Pebble Project

NORTHERN DYNASTY MINES INC.

DRAFT ENVIRONMENTAL BASELINE STUDIES PROPOSED 2007 STUDY PLANS

CHAPTER 11 FISH AND AQUATIC RESOURCES

DRAFT

SEPTEMBER 2007

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ACRONYMS AND ABBREVIATIONS

ADF&G	Alaska Department of Fish and Game
ADNR	Alaska Department of Natural Resources
APC	Alaska Peninsula Corporation
ASCI	Alaska Stream Condition Index
CAS	Columbia Analytical Services
ENRI	Environment and Natural Resource Institute
EPA	U.S. Environmental Protection Agency
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera*
FSP	field sampling plan
GPS	global positioning system
HDR	HDR Alaska, Inc.
MLE	maximum likelihood estimation
µm	micrometer(s)
mm	millimeter(s)
MSK	Mainstem Koktuli River
NDM	Northern Dynasty Mines Inc.
NFK	North Fork Koktuli River
OCH	off-channel habitat
QA	quality assurance
QAPP	quality assurance project plan
QC	quality control
RDI	Resource Data Inc.
SFK	South Fork Koktuli River
SGS	SGS Environmental Services, Inc.
Shaw	Shaw Environmental, Inc.
STL	Severn Trent Laboratories
TBM	temporary benchmark
UT	Upper Talarik Creek

11. FISH AND AQUATIC RESOURCES

11.1 Fish Resources—Mine Study Area

11.1.1 Introduction

HDR Alaska, Inc., will conduct the 2007 baseline study for fish resources in the mine study area. The 2007 study will build on work completed during the 2004 through 2006 field seasons. Some ongoing programs will be continued, and new studies will be initiated where necessary. A summary of the tasks for the fish resources study in 2004 through 2007 is provided in Table 11.1-1. The overall objectives for this fish resources baseline study are as follows:

- Document the distribution and relative abundance of fish species in the mine study area.
- Acquire predevelopment baseline data on certain parameters for possible use in post-development monitoring.
- Provide information that will help guide project design.
- Develop information for the environmental permitting process.

There are three major stream systems located in the study area: Upper Talarik Creek (UT), South Fork Koktuli River (SFK), and North Fork Koktuli River (NFK). All three rivers originate in the same general vicinity (Figure 11.1-1), near Kaskanak, Koktuli, and Groundhog mountains, approximately 32 kilometers north of Iliamna Lake. The north and south forks of the Koktuli River are separated by Kaskanak Mountain and flow generally westward for approximately 40 kilometers until they converge to become the mainstem of the Koktuli River, a tributary to the Mulchatna River. Upper Talarik Creek flows southeast and then southward for approximately 65 kilometers and discharges into Iliamna Lake on its north shore, approximately 27 kilometers west of the community of Iliamna. The nearest communities are the villages of Iliamna and Newhalen located approximately 27 kilometers southeast of the study area and Nondalton, located approximately 25 kilometers east-northeast of the study area.

Together, the three major stream systems in the vicinity of the proposed Pebble Project support populations of sockeye, Chinook, coho and chum salmon, northern pike, least cisco (North Fork Koktuli only) Arctic grayling, Dolly Varden char, rainbow trout, threespine and ninespine stickleback, and slimy sculpin. Fish species encountered rarely or in small numbers include round whitefish, humpback whitefish, burbot, pink salmon (Upper Talarik Creek only), and lamprey.

Major components of the 2007 field study program are as follows:

- An evaluation of fish use of overwintering habitats.
- A telemetry study of rainbow trout on Upper Talarik Creek.
- An estimate of salmon escapement in the three major streams in the study area.
- A study of fish abundance in Upper Talarik Creek.

- A distribution study of juvenile anadromous fish.
- A fish-tissue study.
- An instream flow study focusing on main-channel habitats.
- An instream flow study focusing on off-channel habitats.

The personnel assigned to the fish-related studies in 2007 are as follows:

- Paul McLarnon—all studies.
- Patrick Blair—fish abundance and instream flow studies.
- Brian Bue—salmon escapement study.
- Erin Cunningham—overwintering habitat, fish abundance, and fish distribution studies and fish presence surveys for instream flow study.
- Stephen Crawford—overwintering habitat, telemetry, salmon escapement, and fish distribution studies and fish presence surveys for instream flow study.
- Brian Donahue—instream flow study.
- Jenni Dykstra—fish distribution study and fish presence surveys for instream flow study.
- Todd Heyworth—instream flow study.
- Jason Kent—instream flow study.
- Jed Konsor——telemetry, salmon escapement, and fish distribution studies and fish presence surveys for instream flow study.
- Adam Lewis—instream flow study.
- Bill Mavros—fish abundance study.
- John Morsell—telemetry study.
- Malcolm Salway— overwintering habitat and fish distribution studies and fish presence surveys for instream flow study.

11.1.2 Study of Fish Use of Overwintering Habitats

11.1.2.1 Introduction

Harsh winter conditions often limit salmonid populations during their fresh-water life stages (Giannico and Hinch, 2003). Winter conditions for streams in the vicinity of Pebble Project are usually quite severe, with freeze-up generally occurring by late October and breakup usually occurring after mid-April. Streams in the project vicinity experience base-flow (low-flow) conditions in mid- to late winter, with some reaches becoming completely dry. In spite of these conditions, streams in the vicinity support populations of resident and anadromous fishes.

It is important to document fish use of winter habitats in the Pebble Project vicinity to accomplish the following:

- Characterize fish overwintering habitats in the project vicinity, especially those habitats that may limit populations.
- Establish fish use of available habitats under base-flow conditions, especially in areas that may be subject to project-induced changes in conditions.
- Identify those areas that may deserve special protection during the project design phase.

It is likely that, during harsh winter conditions, juvenile fish seek habitats that favor survival (Giannico and Hinch, 2003), such as groundwater upwelling areas, beaver ponds, and alcoves associated with springs, and sections of the stream with perennial flow. Overwintering investigations were first initiated in 2004 and continued through November of 2006 as a part of the environmental baseline-data collection associated with the Pebble Project. The study area includes the full lengths of SFK and NFK and a 28-mile section of the UT upstream of land owned by the Alaska Peninsula Corporation (Figure 11.1-1).

11.1.2.2 Goals and Objectives

The primary goal of this study is to document the spatial distribution, relative abundance, and habitat associations of juvenile fish during winter conditions. The 2007 effort will supplement and add to previous years' information. Sample methods will be consistent with those used during previous years; however, increased emphasis will be placed on sampling off-channel habitats, especially those associated with springs and accreting flow.

The primary objectives of the overwintering study are as follows:

- Sample various habitat types and locations which were previously sampled and/or where fish were previously captured.
- Sample new sites and/or habitat types considered to have high potential to support over-winter fish use, such as alcoves associated with springs, side channels with perennial flow, beaver ponds, etc.
- Conduct three sampling events during the year: during severe winter conditions, just prior to breakup (late April), and just prior freeze-up (October-November).
- Relate fish presence or absence to habitat types and/or physical features such as springs, upwelling, etc.
- Document the behavior, distribution, and relative abundance of juvenile fish just prior to breakup in the spring and just prior to freeze-up in the fall.

11.1.2.3 Study Design

Field Sampling Schedule

Three field trips are planned for the 2007 field season: one under harsh winter conditions (early April), a second during early thaw but before high freshet flows (late April), and a third just prior to freeze-up (tentatively scheduled for late October through early November).

Selection of Sample Sites

In previous winters (2004 through 2006), sampling occurred at sites that were selected based on the presence of open water and safe access. In 2007, emphasis will be placed on identifying areas that are believed, based on previous years' experiences, to have high probabilities of supporting overwintering fish and have not yet been sampled. Sampling locations will include the following:

- A higher proportion of off-channel habitat, side channels, alcoves associated with springs, and deep-water areas, such as beaver ponds and scour pools.
- Areas fed by groundwater as determined by the presence of open water or thin ice.
- Sites that have had consistently yielded captures in previous surveys.
- Areas where juvenile salmon and Dolly Varden have been especially abundant during summer sampling efforts.

Some sampling sites will overlap those of the off-channel habitat study and will compliment that effort.

Sampling Methods and Data Recording

Access to sample sites will be by helicopter. Sampling methods will duplicate those employed during 2006, as described below. Electrofishing and minnow trapping will be the primary sampling techniques used; however, field crews will be prepared to conduct snorkel counts if conditions require this method.

Minnow Trapping/Electrofishing. At each site, three to five 1/4-inch-mesh minnow traps, baited with cured salmon eggs, will be set in habitats such as pools, undercut banks, and beaver ponds. The number of traps set will depend on the availability of suitable trapping locations within a site and safe access to the open water or breakable ice. Traps will be fished for approximately 24 hours. Single-pass electrofishing surveys will be conducted using a backpack electrofisher.

Snorkeling (as required). An experienced snorkeler will typically conduct three passes through the sample site. Fewer passes may be made if the sample site is small and can be fully viewed. The species of observed fish will be identified, and the size of each fish estimated.

Information Recorded. All overwintering habitats observed will be cataloged as to type (springs or upwelling areas, deep pools, alcoves, beaver ponds, etc.), location (global positioning system [GPS] coordinates), size (dimensions), and associated ice cover, if any. All captured fish will be identified to species, measured to fork length (length from the fork of the tail to the nose of the fish, in millimeters), and released at the point of capture. Additional information recorded on data sheets will include capture date, time, and method; habitat conditions (habitat type, ice cover or open water); estimated length and/or area surveyed; and water temperatures (in degrees Celsius). The frequency and voltage settings and level of effort (i.e., minutes of use) will be recorded for each electrofishing survey. Incidental observations of fish or other wildlife will also be recorded.

Newly emerged salmon species can be difficult to identify in the field. In cases where fish identification is uncertain, reference samples will be retained for identification at a field laboratory in Iliamna or in Anchorage. Voucher specimens will be archived.

11.1.2.4 Quality Control

Each field crew will be composed of two experienced biologists/technicians. Prior to initiating sampling, all staff will meet to review sampling protocols and documentation requirements. The following publications will be used to ensure safe and effective electrofishing techniques are employed and to minimize fish mortality.

- *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS, 2000)
- *Fish Exclusion Protocols and Standards* (WDOT, 2006)
- *Backpack and Drift Boat Design Considerations and Sampling Protocols* (WDFW, 2005)

During the first day of sampling, all field crews will conduct sampling together at a minimum of one site to ensure accuracy of species identification and consistency of sampling methods and data documentation.

11.1.2.5 Data Management

Data collected during 2007 will be entered into an electronic database shortly after returning to the office. The database has been designed to include the use of look-up tables to maintain consistency and to provide an initial level of quality assurance (QA) and quality control (QC) during data entry. After being entered into the database, all data will be checked against the original field data.

