etc.). Global positioning system (GPS) waypoints will be recorded approximately every mile, or at the start and end of each area of concentrated spawning. GPS waypoints also will be recorded at the start and end of each area where conditions of low visibility, intermittent flow, or other environmental factors affect the counting process. In such areas, the condition affecting the count will be briefly noted on the field sheet and will be described in more detail in the post-survey notes. Deviations from the survey schedule or changes to the methodology (if any) will be recorded, as will the rationale for diverging from the study plan.

Data will be recorded on field forms printed on Rite-in-the-Rain paper. Examples of the field forms are provided in Appendix 11B. One field form will be completed for each stream. The following information will be recorded for each survey:

- Survey date.
- Drainage.
- Start time and end time.
- Observer name(s).
- Waypoints.
- Number of individual adult fish by species from the starting waypoint to the end of the next counting area.

Survey results will be reviewed for completeness at the end of each survey and initialed by the field reviewer. Data will be entered into an Excel spreadsheet following the survey. Flow data at the reference gage at the survey start and end will be requested from the consultant responsible for the surface hydrology study and will be filled in at the end of the survey season.

Prior to completing the survey on each mainstem river, observers will record qualitative information on environmental conditions during the survey on a standardized field form. The following parameters and their subjective ranking will be recorded:

- Flow level: a qualitative assessment of river discharge at the time of the survey using three categories indicating high, medium, and low flow conditions.
- Water clarity: a numerical index measuring the effect of water clarity on the survey, with 1 indicating highly silted waters and 4 indicating extremely clear water.
- Glare: a numerical index from 1, indicating glare sufficient to obscure viewing, to 4, indicating no effect associated with glare during the survey.
- Extent of ice: an estimate of the percent of the survey field covered with ice.
- Weather conditions: a numerical index from 1, indicating that weather conditions having a significant effect on viewing, to 4, indicating no effect resulting from weather conditions.
- Sun angle: A numerical index measuring the effect of sun direction on the survey, with 1 indicating the sun angle results in a totally obscured view and 4 indicating no effect to viewing from the angle of the sun.
- Extent of overhanging vegetation: an estimate of the percent of the river that is obscured by overhanging vegetation.
- Average helicopter elevation and ground speed: an estimate of the average elevation and speed at which the survey is conducted.

11.3.3.2 Calibration Surveys

Observer efficiency is an estimate of the proportion of the number of fish actually present that are observed and counted by the aerial observer. Observer efficiency can vary both spatially and temporally, as well as between observers. Variation in observer bias will be minimized as much as possible by having the same individuals lead the aerial count during each survey.

To calibrate observer efficiency, calibration reaches will be selected within each watershed that will be surveyed using aerial videography taken simultaneously with the visual survey. A total of 12 to 18 calibration reaches will be selected through the spawning season so a stratified sample of representative riverine habitat conditions (wide open, heavily shaded, etc.) within each basin will be included and calibration coefficients can be adjusted by basin if necessary. Calibration reaches will be selected during a presurvey flight, which will be conducted before spawning begins. The upstream and downstream end of each calibration reach will be flagged so that it is clearly visible from the air. Calibration reaches will be located in areas of known concentrated spawning based on surveys from previous years.

The calibration reach will be videotaped during each spawner survey. A video recorder will be mounted on the helicopter, with recorder controls inside the aircraft. GPS waypoints will be recorded at the upstream and downstream ends of the calibration reach to distinguish the fish count in that reach. Video images will be reviewed on a time-lapse video camera by an independent observer, and species counts will be recorded. Observer-efficiency calibration factors will be generated from the ratio of observed to video counts.

11.3.3.3 Escapement Estimates

Escapement will be estimated using the area-under-the-curve method (Bue et al., 1998). According to this method the number of live salmon observed during any survey is a function of the number of the fish that move into the area, the number of fish that leave the area or die, and the observer efficiency for that reach and viewing period. The total number of fish entering the area is estimated by developing a curve representing fish abundance by day for each day in the spawning season. The area under this curve represents total fish-days. Dividing total fish-days by the average number of days an individual fish is present in the survey area (residence time or “survey life”) gives the total number of fish that enter the area each spawning season. The estimate is then adjusted by the observer-efficiency calibration factor.

Two versions of curve development will be used: the trapezoidal model and the maximum likelihood estimation (MLE) model. Analytical results from both models will be presented to encompass the range of results. R2 will work with agency biologists to develop weighting factors for each model output that represent the level of confidence for each method.

Trapezoidal Model

Assumptions:

- Fish observed during first survey entered the stream one survey life prior to observation.
- Fish observed during the final survey leave the system within one survey life following the observation.
- No additional fish enter the study area following the final survey.

Interpolations are necessary for data sets in which observations for the first or last survey count were not zero. In the trapezoidal model, the number of fish present in the study area per day is estimated by linear interpolation across days not surveyed using observation values at the beginning and end of that period (Bue et al., 1998).

MLE Model

Assumptions:

- No fish enter the survey area before July 1.
- No fish enter the survey area within one survey life after the final survey.

The MLE model applies curve-fitting techniques based on actual observations and adjusts them to fit modeled abundance patterns (Hilborn et al., 1999).

11.3.4 Data Management and Quality Assurance/Quality Control

At the end of each survey day, a Level I quality assurance/quality control (QA/QC) review of the field data sheets will be completed to check for accuracy and completeness. Each field data sheet will be dated and initialed by the field reviewer. Data will be entered into an Excel spreadsheet. Separate workbooks will be maintained for each stream. Changes/corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field data forms will be archived at R2 with a copy delivered to Pebble Partnership.

Excel data files will be imported into the aquatic habitat Access database. Once in the Access database, electronic data will undergo a Level II QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level III QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

11.3.5 Schedule

Spawning survey results from 2004 through 2007 indicate that Chinook, sockeye, and chum salmon have begun entering the systems as early as the first week in July. Spawning surveys will commence on or about July 1 in order to capture the beginning of the spawning runs. Surveys will be conducted at five-day intervals through approximately October 31 or until no live fish are identified during two consecutive surveys with good visibility. Approximately 24 surveys of each stream are expected. Helicopter time will be scheduled through Pebble Partnership’s environmental studies coordinator.

11.4 Fish Distribution and Relative Abundance

11.4.1 Objectives

The objectives of the 2008 fish distribution and relative abundance study are as follows:

- Review exiting data to identify the geographic extent of any data gaps.
- Document fish distribution in selected tributary and mainstems of NFK, SFK, and UT to supplement and extend existing geographic coverage.
- Document relative abundance and/or quantitative population estimates of fishes in the areas of NFK, SFK, and UT where data gaps exist.

11.4.2 Survey Areas

Specific survey reaches for the fish distribution and relative abundance surveys for 2008 will be determined after completion of the data review to identify the geographic extent of data gaps. The general survey area is expected to encompass the following vicinities:

- NFK 1.190 watershed and upper mainstem of NFK.
- SFK 1.190 watershed, SFK 1.240 watershed, and SFK mainstem and tributaries above Frying Pan Lake.

- Mainstem UT and all tributaries upstream of UT 1.350.

11.4.3 Methods

11.4.3.1 Fish Distribution

The distribution of fishes within the study area will be determined using one of several methods depending on riverine conditions (such as depth and flow) and the presence of adult salmon. Given that spawning runs in the study area occur over a 22-week window, the primary method to be used will be snorkeling. In stream channels with a width of less than 5 meters, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 5 meters, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

Electrofishing will be used in habitats not conducive to snorkeling (i.e., water is too shallow or visibility is insufficient). One pass with the electroshockers will be completed to determine the fish species present within a 200 meter reach of stream habitat. If multiple habitat types are present at the sampling site, electrofishing will be conducted within multiple representative habitat units.

In reaches where both electrofishing and snorkeling would be ineffective because of stream conditions such as deep, fast water, baited minnow traps or beach seines may be used to determine fish presence. Traps will be baited with processed salmon eggs contained in perforated plastic bottles. The minnow traps will be set in areas to maximize catch and will be set for a period ranging from 2 to 24 hours. Beach seines may be used in deeper pools with uniform substrates.

All fish captured will be identified to species, measured, and released alive near the point of capture.

11.4.3.2 Fish Abundance Surveys

There are three methods that can be used to estimate relative abundance and fish population size. Calibrated snorkel surveys will be the primary method and will be used whenever habitat conditions are suitable to snorkeling. In habitats not suitable for snorkeling or in locations where exact population estimates are needed, either electrofishing depletion estimates or mark-and-recapture electrofishing may be used. The specific locations for application of snorkeling or electrofishing methods will be determined after a review of the habitat data.

Snorkel Surveys

Snorkel surveys will be the primary method used to determine which fish species are present and to estimate relative fish abundance and calculate densities for abundant species in stream reaches where Tier 3 habitat surveys have been conducted. Habitat-mapping data documenting the distribution and abundance of habitat types will be reviewed. Habitat units to be included in the abundance surveys will be randomly selected. The percentage of units per habitat type that are surveyed will depend on the overall proportion of units within the stream. The goal is to survey approximately 25 percent of the units of each habitat type that supports juvenile rearing, with a minimum sample effort of 10 percent of existing units that do not appear to be preferred habitats (Dolloff et al., 1993). The selection of units to be snorkeled will occur in the office prior to initiating the field effort and GPS coordinates of each pool/riffle/glide habitat to be snorkeled will be entered into a field GPS unit to guide snorkel teams to the appropriate habitat.

In designated units, one-pass snorkel surveys (Dolloff et al., 1993) will be conducted by team members trained in fish-species identification and in conducting snorkel surveys. Before a survey begins, climatological and hydrological conditions, including air and water temperature, visibility, and stream reach characteristics such as substrate and riparian vegetation, will be measured and recorded. To evaluate visibility, snorkelers will use a salmonid silhouette with parr marks and spots. A surveyor should approach the silhouette until the parr marks are clearly visible and then move away from the silhouette until the marks cannot be distinguished. The average of these two distances will be the measure of the water visibility (Thurow, 1994).

Snorkelers will visually identify and count all adult and juvenile species encountered. Survey reaches will be snorkeled starting at the downstream end and working upstream. In stream channels with a width of less than 5 meters, the survey will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right counts. In stream channels with a width greater than 5 meters, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. Snorkelers will collect data on the species and size of fish observed. Data will be called out to a non-snorkeling team member and will be recorded on a field data sheet (Appendix 11C).

Snorkeling Calibration Surveys

Calibration will occur in every Xth unit of each habitat type snorkeled. The proportion of calibration units per habitat type will be determined once the total number and distribution of habitat units are mapped; the proportion is expected to vary depending on the proportion of a specific habitat type found with the section of stream to be surveyed.

Snorkel surveys will be calibrated using four-pass electrofishing depletion sampling. Block nets will be placed at the upstream and downstream ends of each habitat unit prior to snorkeling and will be kept in place through calibration to ensure that fish do not drift downstream or escape upstream between surveys. Calibration units will be flagged during the initial snorkeling event, but calibration will be conducted at least one hour after snorkeling has been completed, to allow fish disturbed by snorkeling activity to redistribute among preferred habitats (Dolloff et al., 1993). Electrofishing calibration surveys will occur on the same day that the snorkel surveys are completed.

In waters were electrofishing cannot be applied, a mark-and-recapture protocol will be used to calibrate snorkeling. Fish will be collected with minnow traps or seines. Marking methods will involve dye (Bismark Brown) immersion for fry and caudal clips or paint marking (with a Madajet marking tool) for juveniles over approximately 60 millimeters in length. Fish will be allowed to recover in a freshwater tank after marking and will be returned to the habitat unit. After several hours or, if possible, the next day the recapture event will occur.

Given the focus on the upper watersheds in 2008, it is assumed that calibrations will be conducted within the entire habitat unit. In some cases, for example a deep pool where electrofishing is not feasible, subsampling will be required for calibration. When this occurs the unit will be partitioned using block nets, and calibration will occur in the portion of the unit that can be effectively sampled.

Electrofishing Abundance Estimates

Multi-pass depletion electrofishing will be conducted according to National Marine Fisheries Service guidelines (NMFS, 2000). Field electrofishing teams will consist of a team leader and two biological technicians. In wide streams, two electrofishing teams may be necessary to adequately sample the reaches. The field team will have training and field experience using a backpack electroshocker. Climatological and hydrological conditions, including air and water temperature, water conductivity, and stream reach characteristics such as substrate and overhanging riparian vegetation, will be measured and recorded. The protocol followed will be consistent with Johnson et al. (2007).

Block nets will be placed at the upstream and downstream ends of each habitat unit being sampled to ensure that shocked fish do not drift downstream or escape upstream. One team member will operate each electrofishing unit while two team members will follow with a dip net (3-millimeter nylon mesh) to capture stunned fish as they are encountered. The fish will be placed directly into a closed, aerated container that is carried along the sampling unit. When the container is full, one of the netters will transport the fish into a net pen located along the creek's edge. In each pass through the habitat unit, the electrofishing team will progress from the downstream end of the reach towards the upstream end. Following each pass, upstream and downstream nets will be checked for fish. When collection is completed, fish will be placed into an anesthesia bath containing ambient stream water and a solution of 1 part clove oil to 9 parts ethanol at a concentration of 30 milligrams of solution per liter of water. Each fish will be identified to species, measured to the nearest millimeter in total length, and then placed into a 20 liter bucket with an aerator, where the fish will be allowed to recover before being returned to the stream as close as possible to the sampling site. Backpack unit settings, start time and stop time for each habitat unit sampled, and sampling notes will be recorded for each site on a field form (Appendix 11C).

Electrofishing Calibration

Electrofishing calibration is needed to assess the efficiency of the electrofishing. At the beginning of the field season, up to six electrofishing calibration surveys will be conducted. The surveys will be conducted in each of the three watersheds in randomly selected fast- and slow-water habitats. The calibration will entail setting up block nets and then electrofishing the habitat unit to collect a sample of 100 fish. These fish will be anesthetized, measured, marked, and returned to the creek after recovery. Marking methods will involve dye (Bismark Brown) immersion for fry and caudal clips or paint marking (with a Madajet marking tool) for juveniles over approximately 60 millimeters in length. The fish will be allowed to redistribute overnight, if possible, or for a period of several hours from morning to late afternoon. After the redistribution period, a second electrofishing event will occur. During this event a multi-pass depletion electrofishing survey will be conducted. The number of marked and unmarked fish collected on each pass will be recorded. A measure of electrofishing efficiency estimating will be generated for one-pass and multi-pass depletion based on the number of marked and unmarked fish collected. The electrofishing efficiency estimator will be used to provide information on the accuracy of both one-pass and depletion surveys that are conducted during the 2008 field season.

Electrofishing Population Estimates

Electrofishing will be conducted as described above under Electrofishing Abundance Estimates; however, for the population sampling, the block nets will be left in place for approximately 24 hours until the crew returns to conduct recapture sampling. Leaving the block nets in place for 24 hours prevents fish from migrating out of or into the sample area for long enough to allow fish to recover. The same electrofishing protocol as before will be followed, with the exception that all captured fish will be classified as marked or unmarked and will be recorded as such. Only previously unmarked fish will be measured to the nearest millimeter in fork length.

The standard premise of mark-and-recapture population estimates is that the ratio of marked fish to unmarked fish collected in a recapture event is the same as the ratio of originally marked fish in the total population. An estimate of abundance can be calculated using the following Petersen estimator (Johnson et al., 2007):

$$N = MC/R$$

Where:

N represents the total population.

M represents the number of fish marked in the original sample.

C represents the total number of fish captured in the second sampling event.

R is the number of marked fish captured during the second sampling event

To account for potential bias with small sample sizes, Chapman (1951) recommended the following corrections to the Petersen estimator:

$$N = \frac{(M+1)(C+1) - 1}{R+1}$$

Total population estimates then will be calculated using standard mark-and-recapture formulas.

11.4.4 Data Management and QA/QC

At the end of each survey day, a Level I quality assurance/quality control (QA/QC) review of the field data sheets will be completed to check for accuracy and completeness. Each field data sheet will be dated and initialed by the field reviewer. Data will be entered into an Excel spreadsheet. Separate workbooks will be maintained for each stream. Changes/corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field data forms will be archived at R2 with a copy delivered to Pebble Partnership.

Excel data files will be imported into the aquatic habitat Access database. Once in the Access database, electronic data will undergo a Level II QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level III QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

11.5 Aquatic Habitat Assessment

Aquatic habitat and fish abundance surveys will be conducted to document the distribution and quantity of aquatic habitat types in specified locations in the NFK, SFK, and UT watersheds. These aquatic habitat surveys are a continuation of similar surveys initiated in 2004 and are focused in the upper watersheds closer to the zone of possible direct influence from the Pebble Project.

11.5.1 Objectives

The goal of the aquatic habitat assessment is to first characterize the types, spatial distribution, and abundance of aquatic habitats currently occurring in the mine study area and then to document fish distribution and relative abundance within those habitats. Specific objectives are as follows:

- Validate and extend previous habitat survey data in the NFK 1.190 and SFK 1.190 watersheds
- Validate and extend previous habitat survey data in the upper UT watershed, including the mainstem UT and all tributaries above UT 1.350.
- Assess the sufficiency of existing habitat data to meet the needs of Pebble Project and fill in any data gaps identified.
- Document the distribution and relative abundance of fish species located in NFK 1.190, SFK 1.190, and the UT watershed above UT 1.350.

11.5.2 Study Area

New habitat surveys will be conducted in the following areas:

- NFK 1.190 and SFK 1.190 watersheds.
- The mainstem UT and its tributaries upstream of UT 1.350.
- Any area where the assessment of existing data shows that additional surveys are needed.

11.5.3 Methods

11.5.3.1 Aquatic Habitat Surveys

Aquatic habitat surveys will be conducted by two-person survey crews. Each survey crew will consist of a fish biologist and a qualified fisheries technician. On-the-ground surveys will generally begin at a tributary confluence or a predetermined location and proceed upstream. Boat surveys will be conducted by raft and will be limited to stream segments where flow conditions and channel size preclude on-the-ground surveys. The goal of both survey types will be to collect continuous habitat data to the upper extent of the distribution of anadromous fishes. If permanent impassable barriers are encountered, those features will be documented and the surveys will end at the barriers.

The protocol for the 2008 surveys is designed to be consistent with methods outlined in the U.S. Forest Service (USFS) *Aquatic Management Handbook* (USFS, 2001) and used in previous habitat assessment work conducted in the mine study area. The USFS protocols have been modified to meet the needs of the project.

Habitat surveys for this project will include three components:

- A reach-scale description of channel morphology.
- A stream survey consistent with the USFS Tier III survey (USFS, 2001).
- Location and description of special habitat features.

A brief description of each survey component is provided below.

11.5.3.2 Channel Morphology

The USFS developed a protocol using a hierarchical habitat-classification system to provide consistent databases based on the same framework to allow for with database comparisons as well as comparisons among data from different streams. At the highest level, the Tier 1 survey incorporates information on channel morphology and valley form. Channel morphology data provide a foundation for understanding the channel-forming process that, on a river level, drive the distribution and abundance of distinct aquatic habitat types. Furthermore this information can provide a process-based context for interpreting future responses of the stream channel to perturbations. For purposes of this study, a reach is defined as a section of channel that has consistent channel morphology and flow volume. Reaches delineated for this study will be a minimum of 100 meters long. The start and end point of each reach will be located using a GPS. Reach-scale channel-morphology variables to be measured or calculated for this survey include the following:

- Bankfull width.
- Bankfull depth.
- Gradient.
- Channel pattern.
- Channel type.
- Substrate D16, D50, D84 (calculated from pebble counts).
- Sinuosity (calculated).

Reaches will be delineated by a significant change in a reach-scale geomorphology (e.g., channel type, gradient, major tributary junction). Channel morphology measurements are conducted at the reach scale and should be collected from fast-water habitat units only, as those features tend to have a channel geometry that reflects reach-scale flow volume and geomorphic processes. If major side channels are present throughout the reach, channel morphology measurements (i.e., bankfull width) should be extended across and include those features. Reach-scale data will be measured at least three times per reach. In reaches longer than 333 meters, channel morphology measurements should be collected approximately every 170 meters.