11.1.2.6 Data Analysis

Data analysis will include the development of overwintering habitat maps indicating size and type of habitat as well as location. For fish taken or observed, analyses will include length-frequency graphs, an overall description of species composition, geographical distribution, and relative abundance in the study area. A comparison will be completed to determine which of the habitats sampled produced the greatest capture rates for each species. This information will be used to identify sensitive overwintering habitats and to help describe the early life history, behavior, distribution, and relative abundance of juvenile fish in the study area during winter conditions.

11.1.3 Rainbow Trout Telemetry Study in Upper Talarik Creek

11.1.3.1 Introduction

Upper Talarik Creek is tributary that discharges to the north shore of Iliamna Lake. UT originates on a plateau near the northern margin of the Pebble Project mineralized zone. The creek initially flows southeasterly for about 10 kilometers, then turns south to pass around the north end of Kaskanak Mountain, continues in a southerly direction for an additional 55 kilometers, and enters Iliamna Lake (Figure 11.1-1) about 27 kilometers west of the community of Iliamna. UT flows through remote, rugged terrain and is not accessible by road. The lower portion of the creek is accessible by boat from Iliamna Lake and by float plane. The lower approximately 13 kilometers of the creek flow through land owned by the Alaska Peninsula Corporation (APC) and a small parcel of native- and state-selected land adjoining the APC land (Figure 11.1-2). The remainder of the creek flows through state land.

UT supports spawning populations of sockeye and coho salmon and lesser numbers of Chinook salmon. Pink salmon have occasionally been noted in the creek. Most of the creek provides rearing habitat for juvenile coho salmon and some areas support rearing Chinook salmon. Resident fish species include all life stages of Arctic grayling, rainbow trout, and Dolly Varden char. Rainbow trout are primarily limited to the lower and middle portions of the drainage, although some juveniles ascend the system to rear in upper reaches. Much of the rainbow trout population appears to be adfluvial (living in the lake and traveling to the river to spawn), although one small lake in the northeast part of the system supports a local population. UT is one of several Iliamna Lake tributaries that are managed as catch-and-release trout fisheries. Sport fishermen are accompanied by guides operating under agreements with APC for access to the lower approximately 13 kilometers of the creek. Some subsistence fishing by local residents occurs during the late fall and winter.

To date, the fish and aquatic resources program has sampled primarily in the upper portion of this drainage because of its proximity to the study area. Snorkel surveys and electrofishing in the upper third of the creek have shown that a relatively low number of juvenile fish are present.

Rainbow trout catch in sport and subsistence fisheries, combined with possible changes in the proposed project, has created a need for more comprehensive data on potions of UT. In addition, the Alaska Department of Fish and Game (ADF&G) and APC have encouraged Northern Dynasty Mines Ind. (NDM) to specifically study rainbow trout in UT with emphasis on use patterns by adults, including spawning.

Early life-stage rearing of rainbow trout is known to occur in UT, with most juvenile fish occurring in the lower two thirds of the drainage. Investigations of other complex drainage systems that include a mixture of lakes, small streams, and large streams have suggested the presence of several possible life-history strategies. A study of the nearby Alagnak River drainage (Meka et al., 2003) suggested three possible life-history strategies:

- Adfluvial type, where fish spend most of their time in lakes with some time spent in lake outlets or inlet tributaries.
- Lake/river type, where fish divided their time between large river mainstems, lakes, and tributaries.
- River type, where fish remained in large river systems with no obvious migratory movements.

Russell (1977) used a weir to monitor fish movements in Lower Talarik Creek (a completely separate stream that enters Iliamna Lake about 12 miles west of Upper Talarik Creek). His results showed that adult rainbow trout entered the creek to spawn during late April to mid-June, with most returning to Iliamna Lake after spawning. Another upstream migration of adult fish occurred in the fall with fish entering the creek during September to early October. Since the weir was removed in late October, this study could not determine whether there was another downstream movement prior to winter. Most juvenile trout remained in the creek during the spring, summer, and fall. A mark-and-recapture study (Minard et al., 1992) conducted on spawning trout in the Kvichak River (outlet of Iliamna Lake) suggested that both adult and subadult trout congregate on spawning grounds in the Kvichak River in the spring, then disperse into Iliamna Lake in June. At least some of these fish entered lake tributaries, including Upper Talarik Creek, in the fall, but most returned to the Kvichak River. The Kvichak spawners may be comparable to the lake/river or river ecotypes described by Meka et al. (2003).

Understanding rainbow trout life history behavior within Upper Talarik Creek is an important component of the fish resources baseline study program. The studies described above provide some suggestions regarding possible region-wide migratory behavior of adult rainbow trout, but do not specifically address rainbow trout behavior in Upper Talarik Creek.

11.1.3.2 Goals and Objectives

The goal of this study is to document the migratory behavior and use (including timing) of stream habitats by this species. Migratory behavior includes potential migrations to nearby lakes and/or streams and stream fidelity for both spawning (spring) and foraging (fall) incursions.

The specific objectives of the study are as follows:

- Document the movements of adult rainbow trout through a two-year period using remote telemetry.
- Document spatial and temporal migratory patterns and habitat use by adult rainbow trout originally tagged in UT.
- Compare the rainbow trout life-history strategy observed in UT with life-history strategies documented for nearby areas in the Iliamna Lake drainage.

11.1.3.3 Study Design

Sampling Design

Movements of adult rainbow trout will be documented for approximately two years using radio telemetry. Up to 75 adult rainbow trout will be fitted with surgically implanted radio transmitters. Adults will be captured at a minimum of two different sites and at time intervals of at least two weeks in the lower third of UT in an attempt to obtain a representative sample of adults.

The minimum size of fish selected for radio tagging will be 500 millimeters, based on the size distributions of sexually mature fish as documented by the Russell (1977) and Minard et al. (1992). Rainbow trout greater than 500 millimeters are likely to be Age VI or older and comprise the vast majority of trout in the spawning population (Russell, 1977; Minard et al., 1992). Tracking will involve both fixed, automated receiving stations and periodic active tracking from aircraft and boat to maximize information and minimize the chances of missing fish movements. The fixed stations will be located at the mouth of UT and at the mouth of Lower Talarik Creek (Figure 11.1-2). The latter station will be used to determine if adult rainbow trout captured in UT are using this nearby stream as part of their life-history strategy. Other telemetry studies are being conducted in the area in 2007 by ADF&G and the National Park Service. These efforts will incorporate at least one fixed station on the Newhalen River and perhaps other fixed stations at other nearby locations. For this reason, radio frequencies will be coordinated with ADF&G (sport fish and wildlife) and the National Park Service to avoid potential problems related to competing frequencies and, if possible, to scan for tagged fish from other studies.

Sampling Schedule

The tentative 2007/2008 field schedule is as follows:

- Establish fixed monitoring stations—late July 2007
- Capture fish and surgically implant tags—mid-August to early September 2007
- Service fixed receiving stations—twice a month through November 2007
- Remove fixed stations—November 30, 2007
- Reinstall fixed stations—April 1, 2008
- Minimum aerial tracking of tagged fish—twice a month through October 31, 2007; twice each month April through October 2008. Additional aerial surveys will be made between November 2007 and March 2008 if weather permits.

Field Methods

Fish Capture. The primary capture method will be hook and line using barbless hooks. Beach seining will also be considered if it can be done without disrupting salmon spawning and if physical stream conditions allow the use of a seine. Fish selected for radio tagging will be handled as gently as possible and placed into holding tanks while awaiting tag implantation. No more than four fish will be held at any one time until surgical implantation is complete. A minimum of two capture periods are currently planned— mid-August and late August to early September—depending on the availability of adult fish of the minimum size. Approximately half of the total fish will be captured during each capture period. Fish selected for tagging will consist of approximately equal numbers of males and females.

Radio Tag Implantation. Radio transmitters will be surgically implanted into the abdominal cavity of up to 75 mature rainbow trout captured from UT. Fish within the dominant size range of mature rainbow trout (500 to 700 millimeters) will likely weigh 1,800 to 6,000 grams (Russell, 1977). It is recommended that radio tags not exceed 2 percent of body weight, thus tags weighing less than 35 grams are appropriate for this study. Lotek Model SR-M11-35 telemetry tags will be used; these tags weigh 10 grams, well below the acceptable weight limit. The tags will be individually coded to allow identification of specific fish. The signal life span is 741 days (2+ years) at a 5 second continuous burst rate. The tags also incorporate motion-sensing capability that allows remote sensing of motion history, providing information on whether a tagged fish is dead or alive. The tags are 11 millimeters in diameter and 61 millimeters long, with an external whip antenna.

Surgical implantation methods will be based on those described by Summerfelt and Smith (1990). The fish selected for surgery will be placed in a bath containing anesthetic and allowed to remain until they become immobile. The anesthetic Aqui-S is currently under review for "zero withdrawal" use. Anesthetic concentrations and immersion times will be based on existing trials with salmonid fishes.

Anesthetized fish will be placed in a neoprene-lined cradle, and gills will be irrigated with water from the anesthetic bath during surgery. A 2 to 3 centimeter incision will be made near the mid-ventral line, 3 to 4 centimeters in front of the pelvic girdle. The tag antenna wire will be threaded through the abdominal cavity using a hollow needle combined with a groove director and will exit through a small hole in front of and to the side of the vent. The tag will be inserted into the incision using the antenna wire to help pull it into place. The incision will be closed using three to four sutures, and the incision will be coated with Vetbond glue. Near the end of the surgery, irrigation fluid will be switched to fresh water to enhance and speed recovery. Following surgery, fish will be held in a fresh-water bath until they are fully mobile, then released into a nearby holding area for an additional hour. Tag operation will be tested before fish are released. Instruments will be disinfected between surgeries.

Only experienced personnel will conduct surgery. A representative of ADF&G will conduct and/or supervise the surgery. The surgical procedure is expected to take 6 to 8 minutes per fish. It is expected that radio tags will be implanted into about 20 fish per field day.

Tracking. Both active and passive tracking will be used to monitor fish movements. Fixed datalogging receivers (Lotek Model SRX600) will be installed near the mouths of Upper Talarik Creek and Lower Talarik Creek. The receivers will operate continuously and will log all radio-tagged fish passing the station, as well as identifying an upstream or downstream direction of travel. Electronic equipment and batteries will be enclosed in a weatherproof box. Solar battery charging will be considered. Fixed stations will be serviced approximately every two weeks, at which time logged data will be downloaded to a laptop computer and batteries will be changed as needed. Access to the fixed stations will be by boat via Iliamna Lake, rather than by helicopter, to minimize disturbance to popular sport-fish areas. The stations will be installed in July 2007 so they can be established and thoroughly tested before release of tagged fish. Simulated fish carrying radio tags will be used to test the receivers and dataloggers. Fixed receiving stations will likely be removed in late October or early November and reinstalled in early the following April. old temperatures and snow are expected to make winter use impractical.