Bankfull width will be measured using a 50-meter Kevlar tape or a calibrated laser rangefinder. The maximum depth relative to the bankfull flow level will be measured using a graduated wading rod or stadia rod. Gradient will be measured using a clinometer over a distance of at least 20 bankfull widths at each site where bankfull width and depth data are collected. Substrate will be characterized once per reach at a representative riffle segment by conducting a Wolman pebble count (Wolman, 1964). Pebble-count data will be used to calculate the D16, D50, and D84 particle size. Sinuosity is a calculated variable, representing the ratio of channel thalweg length (i.e., survey distance) to valley-bottom length (i.e., straight-line distance between reach start and endpoints). Sinuosity will be calculated during data entry.

Reach-scale channel-morphology data will be recorded on the channel morphology data form (Appendix 11D). One channel morphology form will be completed for each reach.

11.5.3.3 Stream survey

Stream survey data are used to describe aquatic habitats at the meso-scale. Habitat data will be recorded on stream survey data sheets (Appendix 11D). Separate stream survey data sheets will be completed for each reach. Habitat units will be sequentially numbered as they are encountered during each survey. Habitat parameters to be measured for this study include the following:

- Habitat unit type (Table 11-2).
- Habitat unit length.
- Average wetted width (three measurements of wetted width from which an average wetted width will be calculated).
- Percent substrate composition.
- Percent eroding bank on each side of the channel.
- Length of undercut bank on each side of the channel.
- Dominant riparian vegetation type.
- Cover type and percent.

For fast-water habitats, data will be visually estimated for each unit and measured in every fifth unit of each individual fast-water habitat type (e.g., every fifth riffle, every fifth run, etc.) for calibration purposes. Data will be measured for every pool habitat unit. The type and amount of overhead cover will be visually assessed and recorded.

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

Split channels are defined as separate flow paths located within the bankfull channel and separated from each other by gravel bars that are barren or support only annual vegetation. When split flow is encountered, each split will be surveyed and the proportion of flow transmitted by the split will be recorded and used to classify each channel as primary (majority of the flow) or secondary (minority of the flow). Habitat units in the primary channel will be designated primary units and will continue to be numbered sequentially as part of the main channel survey. Split flow channels transmitting less flow will be designated secondary units and will be numbered as SP1-1, SP1-2 etc.

Data also will be collected for side channels. Side channels are defined as features with a fluvially sorted mineral bed that are separated from the main channel by an island that is at least as long as the bankfull width of the main channel and that supports permanent vegetation. At a minimum, the inlet and outlet of each side channel will be documented by collecting a GPS waypoint and taking a photograph looking upstream from the outlet and downstream from the inlet. The side channel will be identified as entering from the left or right bank (looking downstream) and classified as wet or dry. Habitat data for wetted side channels will be collected as described above. Side channels will be labeled SC-LB1, SC-RB2, etc. in the order they are encountered.

11.5.3.4 Special Habitat Features

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

For tributaries, the contribution to flow (percent) will be visually estimated, and the temperature of the tributary inflow and mainstem flow upstream and downstream will be recorded.

For features classified as seeps or springs, the contribution to flow (percent) will be visually estimated, and the temperature of the seep/spring inflow and mainstem flow upstream and downstream will be recorded.

For features classified as stream barriers, the following information will be recorded in the comments section of the data sheet:

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

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

11.5.3.5 Data Management and Analysis

To ensure data-collection consistency among surveyors, all survey crews will complete habitat training before the habitat surveys begin. Survey crews will remain assigned to a stream until completion of a survey to maintain intra-stream data-collection consistency. One of three supervising fish biologists from

R2 will be present on site and will rotate between survey crews to provide quality assurance and quality control for protocols and data collection.

At the end of each day, a Level 1 QA/QC review will be completed on the field data sheets to check for accuracy and completeness. No blank spaces will be left on field forms; if a data field is not applicable, “NA” will be entered into the field, or if the appropriate value to be entered is zero, “0” will be entered into the field. Each field data sheet will be dated and initialed by the field reviewer.

Data will be entered into an Excel spreadsheet. Separate Excel workbooks will be maintained for each stream. Changes/corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field forms will be archived at R2, and a copy of the corrected forms will be delivered to Pebble Partnership after data entry.

Excel data files will be imported into the aquatic habitat Access database. Electronic data will undergo a Level 2 QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level 3 QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

The Pebble aquatic habitat database will be structured around the field sheets for each survey component. The data records will be nested in three summary data tables. A channel morphology table will summarize average channel morphology characteristics by reach. A Tier 3 habitat table will be developed to summarize unit-level habitat data by reach and will include data on special features encountered in the field. A data dictionary table will be prepared that describes each of the fields in the database.

11.5.4 Schedule

Habitat surveys will be conducted from July 2008 through October 2008.

11.6 Fish Population and Habitat Assessment for Upper Talarik Creek

Surveys will be conducted to document the type and distribution of aquatic habitat types and to describe the fish community present in the lowest segment of Upper Talarik Creek, which has been designated Segment 1 and which encompasses approximately 14.5 kilometers of the creek (Figure 11-3). This lower segment of UT passes through APC-owned land and supports a rainbow trout sport fishery. Both the habitat and fish population surveys will be conducted in coordination with fisheries staff from APCS. The aquatic habitat surveys will describe the types, spatial distribution, and relative abundance of aquatic habitats, while the fish population surveys are intended to document the presence of fish species within Segment 1.

11.6.1 Objectives

The goal of the aquatic habitat assessment is to document the fish resources and existing aquatic habitat conditions in UT from approximately river kilometer (RK) 0 to 14.5. Specific objectives are as follows:

- Confirm the downstream extent of the existing aquatic habitat data from surveys conducted in 2004 through 2007.
- Map the distribution of meso-scale habitat types within the study reach using a combination of existing data, remote sensing, and float surveys.
- Identify the species and life stages of fish present in the lower UT.

11.6.2 Study Area

The study area extends along the mainstem UT from the stream's confluence with Lake Iliamna (RK 0) upstream approximately 14.5 kilometers (Figure 11-3). In order to ensure that the Pebble Project habitat database includes continuous coverage in UT, surveys will extend farther upstream if review of the existing data indicates a data gap.

11.6.3 Methods

The protocol for 2008 habitat surveys was developed to be consistent with the U.S. Forest Service stream habitat classification methodology (USFS, 2001) that was used in previous surveys conducted in 2004 through 2007, but was modified to accommodate a boat-survey protocol necessary because of the wider, swifter, deeper waters of lower UT. The variables selected provide a first-order description of baseline habitat conditions for comparison with past and future monitoring efforts.

GPS coordinates will be taken at 0.5-kilometer intervals in the center of the channel and to approximately locate tributary confluences, major side-channel inlets and outlets, and unique landscape features. GPS coordinates of river kilometer stations (the endpoints of the 0.5 kilometer intervals) and significant features identified during the office mapping phase will be downloaded to the field unit to assist in navigation and to guide field mapping.

Habitat surveys will be conducted by a two-person survey crew floating on a raft. Each survey crew will consist of two fish biologists, one from R2 and one from APCS. Surveys will begin at a tributary confluence or a predetermined location.

The field survey protocol is designed to be generally consistent with Tier 2 methods outlined in Chapter 20, Fish and Aquatic Stream Habitat Survey, of the U.S. Forest Service's Region 10 *Aquatic Habitat Management Handbook* (USFS, 2001). Methods will be modified from the Tier 2 protocols by the inclusion of habitat units delineated at the Tier 3, meso-scale, habitat level. As the survey crew travels downstream, the type of each habitat unit will be identified to the meso scale. For pools, the maximum depth will be recorded using a weighted depth sounder. The dominant and subdominant substrate for each unit will be visually estimated and recorded. Qualifying logs, root wads, and key large pieces of wood will be recorded if encountered. Evidence of bank disturbance (e.g., erosion, mass wasting) will be noted and photographed.

Every 1.0 kilometer the survey crew will pull over to measure channel morphology parameters and to establish a habitat measurement site. Data collected at 1.0-kilometer intervals will include the following (see example field forms in Appendix 11D):

- Channel type.

- Channel planform (single thread, multiple thread, braided).
- Gradient.
- Bankfull width.
- Bankfull channel depth.
- Channel bed width.
- Wetted width.
- GPS coordinates of the measurement site.

Gradient will be recorded over a distance of 30 meters upstream and downstream of the measurement site (60 meters total) or across at least one complete pool-riffle sequence, whichever is less. Widths will be measured using a calibrated laser rangefinder. Depths will be measured using a stadia rod and/or weighted depth sounder. Photographs will be taken looking upstream, downstream, and across the stream from each bank. The habitat team will stake each measurement site with a marking denoting the site name and the date for subsequent identification by the fish assessment team.

After the habitat surveys are completed the fish assessment team will conduct snorkel surveys at each habitat measurement site. These teams will consist of two snorkelers and one data recorder. Two people will snorkel while the other records data. Snorkel surveys will be conducted over a 15-minute interval. The snorkelers will concentrate on pool habitats, channel margins, and other features that would provide hiding cover or resting areas for juvenile and adult fish. Data recorded at each snorkel site will include the following (see example field forms for snorkel surveys in Appendix 11C):

- Meso-scale habitat unit type and unit number.
- Visibility.
- Substrate.
- Temperature.
- Area covered (estimated length and width of surveyed unit).
- Cover within sample area.
- Number of fish observed by species/life stage (juvenile or adult).
- Total time snorkeling.

Notes describing the sample area, flow conditions, and any other relevant observations also will be recorded.

If flow conditions preclude safe snorkeling, fish presence may be assessed with the use of a beach seine. If sampling is conducted using a seine, three to four field staff will be required. Seining would be conducted for the same time interval as for snorkel surveys, and the same data would be recorded.

11.6.4 Schedule

Habitat and fish surveys will be conducted in early September 2008.

11.7 Fish Tissue Study

Fish tissue sampling is planned in 2008 and will duplicate the sampling completed in 2007. Table 11-3 shows the sampling schedule for collection of fish tissue during the period-of-record (2004 through 2008).

11.8 Instream Flow Study

The instream flow study is composed of three studies: a main channel flow habitat study, an off-channel habitat study, and a study of surface water temperature. The study was initiated in 2004. The area specific to the instream flow study includes the upper portion of the mainstem Koktuli River and the full lengths of Upper Talarik Creek and the south and north forks of Koktuli River (Figure 11-4).

The primary purpose of the instream flow study is to determine the relationship of flow to both main-channel and off-channel habitats. This study will include a consideration of such components as surface water temperature, geomorphology, availability of suitable spawning/rearing/incubation habitat, and fish use.

The overall goal of the instream flow study is to establish habitat/flow relationships for each of the channel reaches measured and modeled. This information can be used to accomplish the following:

- Characterize the existing fish-habitat conditions in the study area.
- Provide input to the project design process.
- Predict possible changes in physical habitat conditions that could occur as a result of any changes in flow regimes resulting from project operations.
- Assess possible effects of flow changes on important fish species within these systems.

The assessment will be completed using the U.S. Fish and Wildlife Service’s (USFWS’s) Physical Habitat Simulation (PHABSIM) system, which is an integral component of the Instream Flow Incremental Methodology (IFIM; Stalnaker et al., 1995; Bovee, 1982; Bovee et al., 1998).

11.8.1 Main Channel Flow Habitat Study

During the flow-habitat surveys to date, water surface elevations, discharge, water-column depth, channel geometry, velocity, substrate, and cover have been measured at a total of 92 transects at various levels of flow, with the goal of capturing conditions during representative high, middle, and low flows within the study streams. Transects have been located on the South Fork Koktuli (28 transects), North Fork Koktuli (21 transects), mainstem Koktuli (5 transects), Upper Talarik Creek (32 transects), and Upper Talarik tributary UT1.190 (6 transects). Additionally, fish-presence surveys that enumerate fish by species and size class have been conducted at each site at various flow levels.

Although considerable data collection has occurred since the instream flow study was initiated in 2004, additional work for 2008 will focus on increasing the number of transects within certain stream segments to capture important habitat features and to increase and/or balance the overall density of transects among watersheds in order to better determine stream and reach-specific habitat/flow relationships. Existing transect data are being analyzed, and preliminary hydraulic models are being developed. It is possible that certain transects may need to be resurveyed in 2008 to account for channel changes and to facilitate model calibrations.

11.8.1.1 Goals and Objectives

Specific objectives of the flow habitat study in 2008 are as follows:

- Review existing transect data for suitability in developing hydraulic models and identify any transects requiring supplemental survey information, then collect any supplemental data needed.
- Evaluate the geographic coverage of existing transects, and if necessary, complete data collection during high-, mid-, and low-flow conditions at newly established transects.
- Compile, review, and assess habitat suitability criteria (HSC) curves developed for other habitat- and flow-related projects completed in Alaska and the Pacific Northwest for stream systems with similar fish-species composition, and evaluate the applicability of those curves to this study.
- Review and evaluate site-specific HSC curve data collected during previous sampling efforts on this project, and compare data with literature-derived HSC curves.
- Conduct the appropriate surveys to collect additional site-specific species and life-history data needed to develop site-specific HSC criteria and/or to refine or validate literature-derived curves. Conduct a technical working group (TWG) meeting to present proposed HSC curve sets and reach consensus on final curve sets to be applied in habitat/flow analysis.
- Perform data entry, quality control reviews, and data reduction for all data collected during the 2008 study.
- Develop calibrated hydraulic models for all transect data, and provide it to technical representatives of the TWG for review.
- Perform hydraulic and habitat modeling and analysis to characterize flow/habitat relationships for each of the channel reaches in the study area, and provide results to the TWG for review.

11.8.1.2 Site and Transect Selection

The selection of study sites and transect locations within the streams will be based on a review of existing transect locations, habitat types, and channel characteristics. To date, data have been collected from a total of 92 transects in the various channel reaches, with transect locations based on habitat types and diversity, channel morphology, and locations relative to tributary inflow and connectivity with side-channel and off-channel habitats. The selection of sites to be measured in 2008 is ongoing and will be reviewed and discussed with the TWG. Tentative transect locations will be identified on maps, and the rationale for the transect locations will be discussed. To the extent possible, final transect selections will be made jointly with members of the TWG during a field reconnaissance tentatively scheduled for the last week in May.

11.8.1.3 Field Methods

The collection of field data from each transect will follow procedures consistent with those used during previous sampling efforts and as outlined in Trihey and Wegner (1981). Following these procedures, three sets of flow measurements will be made to allow the hydraulic modeling of select habitat variables over a range of flow conditions. Sampling will be coordinated with annual hydrograph variation and will be based on a review of existing study area hydrology. Three distinct flow levels will be targeted for transect sampling: low flow (approximately 80% exceedence), mid-level flow (approximately 50% exceedence), and high flow (approximately 20% exceedence).

Data Collection for Physical and Hydraulic Measurements

The establishment of transects at each sampling location will be completed as follows:

- **Survey Preparation**—All field equipment used for collecting transect data will be checked and assembled for use. This will include a spin test of calibrated velocity meters, assembly of the top-setting wading rod, calibration of a global positioning system (GPS) unit, and peg testing of the survey level. Stream discharge data for the reach sampled will be obtained from flow-monitoring gages or by direct measurement on the day of the survey.
- **Locations of Transects**—Transect locations will be recorded and mapped in a field book and on a topographic map or orthographic rectified aerial photographs. Additionally, location coordinates will be determined using a hand-held GPS unit. Muted survey flagging will be used to mark the position of each transect.
- **Establishment of Transect Benchmarks**—Permanent surveying benchmarks will be established at each transect. All survey measurements within a site, including headpin and water surface elevations, will be referenced to an arbitrary benchmark elevation (i.e., 100.00). The benchmark (e.g., bedrock or boulder point, star-bolt anchors, rebar) will be placed above the floodplain of the river and marked with survey flagging.
- **Establishment of Working Pins**—Working pins (e.g., wood stakes, tree stem or branch, star-bolt anchors) will be established on both sides of the river. These working pins will be positioned in such a way that the line connecting these points is perpendicular to the main flow of the stream channel. A surveying tape will be stretched across the stream channel and connected to these points during the collection of instream flow data.
- **Survey of Headpin Elevations and Completion of Level Loop**—Following the installation of the head pins, a level-loop survey will be completed to establish pin elevations. The elevation data will be obtained using an automatic level and stadia rod (0.01-foor accuracy). The level loop will be considered accurate if closed to within 0.02 feet of the benchmark elevation.

Figure 11-5 is a schematic illustrating survey techniques and locations for depth, velocity, and substrate measurements along a hypothetical transect.

Transect depth and velocity, and water surface elevation will be measured under all three flow conditions. Substrate composition will be recorded during the low-flow sampling only. The following data will be recorded at each transect:

- **Stream reach and transect number**.
- **Habitat type**—classified as glide, run, riffle, pool, cascade, or island complex (following definitions described in Bain and Stevenson, 1999).

- **Sampling date, time, investigators, and flow**—information regarding when data were collected, who collected the data, and under what flow conditions the data were collected.
- **Water surface elevations** measured to the nearest 0.01 feet. at three locations in the channel—left bank, center of channel, and right bank. The survey instrument manufacturer and serial number will be noted for each transect.
- **Photographs** showing each of the three flow conditions.

Data will be collected at set intervals across each transect. These intervals (cells) will be established so that the flow within any cell does not exceed 10 percent of the total flow in the channel and each transect will include a minimum of twenty cells. The following data will be collected at measurement points (verticals) across each transect:

- **Bed Elevations** (to nearest 0.01 foot) measured during low-flow conditions using an automatic level and stadia rod (bed elevations in pools may be determined by subtracting the depth measurement from the water surface elevation).
- **Water Depth** (to nearest 0.05 foot) measured using either a 4-foot or 6-foot top-setting rod, depending on water depth.
- **Mean Column Water Velocity** (to nearest 0.01 ft/sec) measured using a Swoffer Model 2100, Marsh McBirney, or Price AA velocity meter. Velocities will be measured at 6/10ths depth in the water column for total depths less than 2.5 feet, and at 2/10ths and 8/10ths depth in the water column for total depths greater than 2.5 feet. All current meters will be calibrated according to the manufacture's instructions prior to the first field trip and field calibrated during each subsequent trip. The velocity meter serial number, propeller assembly code, and calibration number will be noted for each transect surveyed.
- **Substrate** classified visually for each cell using dominant and subdominant substrates (based on a modified Wentworth Scale [Table 11-4]).
- **Cover** determined by a visual assessment of the bank cover, object cover (e.g., overhanging boulders), and woody debris cover (Table 11-5).

A crew of two or three individuals experienced in collection of PHABSIM field data and in PHABSIM modeling will perform the field work. All data will be recorded in waterproof field-survey books. All data will be reviewed prior to departing the sample site to ensure that all necessary data have been collected and are legible. After each field effort, all data will be photocopied, checked, and entered into computer data files.

Habitat Suitability Criteria Curve Development

Habitat suitability criteria curves reflect species and life-stage use and preference for selected habitat parameters (depth, velocity, substrate; Bovee, 1982; Bovee, 1986). Depending on the extent of data available, HSC curves can be developed from the literature (Category 1 curves) or from physical and hydraulic measurements made in the field over species microhabitats (Category 2 curves). When adjusted for the availability of habitat, these latter curves may more accurately reflect species preference (Category 3 curves), as described by Bovee (1986; see Section 11.8.1.4 below).

The characteristics of the HSC curves have a major influence on calculations of the relationship between flow and potential habitat. Since only a limited amount of site-specific HSC-curve data are available for streams in the study area, additional data on site-specific microhabitat (depth, velocity, substrate, and cover) use will be collected for certain target species and life stages (Tables 11-6 and 11-7). The list of target species for which site-specific data will be collected will be discussed and agreed upon with resource agency personnel during a TWG meeting.

The objective of this task is to collect data at 75 to 150 points for each of the target fish species and life stages in order to generate site-specific HSC curves. However, if a sufficient number of observations cannot be collected for a particular species or life stage, then the existing data will be used to validate and/or modify literature-based curves to better reflect habitat use in study area streams. In the event data for a particular species/life stage cannot be collected, then values from published literature will be compiled and reviewed for their potential application in the modeling.

The seasonal presence or absence (i.e., periodicity) of each species and life stage will be determined so that the habitat/flow modeling can reflect temporal changes in target species' life-stage requirements. Additionally, this information will be used to direct HSC-curve data-collection efforts to ensure that field surveys occur during the most likely time for locating and observing the target species and life stages. Preliminary periodicity tables were broadly determined for each of the anadromous (Table 11-6) and resident (Table 11-7) fish species and life stage of concern. These periodicities will be finalized based on discussions with agency personnel, as well as on the results of ongoing fish-resource studies.