A Lotek Model SRX400A manual tracking receiver in combination with a directional antenna will be used during active tracking from either a helicopter or a boat. Frequency of active tracking will depend in part on fish behavior, but it will occur at least once every two weeks during the open-water season and once per month during the winter. Areas to be surveyed from the air will include the full extent of Upper and Lower Talarik creeks and the Iliamna Lake shoreline between the two creeks. Other areas, such as Kvichak River and selected Iliamna Lake tributaries, may also be surveyed intermittently. Survey boundaries will be modified depending on the locations of tracked fish. Again, coordination of radio frequencies will allow sharing of tracking data among various parties conducting concurrent tracking studies.

11.1.3.4 Data Collection and Management

Several different kinds of information will be collected:

- **Field Journal**. A chronological narrative of field activities will be entered in a field diary. Information recorded will include team members, weather conditions, deviations from the sampling plan, challenges encountered and their solutions, logistical considerations, and other pertinent information.
- **Capture and Surgical Data**. This information will include date, time, and location of capture; stream conditions; equipment used; fish length, weight, sex, and physical condition; success of implant operation, surgical time; any complications; radio-tag code; confirmation of transmission success; and time of release.
- **Active Radio-tracking Data**. This information will include date, time of fish encounter, fish code, GPS coordinates and waypoint number, descriptive locator based on landmarks, determination if fish is still alive, habitat type, presence of other fish, and any other relevant information. This information may include data from transmitters associated with concurrent

studies being conducted by others, as well as data collected by others from transmitters associated with this study.

- **Downloaded Output from the Fixed Dataloggers**. Data will be downloaded in a spreadsheet format and will include date and time fish passed the station, fish code, and direction of travel. This information may include data from transmitters associated with concurrent studies being conducted by others, as well as data collected by others from transmitters associated with this study.

Before project start-up, personnel will be instructed in proper data procedures. Field forms will be reviewed along with the information required and appropriate entry format. Completeness and consistency will be emphasized. Field journal entries and field forms will be photocopied at the end of each field day, and the originals will be filed in a safe location. Data downloaded from fixed stations will be copied from the designated field computer to a second computer at the field headquarters as soon as possible following the initial download. One complete copy of field data, including printed versions of downloaded fixed station data, will be delivered to the HDR Anchorage office at the completion of each field trip.

Following initial QC (see below) and associated corrections, all data will be transmitted to Resource Data Inc. (RDI) for inclusion in the Pebble Project database.

11.1.3.5 Quality Control

Field Procedures

Surgical implantation of radio tags is a critical study element. All surgery will be done by experienced and/or well trained personnel who have had adequate practice in the use of surgical techniques. This will assure consistency in operating procedures and minimize operation time. A biologist from ADF&G will provide a third-party presence and will either perform or assist in radio-tag implantation. If difficulties are encountered during any individual surgery and the surgery lasts longer than 10 minutes, or if recovering fish show signs of acute distress, that fish will be discarded and the tag will be implanted in a different fish.

In the unlikely event that fixed station receivers become inoperable, active tracking will be increased until the fixed station can be repaired. Receivers will be serviced on a regular basis to assure that problems are identified and corrected early.

Data Procedures

In addition to the data collection and management procedures described above, a field team meeting will be held each evening to discuss the day’s events. Since this study element does not involve large amounts of complex data, the field journal and any relevant data sheets will be reviewed for completeness and accuracy during evening meetings by the senior biologist or his designee. This data QC review will be noted in the field journal and on each reviewed data form by inserting the date, time, and reviewer’s initials. Additional field data QC will not be necessary.

11.1.3.6 Data Analysis

The primary output of this study will be a series of fish locations, accompanied by the date and time that the fish was located. A spreadsheet will be developed listing each of the 75 radio-tagged fish along with the tracking record for each fish.

Maps of the movements (tracks) of each fish will be prepared using geographic information system (GIS) software in combination with detailed aerial photography for the project area and the GPS coordinates of each observation. Date of observation will be included with each geographical location. The maps will provide the raw material for determining temporal and spatial movements, habitat use and stream fidelity for spawning, and foraging incursions into Upper Talarik Creek. Maps of individual fish tracks will be compared to determine whether common patterns have been detected.

11.1.4 Salmon Escapement Study

11.1.4.1 Introduction

This section describes the 2007 field study plan for estimating salmon escapement in the mine study area and incorporates refinements to the field and analytical methods used in 2004 through 2006. Surveys to count spawning salmon will be conducted on each of the three primary streams in the mine study area (Figure 11.1-1).

11.1.4.2 Goals and Objectives

The goal of this study is to conduct salmon spawning surveys that will be used to estimate 2007 salmon escapement to the mainstems of UT, SFK, and NFK.

Specific objectives of the 2007 salmon spawning surveys are as follows:

- Obtain estimates of timing and escapement of salmon by species (sockeye, Chinook, coho, and chum) to UT, NFK, and SFK through direct observation during a series of helicopter overflights throughout the duration of the run. Because of very low numbers, pink salmon will be enumerated only as peak counts.
- Reduce estimation error related to “survey life” and “observer efficiency” in the escapement estimation models.
- Obtain data on spawning distribution by species, observed mortality, and other general data regarding salmon runs in the study area.

11.1.4.3 Survey Methods

Aerial Surveys

Spawning surveys will be conducted from a helicopter flying at low altitude (typically less than 500 feet) and at ground speeds between 5 and 20 knots over the entire length of the main channel for each stream. Aerial surveys will occur every five to six days and will be scheduled for late morning to early afternoon when the sun is generally high in the sky and glare is minimal. If poor weather conditions or helicopter availability prohibits aerial surveys on the prescribed survey dates, surveys will be conducted on the next possible day.

Fish counts will be recorded by species; live fish and carcasses will be counted separately. Adult salmon will be counted as individuals whenever possible. When large numbers of fish are encountered, or when observation of individual fish is impaired by environmental conditions (weather, flow/turbidity, etc.), these factors will be noted and numbers will be entered as estimates made by the observers. Two qualified aerial observers will be used when overlapping runs of different species occur; all observers will wear polarized sunglasses. Any changes to the survey schedule or methods will be recorded, as will the rationale for diverging from the study plan.

Assessment of Observer Efficiency

Observer efficiency is an estimate of the proportion of the true number of fish actually present that are observed and counted by the surveyor. This proportion can vary both spatially and temporally, as well as between observers, depending on factors that affect an observer's ability to view an individual fish. Such factors include stream width, depth, turbidity, precipitation, glare off the water surface, helicopter speed and altitude, and observer experience.

Observer efficiency will be calculated at a minimum of two calibration sites (stream reaches of approximately 1/2 kilometer) in the Koktuli stream system and at a minimum of three calibration sites on the UT. The calibration locations will be representative of stream conditions that may affect aerial observations. For example, three (or more) calibration sites will be established on the UT. Two sites will be in the lower reach where large woody debris and undercut-bank habitat are abundant and may have a greater effect on the proportion of fish observed compared to the actual number of fish present. An additional calibration site will be located further upstream in the drainage where these features are not as abundant and observer efficiency may be different.

At each location, observer efficiency will be evaluated or calibrated by enumerating fish using the following three methods:

- When large numbers of multiple species are present, a second observer in the same helicopter will conduct simultaneous counts.
- A single-pass aerial survey of the calibration area will be conducted by helicopter. A separate observer will conduct a foot survey immediately afterward over same area.
- A photograph or video of the calibration area will be recorded during the helicopter survey. The video or photo will be used verify ground and aerial counts.

After each aerial survey, observers will complete a standardized worksheet that rates an established set of aerial observation criteria such as (but not necessarily limited to) weather conditions, sun angle, overall visibility, overhanging vegetation, and fish density. A score for each survey will be tallied. This score will be used to develop an index of observer efficiency and to help evaluate the level of variability associated with aerial surveys.

11.1.4.4 Data Collection and Management

Visual counts of spawning salmon made by the observers will be recorded on data forms or in notebooks in the field during the survey.

All data forms and field notebooks used to record survey data will consist of all-weather paper. During each spawning survey the observer will record the following information:

- Date.
- Time (survey beginning and ending times).
- Observer(s) Name.
- Weather Conditions (e.g., sun, clouds, fog, rain, wind).
- Water Conditions (e.g., clear, turbid, high flow, low flow).
- Location (drainage name).
- Helicopter elevation (above ground level) and ground speed.
- Count calibration (recounts, photos taken, etc.).

Survey results recorded in the field will be collected, proofed for quality control, and electronically recorded at the end of each survey day for storage.

All data will be archived at HDR. Following in-house QA/QC procedures, data will be transmitted to RDI for incorporation into the master Pebble Project database.

11.1.4.5 Quality Control

Data collected by observers in the field will be entered into a spreadsheet at the earliest opportunity. The data will be subject to a 100 percent QC review by project staff to ensure accuracy of data entry. The QC process will be documented line-by-line, with the quality controller initialing every line in the spreadsheet or database that was verified against the original data form. One hundred percent of each line of data will be subject to quality control review.

11.1.4.6 Data Analysis

Two versions of the area-under-the-curve method will be used to estimate salmon escapement in the study area. Those two methods used to estimate daily in-river fish abundance and ultimately total escapement for each species are the trapezoidal model and the maximum likelihood estimation (MLE) model.

These mathematical models provide calculated estimates of when runs begin and end and estimates of total escapement by species. For these area-under-the–curve methods, counts of salmon in the study area must be made systematically throughout the spawning periods for each of the salmon species (as described in Section 11.1.4.3). The number of live salmon observed during any survey will be a function of the number of fish that move into the area, those that die or leave, and observer efficiency. The total number of fish entering the area is estimated by developing a curve representing fish abundance by day for the season, estimating the area under this curve (total fish-days), and dividing total fish-days by the average number of days a fish is present in the survey area (survey life). The estimate is then adjusted to account for the proportion of the fish not seen or counted by the aerial observer (observer efficiency). This method has been in general use for more than 25 years (Neilson and Geen, 1981; English et al., 1992; Bue et al. 1998), and recent work has concentrated on methods to improve reliability in the estimates (Hilborn et al., 1999; Parken et al., 2003).

Interpolations will be necessary for data sets in which observations for the first or last surveys were not zero. For the trapezoidal model, the following assumptions apply:

1. The fish observed during the first survey entered the stream one estimated survey-life earlier.
2. The fish observed during the last survey were out of the system within one estimated survey-life after the last survey.
3. No additional fish entered the study area.