The HSC data collection will include measurements of microhabitat data (depth, velocity, substrate data) over redds and at observed locations of juvenile and adult habitat use.

Redd Surveys

Measurements of redds will be made opportunistically in conjunction with the low-flow sampling during transect measurements. Depending on the timing of spawning of different species of salmon, an additional survey focused specifically on collection of redd data will be completed.

The locations of all redds found will be plotted on a low-elevation aerial photograph and a GPS position will be recorded for each redd. The following information will be recorded for each redd:

- Species of fish as determined by direct observation or fish presence in the vicinity of the redd.
- Redd dimensions (area) using procedures described by Reiser (1981).
- Water depth to the nearest 0.1 foot at the upstream end of each redd measured using a top-setting wading rod.
- Mean water column velocity at the upstream end of each redd measured to the nearest 0.01 feet per second using a Swoffer Model 2100,Marsh McBirney, or Price AA current meter.
- Substrate size (dominant, subdominant, and percent dominant) using a modified Wentworth scale (Table 11-4).

In addition, representative photographs of selected redds will be taken. All previously collected (prior to 2008) redd data will be incorporated into the development of draft HSC curves.

Snorkel Surveys

Snorkel surveys will be conducted to observe juvenile and adult habitat use. All snorkel surveys will be conducted by a team of two or three fish biologists with extensive experience in the identification of salmonid species. In general, the steps used in completing these surveys will be as follows:

- **Survey Preparation**: All field equipment used for collecting microhabitat data will be checked and assembled for use. This will include a spin test of calibrated velocity meters; calibration of the thermometer; assembly of the top-setting rod; and preparation of marking weights and/or flagging, underwater lights, and dry suits. Stream discharge data for the reach being sampled will be obtained from flow-monitoring gages or by direct measurement on the day of the survey.
- **Sampling Condition/Visibility Assessment**: Prior to each survey, a Secchi disk reading will be taken to determine visibility. A Secchi disk will be held underwater by the person who will be recording data, and a tape measure will be extended by the snorkeler from the Secchi disk outward to a point where the disk is no longer clearly visible. As a general rule, when visibility is less than five feet, no sampling will occur. The water temperature also will be recorded at the beginning of each survey.
- **Preparation for Estimating Fish Sizes**: To ensure accurate estimation of fish size underwater, the snorkelers will calibrate their sight to a ruler prior to beginning each survey. Rulers and objects of known length (e.g., fingers, marks on diving gloves) will be used during the survey to maintain accuracy in the estimation of fish length.
- **Fish Observations**: Starting at the downstream point of the study reach, the snorkelers will proceed upstream while observing all microhabitat types within their line of sight. When two divers are working together, both sides of the river will be covered, with the midpoint of the river serving as the boundary of coverage for each diver. When a fish is observed, a colored weight will be dropped at the point of initial observation, and the snorkeler will verbally transmit the following information to the data recorder:
  - Fish species.
  - Fish length (nearest 10 millimeters).
  - Location in water column (distance from the bottom).
  - Substrate classification using a modified Wentworth scale (Table 11-4).
  - Proximity/affinity to habitat structure/cover features (Table 11-5).
  - Relevant comments pertaining to cover associated with and/or behavioral characteristics of the fish observed.
- **Microhabitat Measurements**: Only fish holding over a fixed position will be included in the microhabitat survey. To minimize inaccurate habitat measurements and to prevent double-counting of fish, moving fish will not be counted. After locating a fish and marking the observation location, the data recorder will proceed to the colored weight and will collect the following information:
  - Water depth measured to the nearest 0.1 foot using a top-setting rod.

- Mean column velocity in feet per second measured using a Swoffer Model 2100, Marsh McBirney, or Price AA current meter.
- Nose velocity in feet per second measured at the location in the water column noted by the snorkeler.
- Substrate classification using a modified Wentworth scale (Table 11-4).

All data will be recorded in field notebooks and will be reviewed in the field to ensure that all measurements have been properly recorded and are legible prior to departure. Photographs will be taken of representative habitat types where fish of different species and size classes are observed.

11.8.1.4 Data Analysis

Development of HSC Curves

Before the microhabitat data are analyzed, an evaluation of the different methods for developing HSC curves will be completed. Three different methods are commonly used for converting habitat utilization-frequency data into HSC curves: function fitting, nonparametric tolerance limits, and histogram analysis (Bovee, 1986; Slauson, 1988). The selection of which method to use for developing the HSC curves for this study will be based on the number of observations obtained and the variation in microhabitat use by species and life-history stage. For discussion purposes, it is assumed that a histogram analysis (described below) will be used for development of HSC curves.

Before calculation of the HSC curves, the habitat data will be entered into Excel spreadsheets and subsequently checked for data-entry accuracy. Data will then be sorted according to species and life-history stage (based on size class). Frequency distributions will then be generated for mean velocity, depth, and substrate type for each species. Frequency bin widths of 0.2 will be initially used to produce histogram plots for evaluating the mean velocity and depth utilization distributions. Histogram plots of nose depth and nose velocity utilization also will be produced using a 0.2 bin width. Bin widths may be modified in accordance with the Sturges Rule (Sturges, 1926, as cited in Cheslak and Garcia, 1988), which is a method for determining the optimal histogram bin width for a frequency distribution based on the sample and range of values observed in the distribution.

The resulting frequency distribution will then be smoothed using a three-point running mean filter to remove multiple peaks and discontinuous values in histogram-generated HSC curves. The smoothed frequency distributions will then be converted into HSC curves by scaling the distribution between 0 and 1 (utilization values divided by the maximum value observed). These HSC curves will then be compared to curves sets from published literature.

Technical Review Meeting

Results of the HSC-curve development will be presented and discussed during a special TWG meeting. Copies of candidate HSC curves will be provided to TWG members at least one week before the meeting. The presentation will include a discussion of data-collection and analysis techniques, other data sets reviewed and analyzed, and the technical basis and rationale for each of the candidate curves. Comments on each of the HSC curves will be solicited from the TWG during the meeting. The objective of the meeting will be to reach a consensus on the HSC curves that will be used in the habitat/flow modeling.

Habitat Availability

The availability of microhabitats (depth, velocity, substrate, and cover) will be estimated using the frequency of different ranges of habitat dimensions from the results of hydraulic measurements and modeling completed as part of the instream flow study. Depth, velocity, substrate, and cover elements will be measured across each of the instream flow transects that have been placed to represent the full complement of habitat types that occur in the study area (i.e., riffle, run, glide, cascade, island complex, and pool). These data will be presented in tabular and graphical form to allow comparisons with the microhabitat data.

Hydraulic and Habitat Modeling

The latest version of the USFWS microcomputer software PHABSIM (PHABSIM for Windows, Version 1.20) will be used for all hydraulic and habitat modeling analysis (Waddle et al., 2001). Based on channel morphologies, the most appropriate computer model (i.e., IFG4, MANSQ, or WSP) will be selected to develop stage/discharge relationships for the various transects. Details of all calibration steps will be documented and made available to the TWG members for review. Hydraulic simulation modeling will include the following steps:

- Raw field data will be entered into Excel spreadsheets, reviewed, and reduced into a form ready for creation of hydraulic data decks. Data entry errors will be identified, noted in a copy of the field notebook, and corrected. These computer spreadsheets will then be used to generate hydraulic-data input files for the PHABSIM hydraulic simulation program, IFG4.
- The IFG4 data files will be checked for any errors or erroneous field measurements using the REVI4 and CKI4 computer programs.
- Stage/discharge relationships will be developed using one or more hydraulic simulation procedures, depending on the hydraulic characteristics of individual transects. An initial stage/discharge calibration will be conducted using IFG4. Depending on the hydraulic characteristics of a given transect, a stage/discharge relationship will be developed using one of three methods: a log-log regression method (rating curve developed using the program STGQS4), a channel geometry and roughness method (rating curve developed using the Manning's Equation-based program MANSQ), or a step-backwater method (rating curve developed using the program WSP).
- Velocities across each transect will be calibrated to provide a realistic distribution of mean column velocities across the river channel for the entire range of flows employed in habitat simulations.

Output from the hydraulic simulation modeling will be used in conjunction with final HSC criteria to simulate habitat conditions for each target species and life stage over a wide range of flows. Habitat simulations will be conducted using the HABTAV habitat simulation-modeling program. HABTAV uses velocities obtained directly from the hydraulic model (IFG4) output files for habitat area calculations (Milhous et al., 1989).

Weighted usable area (WUA) habitat versus discharge curves will be calculated for each target fish species and life stage for all transects and sites. WUA is a habitat index that combines the quantity and quality of a given habitat as predicted by alternative flows. WUA is expressed in units of square feet of habitat area per 1,000 linear feet of stream (sq ft/1,000 ft; Bovee, 1982; Milhous et al., 1989). The WUA versus habitat curves for each site will then be used to estimate total habitat areas (HAs) for each reach (Bovee, 1982). "HA" is used to express the total habitat area provided by a specified flow for a given river or segment, and is typically expressed in square feet, acres, or hectares. HA combines the amount of WUA provided among the different instream flow transects, sites, or representative reaches present in a river segment. The WUA values for each transect will be weighted according to the total length of habitat represented by habitat type which the transect represents. Habitat weightings will be based on the results of habitat-mapping surveys.

11.8.2 Off-Channel Habitat-Flow Study

Off-channel habitats (OCHs) can serve as important rearing and refuge habitats for salmonid species that use streams and rivers within the study area; therefore, it is important to understand physical, chemical, and hydrologic linkages between these types of habitats and the mainstem channels of the NFK and SFK and UT. The OCH component of the instream flow study was initiated in 2005 and focuses on habitats near or adjacent to the mainstem. For this study, an off-channel habitat is defined as follows (NDM, 2007):

> . . . a distinct waterbody with vegetated banks, separate from other waterbodies such as the mainstem and side channels; however, OCH units may be linked to the mainstem or side channels permanently at one end or, occasionally, at both ends. Off-channel habitats are considered distinct from side channels, which have stream-channel connections to the main channel, receive surface water flow from the stream at the upstream end, and are wetted each year during bank-full or lower flow conditions.

To date, a total of 15 OCH transects have been established and measured in the SFK, and 16 OCH transects are established in UT.

OCHs form in association with alluvial rivers that move back and forth across a floodplain creating a complex mosaic of abandoned channels, oxbow lakes, and side channels. Peterson and Reid (1984) developed a classification system that described OCH as relict channels (abandoned former stream channels, including oxbow lakes), overflow channels (high-flow channels that form where floods cut across the top of gravel bars), and wallbase channels (groundwater-fed channels that form at the base of valley side slopes). Classification of OCHs may be used to support instream flow studies and other assessments of habitat availability by describing and quantifying locations that provide similar habitats and that respond similarly to changes in mainstem flow (USACE, 1998; R2, 2007). A modified version of Peterson and Reid's classifications system will be used for this study. Modifications were developed specifically for this study to incorporate OCH habitat types observed in the tundra environment during the first three years of data collection (e.g., potholes, beaver pond complexes).

A schematic depiction of OCH types to be assigned in this study is provided in Figure 11-6. The preliminary list was developed based on review of aerial imagery and data from past years. Additional OCH types may be identified based on field surveys. OCH types identified to date include the following:

- Beaver pond complexes.

- Potholes.
- Relict channels (side channels connected to mainstem at the upstream end during high flows).
- Backwater sloughs.
- Overflow channels.
- Wallbase channels.

Channels that are separated from the mainstem by islands and are typically wetted at moderate or low flows are classified as "secondary channels" and are being surveyed as "island complex" habitat types as part of the mainstem flow habitat study. Secondary channels are not classified as OCHs for this study.

11.8.2.1 Objectives

The overall goal of the 2008 OCH study is to correlate the amount of accessible OCH to flow levels in adjacent mainstem reaches of the NFK, SFK, and UT. Specific objectives of the OCH-habitat study in 2008 are as follows:

- Review existing OCH data collected in the SFK and UT to assess whether they are sufficient to link data on water surface elevation and habitat area to nearby existing or proposed mainstem instream flow transects.
- Establish approximately 10 new OCH transects on the NFK, and complete data collection during high-, mid-, and low-flow conditions.
- Identify locations at which both new and previously surveyed OCH habitats connect to the mainstem, and estimate the flow required to allow fish access to those features.
- Collect additional data on stage and water surface elevations in representative OCH types to better document the relationship between mainstem flow and OCH availability.

Data on fish utilization in OCHs and adjacent mainstem habitats were collected in 2005, 2006, and 2007 for the SFK and in 2007 for the UT. Data on fish utilization of OCHs and adjacent mainstem habitats will be collected in the NFK in 2008 as part of a separate study (Section 11.10). Site-specific data on OCH availability will subsequently be extrapolated to the entire study area based on remote sensing analysis and geographic information system (GIS) coverage.

11.8.2.2 Study Area

The primary area of interest for OCH surveys in 2008 will be the NFK. One or two OCH survey areas will be selected based on the abundance of OCHs and the presence of existing or proposed instream flow transects. OCH study areas established in 2005, 2006, and 2007 will be revisited at least once to evaluate the connectivity of OCHs. These previously established OCH areas are located in SFK Reach 2 and UT Reach 2 (Figure 11-4).

11.8.2.3 Field Methods

Transect and Water Surface-elevation Surveys

Site selection and establishment of OCH transects on the NFK will be consistent with the *2005 Off-channel Habitat Study Field Sampling Protocol* (ERL and HDR, 2005) used during previous sampling efforts. OCH transects will be selected to reflect the variety of OCH types present in the study segment, using the most recent set of aerial or orthophotos. All new OCH transects will be linked to an existing or proposed instream flow transect. OCH transects will be perpendicular to the lengthwise axis of the valley floor, crossing the mainstem at the associated instream flow transect, and will extend across the floodplain for 1000 feet on either side of the channel or to the point where a significant increase in slope (valley wall or terrace) is encountered. Transect endpoints will be marked with a headpin and tailpin. Transect locations will be recorded using a GPS unit and will be mapped in a field book and on a topographic map or ortho-rectified aerial photographs.

Valley bottom and OCH channel geometry will be surveyed during the initial site visit using a high resolution Real Time Kinematic (RTK) GPS. Vertical control will be established by linking OCH data to the temporary benchmark associated with the coincident instream flow transect. A profile of the valley bottom will be surveyed along the OCH transect, with elevation collected at major slope breaks. When OCHs are encountered, they will be assigned an identification code that reflects the stream name, the instream flow transect identification code, "OCH," and a number and/or letter code (e.g., SFK-TR1_08OCH-5a, etc.).

Using RTK GPS, water surface elevations will be measured at the right bank, center, and left bank in the mainstem and in each OCH encountered over a series of three flow levels. Target flow levels for the OCH study will be the same as those for the instream flow study—low, middle, and high flows.

The relationship between mainstem flows and water levels in OCH features is expected to be more complex than the relationship between flow and habitat in the mainstem. Additional data will be collected from two or three representative examples of each type of OCH. A pressure transducer that can record stage in 15-minute to 1-hour intervals will be installed in one example of each habitat type during the initial field surveys. If possible, these data will be linked to mainstem sites for which continuous stage data are being collected as part of the surface hydrology studies. If no continuous gages are located nearby, additional sensors will be installed at the associated mainstem instream flow transect. Temporary staff gages will be installed at two to three other representative examples of OCHs. Paired staff gages will be installed in the OCH and in the associated mainstem habitat at each transect. Temporary staff gages will consist of a 3- to 5-foot graduated gage plate fastened to 5- to 7-foot-long metal T-post. (Stage recorders—staff gages or pressure transducers—installed in support of the OCH study will be used only to compare the timing and pattern of changes in water level between OCH units and the mainstem. No hydrologic analyses or flow data will be developed at OCH sites).

Elevations of sensors and staff gages will be surveyed relative to the temporary benchmark during transect setup. Staff gage elevations will be recorded during flow surveys and habitat utilization surveys conducted as part of another task to support a more rigorous evaluation of the relationship between OCH and main-channel water levels in the various OCH types.

Physical and Hydraulic Measurements

Depth, substrate, and cover will be assessed in each OCH under all three flow conditions. In small OCH features (less than 10 feet wide), depth and substrate measurements will be taken at each wetted edge and at 1-foot intervals across the feature. In larger features, data will be collected at a minimum of 20 verticals. If flowing water is encountered, velocity at each vertical will be measured as well; however, data collected in the past three years of this study suggest that most OCHs encountered have minimal to no measurable velocity. Substrates will be classified using a modified Wentworth scale (Table 11-4). Cover will be classified in accordance with the classification codes noted in Table 11-5. Photographs will be taken of each site at each flow level looking upstream, downstream, and across the feature.

A crew of two individuals will complete the OCH field work. All data will be recorded in waterproof survey books. All data will be reviewed prior to departing the survey site to ensure that all necessary data have been collected and are legible. After each field effort, all data will be photocopied, checked, and entered into computer data files.

Water Quality

Water quality characteristics will likely vary between OCH types. For example, wallbase channels that are fed by groundwater flow are expected to have a signature characteristic of that source (e.g., stable temperatures, lower dissolved oxygen, higher conductivity) that is consistent over time. In contrast, relict channels frequently transmit a combination of surface and hyporheic flow, and thus would be expected to exhibit a varying degree of groundwater influence depending on the mainstem flow level. Groundwater influence will be described qualitatively for each OCH type based on stage and water quality data.

Selected water quality parameters will be measured at each mainstem and OCH sample site to assist in identifying the primary source of the water in the various OCHs. Water quality data will be measured in situ at the center of each OCH feature and associated mainstem site using a Quanta Hydrolab or Yellow Springs Instrument (YSI) meter. Measurements will be taken at two depths at each sample point: 2 inches below the water surface and at the bed. Parameters to be measured are as follows:

- Temperature (°C).
- Dissolved oxygen (milligrams per liter).
- Conductivity (milliSiemens per centimeter).

Water quality collection instruments will be calibrated daily and will be audited before and after each field sampling effort. Records of calibration and audit results will be kept on file at R2 and will be made available on request. If post-sampling audits differ from presampling audits by more than 10 percent, data from that sampling session will be flagged and may be eliminated from the data set.

OCH Connectivity

A preliminary evaluation of OCH connectivity will be made based on remote-sensing information for features that are identifiable on photographs when transects are selected. The approximate location of OCH inlets (if applicable) and outlets will be marked on a set of field photos and assigned a GPS waypoint to guide field checks. OCH features sampled in this study will be classified by width (less than

10 feet, 10 to 50 feet, greater than 50 feet) and connectivity level (e.g., low flow connected, moderate flow connected, high flow connected). This will facilitate a linkage with remote-sensing-based habitat mapping.

OCH connectivity will be confirmed for all new OCH features identified in 2008. During field surveys, the field crew will walk upstream and downstream (if practicable) to identify the primary inlet and outlet location for each OCH feature. The elevation of the inlet relative to the mainstem water surface elevation will be measured at each site using high-resolution RTK GPS. If wetted, the water depth will be recorded to facilitate an estimate of the flow at which the feature would become disconnected. Any potential barriers to upstream or downstream movement of fish that are encountered during the survey (e.g., dry channel, beaver dam) will be photographed and located by recording a GPS waypoint.

If it is not feasible to walk the OCH feature, the survey crew will access the potential location of inlets and outlets identified on the photos by other means such as float tube (in the case of large beaver complexes, wide deep channels, or long distances to the mainstem), raft, or cross-country traverses. If no inlets or outlets are located for a given feature at or near the GPS waypoint derived from the photos, that feature will be flagged for further investigation by aerial surveys during future work.

Connectivity at OCH inlets and outlets at the OCH transects surveyed in 2005 through 2007 also will be assessed. For these transects, a preliminary evaluation of connectivity will be made based on available remote-sensing information (maps and photos). The approximate location of OCH inlets (if applicable) and outlets will be marked on a set of field photos. A single float-through visit will be conducted in the SFK OCH study reach and the UT OCH study reaches at moderate flow as defined for the instream flow study. OCH inlets and outlets that are clearly visible on the photos will be visited, and the elevation of the inlet and outlet "stage of zero flow" (i.e., height the mainstem flow would have to rise or fall to reach the point where the features are just connected) will be made by measuring the inlet and outlet elevations and the mainstem water surface elevation at the same location. No effort will be made to resurvey mainstem and OCH water surface elevations at previously established OCH sites in 2008.

Data Collection for Hydraulic and Habitat Modeling

By definition, OCH features rarely receive surface inflow. Data collected in 2005 through 2007 on OCH features suggest that water velocities are low, in most instances near zero. If flowing water is encountered, discharge will be measured as described for PHABSIM transects (Section 11.8.1.3, subsection on *Data Collection for Physical and Hydraulic Measurements*). Data that will be collected at the OCH features are bed elevations, water depth, and mean column water velocity.

Habitat and Fish Utilization

Habitat conditions and fish utilization at new OCH sites on the NFK will be assessed as part of a separate study entitled North Fork Koktuli Off-Channel Habitat Use Study (Section 11.10) and are not discussed here.

11.8.2.4 Data Management and Analysis

At the end of each day, field books will be checked for accuracy and completeness. Each page of the field data book will be dated and initialed by the field reviewer.

Data will be entered into an Excel spreadsheet. Separate Excel workbooks will be maintained for each stream. Changes or corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original and corrected field forms will be maintained at R2.

The flow at which each OCH feature becomes connected to the mainstem will be calculated by adding or subtracting the lowest inlet or outlet elevation from the mainstem water surface elevation and then calculating the change in flow required to just exceed that difference in elevation using the stage/discharge relationship developed for the nearest instream flow transect.

Information on the amount of OCH available across the range of flows considered in the instream flow analysis (i.e., 20 to 80 percent exceedence flow) will be derived by identifying the flow at which the OCH becomes accessible and estimating the amount of wetted OCH area based on data collected in companion studies. These data will be used to develop a generalized OCH-versus-flow availability curve.

11.8.2.5 Schedule

OCH surveys will be conducted in coordination with other instream flow field work. OCH transect layout and surveys will be initiated at high flows in June 2008. (Note that if study areas are inaccessible during June, transects will be established in July at moderate flows, and high-flow surveys will be delayed until after the onset of fall rains in September or October 2008.) Additional field visits to check water surface elevations at each new transect will be conducted in July 2008 (moderate flow) and August 2008 (low flow). To maximize efficiency and ensure continuity between efforts, the OCH survey team lead will coordinate moderate- and low-flow work with biologists conducting habitat utilization surveys.

11.8.3 Stream-temperature Modeling

Water temperature can affect a variety of salmonid species and their life-history functions, including the timing of adult upstream migrations and juvenile/smolt downstream migrations, the timing of spawning and duration of egg incubation, growth rates, and overall rates of survival (Quinn, 2005; McCollough et al., 2001; Sauter et al., 2001; Bjornn and Reiser, 1991). Temperatures in streams can vary daily, seasonally, annually, and spatially, with the degree of variation depending on meteorological, topographical, and hydrological characteristics, including patterns of runoff and groundwater exchange. Because stream temperature can be directly influenced by flow (both surface and groundwater), it is important to understand how possible Pebble Project operations that may affect streamflow may also affect water temperatures in the study area streams.

To help improve this understanding, stream-temperature models will be developed and calibrated for each of the three major streams in the study area—NFK, SFK, and UT. These models will be used to define the baseline thermal regimes of the respective systems from which to evaluate possible thermal changes that might occur as a result of possible alterations in flow regimes that might result from project operations.

11.8.3.1 Goals and Objectives

The overall goal of the stream-temperature modeling study is to define, for each of the channel reaches measured and modeled, temperature/flow relationships that can be used to accomplish the following:

- Characterize the baseline thermal conditions in the NFK, SFK, and UT.
- Predict possible temporal and spatial changes in temperatures that might result from possible changes in flow regimes related to project operations.
- Assess the possible effects of flow and temperature change on important fish species within these stream systems.

The assessment will be completed using the latest version (Version 3, revised in May 2005) of the USFWS's Stream Network Temperature Model (SNTEMP; Theurer et al.,1984), which is one component of the Instream Flow Incremental Methodology (Stalnaker et al., 1995; Bovee, 1982; Bovee et al., 1998).

Specific objectives of the stream-temperature modeling study in 2008 are as follows:

- Compile and review existing water temperature data that have been collected in study area streams.
- Maintain and download data from the existing network of temperature monitors in the NFK, SFK, and UT watersheds.
- Collect, compile, and review other meteorological, hydrological, and channel morphological data, including riparian shade information, that are necessary for developing stream-temperature models.
- Develop and calibrate individual stream-temperature models for the NFK, SFK, and UT that would be useful for evaluation of possible effects of flow changes on the thermal regimes of these systems.

11.8.3.2 Model Selection

From a thermal modeling perspective, two different seasons can be defined for the three study streams: a season with no ice cover and a season with ice cover. The model proposed for this study will be based on SNTEMP, a one-dimensional hydrothermal model developed by the USFWS (Theurer et al., 1984). This model will be most accurate under conditions with no ice cover.

The SNTEMP model was developed to predict instream water temperatures based on either historical or synthetic hydrological, meteorological, and stream-geometry conditions. The model can be applied to any size watershed or river basin with a stream network of any stream order and complexity. The model accounts for the physical processes of heat transfer with the following components:

- A heat-transport model that predicts the average mean daily water temperature and diurnal fluctuations in water temperature as functions of stream distance.
- A heat-flux model that predicts the energy balance between the water and its surrounding environment.
- A solar model that predicts the solar radiation that penetrates the water as a function of latitude, time of year, and meteorological conditions.
- A shade model that predicts the solar radiation-weighted shading resulting from both topography and riparian vegetation.

- Meteorological corrections that predict changes in air temperature, relative humidity, and atmospheric pressure as functions of a change in elevation.

The model requires meteorological and hydrologic data, as well as stream morphology characteristics. Instream water temperature data are used to calibrate the model.

Meteorological data required by the model consist of air temperature, relative humidity, sunshine ratio, and wind speed. These data will be obtained from meteorological stations established for the Pebble Project. Solar radiation is entirely modeled as a function of the latitude of the stream basin, time of year, and prevailing meteorological conditions.

Shading, resulting from both topographic features and riparian vegetation, is modeled as a function of latitude, time, basin topographic characteristics, and riparian vegetation parameters.

Hydrological data required by the model consist of discharge or flow data throughout the stream system and initial water temperatures at the beginning locations. The hydrological data needed—either the discharge, initial temperature, or both—can be developed from synthetic hydrological procedures or from known or assumed project operation procedures, where applicable. Calibration of the stream-temperature models developed for the Pebble Project will be based on flows measured by the U.S. Geological Survey (USGS) and the project.

Instream water temperature is needed for all input locations of the stream network. Calibration of the stream-temperature models developed for the Pebble Project will be based on water temperatures measured in the NFK, SFK, UT, and major tributaries of those streams.

Stream-geometry information needed for the model consists of the stream system network (mainstem and tributaries), stream widths, stream gradients, and hydraulic roughness. The stream-temperature models developed for the Pebble Project will be based on surveyed instream flow measurements.

Instream models differ from lake models because the downstream water movement tends to mix the water. This turbulent mixing is assumed to evenly distribute the temperature both vertically and transversely and, therefore, is the basis for using a constant water temperature throughout a given cross-section at any given instant. The purpose of a transport model is to predict the longitudinal temperature variation; while the temperature at a specific cross-section may be constant at any given time, a downstream differential is expected and predicted.

The turbulent mixing, leading to a homogeneous distribution of temperature throughout a given cross-section, simplifies the application of the heat-flux relationships part of the model. All heat entering the water is assumed to be immediately distributed both vertically and transversely. All heat leaving the water is a function of the homogeneous water temperature. Flowing water generally mixes at a far faster rate as a result of the turbulence than through either conduction or convection within the water.

11.8.3.3 Study Area

The geographic area included in the stream-temperature models comprises the following three reaches:

- The North Fork Koktuli River from Station TEMPNK9 to Station TEMPNK1. Continuous water temperatures will be measured at 10 stations in the NFK within this reach and at six stations in five tributaries to the NFK within this reach.
- The South Fork Koktuli River from Station SK100F to Station SK100A. Continuous water temperatures will be measured at nine stations in the SFK within this reach and at six stations in four tributaries to the SFK within this reach.
- Upper Talarik Creek from Station UT100E to Station UT100APC3. Continuous water temperatures will be measured at 14 stations in UT within this reach and at seven stations in five tributaries to UT within this reach.

A complete list of temperature-monitoring stations is provided in Table 11-8.

11.8.3.4 Field Data-collection Methods

Instream Water Temperature

Instream water temperatures have been continuously recorded at 52 stations (Table 11-8) since August 2007 using Onset Hobo TidbiT v2 recorders. These stations will be visited during the summer of 2008 to download data and to relaunch the temperature recorders. During the site visits, water temperature will be measured with a thermometer as a QA/QC check. (Upon final retrieval, all recorders will be returned to the office and QA/QC checked using a two-point—ambient air temperature and ice-water temperature—calibration procedure.) The water temperature and time of day will be recorded in a field book.

During each site visit, a thermograph of the downloaded data will be checked on a laptop computer to ensure that the recorder has been functioning correctly. Backup temperature recorders will be brought to each site in case the originally installed temperature recorder cannot be found or has malfunctioned. If necessary, backup units will be installed to replace lost or malfunctioning units.

Air Temperature

Air temperatures also are continuously measured at eight sites established near corresponding water-temperature sites. These air temperature-monitoring sites include two on the NFK (TEMPNK7 and NK100A1), three on the SFK (SK100F, TEMPSK4, and TEMPSK1), and three on UT (UT100E, UT100C1, and TEMPUT3). During the site visits to download data from the corresponding water-temperature site, air-temperature data will be downloaded from the air-temperature recorder. At the same time, air temperature will be measured with a thermometer as a QA/QC check. The air temperature and time of day will be recorded in a field book.

During each site visit, a thermograph of the downloaded data will be checked on a laptop computer to ensure that the recorder has been functioning correctly. Backup temperature recorders will be brought to each site in case the originally installed temperature recorder cannot be found or has malfunctioned. If necessary, backup units will be installed to replace lost or malfunctioning units.

Riparian Shade

During each site visit to download water-temperature data, additional data will be collected to characterize riparian shade. Riparian vegetation influences heat input from sunshine by providing shade for the stream. The data on riparian vegetation needed for the SNTEMP model will be derived from field observations and from review of available orthophotographs.

The shade from riparian vegetation is modeled in SNTEMP by specifying various parameters to characterize the riparian community. These parameters include the following:

- Vegetation Height: average maximum height of the overstory riparian vegetation above the water surface. This can be measured using an inclinometer and a 100-foot tape measure.
- Vegetation Crown Width: average of the maximum diameters of the crowns of the plants that compose the riparian vegetation adjacent to the stream.
- Vegetation Offset: average lateral distance of tree trunks from the water surface.
- Vegetation Density: ratio (between 0 and 1) that quantifies the effective shading provided by the riparian vegetation.

While the SNTEMP model is capable of modeling shade from trees and other riparian vegetation, it is recognized that NFK, SFK, and UT generally lack trees along their banks. Input to the SNTEMP model will be adjusted or a specific value inserted to account for the lack of shade from trees and to account for the shade provided by other riparian vegetation.

Intragravel Water Temperature

Additional temperature data will be useful for characterizing the thermal regime of lateral (ungaged) inflow to the study reaches. The lateral inflow comes from both groundwater and surface water sources. These data, where available, can be used in calibrating the model.

On many projects, groundwater temperature data are unavailable, and USGS (1999) suggests that groundwater temperature can be approximated by mean annual air temperature. For this study, however, groundwater temperatures have been measured at 27 sites established to monitor intragravel water temperatures. These sites include one on NFK, 14 on SFK, and 12 on UT (Table 11-9).

These stations will be visited during the summer (July) of 2008 to download data and to relaunch the temperature recorders. During each site visit, a thermograph of the downloaded data will be checked on a laptop computer to ensure that the recorder has been functioning correctly. Backup temperature recorders will be brought to each site in case the originally installed temperature recorder cannot be found or has malfunctioned. If necessary, backup units will be installed to replace lost or malfunctioning units.

11.8.3.5 Review of Available Data Obtained from Other Studies or Data Sources

Data will be obtained from other studies and data sources and will be QA/QC checked prior to incorporation in the SNTEMP model. Types of data will include hydrologic data, meteorological data, information on river and valley morphology, and seasonal thermal characteristics.

Hydrologic Data

The SNTEMP model will rely on continuous flow records measured at 38 stations comprising six in the NFK drainage (four on the mainstem and two on one tributary), 15 in the SFK drainage (eight on the mainstem and seven on six tributaries), 16 in the UT drainage (10 on the mainstem and six on five tributaries), and one on the mainstem Koktuli River (Table 11-10).

Meteorological Data

The types of meteorological data required by the SNTEMP model include air temperature, relative humidity, wind speed, and sunshine ratio. These data will be obtained from five meteorological stations established for the Pebble Project: Pebble 1, Pebble 3, Pebble 4, Pebble 5, and Pebble 6. In addition to these five meteorological stations, continuous air temperatures also are measured at the eight air-temperature stations described in Section 11.8. 3.4.

The SNTEMP model uses orographic correction algorithms to determine air temperature and relative humidity at other locations within the study reach based on elevation relative to a designated base station. The air temperature is determined from the moist air lapse rate (MALR) of 0.00656 °C decrease in air temperature per one-meter rise in elevation. The relative humidity is determined from the ideal gas law.

The SNTEMP does not have similar algorithms for extrapolating wind speed or sunshine ratio from the base station to other locations in the study reach. Wind speed is sometimes used to calibrate the SNTEMP model.

The SNTEMP model requires that a ground temperature be specified. The default value for ground temperature (average annual air temperature) will be assumed for the temperature models developed for NFK, SFK, and UT.

River and Valley Morphology

In the SNTEMP model, river and valley morphology influences heat input from sunshine, orographic adjustments to meteorological conditions, and travel time through the study reach. Thus, it will be necessary to specify a number of factors related to the morphological characteristics of the rivers and the valleys. The following characteristics will be determined for the SNTEMP models of the NFK, SFK, and UT:

- **Longitudinal Profile**: needed to perform orographic adjustments to meteorological conditions and to calculate travel time. This will be derived from 1:24,000-scale USGS topographic maps.
- **Latitude**: needed to calculate heat input from sunshine. This will be derived from 1:24,000-scale USGS topographic maps.
- **Stream Reach Alignment (Azimuth)**: needed to calculate heat input from sunshine. This will be derived from 1:24,000-scale USGS topographic maps.
- **Channel Width**: needed to calculate heat input from sunshine and to determine travel time. This will be determined from channel cross-sections and stage/discharge ratings curves obtained from USGS gaging stations and from PHABSIM study sites throughout the study reaches.

- **Topographic Altitude (Lateral Valley Slope)**: specified for both sides of the river and needed to calculate heat input from sunshine. This will be derived from 1:24,000-scale USGS topographic maps and from field observations.
- **Channel Roughness (Manning's "n")**: used to calculate the diurnal range of water temperatures. Manning's "n" will be used as a calibration parameter, as discussed in Section 11.8.3.6, subsection title *Calibrate Stream-temperature Models*.

Seasonal Thermal Characteristics

The SNTEMP model allows some parameters to be specified on a seasonal basis. These parameters include the dust coefficient, ground reflectivity (which will be seasonally adjusted to account for snow cover in the winter), and calibration factors for air temperature and wind speed. Appropriate values based on project characteristics will be selected for these parameters.

11.8.3.6 Development of Stream-temperature Models

The SNTEMP model is used to simulate heat transfer processes in a river network (mainstem and tributaries) where a steady-state solution is determined within each computational time step. The models to be developed for the river networks for NFK, SFK, and UT are described below, as is the rational for the computational time step.

Model Structure

The structure of the SNTEMP model developed for each of the three study reaches will be based on computational nodes established to define the upstream and downstream end of each study reach, the confluence of major tributaries, and locations where temperatures have been measured in each stream.

Computational Time Step

The computational time step used in the SNTEMP model should not exceed the travel time from the most upstream location in a study reach to the most downstream location. The computational time step should also be as small as possible during the time of year when water temperatures are coolest because this is a period with potential to affect eggs and alevin prior to emergence.

Travel time through the study reach will be determined from flow velocity/discharge relationships developed for the main channel flow study PHABSIM sites, as well as flow velocity/discharge relationships derived from data collected at USGS gaging stations.

Calibration of Stream-temperature Models

The SNTEMP models developed for the three study reaches will be calibrated to ensure that predicted instream water temperatures will match observed water temperatures during periods with concurrent water temperature, meteorological, and hydrologic records. Typical input variables that might be adjusted during the calibration process include wind speed, temperature of accretion flows (surface water and groundwater), and Manning's "n."

11.9 Ephemeral Reach, South Fork Koktuli River

A section of the South Fork Koktuli River, upstream of the confluence with SFK 1.190, has been observed to go dry in late winter to early spring (February through April) and again in late summer (July through August). In April 2006, the affected reach was at least 12.67 kilometers long, but was less than 16 kilometers long. Loss of flow has various possible consequences for fish and their aquatic habitat, including loss of water covering redds, fish stranding, and effects on food sources. The study proposed for 2008 will evaluate possible effects on fish spawning, rearing, and migration using existing data from 2004 through 2007 and will include a preliminary field evaluation of the effects of stranding of fish.

11.9.1 Objectives

The objectives of the 2008 study of the ephemeral reach of SFK are as follows:

- Describe the length of stream in the SFK that seasonally went dry and the timing and duration of the dry periods during 2004 through 2007 using existing hydrologic data.
- Conduct a field reconnaissance to identify the location and characteristics of isolated wetted refugia (if any) that persist throughout the dry periods.
- Assess the number, species, and age class of fish affected by stranding within the ephemeral reach.

11.9.2 Study Area

Based on existing hydrologic data collected during Pebble Project baseline studies, intermittent flow conditions may occur on the main channel of SFK for up to 16 kilometers above the confluence with SFK 1.190. In March 2005 dry conditions occurred from RK 29.9 to RK 31.3. In April 2006 dry conditions occurred between RK 28.9 and RK 41.7. In order to encompass the entire reach potentially subject to going dry seasonally, the study will include the stream segment between stream gage SK100LF7 (RK 28.56) and stream gage SK100LF2 (RK 44.77).

11.9.3 Methods

11.9.3.1 Review of Existing Data

The length of stream in the SFK that seasonally goes dry and the timing and duration of the dry periods initially will be assessed using hydrology data collected during 2004 through 2007. Available daily flow data for the stream between RK 28.56 and RK 44.77 will be reviewed and the extent of reaches that go dry each year will be evaluated. The duration of seasonal dry conditions at each flow-monitoring station in late winter and early spring and again in late summer and early fall will be determined for each year that data exists. A minimum length of the section that goes dry will be approximated based on the distance between consecutive dry stations, and a maximum length will be approximated based on the distance between the first wetted stations upstream and downstream of the dry section. Tables will be produced for each season (i.e., late winter and late summer) summarizing the length of the dry section, the date the channel goes dry, the date the channel becomes rewetted for a period of more than two weeks, and the duration of the dry period. Existing habitat and fish population data will be reviewed to qualitatively characterize the potential for juvenile fish to be stranded if the stream goes dry.

11.9.3.2 Reconnaissance Surveys of the Ephemeral Reach

Reconnaissance-level field surveys of the ephemeral reach will be conducted by walking the potentially affected reach during two periods when water levels will differ. The first survey will be conducted on the receding limb of the snowmelt hydrograph when the entire reach is still partially wetted (late July). The second survey will be conducted at low-flow conditions, expected to be in early to mid-August, when wetted areas are limited to isolated pools . Specific survey dates will be identified by tracking flow conditions in the ephemeral reach during aerial spawning surveys. The field team leader responsible for spawning surveys will notify the lead investigator for the ephemeral reach study as soon as the conditions described above occur.

Surveys of the potentially affected reach will be conducted by a team of two or three investigators on foot. The reconnaissance surveys will start at SK100LF8 and continue upstream to SK100F. During the initial survey the field crew will identify the location of deep pools (residual depth greater than 1 meter) using a hand-held GPS unit. Pool characteristics to be recorded will include the following:

- Residual depth (maximum depth minus outlet depth).
- Overhead cover (percent).
- Pool area (length and width).
- Water temperature (°C).