For the statistical MLE model, the following assumptions apply:

1. No fish entered the survey area before July 1.
2. No fish remained in the survey area one survey life estimate after the last survey.

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). The MLE model uses sophisticated curve-fitting techniques based on actual observations and adjusts these to fit modeled abundance patterns (Hilborn et al., 1999). The statistical background for the MLE model can be found in Hilborn et al. (1999). The trapezoidal model has been in general use by salmon biologists for over 25 years and is a well accepted method. The MLE model is newer and has corrected many of the shortcomings of the trapezoidal model, but it has yet to gain wide acceptance throughout the scientific community. For these reasons, the analytical results from both models will be presented, and readers can compare results and place whatever weight they choose on each of the two model outputs.

11.1.5 Fish Abundance Study in Upper Talarik Creek

11.1.5.1 Introduction

Upper Talarik Creek supports spawning populations of sockeye and coho salmon and lesser numbers of Chinook salmon and provides rearing habitat for juveniles. Resident fish species include Arctic grayling, rainbow trout, and Dolly Varden. Based on data from snorkel surveys, adult rainbow trout are primarily limited to the lower reaches of Upper Talarik Creek (within APC land). Whitefish also have been observed in relatively low abundance in the lower reaches of Upper Talarik Creek.

During the 2005 field season, the most upstream reach (UT Reach 3; Figure 11.1-3) was sampled using a multiple-pass depletion method to generate fish abundance estimates. Snorkel surveys were completed for 25 sites in all three reaches of the UT in 2005 and 2006. With the exception of snorkel surveys, the earlier investigations were limited to Reach 3 because the then-current mine development alternatives did not suggest that effects on flow or habitat would extend beyond the upper extremities of the stream system. Evolving exploration results, especially those from the area east of the initial exploration, suggest that project influence may extend further downstream than previously thought. The study area for fish abundance estimates using depletion sampling methods has therefore been extended downstream.

This study will use a combination of two methods: a quantitative and focused method (removal sampling) will be used to calibrate a variable but wider-ranging method (snorkel surveys; Hankin and Reeves, 1988). Reaches 1 and 2 of Upper Talarik Creek differ from Reach 3 by having a wider, deeper channel and higher flows. These conditions do not preclude the use of a depletion sampling method, but a slightly different approach from that used in Reach 3 is needed to accommodate the higher flows. Specific sampling methods are discussed in Section 11.1.5.3.

11.1.5.2 Goals and Objectives

The goal of the fish abundance study in UT is to develop fish abundance estimates and habitat associations for juvenile salmonids in the lower two-thirds of Upper Talarik Creek under summer conditions.

The study is intended to accomplish the following objectives:

- Generate fish population and density estimates for representative habitat types.
- Use a second independent method to verify and calibrate the results of snorkel surveys.

11.1.5.3 Study Design

Survey Methods

Studies similar to the one described here have indicated that snorkeling may be the most appropriate technique for enumerating small fishes and for establishing quantitative habitat associations over large areas of streams; however, those studies also show that this method generally yields highly variable results. It has also been shown that high variability can be compensated for by subjecting representative subsets of habitats to another less variable method of estimating population size. Such methods include mark-recapture (Petersen-type) or successive removal (Zippen-type; Hankin and Reeves, 1988; Rodgers et al., 1992). Therefore, the sample sites for the fish abundance study will first be snorkeled, and the fish will be identified and counted. The same sites will then be subjected to the more quantitative successive removal sampling (Zippen method) using electrofishing equipment and nets.

Selection of Sampling Sites and Schedule

Sample sites will be selected in the field and will be a subset of the sample sites previously established in the Upper Talarik for the flow-habitat study (Figure 11.1-3). All flow-habitat sites were selected using a stratified random approach (Section 11.1.8.4).

Sampling will occur during the last two weeks in June and will be completed before adult salmon are present in the UT.

Field Methods

The field work will involve a fish count by snorkeling, followed by a multiple-pass depletion/recapture method using electrofishing (Zippen, 1956, 1958). Approximately 12 to 16 sample sites in the lower and middle sections of Upper Talarik Creek will be sampled. The length and width of each habitat unit will be recorded to determine the surface area. In most cases, surface area will be calculated from a single length and the average of three measured widths. Habitat characteristics and features within each study reach also will be recorded. All sites will be photographed.

Snorkel Studies. The selected sites will be snorkeled, as described below, and population estimates from these surveys will be calibrated from the depletion studies. Snorkel counts will be divided by the electrofishing counts to obtain an index of accuracy by species (Rodgers et al., 1992; Thurow and Schill, 1996). Removal counts will be assumed to be representative of complete population estimates for each flow-habitat reach sampled (Slaney and Martin, 1987; Zubik and Fraley, 1988).

Snorkeling methods for the abundance study will follow the same snorkeling protocols established for the flow-habitat study (Section 11.1.9.4) so that data from previous snorkel studies conducted on the Upper Talarik can be used for temporal analyses of fish distribution.

Electrofishing. The recapture electrofishing will occur immediately after the snorkel counts. The field team will collect fish at each of the selected sample sites using depletion electrofishing methods. Block seine nets will be placed above each habitat unit and a fyke net will be placed below prior to sampling, thus forming an exclusion zone. This will prevent premature escape of fish already inside the habitat unit and unwanted entry of fish from outside the habitat unit. Due to the large size of the stream and possible high flows in late June, placement of fyke nets might not be feasible at all preselected sites. Preference will be given to sites that contain natural confined channel widths upstream and downstream of the selected habitat unit.

A team of five or more biologists will conduct the survey; two biologists will operate backpack electrofishers and the other team members will collect stunned fish using dip nets. Sampling will be conducted from the upstream barrier to the downstream end of the habitat unit. Electrofishers will proceed in a line across the stream to drive fish downstream into the combination barrier net and fyke net. Fish will be identified and counted after each pass, but not re-placed in the stream until all successive removal passes are completed for that site.

The sampling team will complete a minimum of three depletion passes at each habitat unit. Captured fish will be removed from the habitat unit to an enclosure outside of the sample reach after each shocking pass so that electrical fields from the electrofisher do not stress the fish. Care will be taken to standardize the level of effort so that each pass will be comparable. All fish captured during each pass will be counted, measured, and identified to species. A subsample of 25 fish of each species will be weighed.

Upon completion of the successive removal sampling, all fish will be released in small batches near cover and/or in slow velocity refugia downstream of the fyke net so they have time to recover and acclimate to their surroundings. Snorkel surveys will be conducted following the electrofishing effort for the first few sites to validate that depletion electrofishing has been effective.

11.1.5.4 Data Management

Standardized data forms will be developed and completed for each sample site. Prior to project start-up, project personnel will be instructed in proper data procedures, including a review of the data forms, the information required, and appropriate entry format. Completeness and consistency will be emphasized.

Field forms will be photocopied at the end of each field day, and both the originals and the copies will be filed in a safe location. One complete copy of the field data, including printed versions of fixed-station data down-loaded from computers, will be delivered to the HDR Anchorage office at the completion of each field trip.

11.1.5.5 Quality Control

All electrofishing and snorkeling will be completed by experienced and well-trained personnel. Consistency will be assured in all field procedures.

In addition to the data management procedures described above, a field team meeting will be held each evening to discuss the day's events. Relevant data sheets will be reviewed for completeness and accuracy by the senior biologist, or his designee. Any corrections or additions will be made at that time following procedures described in the 2007 quality assurance project plan (NDM, In press4). The data QC review will be noted in the field journal and on each reviewed data form by inserting the date, time, and reviewer's initials. This study element does not involve large quantities of complex data, consequently all field data will be reviewed using the above procedure.

A second preliminary QC review for completeness and accuracy will be conducted in a timely manner by the senior biologist at the HDR office in Anchorage. Following this review, all data will be transmitted to RDI for incorporation into the Pebble Project database.

11.1.5.6 Data Analysis

The Zippen maximum likelihood method (Zippen, 1956, 1958) will be used to estimate species density. MLE calculations using Microsoft Excel will be performed for each species detected within a sample site. An assumption of this method is that each pass depletes the number of fish available to sample; therefore, fewer fish would be collected during subsequent passes with equal effort.

The density of fish for each species and age class within a single habitat unit will be calculated by dividing the number of fish by the area of the sample site. The density will be averaged by habitat unit over a stream reach and subreach to obtain an overall fish density estimate for each habitat type within a study reach. Estimated fish abundance for each major reach of Upper Talarik Creek (Reaches 1 and 2) will be calculated by multiplying the density calculated for each habitat type by the surface area of available habitat per unit type (e.g., riffle, glide, pool) for the reach as a whole.

11.1.6 Study of Distribution of Juvenile Anadromous Fish

11.1.6.1 Introduction

This section describes the 2007 field efforts designed to document distribution and relative abundance of juvenile anadromous fish in the study area.

Spatial and temporal distributions of juvenile anadromous fish commonly vary from year to year in most aquatic systems. This variation can be attributed to a number of factors, including overwinter conditions, food availability, flow regime, predation, and previous year's run strength. More specifically the distribution patterns of juveniles are determined by broad, species-specific habitat selections for adult breeding and for rearing, preferences for physical habitats, and competition with other fishes (Quinn, 2005).

As early as 1991, investigations of distribution and relative abundance of juvenile anadromous fish have been conducted in the vicinity of Pebble Project. Studies also have been conducted as part of the ongoing environmental baseline study of fish and aquatic resources for the Pebble Project. Based on the work conducted in the area to date, the dominant juvenile anadromous fishes found in the mine study area include Chinook, coho, sockeye, and relatively lower numbers of chum salmon.

Certain patterns of occurrence of juvenile salmonids have been noted in the general vicinity of the proposed Pebble Project. These include the following:

- Low levels of abundance in the intermittent reach of the SFK.
- Usual absence of juveniles in small channels in the upper SFK basin upstream of Frying Pan Lake.
- Wide distribution of coho juveniles in most accessible mainstem and tributary reaches in the NFK and UT.
- Scattered distribution of rearing sockeye salmon in lakes in the upper basin of NFK (e.g., Big Wiggly Lake) and certain off-channel habitats along the lower reaches of SFK.
- Moderate relative abundance of juvenile Chinook salmon in the NFK and SFK below the "springs" and in the middle reaches of UT.
- Scattered presence of juvenile chum salmon in the lower reaches of NFK and SFK.

The recent focus of the mine development concept known as "Pebble East" has resulted in a shift of focus of the environmental study into the UT drainage. As a result, additional efforts are required to confirm the distribution and relative abundances of juvenile salmon in the upper portion of the UT (Reach 3; Figure 11.1-4) and tributaries to Reach 3.