Snorkel surveys will be conducted in each pool to identify the species, number, and density of fish holding in the pool. Snorkel surveys will be calibrated by multi-pass depletion electrofishing (as described in Section 11.4.3) at a minimum of two pools. In addition, notes will be taken on evidence of predation at each pool. Any stranded fish encountered during the walk-through survey will be counted, identified to species, and measured (fork length). Pool characteristics and fish density will be reassessed during each visit; fish numbers will be quantified using snorkeling/electrofishing in pools during the final survey.

11.9.4 Data Management and QA/QC

Field data will be recorded on field forms (Appendix 11E) printed on waterproof paper. At the end of each day, a Level 1 QA/QC review will be completed on the field forms to check for accuracy and completeness. No blank spaces will be left on field forms; if a data field is not applicable, “NA” will be entered into the field, or if the appropriate value to be entered is zero, “0” will be entered into the field. Each field data sheet will be dated and initialed by the field reviewer. Photographs will be downloaded into a photo log and labeled using a naming convention that identifies the orientation, date, and location of the photograph.

Data will be entered into an Excel spreadsheet. Separate Excel workbooks will be maintained for habitat and fish presence data. Changes or corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field forms will be archived at R2, and a copy of the corrected forms will be delivered to Pebble Partnership after data entry.

Excel data files will be imported into an Access database. The electronic data will undergo a Level 2 QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level 3 QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

11.10 Fish Use in Off-channel Habitats in the North Fork Koktuli River

Studies in the South Fork Koktuli River and Upper Talarik Creek indicate that off-channel habitats may provide important habitat for the fish assemblage found in the study area. OCHs are extensive in the North Fork Koktuli River basin; however, to date no information exists on off-channel habitat use in those areas. Study efforts in 2008 will focus on characterizing NFK OCH conditions and use by juvenile salmonids in the spring and summer. This work will be complemented by instream flow habitat studies in the same area (Section 11.8).

11.10.1 Objectives

The objectives of the OCH studies in NFK in 2008 are as follows:

- Document fish species using selected OCHs in the NFK during summer and into fall.
- Compare the relative abundance of juvenile fish in OCH features and in adjacent mainstem habitats.
- Characterize habitat conditions in common types of OCH features associated with selected reaches of the NFK.

11.10.2 Study Area

Off-channel habitats (as defined in Section 11.8.2) occur throughout the NFK, but as indicated by remote images, they appear to be most abundant in three river segments: from RK 1 to 14.5, from RK 22 to 33, and from RK 48 to 56. The assessment of OCH use by fish and of physical characteristics will be complemented by instream flow study results. Thus the current study will focus on areas with abundant OCHs where instream flow transects have been established. Specific study areas will be located at transects selected to model OCH flow conditions as part of the instream flow study.

11.10.3 Methods

11.10.3.1 Characterization of OCH Features

A series of up to 10 OCH fish study sites will be established in one or two areas of interest identified during a field reconnaissance. Areas of interest will represent sites where a large number and wide variety of OCHs are present. OCH fish study sites will coincide with selected OCH transects for the instream flow study. Hydraulic conditions (depth and velocity) and channel geometry will be measured as part of the instream flow study.

Existing data indicate that the primary types of OCH features found in the study area will be beaver ponds or pond complexes. As such, the majority of the 2008 sampling effort is expected to occur in these types of features. A review of the prevalence of other off-channel features (e.g., backwater, oxbow, abandoned channel) in the existing database will be conducted, and researchers will attempt to sample those features at a rate proportional to their occurrence in the watershed.

OCH at fish-use study sites will be characterized by mapping meso-scale habitat units in a reach extending upstream and downstream of the transect site for a distance equivalent to 10 times the width of the OCH feature (i.e., total survey-reach length will be 20 times the feature width). If the feature is less than 100 meters long the entire area will be surveyed. For beaver pond complexes, the surface area of the complex in which the study site is located will be estimated using a laser rangefinder. Habitat mapping will be conducted according to USFS *Aquatic Management Handbook* (USFS, 2001).Habitat data will be used to represent typical OCH features and may be extrapolated to similar OCH features identified by remote habitat mapping.

Each OCH selected for sampling will be traversed on foot to determine if there is a surface connection to the mainstem. The approximate route of the OCH will be sketched onto orthophotos. Waypoints will be taken at each surface connection and important feature (e.g., beaver dams, dry sections) encountered during the traverse.

11.10.3.2 Fish Utilization

Off-Channel Habitats

Fish using OCHs will be counted using snorkel surveys. Snorkel surveys will be conducted by a team of three biologists in conjunction with habitat surveys. In OCHs with a width of less than 5 meters, the survey will be conducted by a single snorkeler, with a second crew member recording notes and a third crew member recording habitat data. In OCHs with a width greater than 5 meters, the surveys will be conducted by two snorkelers working side by side and moving upstream in tandem. The two snorkelers will survey from the middle of the channel looking toward opposite banks. Each individual will count fish within their predetermined observation lane.

Data will be recorded following completion of the survey of each selected habitat unit. Sample reaches will be covered starting at the downstream end and working upstream. At least 25 percent of the habitat units within the survey reach will be snorkeled. If less than three units of any given habitat type are present, then all units will be snorkeled. Sample units will be selected randomly. For each unit sampled, the field crew will record the habitat unit and type, habitat unit length, average width and maximum depth, and the number of fish seen by species and size class. If the OCH feature is very large and uniform, for example consisting of only one habitat type such as a large beaver pond or backwater slough, the survey team will subsample an area representing from 15 to 30 percent of the total habitat.

In the event that snorkeling is not feasible because of insufficient water depth or visibility limitations, three-pass electrofishing, using approximately the same amount of effort in each pass, will be used. Catch within a predefined habitat unit will be recorded by pass. Block nets will be set up at each end of the unit to prevent fish from leaving the sampling unit.

Supporting data on water quality will be collected during each fish utilization survey. Water quality data collected at all OCH fish sites will include temperature and visibility. When electrofishing is used, conductivity measurements also will be collected. Horizontal visibility will be assessed using a Secci disk.

Main-channel Habitats

Fish use within OCHs will be compared to fish use in main-channel habitats where the off-channel transect crosses the main channel. As with the off-channel reaches, the main-channel survey reaches will extend upstream and downstream from the transect site for a distance equivalent to 10 times the width of the main-channel bed (i.e., total survey-reach length will be 20 times the bed width). Main-channel surveys will follow protocols described in the USFS *Aquatic Management Handbook* (USFS, 2001).

Supporting data on water quality will be collected during each fish utilization survey. The water quality data to be collected at OCH fish sites are temperature, conductivity, and dissolved oxygen—all measured with a Quanta Hydrolab—and visibility assessed using a Secci disk.

Calibration

Snorkel surveys will be calibrated in a variety of different habitat types with three-pass electrofishing surveys. Electrofishing calibrations will be conducted over the course of the sampling window and in multiple habitat types. At a minimum, electrofishing calibration surveys will be conducted at three representative OCH features and the associated main-channel site or sites.

Electrofishing calibration surveys will cover the same area and habitat units as snorkel surveys and will be conducted at least 1 hour after snorkeling has been completed in order to allow fish disturbed by snorkeling activity to redistribute among preferred habitats. Electrofishing calibration surveys will occur on the same day that snorkel surveys are completed.

Electrofishing will be conducted according to NMFS guidelines (NMFS, 2000). Electrofishing teams will consist of a team leader and two biological technicians. The field team leader will have training and extensive field experience using a backpack electroshocker. All crew members who will participate in snorkel survey calibration will be trained in the proper use and safety procedures for backpack electrofishing units. All crew members also will have experience and training in the field identification of endemic fish species.

Block nets will be placed at the upstream and downstream ends of each habitat unit being sampled to ensure that shocked fish do not drift downstream or escape upstream. Two team members will conduct electrofishing, while the remaining team member will process fish. The electrofishing team will make three passes through the habitat unit and will remove the shocked fish as they are encountered. Fish will be captured with a dip net (3-millimeter nylon mesh) and placed into an anesthesia bath containing ambient stream water and a solution of one part clove oil to nine parts ethanol at a concentration of 50 milligrams of solution per liter of water. Each fish will be identified to species, measured to the nearest millimeter total length, and placed into a 20 liter bucket with an aerator, where they will be allowed to recover before being returned to the survey area at least 35 meters downstream of shocking activities. Backpack unit settings, start time and stop time for each habitat unit sampled, and sampling notes will be recorded for each site.

11.10.4 Data Analysis

Catch per unit effort (CPUE) will be calculated. In addition, all fish captured will be enumerated by species and life stage (fry 0+, yearling 1+, or adult). Life stages will be differentiated based on length frequency analysis. Data comparisons will be used to determine relative abundance between meso-scale-habitat unit types in off-channel and main-channel habitats and relative abundance between main-channel and off-channel sites (combined meso-scale habitat types). Habitat data from OCH features will be used to describe average conditions (e.g., width, depth, percent frequency of meso-scale-habitat unit types) associated with each general feature type.

11.10.5 Data Management and QA/QC

Field data will be recorded on forms printed on waterproof paper. Copies of the field forms are provided in Appendix 11F. At the end of each day, a Level 1 QA/QC review of the field forms will be completed to check for accuracy and completeness. No blank spaces will be left on field forms; if a data field is not applicable, “NA” will be entered into the field, or if the appropriate value is zero, “0” will be entered into the field. Each field data sheet will be dated and initialed by the field reviewer. Photographs will be downloaded into an aquatic habitat photo log and labeled using a naming convention that identifies the orientation, date, and location of the photograph.

Data will be entered into an Excel spreadsheet. Separate Excel workbooks will be maintained for habitat and fish presence data. Changes or corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field forms will be archived at R2, and a copy of the corrected forms will be delivered to Pebble Partnership after data entry.

Excel data files will be imported into an Access database. The electronic data will undergo a Level 2 QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level 3 QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

11.10.6 Schedule

Snorkel surveys will commence as soon as flows in main-channel habitats drop to levels that will allow safe snorkeling. The goal is to sample OCHs as soon as possible in the early summer while they remain connected to the main channel. If flow conditions prevent surveys early in the season, off-channel fish utilization surveys will be conducted in late summer following the first major rain event sufficient to temporarily connect OCHs to the main channel.

Off-channel fish utilization surveys are expected to require at least one day per transect, assuming that each transect represents a pair of sites (off-channel feature and associated main-channel area). Electro-fishing calibration surveys conducted at the start and end of the survey period will require two to three additional 10-hour days. The field work is expected to require approximately three weeks of field effort by two 3-person crews.

11.11 Fisheries Studies in the Transportation-corridor Study Area

Development of the Pebble Project is expected to include construction of an approximately 90-mile-long access road that crosses numerous drainages, including streams that are used by anadromous fish. Design of stream crossings to ensure volitional passage for all fish species and life stages will require site-specific information on species distribution, habitat utilization, channel morphology, and hydrology (USFS, 2002). Fish and aquatic habitat data were collected in 2004 and 2005 at most of the possible crossing sites identified at that time; however, given the dynamic nature of the road-corridor selection process, data gaps now exist. An estimated 36 streams that may be crossed by the possible road alignment still need to be surveyed. In addition, it is expected that approximately 12 more sites will require surveys as a result of changes in the possible alignment.

11.11.1 Objectives

The goal of the 2008 fisheries study in the transportation corridor study area is to develop sufficient data to document the existing conditions at possible stream crossings along the possible road alignment and to identify possible aquatic-resource issues that may influence final selection of the road alignment. Work proposed for 2008 will facilitate planning and will provide a framework for conducting future detailed site-specific investigations of crossing sites to support road design. Specific objectives of the 2008 study include the following:

- Assess existing survey data and, where possible, consolidate data from multiple survey types.
- Determine possible stream crossings for which no information exist, and conduct fish presence and habitat surveys to fill in data gaps (maximum estimate 36 sites).
- Conduct fish presence and habitat surveys at possible stream crossings that have emerged in alignment changes that have occurred since 2005 (estimated 12 sites).
- Incorporate the data collected into the database containing all data from previous surveys of the transportation-corridor study area.
- Document any fish-migration barriers encountered.

11.11.2 Study Area

The possible transportation corridor extends approximately 90 miles from the Pebble deposit area east to Williamsport and then to Iniskin Bay on Cook Inlet. The transportation corridor study area is 2000-foot-wide corridor that encompasses all locations where the possible road alignment would cross streams.

11.11.3 Methods

After a review of existing data to confirm data gaps at possible stream crossings, a field team will conduct fish presence and aquatic habitat surveys at approximately 48 possible stream crossings for which no current survey information exists. Because a specific alignment has not been surveyed at this time and the alignment would likely to be subject to field design changes, the actual sample locations will be an approximation of crossing locations as supplied by the road design team.

11.11.3.1 Fish Presence

Streams at possible road crossing locations will be sampled for fish presence using a variety of methods, depending on the physical and biological characteristics of the stream. The primary method to be used is backpack electroshocking. For the 2008 sampling, one pass with the electroshocker will be completed to determine the fish species present in a 200-meter reach of stream habitat. If multiple habitat types are present at a sampling site, electrofishing will be conducted in multiple representative habitat units.

Where electrofishing cannot be conducted because of the presence of adult salmon, a one-pass snorkeling survey will be conducted. In stream channels less than 4 meters wide, surveys will be conducted by a single snorkeler viewing and counting fish on both sides of the channel, alternating from left to right. In stream channels more than 4 meters wide, surveys will be conducted by two snorkelers working side by side and moving upstream in tandem, with each individual counting fish on one side of the channel. Data will be recorded following completion of the survey. Survey reaches will be snorkeled starting at the downstream end and working upstream.

In reaches where both electrofishing and snorkeling would be ineffective because of stream conditions such as deep, fast water, baited minnow traps will be used as a last alternative to determine fish presence. Traps will be baited with processed salmon eggs contained in perforated plastic bottles. The minnow traps will be set in areas to maximize catch and will be set for a period ranging from two to 24 hours. All fish captured will be identified to species, measured, and released alive near the point of capture.

11.11.3.2 Aquatic Habitat Survey

A standard suite of physical habitat data and descriptive information will be collected at each possible stream crossing. These parameters have been modified from the USFS aquatic habitat Tier One survey methodology (USFS, 2001, Chapter 20). Data will be collected over a 200-meter-long reach or, for channels with a bed width of less than 5 meters, a length equal to 40 stream bed widths. Channel morphology and water quality characteristics will be documented at the reach scale and will include the following:

- Channel type.
- Channel pattern.
- Average bankfull width.
- Bankfull maximum depth.
- Water surface gradient.
- pH.
- Conductivity.
- Temperature.
- Turbidity.

- Riparian vegetation.
- Location/type/area of off-channel habitats.
- Width and status of side channels (wet and dry).

Habitat units that fall within the survey reach will be delineated. Nomenclature for habitat types will be consistent with that used by USFS for meso-habitats, including backwater pool (PL-bw), scour pool (PL-sc), glide (GL-gl), riffle (RF-rf), and beaver pond (BP).

Within each habitat unit the following data will be collected:

- Unit type and number.
- Unit length.
- Average wetted width.
- Average wetted depth.
- Substrate composition (by percentage).

If encountered during surveys, fish migration barriers will be assessed using criteria described in the USFS Region 10 *Aquatic Habitat Management Handbook* (Table 11-11; USFS, 2001). Data on migration barriers will be recorded on a barrier field data form (Appendix 11G). Field forms that have been modified to collect additional data deemed necessary for this study are provided in Appendix 11G. Photographs of representative habitats as well as any special habitat features will be taken at each survey reach.

11.11.4 Data Management and QA/QC

Field data will be recorded on field forms printed on waterproof paper. At the end of each day, a Level 1 QA/QC review of the field forms will be completed to check for accuracy and completeness. No blank spaces will be left on field forms; if a data field is not applicable, “NA” will be entered into the field, or if the appropriate value is zero, “0” will be entered into the field. Each field data sheet will be dated and initialed by the field reviewer. Photographs will be downloaded into an aquatic habitat photo log and labeled using a naming convention that identifies the orientation, date, and location of the photograph.

Data will be entered into an Excel spreadsheet. Changes or corrections to the data will be made on the original field forms in red and will be initialed by the individual responsible for data entry. Original field forms will be archived at R2, and a copy of the corrected forms will be delivered to Pebble Partnership after data entry.

Excel data files will be imported into an Access database. The electronic data will undergo a Level 2 QA/QC review to check for entry and transcription errors. In addition, the Access database will undergo a Level 3 QA/QC review by an objective senior scientist as a final check for erroneous records. At the end of each field season, final database files will be converted back to Excel for delivery to Resource Data Inc. for incorporation into the master Pebble Project database.

11.11.5 Schedule

Surveys will commence in late summer, with an expected start date of September 1. It is expected that the survey team can complete an assessment of two stream segments per day. Assuming that all streams need to be visited, the maximum level of effort expected is 24 days.

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TABLES

TABLE 11-1
Pebble Project Environmental Studies
Fish Studies Summary 2004-2008
Consultant: R2 Resource Consultants

Field Studies Discipline	2004 Study Tasks	2005 Study Tasks	2006 Study Tasks	2007 Study Tasks	2008 Study Tasks
Fish			**Mine Studies Area**		
	Winter Sampling	Winter Sampling	Winter Sampling	Overwinter Sampling	
	Salmon and Rainbow Trout Spawning Surveys	Salmon and Rainbow Trout Spawning Surveys	Salmon and Rainbow Trout Spawning Surveys	Salmon Escapement, Aerial Surveys	Salmon Escapement
	Fish Characterization Population analysis FPL, Removal Sampling, Habitat Surveys	Arctic Grayling Telemetry	Arctic Grayling Telemetry		Fish Distribution in Upper NFK
	Fish Tissue and Index Species Sampling	Fish Tissue and Index Species Sampling	Fish Tissue and Index Species Sampling- Black Lake and Lake No. 2	Fish Tissue: Frying Pan Lake, Black Lake, Big Wiggly and Lake No. 2	Fish Tissue: Frying Pan Lake, Black Lake, Big Wiggly and Lake No. 2
	Flow Habitat Study	Flow Habitat and Snorkel Study (Main Channel)	Flow Habitat and Snorkel Study (Main Channel)	Flow Habitat and Snorkel Study (Main Channel)	Main Channel Instream Flow Habitat Study
		Off-channel Habitat Study	Off-channel Habitat Study	Off-channel Habitat Study	NFK Off-channel Habitat Study
		Habitat Mapping and Fish Density Sampling			Remote habitat mapping
				Rainbow Trout Telemetry Study	Rainbow Trout Telemetry Study
				Upper Talarik Juvenile Fish Abundance Study	Fish Population and Habitat Assessment for Upper Talarik Reach 1
					Mainstem Index Surveys
				Juvenile Anadromous Fish Distribution Study	Fish Population and Habitat Assessment
			Transportation Corridor		
	Road Corridor Survey	Y Creek Investigation	No field work planned	No field work planned	Road Corridor Survey
		Salmon Spawning Surveys			
		Barge Landing Area Survey			
		Transmission Line Corridor Survey			

TABLE 11-2
Habitat Unit Types for 2008 Surveys, Mine Study Area[a]

Macro-scale Habitat Type	Meso-scale Habitat Types	Description[b]
Pool	Backwater pool (PL-bw)	Found along channel margins, created by eddies around obstructions such as boulders, root wads, or woody debris. Alcoves included.
	Scour pool (PL-sc)	Formed by flow impinging against a stream bank, partial obstruction (logs, root wad, or bedrock), or substrate. Includes both lateral and mid-channel scour pools.
Fast-water	Glide (GL-gl)	An area with generally uniform depth and flow with no surface turbulence. Glides may have some scour areas but are distinguished from pools by their overall homogeneity and lack of structure.
	Riffle (RF-rf)	Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates.
Beaver Pond	Beaver pond (BP)	Water impounded by the creation of a beaver dam.