11.1.6.2 Goals and Objectives

The goal of this study is to build on information from earlier studies and to continue to examine the overall distribution and relative abundance of juvenile anadromous fish in the study area.

Specific objectives of this study are as follows:

- Supplement information from earlier studies completed in the study area documenting juvenile fish distribution and relative abundance, including in SFK above Frying Pan Lake and in the SFK intermittent flow reach (SFK Reach 3).
- Sample tributaries of the UT Reach 3 drainage for fish presence to supplement existing data on the extent of anadromous fish in this area.

11.1.6.3 Study Design

Sampling Design

An emphasis will be placed on determining the extent of fish distributions in areas that may be directly affected by project development and to continue to sample previously established sampling sites in the SFK above Frying Pan Lake and in the SFK intermittent reach. Data from this study and previous baseline data will be used to assess the extent of anadromous fish use in these areas of the SFK. Tributaries to UT Reach 3 will be sampled to supplement information on the upstream limits of anadromous fish distribution in this area.

In the SFK drainage sampling will be conducted seasonally during the early summer (June), mid-summer (early August), and late fall (late October/early November). Tributaries to UT Reach 3 will be sampled in mid- to late August when juvenile salmon distributions are the greatest.

Sampling Methods

Field methods for 2007 will be similar to those used during previous years. Snorkeling will be conducted at five 100-meter-long sites in the SFK above Frying Pan Lake and within the intermittent reach. If conditions (e.g., shallow water, poor visibility) limit the effectiveness of this method, electrofishing will be used. One or two field crews, each composed of two biologists, will complete fish-presence surveys at all previously established sites.

In areas not suitable for snorkel surveys, such as small tributaries in the UT or potentially in the SFK during low summer flows, a backpack electrofisher will be used. All fish captured will be identified to species, measured to fork length, and released at the point of capture. For analysis purposes, fish captured during electrofishing also will be grouped into size ranges consistent with those estimated during snorkel surveys.

Crews sampling in the UT will begin sampling in areas where juvenile salmon are known to be located, then work upstream until sampling no longer produces juvenile salmon.

Snorkeling Approach. At each previously established study site suitable for snorkel surveys, one biologist will snorkel while a second biologist records the observations. Snorkel observations will enumerate fish by species and size class, indicate cover availability where fish are identified, and estimate the relative visibility. The length of stream snorkeled and the three stream-width measurements taken within this distance will be recorded for each sample site. Sample date, time, and method; water temperatures (^{o}C); and incidental observations of fish or other wildlife also will be recorded on data sheets.

Some salmon species can be difficult to distinguish from one another in the field. In cases where fish identification is in doubt, reference samples will be obtained (by hand net, electrofisher, or other suitable method) for identification at a field laboratory in Iliamna or elsewhere at the end of the field effort. Where possible, fish identification will be confirmed using physical characteristics, such as branchiostegal rays and/or dorsal-fin ray counts.

Fish length will be estimated using size classes in 20-millimeter increments: 0-19, 20-39, 40-59, and so on. Estimating underwater fish lengths can be challenging, especially considering that objects generally appear up to 1.3 times larger underwater (Thurow, 1994). To improve the accuracy of fish-length estimates, the neoprene gloves used by each snorkeler will be marked in 20- and 40-millimeter increments. Additionally, flagging marked in a similar manner will be tied to the other glove to aid in estimating the length of fish longer than 200 millimeters. Fish estimated to be longer than approximately 300 millimeters may be recorded as “300+” or “adult” (for most species), since accuracy of estimation in 20-millimeter increments likely declines with increased length.

Relative underwater visibility estimates will be recorded for each study site using two approaches.

The first approach involves measuring the visibility of an object, such as a floating fishing lure or other salmonid silhouettes painted with parr marks (distinctive vertical bars on the sides of young salmonids), similar to the method described by Thurow (1994). At the onset of each survey, the snorkeler will place the object in the water and measure the distance at which the parr marks become visible while moving toward the object. This exercise will be repeated twice, and the two distances will be averaged to provide an index of underwater visibility. Through other studies, researchers have recommended a visibility range of 1.5 meters to 4 meters (Thurow, 1994).

The other approach incorporates an underwater visibility ranking system developed by the Colville Confederated Tribes (CCT, 2005) where visibility is ranked on a scale of 0 to 3, as follows:

- 0 indicates less than 25 percent visibility (very poor water clarity or dense cover).
- 1 indicates approximately 25 to 50 percent visibility (less cover, slightly better clarity).
- 2 indicates approximately 50 to 75 percent visibility (moderate water clarity), a score considered by the Colville Confederated Tribes not to impede accurate fish counts.
- 3 indicates more than 75 percent visibility (water clarity is good, very little cover or few hiding places).

Collection of Dolly Varden. There is some question as whether or not anadromous Dolly Varden are present in the study area. In the falls of 2004, 2005, and to a lesser extent in 2006 several aggregates of large Dolly Varden were observed moving into the lower portions of the SFK and NFK. These fish may have been moving into the drainage to spawn or to feed on salmon eggs or both. The Alaska Department of Natural Resources, Habitat Division, has requested that Dolly Varden adults and juveniles be collected so that otoliths (inner ear structures used to determine age, growth, and saltwater residence time) can be examined to determine if Dolly Varden in the study area have a saltwater lifecycle phase.

Field crews will opportunistically collect juvenile and adult Dolly Varden in the study area. Capture methods may include electrofishing, rod and reel, beach seines, and minnow traps. Once captured, either the whole body or just the head of the fish will be transported back to Iliamna and frozen as soon as possible. All samples will have a tag attached noting species, length, location of capture, and crew.

Training Requirements and Field QA/QC Protocols. Prior to the initiation of sampling, all staff will meet to review the objectives of the study, sampling protocols, and documentation requirements. Multiple fish-identification reviews also will be conducted prior to entering the field. Photographs of typical juvenile and adult fish taken during previous years in study area streams will be compiled and reviewed by field staff. Underwater video clips recorded during previous snorkel surveys will be used as a training and review tool.

During the first day of sampling, field crews will conduct snorkel surveys together to ensure consistency of sampling methods and data documentation, and accuracy of species identification and fish-length estimates. In addition, a backpack electrofisher may be used to capture fish on the first day and periodically throughout the season to confirm consistency of species identification and size-class estimation among field staff. Before the electrofisher is used, the following publications will be reviewed to ensure that safe and effective electrofishing techniques are employed and to minimize fish mortality to the greatest extent possible:

- *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS, 2000).
- *Fish Exclusion Protocols and Standards* (WDOT, 2006).
- *Backpack and Drift Boat Design Considerations and Sampling Protocols* (WDFW 2005).

11.1.6.4 Data Management and Quality Control

Data collected during 2007 will be recorded on data sheets and entered into an electronic database (Excel and Access) shortly after returning to the office. The database design will include look-up tables to maintain consistency during data entry and thereby provide an initial level of QA/QC.

Electronic data will be checked against the corresponding hardcopy data. If discrepancies or incorrectly entered data are found, these will be noted and the electronic spreadsheet will be updated to reflect the rectified information. After each line of data has been either confirmed for accuracy or rectified, a “yes” will be entered in a QC column in the electronic file. This protocol will be performed for 100 percent of the data collected in 2007. After preliminary QA/QC, all data will be transmitted to RDI for incorporation into the Pebble Project database.

11.1.6.5 Data Analysis

For areas such as the SFK for which yearly and seasonal data exist, a statistical analysis will be conducted to compare spatial and temporal differences among years and on a seasonal basis. Fish density per meter snorkeled will be calculated for each species of fish observed during snorkel surveys. In the areas of the UT, emphasis will be placed on the extent of the distribution of juvenile anadromous fish. Maps will be developed for both drainages showing the relative distribution and abundance by species for the sites sampled during this study.

11.1.7 Fish-tissue Study

The fish-tissue study is described in detail in the 2007 field sampling plan for fish tissue (NDM, in press1). Table 11.1-2 summarizes the sampling performed at each sampling location for the fish-tissue study in 2004 though 2007.

11.1.8 Instream Flow Study—Overview

The instream flow study was initiated in 2004 as a part of the environmental baseline studies associated with the Pebble Project. The study area specific to the instream flow study includes the upper portion of the mainstem Koktuli River (MSK) and the full lengths of SFK, NFK, and UT (Figure 11.1-3).

The primary objectives of the instream flow study are to characterize potential positive and negative effects of flow change, quantify potential effects of flow change on aquatic habitat, and calculate potential habitat losses and/or gains. The instream flow study is multidisciplinary in nature; it will integrate data collected from concurrent baseline studies relating to hydrology, water quality, geomorphology, fish and aquatic biology, and stream and riparian ecology.

Primary components of the instream flow study involve the relationship of flow to both main-channel and off-channel habitats, fish use, surface water temperature, geomorphology, and availability of gravel as suitable spawning habitat. Water-surface elevations, discharge, water-column depth, channel geometry, velocity, substrate, and cover have been measured at each site during flow-habitat surveys at varying flows to encompass the range of stream flows found during the open water season. Additionally, fish-presence surveys that enumerate fish by species and size class have been conducted at each site at varying flows. These data collected during various flows will be used to model how changes to the flow regime may affect habitat quality and quantity. Flow-habitat and fish-presence data are crucial components of the instream flow study. Due to the complexity of data collection necessary for the instream flow study, data-collection efforts planned for 2007 are included in three studies: the main-channel flow-habitat study, an off-channel habitat study, and a study of surface water temperature.

11.1.9 Main-channel Flow-habitat Study (Instream Flow Study)

The main-channel flow-habitat study is one of the integral components of the instream flow study. The flow-habitat study began in 2004 and was expanded in 2005 to include additional study sites and fish-presence surveys. Following is a summary of previous sampling events and an outline for the 2007 data collection activities associated with flow-habitat and fish-presence surveys in the MSK, NFK, SFK, and UT.

11.1.9.1 Summary of Previous Sampling Events

Flow-habitat Surveys (2004 through 2006)

The main-channel flow-habitat study was initiated in 2004, when 40 transects, or sample sites, were established. Each of the four study streams (i.e., MSK, SFK, NFK, and UT) had ten study sites; each set of study sites was composed of three riffles, three runs, two pools, and two island complexes. The 2004 sample locations were selected based on professional judgment with the intention of describing typical habitat across hydraulic-unit types (i.e., riffle, run, pool, and island complex) in each study reach. In 2004, each of the 40 transects was visited three times, at high, middle, and low summer flows. Water-surface elevations and hydraulic slopes were measured using automatic-level and total-station instruments. Direct flow measurements were not taken in 2004.

In June 2005, 49 additional transects were established to increase the sample size in the study area. The increased sample size was intended to capture the variability in fish habitat in the study streams and to allow defensible quantitative predictions of the quantity of habitat in relation to river flow under different scenarios (baseline and operating scenarios). The additional transects were selected using a stratified random approach, where the level of effort focused on each mesohabitat is proportional to the amount of that mesohabitat in each reach.

The 49 additional sites were established as follows: 10 in NFK, 17 in SFK, 16 in UT, and 6 sites in UT190, a tributary of UT. In 2005, five of the MSK sites were randomly selected to be eliminated from further data collection for the flow-habitat study. This was done because hydrology calculations, updated in early 2004, estimated that the point at which flow alterations would cause a maximum 10 percent mean annual change in flow would occur in the lower SFK and NFK, rather than in MSK as earlier believed. The 10 percent threshold for identifying a flow-change of concern was based on Bovee (1997) and was discussed with Joe Klein of ADF&G. The elimination of five sites in MSK left 84 continuing study sites for the flow-habitat study.

In 2005, each of the 84 flow-habitat study sites was visited three times: once during the summer high-flow period in June, once during the mid-range flow period in July, and once in the summer low-flow period in August. High flows in June created dangerous site conditions at a few of the study sites; these sites were visited during the high-runoff period in September to collect data on high-flow conditions. Data collected included water-surface elevation and hydraulic slope (during all three site visits); depth, velocity, and total flow (twice during June, August, and/or September); and substrate and cover (once in July).

The 84 flow-habitat sites were revisited in 2006 to collect additional data in two different periods: a high-flow period (June/July) and a mid-range flow period (July/August). The purpose of the site visits in 2006 was to collect an additional high-flow measurement and mid-range flow measurement to assist in habitat modeling. Data collected during both of the field trips included water-surface elevation, hydraulic slope, depth, velocity, and total flow.

Data for mid-range flows were successfully collected in all streams except NFK in 2006. Local summer storm systems hampered the field efforts on NFK, driving flows into the high range each time the field crew attempted to collect data. Because of the storms, mid-range flow measurements on NFK were postponed to the 2007 field season.

Fish-presence Surveys (2005 through 2006)

In 2005, the fisheries team completed the first set of fish-presence surveys at 86 of the 89 flow-habitat sites in MSK, NFK, SFK, and UT (the five sites eliminated from the flow-habitat surveys were not eliminated from the fish-presence surveys). Fish-presence surveys were initiated in early July approximately eight weeks after the spring flood event (spring flows peaked on May 7, 2005) and continued through late July 2005. Fish-presence surveys completed at 74 sites used snorkeling as the primary method; seven sites not suitable for snorkeling (because of shallow conditions) were surveyed using a backpack electrofisher (Smith-Root Model LR-24), and five additional sites were surveyed using a combination of snorkeling and electrofishing. Three sites were not surveyed for fish presence in 2005 because of shallow water and the presence of adult salmon, which precluded snorkeling and electrofishing, respectively.

In 2006, fish-presence surveys were repeated at 86 main channel flow-habitat sites starting in early July approximately five weeks after the spring flood event (spring flows peaked on May 28, 2006). A total of 76 sites were snorkeled, and 10 sites were surveyed using an electrofisher. In addition, a subset of the flow-habitat sites in NFK, MSK, and SFK was snorkeled in August through September 2006.

In September 2005, a related off-channel habitat study focusing on habitat units adjacent to or near the main channel of the SFK (Reach 2) was implemented. In September 2005, and June, August/September, and November 2006, fish-presence surveys were conducted at 11 main-channel sites common to both flow-habitat studies, as well as at multiple off-channel sites.

11.1.9.2 Goals and Objectives

The goal of the flow-habitat study is to characterize the relationship between habitat quantity and quality and changes in flow.

Objectives for the flow-habitat main-channel study in 2007 are as follows:

- Evaluate the need to establish additional cross-sections in Reaches 1 and 2 of UT, including sites within APC lands, and add cross-sections if needed.
- Complete a winter low-flow study at all flow-habitat transects.
- Use a stratified random approach to select new transects for reaches with mesohabitat data gaps, likely resulting in the addition of two to six sites in UTC, NFK, and possibly in SFK.
- Collect mid-range flows at flow-habitat cross-sections in the NFK.
- Conduct snorkel surveys in July for fish presence at all previously established flow-habitat sites and at additional sites that will be established in 2007.
- Perform data entry, quality control reviews, and data reduction for all data collected.
- Perform modeling and analysis, as needed, to characterize instream-flow baseline conditions.

11.1.9.3 Selection of Sampling Sites

Selection of flow-habitat sites was based on a combination of professional judgment and a stratified random approach. In some reaches, the site selection methodology resulted in a distribution of habitat types being surveyed that did not reflect the relative abundance of habitat types actually found in the field. For instance, no pool habitat was sampled in NFK Reach 1 and UT Reach 1. In 2007, four additional transects in the NFK and SFK and seven new sites in the UT will be established using the stratified random method. The new sites are being added to address data gaps in mesohabitats in these reaches that occurred as a result of the nature of random site selection.

The recent focus of the mine development concept known as "Pebble East" has resulted in a shift of focus of the environmental study into the UT drainage. The majority of existing flow-habitat sites are located upstream of the APC-owned land or within the upper (approximately) 28 miles of the stream.

In 2006, flow-habitat surveys were conducted on the SFK and UT during mid-range flows; however, mid-range flows were not captured on the NFK due to summer rain events and the timing of field events. In 2007, efforts will be focused on capturing data on the NFK during mid-range flows.

Flow-habitat data have been collected from study sites during summer low flows in previous years, but not during annual low flow which occurs during the winter months. Although a winter low-flow program exists under the Pebble hydrology study, those sites do not correspond to the locations of the flow-habitat study sites. A winter low-flow study at all 84 flow-habitat study sites will be conducted in late winter/early spring 2007 to address this data gap.

11.1.9.4 Field Methods

Flow-habitat Surveys

The 2007 flow-habitat study program will be conducted consistent with the *Flow-Habitat Study, Field Sampling Protocol* (HDR, 2005). Water-surface elevation, hydraulic slope, discharge, velocity, water-column depth, channel geometry, substrate, and cover will be recorded at each newly established site in 2007. Water-surface elevation, hydraulic slope, discharge, velocity, water-column depth, and channel geometry will be recorded during the mid-range flow survey on the NFK and during the winter low-flow survey. At sites completely under ice during the winter low-flow survey, only water-surface elevation and discharge measurements will be collected because of the increased risk of inaccuracies inherent in collecting flow-habitat measurements in ice conditions. Vertical control will be validated for those sites that have been previously sampled, such as the NFK sites, and vertical control will be established at new sites (as described below).

Selecting Additional Sites. Additional sites will be selected using a stratified random approach, where the level of effort focused on each mesohabitat is proportional to the amount of that mesohabitat in each reach. Within each mesohabitat type, the locations of the study sites will be selected at random. An evaluation of both the randomness (comparison of variance) and the representativeness (comparison of means) will be performed by comparing values for hydraulic and habitat parameters between transects sampled in different years.

Random sites will be selected by defining points on a stream reach (or within known habitat types for which a data gap exists) every 100 feet. Each point will be assigned a number. A random number generator will select the numbers of the points to be included in the study. For each reach, two sets of numbers (Set #1 and Set #2) will be generated. Study sites will be established from Set #1, except when impractical. For example, if the site related to Set #1 falls within an impoundment created by a downstream beaver dam, the corresponding number from Set #2 will be used to establish the study site. If the number from the Set #2 chooses a location that also is impractical, the study team will choose the closest workable location upstream of the Set #2 coordinates.

Establishing Vertical Control. Similar to previously established flow-habitat study sites, each new site will consist of a cross-section, or transect, perpendicular to the dominant flow direction at the location of the random point. A headpin, a tailpin, and a temporary benchmark (TBM) for vertical control will be established at each site. Headpins and tailpins will typically be established by driving a 30-inch length of 1/2-inch steel rebar into the bank at an elevation above the estimated bank-full flow stage (estimations based on vegetation, substrate, evidence of flood scour or deposits, etc.). When possible, the TBM at each site will be set on an object outside the main channel that is expected to remain immobile for years to come, typically a tree or large boulder. A spike or PK nail (rust resistant survey-grade nail) will be used to mark TBMs on trees; a PK nail or a chiseled or scribed permanent mark will be used to mark TBMs on boulders. If no obviously immobile object is available within a reasonable distance of the cross-section, a 30-inch length of 3/4-inch rebar will be placed in substrate considered to be least susceptible to frost jacking. If two or more study sites are selected in close proximity, one TBM will be used for those sites. The location of the headpin, tailpin, and TBM will be flagged and marked with a top-painted (fluorescent red or safety orange) lath. The lath, typically placed directly behind the headpin, tailpin, and/or near the TBM, will be labeled with the site identification using a permanent marker.

Vertical elevation control will be obtained using standard differential engineering survey methods. A Lietze/Sokkisha BC2 Automatic Level (or similar) will be used for differential observation and collection. Each TBM will be set with an assumed elevation of 100.00 feet; vertical control, with accuracy to the nearest 0.01 foot, will include the elevations of the TBM, headpin, tailpin, and any angle points on the site. At each site and for each data measurement, a method known as "closing the loop" will be used to strengthen the accuracy of the measurements.

On sites with multiple channels, the cross-section will include one or more doglegs to position the cross-section perpendicular to the dominant flow direction. The inflection points, referred to as angle points, will be established with a length of rebar. The angle point rebar may be positioned below the bank-full stage and in silty or sandy soils, as required by the geometry of the cross-section; however, the rebar will be driven into the soil far enough to prevent it from being dislocated if submerged by the stream.

Recording Channel Geometry. A fiberglass survey tape marked with decimal-feet increments will be attached to and pulled taut between the headpin and tailpin. If the cross-section includes one or more angle points, the tape will be looped once around the angle-point rebar in order to retain the stationing on either side of the angle point. This procedure adds about 0.20 foot of length to the total cross-section for each angle point, which will be accounted for in the reduction and analysis of these data.

A survey (stadia) rod will be traversed along the survey tape manually to the vertical station points. The horizontal distance will be recorded at each of these points to the nearest 0.1 foot, and vertical elevation data will be collected with a differential level survey to the nearest 0.01 foot. Vertical station points will be set to describe breaks in cross-section slope and changes in substrate size and cover. Additionally, vertical points will be set in and near the active stream channel with the intention that each cell will include no more than 5 percent of the flow. Boulders and large rocks will be represented in the survey, as described in Bovee (1997).