Notes:

a. Note that habitat unit types are at the meso-scale.

b. Modified from Moore et al., 2006

Table 11-3
Pebble Project
Period-of-Record Index
Fish Tissue, Mine Study Area

Sample Location	Year[1]	Fish Tissue[2]											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
NK100A	2004								W				
	2005								W				
	2006												
	2007								W				
	2008												
NK100C	2004								W				
	2005								W				
	2006												
	2007												
	2008												
NK119A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
SK100A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
SK100B	2004								W				
	2005								W				
	2006												
	2007								W				
	2008												
SK100C	2004								W				
	2005								W				
	2006												
	2007												
	2008												
SK100F	2004								W				
	2005								W				
	2006												
	2007												
	2008												
SK100G	2004								W				
	2005								W				
	2006												
	2007												
	2008												
SK119A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
UT100B	2004								W				
	2005								W				
	2006												
	2007								W				
	2008												
UT100C	2004								W				
	2005								W				
	2006												
	2007												
	2008												

Sample Location	Year[1]	Fish Tissue[2]											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
UT100D	2004								W				
	2005								W				
	2006												
	2007												
	2008												
UT100E	2004								W				
	2005								W				
	2006												
	2007												
	2007												
	2008												
UT119A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
UT138A	2004								W				
	2005								W				
	2006												
	2007												
	2008												
Black Lake	2004												
	2005								T				
	2006								T				
	2007								T				
	2008								T				
Big Wiggly	2004								T				
	2005								T				
	2006												
	2007								T				
	2008								T				
Frying Pan Lake	2004								T				
	2005								T				
	2006												
	2007								T				
	2008								T				
Lake No. 2	2004												
	2005								T				
	2006								T				
	2007								T				
	2008								T				

KEY:

T Fish tissue samples from adult northern pike consisted of discrete muscle and liver samples. Arctic grayling and whitefish are sampled for muscle tissue only.

W Before 2007, fish tissue samples consisted of discrete whole-body juvenile fish. Beginning in 2007, adult grayling and whitefish (muscle tissues) were sampled.

NOTES:

1 Work for 2008 is shown as planned, but has not yet been completed.

2 One stream site (to be determined in the field) in each of the three major drainages will be sampled for arctic grayling and whitefish; the sample matrix will be muscle tissue. In lakes, grayling, whitefish and northern pike will be collected; the sample matrices will be muscle tissue from all three species, as well as liver (archive) samples from northern pike.

TABLE 11-4
Modified Wentworth Scale for Substrate Size Classifications

Description	Size Class (metric/English)	Code
Fines	<2 mm/<0.1 in.	FI
Small Gravel	2-16 mm/0.1-0.6 in.	SG
Large Gravel	16-64 mm/0.6-2.5 in.	LG
Small Cobble	64-128 mm/2.5-5.0 in.	SC
Large Cobble	128-256 mm/5.0-10.0 in.	LC
Boulder	>256 mm/>10.0 in.	BO
Bedrock	Bedrock	BR

in. = inch(es)

mm = millimeter(s)

TABLE 11-5
Cover Classification Codes

Description	Code
Boulder	BO
Large Woody/Organic Debris	LWD
Instream Vegetation	IV
Overhanging Vegetation	OV
Undercut Bank	UCB

TABLE 11-6
Preliminary Periodicity Table for Anadromous Target Species and Life-history Stages, Mine Study Area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chinook Salmon (*Oncorhynchus tshawytscha*)												
Adult Migration							X	X				
Spawning							X	X				
Fry Emergence				X	X							
Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Juv. Outmigration				X	X	X						
Coho Salmon (*O. kisutch*)												
Adult Migration								X	X	X		
Spawning								X	X	X	X	
Fry Emergence				X	X							
Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Juv. Outmigration				X	X	X						
Chum Salmon (*O. keta*)												
Adult Migration						X	X					
Spawning							X	X				
Fry Emergence				X	X							
Rearing												
Juv. Outmigration				X	X							
Sockeye Salmon (*O. nerka*)												
Adult Migration							X	X	X			
Spawning							X	X	X			
Fry Emergence				X	X							
Rearing				X	X	X						
Juv. Outmigration				X	X	X						

TABLE 11-7
Preliminary Periodicity Table for Resident Target Species and Life-history Stages, Mine Study Area

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainbow Trout *(O. mykiss)*												
Spawning					X	X						
Fry Emergence							X	X	X			
Adult & Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Dolly Varden Char *(Salvelinus malma)*												
Spawning								X	X			
Fry Emergence				X	X							
Adult & Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X
Arctic Grayling *(Thymallus arcticus)*												
Spawning				X	X							
Fry Emergence					X	X						
Adult & Juvenile Rearing	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 11-8
Continuous Instream Water Temperature-monitoring Stations in the North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek Drainages

North Fork Koktuli River		South Fork Koktuli River		Upper Talarik Creek	
Mainstem	**Tributary**	**Mainstem**	**Tributary**	**Mainstem**	**Tributary**
TEMPNK9	TEMPNK123	SK100F	TEMPSK124	UT100E	TEMPUT138
TEMPNK8	TEMPNK119	TEMPSK6	SK124A	UT100D	TEMPUT135
TEMPNK7	NK119B	SK100C	TEMPSK119	UT100C2	UT135A
NK100C	TEMPPNK117	SK100B1	SK119A	UT100C1	TEMPUT130
NK100B	TEMPNK112	TEMPSK4	TEMPSK113	TEMPUT5	TEMPUT119
TEMPNK5	TEMPNK140	SK100B	TEMPSK120	UT100C	UT119
TEMPNK4		TEMPSK2		TEMPUT4	TEMPUTFIRST
NK100A1		TEMPSK1		UT100B	
NK100A		SK100A		TEMPUT3	
TEMPNK1				UT100APC1	
				TEMPUT2	
				UT100APC2	
				TEMPUT1	
				UT100APC3	

Note: Stations are listed in order from upstream to downstream.

TABLE 11-9
Continuous Intragravel Water Temperature-monitoring Stations in the North Fork Koktuli River, the South Fork Koktuli River, and Upper Talarik Creek

North Fork Koktuli River	South Fork Koktuli River	Upper Talarik Creek
05-NFK-USGS	05-SFK-below FPL	UT_Temp1
	05-SFK2-PL1	UT_Temp2
	04-SFK-upwell	UT_Temp3
	SFK-DL-Cove	UT_Temp4
	05-SFK2-RN5	UT_Temp5
	05-SFK2-RN6	UT_Temp6
	05-SFK2-RN7	UT_Temp7
	05-SFK2-RN4	05-UT-USGS
	05-SFK2-RF1	UT_Temp8
	04-SFK-RN2	UT_Temp9
	04-SFK-RN3	UT_Temp10
	05-SFK1-RF1	UT_Temp11
	04-SFK-PL2	
	06-SFK-100A	

Note: Stations are listed in order from upstream to downstream.

FPL = Frying Pan Lake

TABLE 11-10
Continuous Surface Water Flow-measurement Stations in the North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek Drainages

North Fork Koktuli River		**South Fork Koktuli River**		**Upper Talarik Creek**	
Mainstem	**Tributary**	**Mainstem**	**Tributary**	**Mainstem**	**Tributary**
NK100C	NK119A	SK100G	SK136B	UT100E	UT146A
NK100B	NK119B	SK100F	SK136A	UT100D	UT141A
NK100A1		SK100D	SK134A	UT100C2	UT138A
NK100A		SK100C	SK133A	UT100C1	UT135A
		SK100B2	SK131A	UT100C	UT119B
		SK100B1	SK124A	UT100B	UT119A
		SK100B	SK119A	UT100A	
		SK100A		UT100APC1	
				UT100APC2	
				UT100APC3	

Notes:

Stations are listed in order from upstream to downstream.

An additional station (KR100A) is located on the mainstem Koktuli River.

TABLE 11-11
USFS Adult Salmonid Migration-blockage Criteria

	Species					
Criterion	**Coho**	**Steelhead**	**Sockeye**	**Chinook**	**Pink/Chum**	**Dolly Varden**
Max. Fall Height—a blockage may be presumed if fall height exceeds the distance shown	11 feet (3.35 m)	13 feet (3.96 m)	10 feet (3.05 m)	11 feet (3.35 m)	a) 4 feet (1.22 m) with deep plunge pools not flooded at high tide b) 3 feet (0.91 m) without pools	6 feet (1.83 m)
Pool Depth—a blockage may be presumed if pool depth is less than the value shown and the pool is unobstructed by boulders or by bedrock	1.25 x jump height, except that there is no minimum pool depth for falls of: (a) <4 feet (1.2 m) in the case of coho and steelhead or (b) <2 feet (0.6 m) in the case of other anadromous fish species					
Steep Channel—a blockage may be presumed if channel steepness is greater than the value shown, without resting places for fish	225 feet (68.6 m) @ 12% gradient 100 feet (30.5 m) @ 16% gradient 50 feet (15.2 m) @ 20% gradient				100 feet (30.5 m) @ 9% gradient	50 feet (15.2 m) @ 30% gradient

m = meter(s)

Source: USFS, 2001.

FIGURES

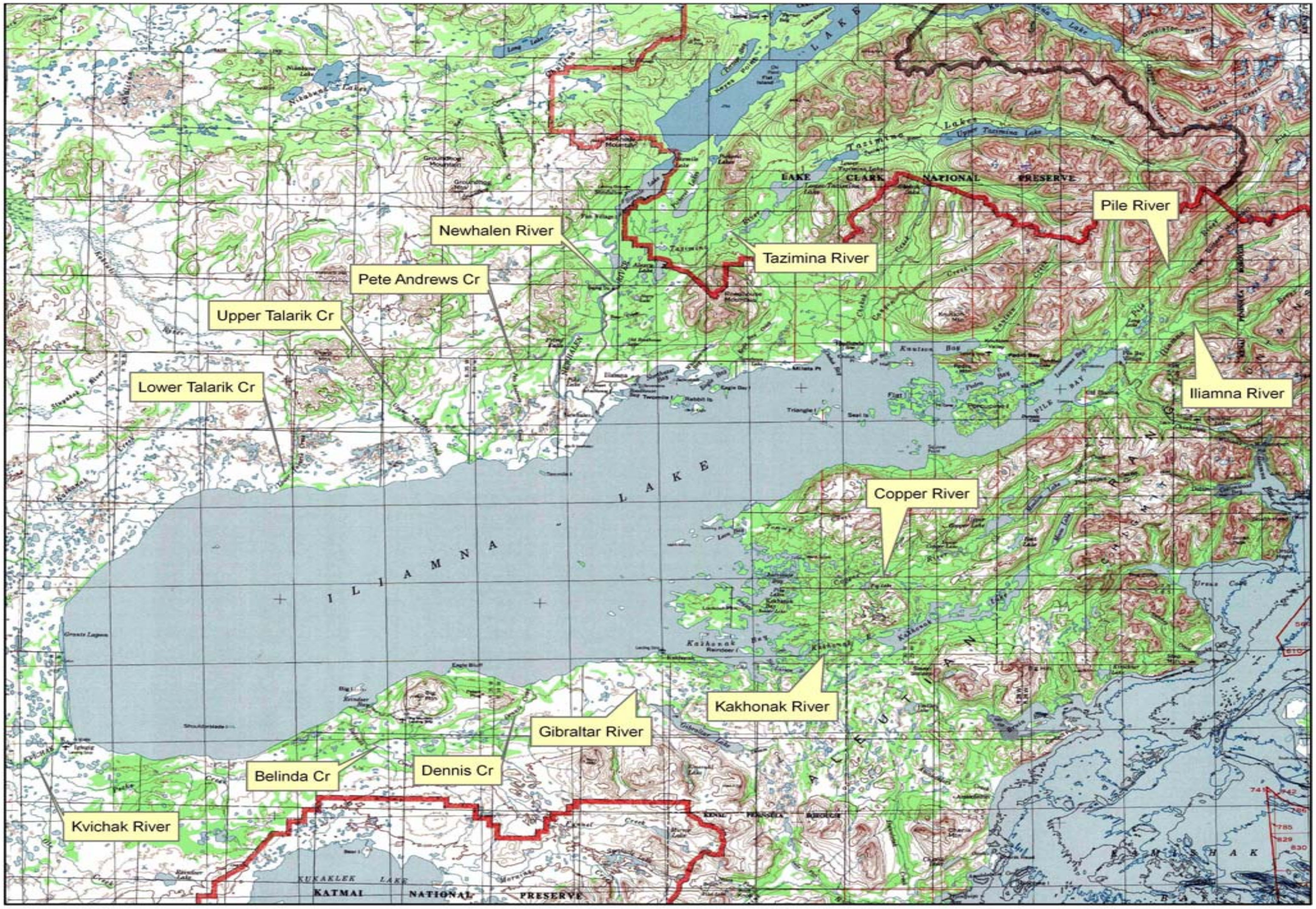

FIGURE 11-1. Study Area for Rainbow Trout Radio Telemetry Study in Upper Talarik Creek, 2008

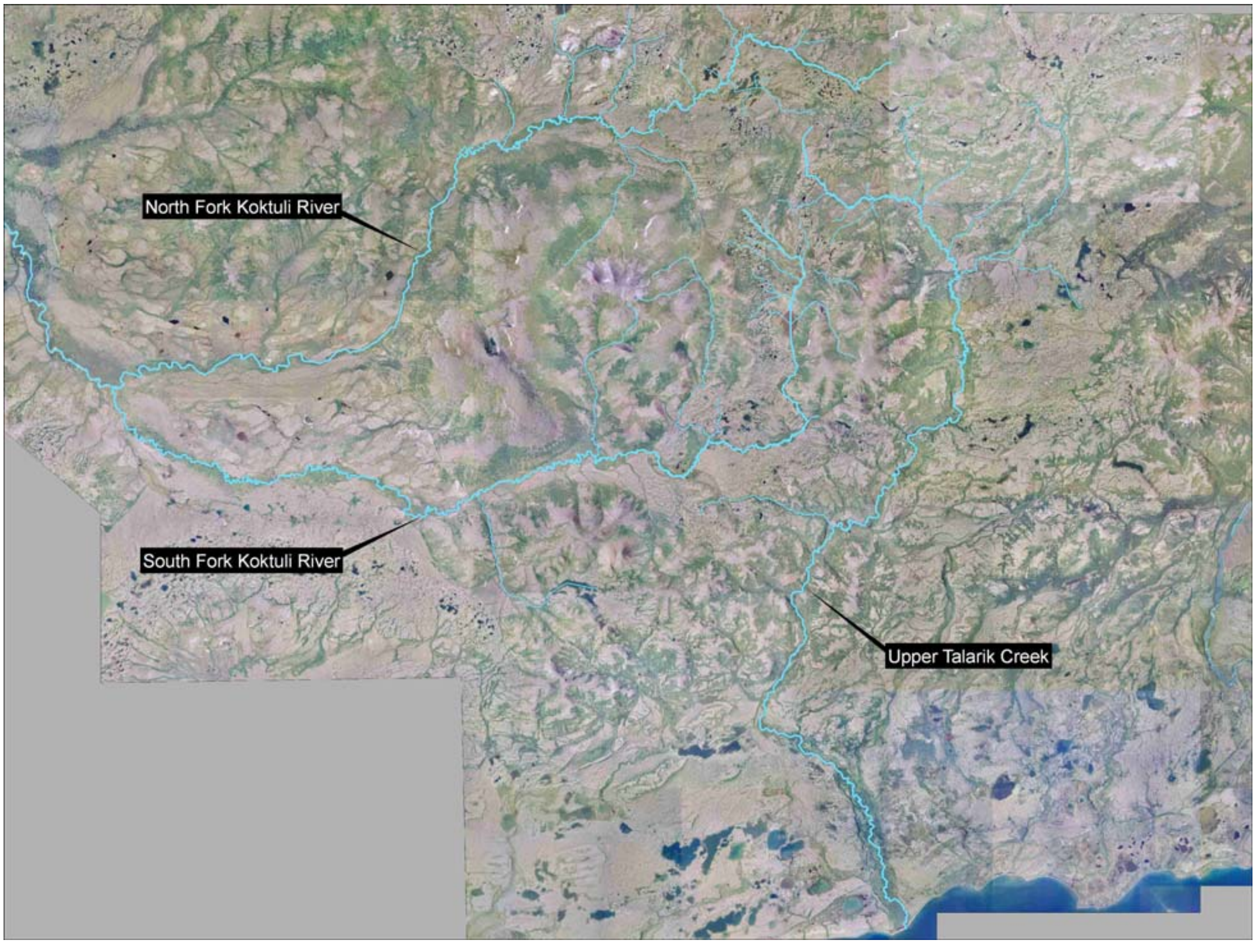

FIGURE 11-2, Aerial Survey Areas for the Salmon Escapement Study, 2008

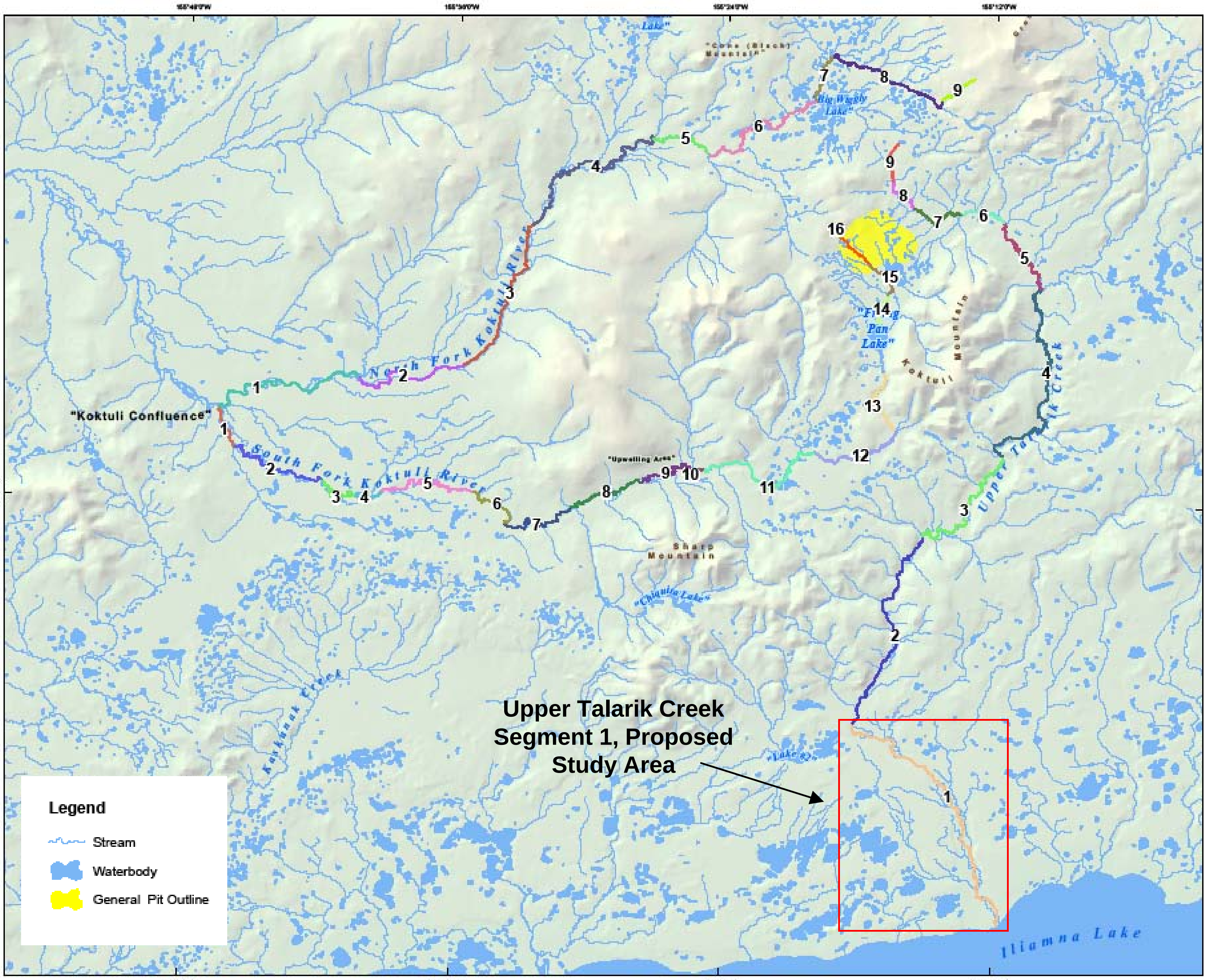

FIGURE 11-3, 2008 Study Area for Fish Population and Habitat Assessment in Upper Talarik Creek, Segment 1