Measuring Water-surface Elevation. Water-surface elevations will be measured with a differential level survey using the protocol described in Bovee (1997). The elevations will be measured at the left, center, and right side of the active channel; additional measurements will be collected if the flow is very turbulent. Water-surface elevations collected in areas of zero flow or terraces will not be used in the calculation of average cross-section water-surface elevations.

Determining Hydraulic Grade. Hydraulic grade will be determined for each newly established study site by measuring upstream and downstream water-surface elevations with a differential level survey, as described above. The distance between the upstream and downstream points will be measured to the nearest 0.1 foot using a fiberglass survey tape. Distances will be selected based on visual observation of the predominant gradeline for the mesohabitat unit being measured and will range from 0 to 200 feet.

Measuring Water-column Velocity and Depth. Water-column velocity and depth measurements will be recorded at each cross-section in 2007. Depth at each vertical cell will be measured to the nearest 0.1 foot using a top-setting wading rod marked with 0.1-foot increments. Velocities will be recorded to the nearest 0.01 foot/second using a Marsh-McBirney Model 2000 electromagnetic flow meter. The flow meter will be set to the fixed-point averaging calculation with a 30-second averaging interval.

In water with depths of 2.5 feet or less, the "0.6 Method" will be used to measure average velocity (velocity measurement taken at 0.6 ∗ depth). At depths greater than 2.5 feet, the "0.2, 0.8 Method" will be used (velocity measurements taken at 0.2 ∗ depth and 0.8 ∗ depth, then averaged).

Current meters will be calibrated according to the manufacturer's instructions prior to the first field trip. Prior to subsequent field trips, the accuracy of flow measurements will be tested by walking the meter through standing water 2 to 3 feet deep over a measured time period to record measured velocity. If measured and recorded velocity are not within 5 percent of each other, up to three additional tests will be conducted. If the measured value is within 15 percent of the recorded value, the meter will be used but will be tested every two days to calculate the difference between the measured and recorded velocity for use as a correction factor. If the measured and recorded values differed by more than 15 percent, the meter will be recalibrated according to the instructions of the manufacturer and retested.

Measuring Substrate and Cover. At each newly established vertical station, substrate and cover characteristics will be measured once during the 2007 field season. Substrate size classes are based on a modified Wentworth Scale, presented in Table 11.1-3. At each vertical station, the field crew will record the percentage of each substrate size class present in a theoretical 1-foot-radius area centered on the point where the vertical station meets with the ground. Substrate size will be estimated by visual observation; direct measurements will be taken at the discretion of the field crew. Observations of cover characteristics will be noted for each vertical station; the appropriate code (Table 11.1-4) will be entered for each observation of cover.

Fish-presence Surveys

Sample collection methods planned for the 2007 field events will be similar to those employed during 2006. Snorkeling will be conducted at each site, unless conditions (e.g., shallow water, poor visibility) limit the effectiveness. The level of effort planned for 2007 is similar to that of previous years. Two to three field crews, each composed of two biologists, will complete snorkel surveys at all previously established main-channel flow-habitat sites in the NFK, SFK, and UT, as well as at the additional sites planned for 2007.

Snorkeling Approach. At each flow-habitat site suitable for snorkel surveys, one biologist will snorkel while the second biologist records the snorkel observations. Snorkel observations will enumerate fish by species and size class, indicate cover availability where fish are identified, and estimate the relative visibility. The length of stream snorkeled and three stream-width measurements taken within that distance will be recorded for each sample site. Sample date, time, and method; water temperatures (in degrees Celsius); and incidental observations of fish or other wildlife also will be recorded on data sheets.

Due to the width of the streams (and resulting visibility constraints), the snorkeling methodology will involve multiple passes, generally up to three or four, throughout each sample site. The stream will be divided into "lanes," with the width of each lane dependent on visibility. The snorkeler will typically begin at the downstream end of the sample reach and move upstream, enumerating fish along one bank and, when visibility allows fish to be positively identified, those fish occupying the mid-channel. The first pass will generally occur along the bank where the person recording the data is, in an effort to avoid unnecessary disturbance to fish and water clarity. The second pass will likely involve an upstream to downstream float to count fish occupying the mid-channel. The third pass will be similar to the first but will occur along the opposite stream bank. Depending largely on visibility, a fourth pass—or additional downstream float—may be necessary. This one snorkeler/multiple pass method assumes that juvenile fish observed along the banks, usually in or near undercut areas, will not leave the habitat in which they are initially observed (i.e., fish are assumed not to swim across the mid-channel to the opposite stream bank).

Juvenile salmonids, particularly young-of the-year, can be difficult to identify to the species level in the field. For example, defining characteristics such as parr marks and fin shape are not well developed in newly emerged fry. In cases where fish identification is not definitive, reference samples will be obtained (using a hand net, electrofisher, or other suitable method) for identification at a field laboratory in Iliamna or elsewhere at the end of the field effort. Where possible, fish identification will be confirmed using physical characteristics, such as branchiostegal rays and/or dorsal-fin ray counts.

Estimating Fish Length and Rating Underwater Visibility. Methods used to estimate fish lengths and rate underwater visibility will be consistent with those described in Section 11.1.6.3.

Recording Cover and Velocity. At each flow-habitat site, fish species, life stage, and depth and velocity measurements will be recorded from approximately five locations where juvenile fish were observed during the snorkel survey. Additionally, the snorkeler will estimate the percentage of each substrate size class (Table 11.1-3) present and indicate the primary cover types (Table 11.1-4), if any, within a one foot radius of each depth and velocity location.

Estimating Accuracy of Snorkel Surveys. The accuracy of snorkel surveys will be estimated by replicating the snorkel surveys or by using a backpack electrofisher, depending on site conditions. Results from snorkel surveys will be calibrated by comparing snorkeling results with results from electrofishing (Section 11.1.5.3) or by replicate snorkel surveys. Replicate-snorkel or electrofishing surveys will be completed at approximately 10 percent of the sites in the SFK and NFK.

All fish captured by electrofishing will be identified to species, measured to fork length (length from the fork of the tail to the nose of the fish, in millimeters), and released at the point of capture. For analysis purposes, fish captured during electrofishing will be grouped into size ranges consistent with those estimated during snorkel surveys.

Training Requirements and Field QA/QC Protocols. Prior to field sampling, all staff will meet to review the objectives of the study, sampling protocols, and documentation requirements. Multiple fish-identification reviews also will be conducted prior to entering the field. Photographs of typical juvenile and adult fish taken during previous years in study area streams will be compiled and reviewed by field staff. Underwater video clips recorded during 2005 snorkel surveys will be used as a training and review tool.

During the first day of sampling, field crews will conduct snorkel surveys together to ensure consistency of sampling methods and data documentation, and accuracy of species identification and fish-length estimates. To calibrate fish-length estimates among the team, floating cut-outs of fish of various sizes will be used as a training tool. In addition, a backpack electrofisher may be used to capture fish on the first day and periodically throughout the season to confirm consistency of species identification and size-class estimation among field staff. Before the electrofisher is used, the following publications will be reviewed to ensure that safe and effective electrofishing techniques are employed and to minimize fish mortality to the best extent possible:

- *Guidelines for Electrofishing Waters Containing Salmonids Listed Under the Endangered Species Act* (NMFS, 2000).
- *Fish Exclusion Protocols and Standards* (WDOT, 2006).
- *Backpack and Drift Boat Design Considerations and Sampling Protocols* (WDFW, 2005).

Each field team will carry reference materials, including Pollard et al. (1997) and a small compilation of fish photographs from the study area, to assist in fish identification while conducting snorkel surveys. If fish cannot be positively identified, the fish will be recorded as “unknown.” If a juvenile salmon cannot be identified to species (sometimes juvenile coho and Chinook can be difficult to distinguish from one another), the fish will be recorded as “salmon, coho or Chinook.”

Surface Water Temperature

Water temperature data will be collected at varying depths in the SFK, UT, and NFK drainages. The task will be similar to the previous intragravel temperature monitoring study conducted in the SFK in 2006, but will also include surface water temperatures. Water temperature dataloggers (e.g., Hobo Temp) comparable to or the same as those used in the SFK will be deployed.

Dataloggers (self-contained temperature recording units) and thermistor strings (multiple sensors spaced along a cable) will measure intragravel and surface water temperatures. To measure surface water temperature, two dataloggers will be deployed in a cross-section—one will be deployed about one-third of the distance from the bank, and the other will be deployed in or near the thalweg (area of greatest flow). The individual dataloggers will be anchored below the channel bed, and the thermistor strings will be entirely exposed to stream flow.

For transects where intragravel temperatures will be recorded, two dataloggers will be attached to a single thermistor string and deployed at varying depths in the channel bed. Up to two thermistor strings will be deployed at each site. Sites with known salmon-spawning occurrence and areas where salmon spawning is considered unlikely both will be chosen. When practical, the intragravel and surface water thermistors will be deployed in the same vertical location in the channel to assist in analysis and linking the two studies together.

The thermistors will be deployed during summer low-flow conditions in July or August, and data will be downloaded, at a minimum, once in 2007 before stream freezeup. Dataloggers will be left in place through the winter of 2007/2008.

Additional water temperature sampling also is planned for tributaries. Tributaries will be selected for sampling during the field effort. Spot temperature data will be collected at selected locations several times during the ice-free season.

Data for surface water temperature and intragravel temperature, and components of the analyses of these data, will be used in the intragravel temperature study that commenced in 2005.

In late 2007, data reduction and analysis will be performed on the data downloaded from the dataloggers. Data reduction, analysis, and QA/QC procedures will be conducted as described in the data management and analysis section below.

11.1.9.5 Field Sampling Schedule

Flow-habitat Surveys

The winter low-flow field effort is scheduled for the first week of April. The reason for this field effort is to collect flow data at flow-habitat sites during the annual low-flow period. Data will be collected at all 84 flow-habitat sites as field conditions allow.

A total of 11 new flow-habitat study sites will be established in various reaches of SFK, NFK, and UT in June. These new sites will fill data gaps for certain habitat types (the data gaps are a natural result of random site selection). Flow-habitat data also will be collected at these newly established sites in July and August, to coincide with mid-range and low summer flows.

The field effort to capture mid-range summer flows in the NFK is tentatively scheduled for July. This effort is needed because mid-range summer flows were not collected in 2006 because of rainy conditions.

Fish-presence Surveys

One field event is planned for 2007 to document fish presence at all main-channel sites during summer conditions. Sampling will be conducted after the spring flood event, when fish will likely be holding in their summer feeding/rearing areas and when emigration and immigration should be minimal. The primary field effort is scheduled to begin in early July and be completed by early August. However, snorkel surveys will be conducted as early as late June at approximately 10 sites on lower UT in order to coordinate data collection with a mark-and-recapture study. The mark-and-recapture study will use a combination of electrofishing and snorkeling to estimate fish abundance. Since electrofishing will be used as the primary capture method, the mark-and-recapture study is tentatively scheduled to begin in mid- to late June, prior to the start of the adult salmon return.

11.1.9.6 Data Management

Quality assurance and quality control procedures will be conducted as described in the *Flow-Habitat Study, Field Sampling Protocol* (HDR, 2005).

Data collected during 2007 will be recorded on data sheets and entered into an electronic database (Excel or Access) shortly after field personnel return to the office. The database will include the use of look-up tables to maintain consistency during data entry and thereby to provide an initial level of QA/QC. Electronic data will be checked against the corresponding hardcopy data. If discrepancies or incorrectly entered data are found, these will be noted and the electronic spreadsheet will be updated to reflect the rectified information. After each line of data has been either confirmed for accuracy or rectified, a “yes” will entered in the QC column set up in the electronic file. This protocol will be performed for 100 percent of the data collected in 2007.

11.1.9.7 Data Analysis

After the QC review, flow-habitat data will be reduced and flows will be calculated from the velocity data. At sites where velocity data are not collected, flows will be calculated using channel geometry, water-surface elevation, and hydraulic slope data and estimates of Manning’s roughness coefficient from previous data-collection trips.

Fish density per meter snorkeled will be calculated for each species of fish observed during fish-presence surveys in 2007. Data will be compared to results from previous years.

All site-specific data, flow calculations, and fish-presence data will be transferred to Ecofish Research, Ltd., for entry into a habitat-quantity model.

11.1.10 Off-channel Habitat Study (Instream Flow Study)

11.1.10.1 Introduction

The off-channel habitat study is one of the integral components of the instream flow study. The instream flow study was initiated in 2004 as a part of the environmental baseline studies for the Pebble Project. In September 2005, an off-channel habitat study was implemented focusing on habitat units adjacent to or near the main channel of Reach 2 of the SFK (Figure 11.1-5). Similar to the main-channel study, data collection for the off-channel study included physical-habitat and fish-presence surveys that continued through 2006. In 2007, the off-channel habitat study will be expanded to include off-channel habitat and fish-presence surveys in UT. Off-channel habitat sites will be established in UT using methods similar to those used for site establishment in SFK.

When the off-channel habitat (OCH) study was initiated in September 2005, 22 cross-sections were established in Reach 2 of the SFK. Of the 22 cross-sections, 16 were sampled as part of the OCH study program. Four transects were not sampled because of lack of an OCH habitat or because of survey difficulties. The transects were parallel to each other and each extended approximately 1000 feet on either side of center of the river’s main channel. Each off-channel habitat unit encountered along each transect was surveyed and established as an off-channel study site. Each off-channel habitat unit is defined as 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. Some habitat units that are occasionally wetted with flow at both the upstream and downstream ends at higher than bank-full flows are intermediate between side-channel and off-channel habitat types.

Eleven of the 16 transects were established in coordination with existing main-channel flow-habitat sites to provide linkage and to allow inferences on water level to be extended from the main-channel flow-habitat sites to the off-channel sites.

The recent focus of the mine development concept known as "Pebble East" has resulted in a shift of focus of the environmental study to the UT drainage. In 2007, the off-channel habitat study will be expanded to include habitat in the UT. Up to 15 transects will be established at or between existing UT flow-habitat cross-sections in a manner similar to that used in the SFK study.

Below are a summary of previous sampling events and an outline of the 2007 off-channel habitat and fish-presence surveys in the SFK and UT.

11.1.10.2 Summary of Previous Sampling Events

Off-channel Habitat Surveys (2005 through 2006)

Data collection of the habitat surveys in 2005 and 2006 occurred during two separate field trips: one in September 2005 during transect establishment and one in August/September 2006. The data collected at each site were water-surface elevations, water-column depth, channel geometry, substrate, cover, water temperature, dissolved oxygen, conductivity, and pH.

Fish-presence Surveys (2005 through 2006)

Fish-presence surveys were conducted in mid-to-late September 2005, during relatively high flow when off-channel habitat sites were connected to the main channel. Surveys were conducted at 72 off-channel sites and at 11 main-channel sites, all located in Reach 2 of the SFK. Snorkeling was the primary method employed; visual surveys were conducted when conditions (e.g., shallow depths) were not suitable for snorkeling.

In 2006 fish-presence surveys were conducted in June, beginning approximately two weeks after the spring flood event when flow was still relatively high. A fish-presence survey also was conducted in August through September 2006, during another period of relatively high flow caused by rain events. In an effort to quantify fish presence during winter conditions, fish-presence surveys were conducted at a subset of the OCH sites during pre-freezeup conditions in late October through early November 2006, in coordination with an overwintering study. Thick ice cover precluded snorkeling at a many of the previously established off-channel sites that were intended to be sampled; snorkel surveys were completed at six main-channel flow-habitat sites and at 13 off-channel sites. Visual observations of juvenile fish were recorded, when possible, at off-channel sites that were covered with relatively transparent ice. An underwater camera was used at both transparent and opaque ice-covered off-channel sites, but was found to be ineffective due to poor image resolution.

11.1.10.3 Goals and Objectives

The goal of the OCH study is to quantify habitat in the off-channel areas and to assess fish distribution and abundance in these habitats. Fish-presence surveys have been conducted seasonally and at varying flow regimes at each established OCH sample site. This information will be used to link fish-habitat usability with observed use and connectivity with the main channel. Models of the productive capacity of fish habitat will be used to predict density at each site, and this will be related to the observed density to provide a validation of the biological inferences of the flow-habitat model.

Off-channel habitat surveys will be conducted along the newly established transects in UT in 2007. Water-surface elevations will be measured with a differential global positioning system (GPS) during two field trips. Additionally, aerial observations of surface water connectivity will be conducted at several main-channel flow levels in the UT during the field season.

Fish-presence surveys will be conducted at OCH sites in both the SFK and UT drainages in 2007. One trip to document fish presence at OCH sites in SFK is planned for mid-summer. The UT OCH sites will be surveyed for fish presence during the early summer—soon after the sites are established—and again in late summer at a different flow regime.

11.1.10.4 Field Methods

Off-channel Habitat Surveys

The 2007 OCH study program will be conducted in conformance with the *2005 Off-channel Habitat Study, Field Sampling Protocol* (ERL and HDR, 2005).

Study Site Selection and Establishment. The target reach for the 2007 study is Reach 2 of Upper Talarik Creek. This reach is most appropriate for this study for the following reasons:

- It has the potential to experience the greatest amount of flow change.
- It has a significant amount of off-channel habitat, as indicated by a review of aerial photographs.

The sites established in 2007 in UT for the off-channel habitat study will link to cross-sections that were established for the flow-habitat study. This will allow inferences on water level to be extended from the flow-habitat sites to the off-channel habitats. Sites for the main-channel flow-habitat study were selected using professional judgment (the 2004 sites) and a stratified-random approach (the 2005 sites), providing a total of 10 sites in UT Reach 2. In addition to these sites, other sites may be added in 2007 for the OCH study by selecting locations midway between some of the existing transects. These additional sites will increase the rate of sampling of off-channel habitat in UT and will eliminate long reaches between the OCH sites, in order that the OCH sites will be spaced relatively evenly.

OCH transects will be selected using the most recent aerial orthophotographs provided by Northern Dynasty Mines Inc. OCH transects will be surveyed perpendicular to the stream channel and across the floodplain. Many OCH transects will intersect a flow-habitat site. Each flow-habitat site consists of a cross-section arranged perpendicular to the stream channel and marked with a headpin and tailpin. An OCH transect will intersect a flow-habitat site at the channel center between the headpin and tailpin and will extend approximately 1000 feet in either direction from the center of the channel. For transects that are located midway between the flow-habitat cross-sections, headpins and tailpins will not be established. OCH units will be selected along each transect wherever off-channel habitat is encountered.

OCH transects will not cross each other. Where the channel is sinuous, a transect could intersect the stream channel multiple times; however, main-channel habitat will be excluded from the OCH assessment. Near significant tributaries, the OCH transect will terminate at the point of divide between the two sub-basins. If this point is not discernable from the aerial photographs, a point halfway between Upper Talarik Creek and the tributary will be selected as the termination point of the transect.

Also using the aerial photographs, OCH habitats will be classified based on the nature of the connection to the mainstem, as follows:

- Connected to the main channel by a visible, wetted channel at least part of the year.
- Connected to the main channel, but with access blocked by beaver dam or other non-permanent feature.
- Isolated from the main channel, with no visible permanent or temporary connection to the main channel.

Data collection at each OCH unit will be conducted as follows:

- At a cross-section following the transect, channel geometry, water-surface elevation, substrate, cover, and depth (if applicable) will be recorded. The cross-section limits, typically the channel edges, will be marked with either lath or flagging, whichever is more appropriate given the bank conditions.
- Water-quality field measurements, including water temperature, conductivity, and dissolved oxygen, will be collected at or near the cross-section.

Establishing Vertical Control. Vertical controls are necessary to monitor the relative height of the water-surface elevation in off-channel habitats. A TBM has been established for each flow-habitat study site, and these TBMs will allow comparisons of stream water-surface elevations to OCH water-surface elevations. High-resolution differential GPS will be used to determine the water-surface elevation at each OHC unit.

For the transect located midway between the flow-habitat cross-sections, a TBM will be established and marked with painted lath and flagging. The differential GPS will be used to determine the elevation of the TBM.

Recording Channel Geometry. Channel geometry will be measured along the transects at each OCH unit. A fiberglass survey tape marked with decimal-feet increments will be pulled taut across the channel. A high-resolution differential GPS will be used to record positions along the survey tape. The horizontal distance between positions will be recorded to the nearest 0.1 foot, and vertical elevation data will be collected with the differential GPS. Vertical stations will be set at breaks in the cross-section slope and at changes in substrate type to describe the habitat unit cross-sectional shape.

Measuring Water-surface Elevation. When applicable, water-surface elevations will be measured at the left and right sides of the habitat unit with the differential GPS. Water-surface elevations will be measured on Upper Talarik Creek at left, center, and right stations of the channel.

Determining Water-column Depth and Velocity. Depth in wetted areas along the transect will be measured to the nearest 0.1 foot using a survey rod at vertical station points. In addition, the maximum depth will be recorded.

Water-column velocity will typically not be measured, as off-channel habitats are expected to have velocities too low to measure.

Recording Substrate and Cover. Substrate and cover characteristics at each vertical station on the transect will be recorded. Substrate size classes will be based on a modified Wentworth Scale (Table 11.1-3). At each vertical station, the field crew will record dominant and subdominant size classes in a theoretical 1-foot-radius area