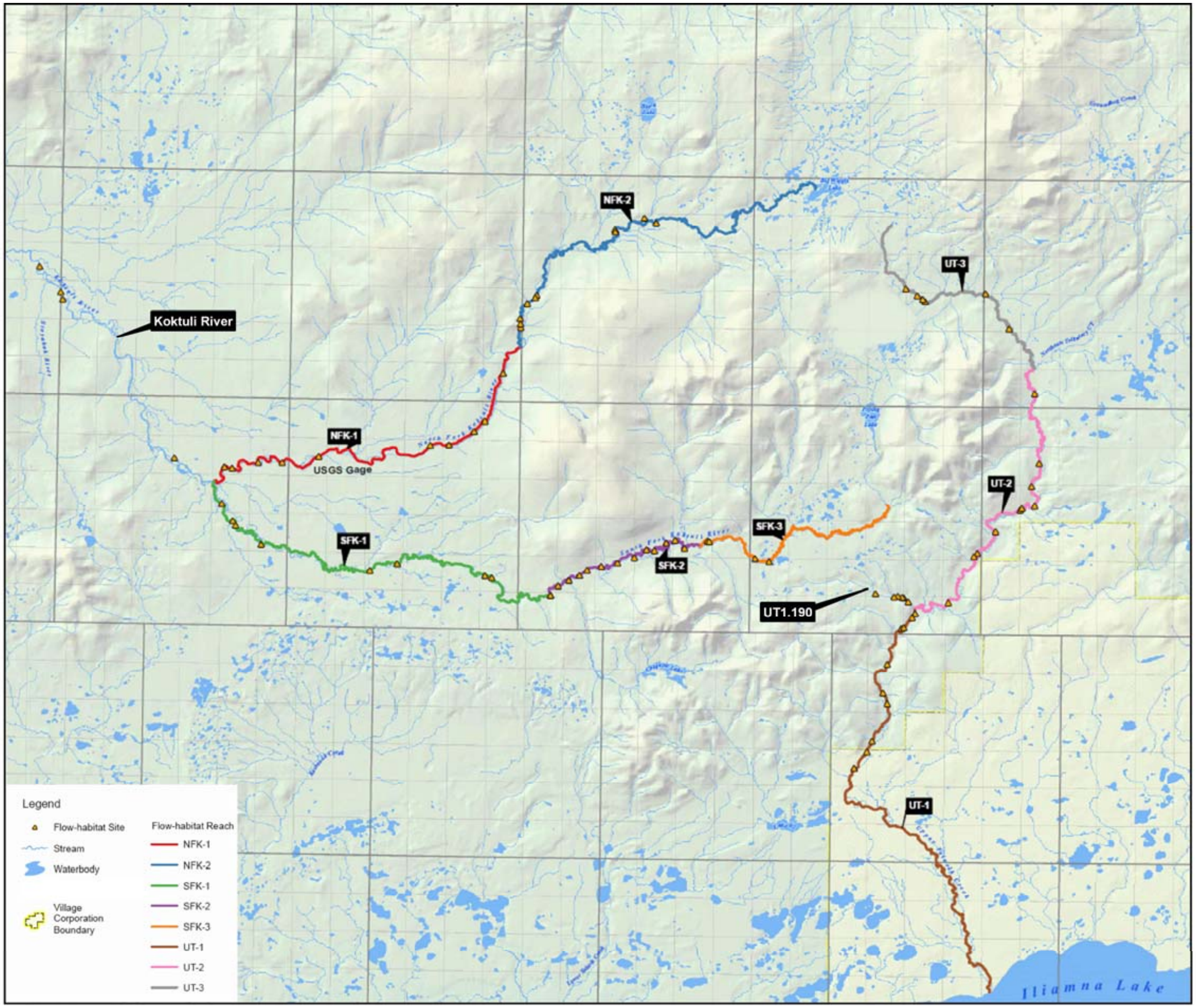

FIGURE 11-4, Study Reaches, Instream Flow Study, 2008

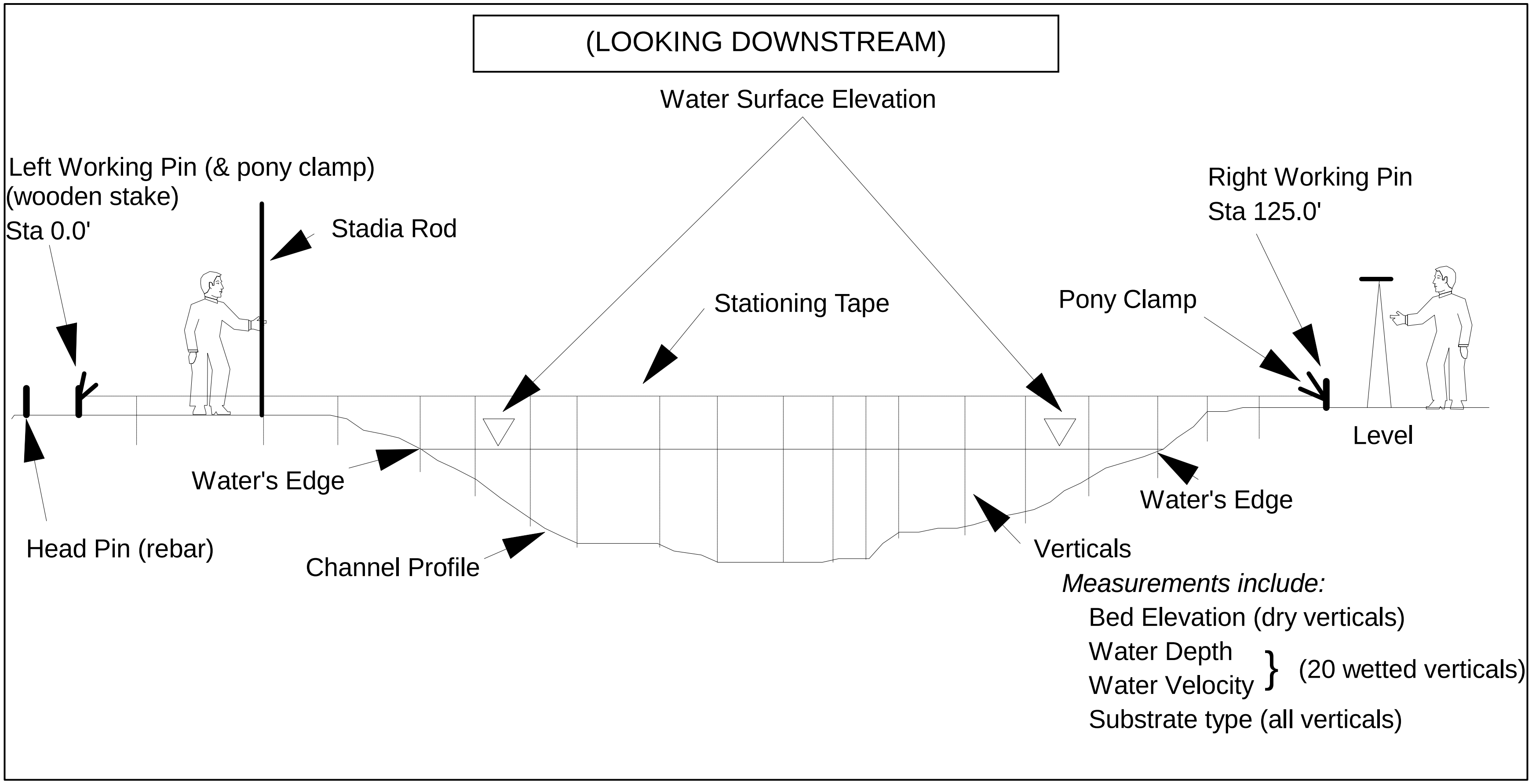

FIGURE 11-5, Schematic of Hypothetical Transect Illustrating Survey Techniques and Verticals for Measurements of Depth, Velocity, and Substrate

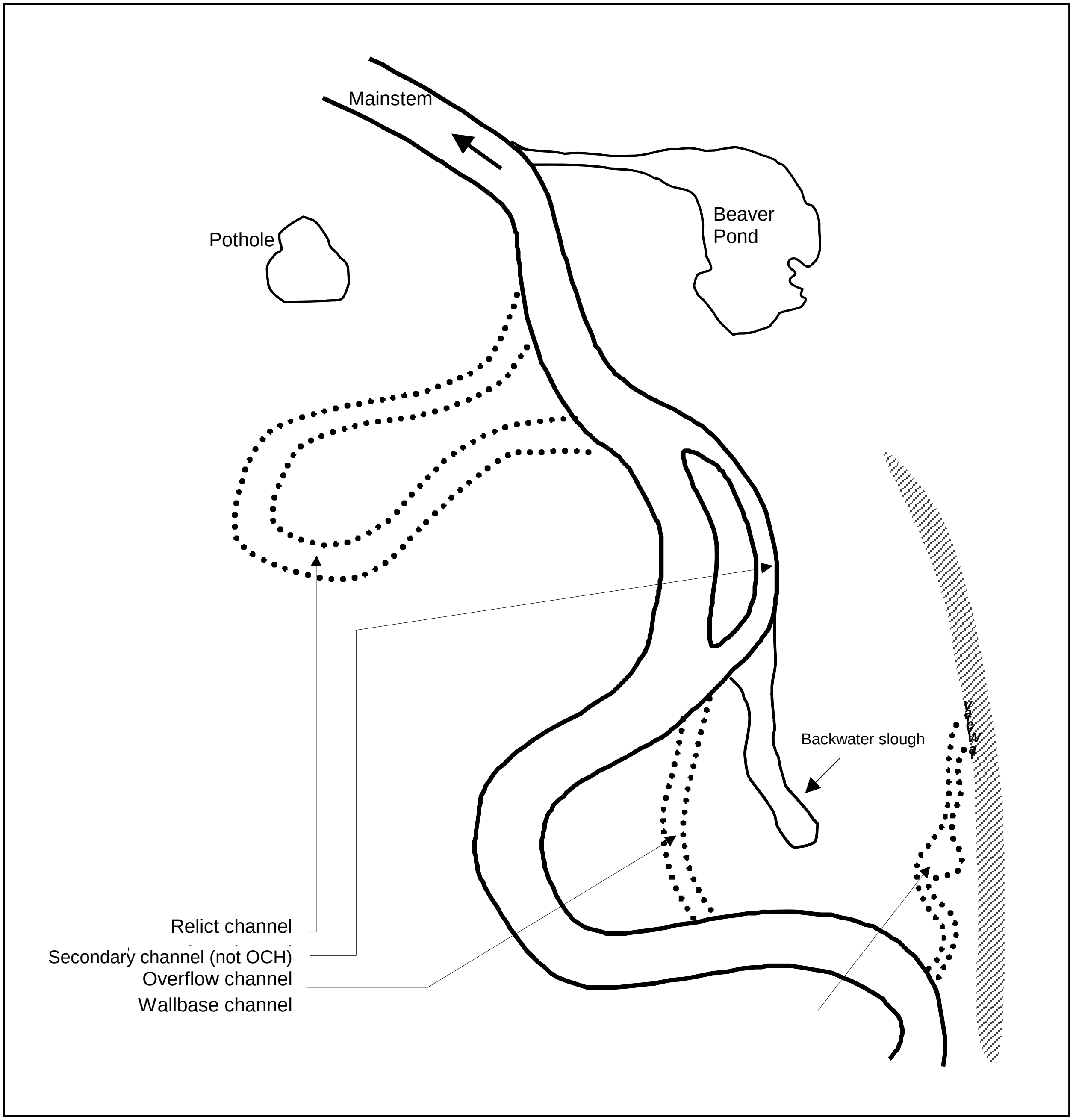

FIGURE 11-6, Preliminary Side- and Off-channel Habitat Classification System for Instream Flow Studies in 2008

APPENDICES

APPENDIX 11A

Field Forms
Upper Talarik Creek Rainbow Trout Radio Telemetry Study

Upper Talarik Creek Rainbow Trout Radio Telemetry Study Tagging Data Form

Fish ID Number	Radio Tag Frequency	Radio Tag Code
Fish Fork Length		
Fish Weight	Anchor Tag Color Green	Anchor Tag Number
Sex		
Fish Condition Comments		

Capture Site	Capture Method	Stream Temp
Site Latitude	Capture Date	Air Temp
Site Longitude	Capture Time	Weather
Environment Comments		

Surgeon	Anesthetic Type	Anesthetic Temp
Anesthesiologist	Anesthetic In Time	Anesthetic Out Time
Assistants	Surgery Begin Time	Surgery End Time
Observers	Recovery Start Time	Release Time
	Recovery Bath Temp	Release Stream Temp
Surgery Comments		

Additional Comments ______________________________

____

Upper Talarik Creek Rainbow Trout Radio Telemetry Study Tracking Data Form

Survey Date	Survey Method	Weather
Receiver Type	Aircraft Type	Pilot
GPS Unit	Average Altitude	Time Start
Crew	Average Speed	Time End
Survey Area		

Basin	Time	Frequency	Code	Power	Latitude	Longitude	Habitat	Comment

APPENDIX 11B

Field Forms
Salmon Escapement Study

Salmon Escapement Data Form (Side A)

R2 Resource Consultants
PPL- Aerial Spawning Survey
Salmon Escapement

Drainage: NFK SFK UT
Segment:___________
Tributary:_______________

Date:____________________ Pilot:_________________/ Aircraft:_________________ Reference Stream gauge:__________
Weather:___________________________ Start Time:__________ / End Time:____________ Flow at Reference gauge (Date and Time):_____________
Survey Type: Aerial Calibration
Fish codes: **KS** = Chinok salmon **CH**= chum salmon **SS**= sockeye salmon **CS**= coho salmon

Observer	Start WP	End WP	Species	Behavior	Tally	Total

Comments:

Salmon Escapement Data Form (Side B)

R2 Resource Consultants

Pebble Project Mine Area Viewing Conditions

Salmon Escapement Study

Page ______of _______ (Side B)

Crew Lead:_____________

Assistant(s):_____________

Drainage: NFK SFK UT

Date	Segment	Tributary	Flow Stage	Water Clarity	Glare	Ice	Weather	Sun Angle	Overhanging Vegetation	Bottom Color

Comments:

Physical Description:

Flow Stage = Qualitative assessment of river discharge at the time of the survey. **1**=High; **2**=Medium; **3**=Medium/Low; **4**=Low
Water Clarity = A measure of the impact of water clarity on the survey. **1**=Muddy; **2**=Semi-turbid; **3**=Clear; **4**=Extremely Clear
Glare = A measure of glare sufficient to obscure viewing at the time of the survey. **1**=High; **2**=Moderate; **3**=Low; **4**=None
Ice = A percent of the survey field covered with ice. **1**=76%-100%; **2**=51%-75%; **3**=26%-50%; **4**=0%-25%
Weather = A measure of the impact weather is having on viewing conditions. **1**=Snow; **2**=Heavy Rain; **3**=Light Rain/Cloudy; **4**=Dry/Sun
Sun Angle = A measure of the impact of sun direction at the time of the survey. **1**=High; **2**=Moderate; **3**=Low; **4**=None
Overhanging Vegetation = Estimate of the percent of the river that is obscured by overhanging vegetation. **1**=76%-100%; **2**=51%-75%; **3**=26%-50%; **4**=0%-25%
Bottom Color = A measure of the impact substrate color is having on viewing conditions

Field QA / QC: _______

Data Entry: _____________

File name:_________________

APPENDIX 11C

Field Forms
Fish Distribution and Relative Abundance Study

Snorkel Survey Form (Side A)

R2 Resource Consultants
Pebble Project Mine Area
Snorkel Survey Form

Page ____ of _____ (Side A)
Crew Lead:______________
Assistant(s):_____________

Study:____

Survey Type: Fish Distribution

Date:______________
Drainage: NFK SFK UT
Tributary:__________________________________
Segment:__________ Time:_________
Survey length:____________
Snorkeler (s):__________ Recorder:_______
Weather:_______________________________________

Habitat Unit:__________Habitat Type:_________
Air Temp (ºC):_______ Water Temp (ºC):_________
Thermometer#/Correction Factor:__________
Visibility (m):_________________________
Start Time__________ End Time____________
Start WP:______________ End WP:________________
GPS Unit #_____________

	Juvenile Salmonids			Resident Species		
Species	YOY	1+	2+	Juvenile	Sub-Adult	Adult

Comments:

Field QA / QC: _______ Data Entry: ________ File name:______________________

Snorkel Survey Form (Side B)

R2 Resource Consultants
Pebble Project Mine Area
Snorkel Survey Form

Page ____ of _____ (Side B)
Crew Lead:______________
Assistant(s):_____________

	Juvenile Salmonids			Resident Species		
Species	YOY	1+	2+	Juvenile	Sub-adult	Adult

Comments:

Field QA / QC: _______

Data Entry: ________
File name:_____________________________

Electroshocking Fish Distribution Survey Form (Side A)

R2 Resource Consultants
Pebble Project Mine Area
Electroshocking Fish Distribution Survey Form

Page ______ of _______ (Side A)
Crew Lead:__________
Assistant(s):__________

Study:___________________________________
Survey Type: Fish Distribution
Date:_______________
Drainage: NFK SFK UT
Tributary:_______________________________
Segment:__________
Survey length:____________
Habitat Unit:__________Habitat Type:_________
Shocker (s):_______ Netter(s):______ Recorder:_______
GPS unit_____ Start WP______________ End WP ________

Voltage (V):_____________
Pulse Rate (Hz):___________
Secchi (m): ____________ SpC (uS)___________
Water Temp (C):_______ Air Temp (C):_________
Start Time__________ End Time____________
Weather:_____________________________

	Beg time	End time	Beg shk time (sec)	End shk time (sec
Pass 1:				
Pass 2:				
Pass 3:				

Pass #	Species	Length (mm)	Pass #	Species	Length (mm)	Pass #	Species	Length (mm)	Pass #	Species	Length (mm)

Comments:

Fish codes:

		CS	coho salmon
KS	Chinook salmon	**SS**	sockeye salmon
CH	chum salmon	**SC**	slimy sculpin
DV	Dolly Varden	**9S**	ninespine stickleback
RT	rainbow trout	**3S**	threespine stickleback

Field QA / QC: _______

Data Entry: ________
File name:____________________________

Electroshocking Fish Distribution Survey Form (Side B)

R2 Resource Consultants
Pebble Project Mine Area
Electroshocking Fish Distribution Survey Form

Page ______ of _______ (Side B)
Crew Lead:__________
Assistant(s):__________

Pass #	Species	Length (mm)	Pass #	Species	Length (mm)	Pass #	Species	Length (mm)	Pass #	Species	Length (mm)

Comments:

Field QA / QC: _______

Data Entry: ________
File name:_____________________________

Electroshocking Survey Form (Side A)

R2 Resource Consultants
Pebble Project Mine Area
Electroshocking Survey Form

Page ____ of ___(Side A)
Crew Lead:_______
Assistant(s):_______

Study:____

Survey Type: **Calibration** **Population Estimate**

Capture Event: **1 or 2**

Date:_______________
Drainage: NFK SFK UT
Tributary:___________________________________
Segment:__________ Time:_________
Survey length:____________
Habitat Unit:__________Habitat Type:_________
Shocker (s):_______ Netter(s):______ Recorder:_______
Weather:____

Voltage (V):_____________ SpC (uS)______
Pulse Rate (Hz):___________
Water Temp (C):_______ Air Temp (C):_________
GPS unit______ Start WP________ End WP ______
Secchi (m): ______________________________

	AST (B)	(E)	Shcktime (B)	(E)
Pass 1:				
Pass 2:				
Pass 3:				

Pass #	Species	Length (mm)	Marked	Unmarked	Pass #	Species	Length (mm)	Marked	Unmarked

Comments:

Fish codes:

		CS	coho salmon
KS	Chinook salmon	**SS**	sockeye salmon
CH	chum salmon	**SC**	slimy sculpin
DV	Dolly Varden	**9S**	ninespine stickleback
RT	rainbow trout	**3S**	threespine stickleback

Field QA / QC: _______

Data Entry: ________
File name:____________________________

Electroshocking Survey Form (Side B)

R2 Resource Consultants
Pebble Project Mine Area
Electroshocking Calibration Survey Form

Page ____ of _____ (Side B)
Crew Lead:__________
Assistant(s):__________

Pass #	Species	Length (mm)	Marked	Unmarked		Pass #	Species	Length (mm)	Marked	Unmarked

Comments:

Field QA / QC: _______

Data Entry: ________
File name:______________________________

APPENDIX 11D

Field Forms
Habitat Assessment

Tier 3: CHANNEL MORPHOLOGY FORM

Date:_____________ Stream:_____________________________________ Reach#:_________ OCH #:________Surveyors:_________ Estimators:___________

Channel Type: ________________Channel Pattern:________________ Reach Length:___________ Valley length (from GIS)______________

Survey Start Time:________ Survey End time:________ Survey Direction: U/S or D/S Survey Type: Foot or Boat

Laser Rangefinder #:________ GPS Unit #:________ Coordinate System:_________ Field QA/QC by:__________ Data Entry by: _________

Start Latitude/Longitude: N___________________________/W_____________________________ Start Waypoint #:__________

End Latitude/Longitude:N____________________________/W_____________________________ End Waypoint #:___________

(Note: A minimum of three channel morphology station measurements required per reach)

NSO:_____ Waypoint:_____ Bankfull width (1):_______Wet width (1)______Bankfull Depth(1):______ Bed width (1):______ Gradient(1)______
NSO:_____ Waypoint:_____ Bankfull width (2):_______Wet width (2)______Bankfull Depth(2):______ Bed width (2):______ Gradient(2)______
NSO:_____ Waypoint:_____ Bankfull width (3):_______Wet width (3)______Bankfull Depth(3):______ Bed width (3):______ Gradient(3)______
NSO:_____ Waypoint:_____ Bankfull width (4):_______Wet width (4)______Bankfull Depth(4):______ Bed width (4):______ Gradient(4)______
NSO:_____ Waypoint:_____ Bankfull width (5):_______Wet width (5)______Bankfull Depth(5):______ Bed width (5):______ Gradient(5)______
NSO:_____ Waypoint:_____ Bankfull width (6):_______Wet width (6)______Bankfull Depth(6):______ Bed width (6):______ Gradient(6)______
Average:_____ Average:_______ Average:______ Average:______ Average:______ Average:______

Pebble Count Data:

Waypoint:_____________ NSO:______________Avg. Embeddedness (%)_____________

Pebble Counts (Measure 100 randomly selected particles in chosen spawning patch)																			

Discharge: Wetted width:______ Depth 1____ Depth 2_____Depth 3_____ Avg. depth_______ Wetted Area: ______
Float distance:________ Time 1:_______ Time 2:_______ Time 3:______ Avg, time_______ Velocity (Distance/Avg. Time_____)
Q=(Wetted area x Velocity)=_________

Comments:____
____
____

Tier 3: STREAM SURVEY FORM

Form Side A **Page____of_____**

Date:________________ Stream:_______________________________________ Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

Weather:__________________ Thermometer: _________ Air Temp:_____ Water Temp:_____ Time Temp Taken: ______ GPS Unit #:________ Camera #:__________

Start Latitude/Longitude: N___________________________/W_____________________________ Start Waypoint #:__________ Field QA/QC by:_________

End Latitude/Longitude:N___________________________/W_____________________________ End Waypoint #:__________ Data Entry by:____________

											Pools Only			Substrate					
NSO #	WP	Channel[1] (MC/SP/SC)	Side Channel/ Split Channel (LB/RB)	% Flow	Habitat Unit Type	Hab. Unit Length	Wet Width (m) (1)	Wet Width (m) (2)	Wet Width (m) (3)	Avg. Depth (m)	Max Pool Depth (m)	Depth At Pool Tail Crest (m)	Pool Forming Factor	% Org	% Sand/ Silt	% Gravel	% Cobble	% Boulder	% Bedrock

[1]**Channel : MC=Main Channel ; SP=Split Channel ; SC=Side Channel**

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; SL-sl=Slough; BW=Backwater; AC=Alcove; FW=Flowing Wetland (Note: BW & AC should be designated as primary habitat units, rather than subunits in order to ensure sampling of this habitat types.)

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

LWD key= Minimum qualifying piece = ≥0.3 meters and ≥ 2 times bankfull width

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

Riparian vegetation: CF=Conifer forest; BC=Broadleaf forest; NSW=willow shrub; NSA=Alder shrub; NSO=other shrub; NHT=tundra; NHB=bog; NHF=fen; NHO=other herbaceous

Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth (≥1m)

Tier 3: STREAM SURVEY FORM

Form Side B **Page____of_____**

Date:________________ Stream:______________________________________Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

NSO #	Hab. Unit Type	% LB Eroding	% RB Eroding	% LB Undercut	% RB Undercut	Riparian Type	Cover Type	% Cover	LWD Key	Photo # (u/s or d/s)	Comments

Comments:

[1]Channel : MC=Main Channel ; SP=Split Channel ; SC=Side Channel

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; BW=Backwater; SL-sl=Slough; AC=Alcove; FW=Flowing Wetland (Note: BW & AC should be designated as primary habitat units, rather than subunits in order to ensure sampling of this habitat types.)

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

LWD key= Minimum qualifying piece = $\geq$0.3 meters and $\geq$ 2 times bankfull width

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

Riparian vegetation: CF=Conifer forest; BC=Broadleaf forest; NSW=willow shrub; NSA=Alder shrub; NSO=other shrub; NHT=tundra; NHB=bog; NHF=fen; NHO=other herbaceous

Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth ($\geq$1m)

Version 07-23-08

SPECIAL HABITAT FEATURES: STREAM SURVEY FORM

Page____of_____

Date:________________ Stream:____Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

General Descriptor Variables					Tributary/Seep/Spring					Barrier						
Feature Bank Location	Feature Type	Habitat NSO#	Feature Waypoint	Photo #	Feature Est. % Flow	Feature Water Temp. (ºC)	Water Temp. US (ºC)	Water Temp. DS (ºC)		Barrier type	Temporal Nature	Barrier Height (m)	Barrier Length (m)	Depth below barrier (m)	% Gradient	Comments

Feature Bank Location; BB=Both Banks (Channel Spanning) RB=Right Bank; LB=Left Bank **Habitat NSO#= NSO# of habitat unit that feature is associated with** **Feature Type: TB=Tributary; SP=Spring; Seep=Seep; BR=Barrier** **Feature Waypoint: Mark each identified barrier, tributary, spring, and seep with a wayoint** **Barrier Type: F=Falls CH=BR chute; CS=Cascade; BV=Beaver Dam; D=Dry channel** **Temporal Nature: P=Permanent (ie. Bedrock Falls); T=Temporary (ie. Beaver Dam)**	**Additional Comments:**

APPENDIX 11E

Field Forms
Ephemeral Reach Study, South Fork Koktuli River

Ephemeral Reach Study, Stream Survey Form

R2 Resource Consultants

PPL Ephemeral Study- Stream Survey Form

SF Koktuli River

Page________of________

Lead:_________________

Assistant(s):___________

Date:_______________ Segement:__________ Surveyors:____________ Estimator:______________ Weather:____________________________________

GPS Unit #:____________ Camera #:________________ Laser Rangefinder #:________________ Field QA/QC by:_________ Data Entry by:___________

Start Time__________ Start Latitude/Longitude: N____________________/W________________________ Start Waypoint #:_____________

End Time__________ End Latitude/Longitude: N_____________________/W________________________ End Waypoint #:_____________

Flow Condition: **Low** **Part. Dewatered** **Dewatered**

Pool #	Pool Type	Waypoint #	Length (m)	Width 1 (m)	Width 2 (m)	Width 3 (m)	Max Depth (m)	Depth at Pool Tail Crest (m)	% Overhead Cover	Temp C

Comments:

Field QA/QC:____________________

Data Entry:___________________________

File Name:_____________________________

Ephemeral Reach Study, Stranded Fish Survey Form

R2 Resource Consultants

PPL Ephemeral Study - Stranded Fish Survey Form

SF Koktuli River

Page________of________

Lead:_________________

Assistant(s):___________

Date:_______________ Segement:__________ Surveyors:____________ Estimator:______________

GPS Unit #:____________ Camera #:________________ Laser Rangefinder #:________________

Field QA/QC by:_________ Data Entry by:___________ Weather:____________________________________

Flow Condition: **Low** **Part. Dewatered** **Dewatered**

Pool #	Waypoint #	Predation ? (Y/N)	Stranded Fish ? (Y/N)	Species	Fork Legnth (mm)	Comments

Field QA/QC:____________________

Data Entry:___________________________

File Name:_____________________________

APPENDIX 11F

Field Forms
Off-channel Habitat Study in the North Fork Koktuli River

NF KOKTULI OFF-CHANNEL: STREAM SURVEY FORM

Form Side A Page____of_____

Date:________________ Stream:_______________________________________ Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

Weather:______________________________ Air Temp (ºC):________ Water Temp (ºC):________ GPS Unit #:______________ Conductivity(um):_____________

GPS Unit #:__________________ Camera #:____________________ Laser Rangefinder #:__________________ Water Visibility (feet):______________________

Start Latitude/Longitude: N___________________________/W_____________________________ Start Waypoint #:__________ Field QA/QC by:_____________

End Latitude/Longitude:N____________________________/W_____________________________ End Waypoint #:__________ Data Entry by:_______________

											Pools Only			Substrate					
NSO #	WP	Channel[1] (MC/OC)	Side Channel/ Split Channel (LB/RB)	% Flow	Habitat Unit Type	Hab. Unit Length	Wet Width (m) (1)	Wet Width (m) (2)	Wet Width (m) (3)	Avg. Depth (m)	Max Pool Depth (m)	Depth At Pool Tail Crest (m)	Pool Forming Factor	% Org	% Sand/ Silt	% Gravel	% Cobble	% Boulder	% Bedrock

[1]Channel : MC=Main Channel ; OC=Off Channel

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; SL-sl=Slough; BW=Backwater; AC=Alcove; FW=Flowing Wetland

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

LWD key= Minimum qualifying piece = ≥0.3 meters and ≥ 2 times bankfull width

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

Riparian vegetation: CF=Conifer forest; BC=Broadleaf forest; NSW=willow shrub; NSA=Alder shrub; NSO=other shrub; NHT=tundra; NHB=bog; NHF=fen; NHO=other herbaceous

Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth (≥1m)

NF KOKTULI OFF-CHANNEL: STREAM SURVEY FORM

Form Side B **Page____of_____**

Date:________________ Stream:____ Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

NSO #	Hab. Unit Type	% LB Eroding	% RB Eroding	% LB Undercut	% RB Undercut	Riparian Type	Cover Type	% Cover	LWD Key	Photo # (u/s or d/s)	Comments

Comments:

[1]Channel : MC=Main Channel ; OC=Off Channel

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; BW=Backwater; SL-sl=Slough; AC=Alcove; FW=Flowing Wetland

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

LWD key= Minimum qualifying piece = $\geq$0.3 meters and $\geq$ 2 times bankfull width

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

Riparian vegetation: CF=Conifer forest; BC=Broadleaf forest; NSW=willow shrub; NSA=Alder shrub; NSO=other shrub; NHT=tundra; NHB=bog; NHF=fen; NHO=other herbaceous

Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth ($\geq$1m)

NF KOKTULI OFF-CHANNEL: STREAM SURVEY FORM

Page____of_____

Date:________________ Stream:_______________________________________ Reach#:_______ OCH #:________ Surveyors:____________ Estimator:_________

General Descriptor Variables					Tributary/Seep/Spring					Barrier						
Feature Bank Location	Feature Type	Habitat NSO#	Feature Waypoint	Photo #	Feature Est. % Flow	Feature Water Temp. (ºC)	Water Temp. US (ºC)	Water Temp. DS (ºC)		Barrier type	Temporal Nature	Barrier Height (m)	Barrier Length (m)	Depth below Barrier (m)	% Gradient	Comments

Feature Bank Location; BB=Both Banks (Channel Spanning) RB=Right Bank; LB=Left Bank
Habitat NSO#= NSO# of habitat unit that feature is associated with
Feature Type: TB=Tributary; SP=Spring; Seep=Seep; BR=Barrier
Feature Waypoint: Mark each identified barrier, tributary, spring, and seep with a wayoint
Barrier Type: F=Falls CH=BR chute; CS=Cascade; BV=Beaver Dam; D=Dry channel
Temporal Nature: P=Permanent (ie. Bedrock Falls); T=Temporary (ie. Beaver Dam)

Additional Comments:

Electroshocking Fish Utilization Survey Form

R2 Resource Consultants
Pebble Project Mine Area
Electroshocking Survey Form

Page ____ of _____ (Side A)
Crew Lead:__________
Assistant(s):__________

Study: ________________________________

Method: Efish Minnow Trap Seine

Survey Type: Fish Utilization

Date:_______________

Voltage (V):___________ Pulse Rate (Hz):___________

OCH Site #:__________ **OCH or MS**

GPS Unit #____________ StartWP_________EndWP________

Tributary:_____________________________________

Water Temp(C):_______ Air Temp(C):__________

Segment:__________ Time:_________

SpC(μs)____

Survey length(m):_____________

Secchi (m): ________

Habitat Unit:__________Habitat Type:_________

Shocker (s):_______ Netter(s):______ Recorder:_______

Weather:____

	Beg time (AST)	End time (AST)	Beg. shock time (sec)	End shock time (sec)
Pass 1:				
Pass 2:				
Pass 3:				

Pass #	Species	Length (mm)	Marked	Unmarked	Pass #	Species	Length (mm)	Marked	Unmarked

Comments:

Field QA / QC: _______

Data Entry: ________
File name:_____________________________

APPENDIX 11G

Field Forms
Fisheries Study in the Transportation-corridor Study Area

TRANSPORTATION CORRIDOR: CHANNEL MORPHOLOGY FORM

Page____of_____

Date:_____________ Stream:_______________________________________ RM #:________ Site #:_______ Surveyors:_________ Estimators:___________

Landform:______________ Channel Type: ______________Channel Pattern:____________ Fish Class:_____________ Valley length (from GIS)___________

Survey Start Time:________ Survey End time:________ Sinuosity:___________ HUC:_____________ Segment Length:_________ Sinuosity:_____________

Laser Rangefinder #:________ Camera #:_______ GPS Unit #:________ Coordinate System:_________ Field QA/QC by:________ Data Entry by: _________

Start Latitude/Longitude: N_________________________/W________________________ Start Waypoint #:_______ Survey Direction: U/S or D/S

End Latitude/Longitude:N__________________________/W_________________________ End Waypoint #:_______ Survey Type: Foot or Boat

(Note: A minimum of three channel morphology station measurements required per Segment)

NSO:_____ WP:_____ BF Width(1):______ BF Depth(1)_____ Incision Depth(1):_____ Wet width(1):______ Wet Depth(1)______ Gradient(1)______
NSO:_____ WP:_____ BF Width(2):______ BF Depth(2)_____ Incision Depth(2):_____ Wet width(2):______ Wet Depth(2)______ Gradient(1)______
NSO:_____ WP:_____ BF Width(3):______ BF Depth(3)_____ Incision Depth(3):_____ Wet width(3):______ Wet Depth(3)______ Gradient(1)______
NSO:_____ WP:_____ BF Width(4):______ BF Depth(4)_____ Incision Depth(4):_____ Wet width(4):______ Wet Depth(4)______ Gradient(1)______
NSO:_____ WP:_____ BF Width(5):______ BF Depth(5)_____ Incision Depth(5):_____ Wet width(5):______ Wet Depth(5)______ Gradient(1)______
NSO:_____ WP:_____ BF Width(6):______ BF Depth(6)_____ Incision Depth(6):_____ Wet width(6):______ Wet Depth(6)______ Gradient(1)______
Average:______ Average:______ Average:_____ Average:______ Average:______ Average:______

Sediment Deposition:_____________ Bed Material Shape:___________ Bed Material Condition:_____________ Substrate:_________________

Riparian Vegetation Type: RB____ LB____
Riparian Veg. Seral Stage: RB____ LB____

Consturction Concerns:________________________________

Construction Concerns Description/Photos: ____
____
____
____
____

Comments:

TRASPORTATION CORRIDOR: STREAM SURVEY FORM

Side A **Page____of_____**

Date:________________ Stream:_______________________________________ Site #:_______ Surveyors:____________ Estimator:_______________

Weather:____________________________________ Air Temp (ºC):__________ Water Temp (ºC):_______ pH:____________ Conductivity(um):_____________

GPS Unit #:__________________ Camera #:____________________ Laser Rangefinder #:_______________ Water Visibility (feet):________________________

Start Latitude/Longitude: N__________________________/W_____________________________ Start Waypoint #:__________ Field QA/QC by:_________

End Latitude/Longitude:N____________________________/W_____________________________ End Waypoint #:__________ Data Entry by:____________

(Collect only WP, channel, location, % flow, type, length, widths, average depth for side channels and off channel habitat.)

											Pools Only			Subst rate					
NSO #	WP	Channel[1] (MC/SP/SC/OC)	SC/ SP/OC Location (LB/RB)	% Flow	Habitat Unit Type	Hab. Unit Length	Wet Width (m) (1)	Wet Width (m) (2)	Wet Width (m) (3)	Avg. Depth (m)	Max Pool Depth (m)	Depth At Pool Tail Crest (m)	Pool Forming Factor	% Org	% Sand/ Silt	% Gravel	% Cobble	% Boulder	% Bedrock

[1]Channel : MC=Main Channel ; SP=Split Channel ; SC=Side Channel ;OC=Off-Channel Habitat

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; SL-sl=Slough; BW=Backwater; AC=Alcove; FW=Flowing Wetland

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

Riparian vegetation: CF=Conifer forest; BC=Broadleaf forest; NSW=willow shrub; NSA=Alder shrub; NSO=other shrub; NHT=tundra; NHB=bog; NHF=fen; NHO=other herbaceous

Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth (≥1m)

TRANSPORTATION CORRIDOR: STREAM SURVEY FORM

Form Side B **Page____of_____**

Date:________________ Stream:_______________________________________ Site#:_______ Surveyors:____________ Estimator:_________

NSO #	Hab. Unit Type	Riparian Type	Cover Type	% Cover	Photo # (u/s or d/s)	Comments

Comments:

[1]Channel : MC=Main Channel ; SP=Split Channel ; SC=Side Channel; OC=Off Channel Habitat

Habitat Type: RF-rf=Riffle; CS-cs=Cascade; GL-gl=Glide; PL-lsc=Lateral Scour Pool; PL-pp=Plunge Pool; PL-msc=Mid-Channel Scour Pool; PL-dm=Dammed Pool; PL-ip=Isolated Pool; PL-st=Step Pool; BP=Beaver Pond; BW=Backwater; SL-sl=Slough; AC=Alcove; FW=Flowing Wetland

Pool forming factor: LWD= large wood; RW=rootwad; BR=bedrock; BO=boulder; C=confluent flow; M=meander channel; BV=beaver dam; O=other (describe in comments)

Substrate: ORG=Organics; SI/SA=Silt/Sand (<2mm);GR=Gravel(2-64 mm);CO=Cobble (64-256 mm); BO=Boulder (>256 mm); BR=Bedrock

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Cover Type: LWD=large wood; SWD= small wood; UB=Undercut bank; OV=Overhanging Vegetation; AV=Aquatic Vegetation; BO=Boulders; TB=Turbulence; WD=Water Depth ($\geq$1m)

TRANSPORTATION CORRIDOR: SPECIAL HABITAT FEATURES: STREAM SURVEY FORM

Page____of_____

Date:________________ Stream:____ Site #:_______ Surveyors:____________ Estimator:_________

General Descriptor Variables					Tributary/Seep/Spring					Barrier						
Feature Bank Location	Feature Type	Habitat NSO#	Feature Waypoint	Photo #	Feature Est. % Flow	Feature Water Temp. (ºC)	Water Temp. US (ºC)	Water Temp. DS (ºC)		Barrier type	Temporal Nature	Barrier Height (m)	Barrier Length (m)	Depth below Barrier (m)	% Gradient	Comments

Feature Bank Location; BB=Both Banks (Channel Spanning) RB=Right Bank; LB=Left Bank
Habitat NSO#= NSO# of habitat unit that feature is associated with
Feature Type: TB=Tributary; SP=Spring; Seep=Seep; BR=Barrier
Feature Waypoint: Mark each identified barrier, tributary, spring, and seep with a wayoint
Barrier Type: F=Falls CH=BR chute; CS=Cascade; BV=Beaver Dam; D=Dry channel
Temporal Nature: P=Permanent (ie. Bedrock Falls); T=Temporary (ie. Beaver Dam)

Additional Comments: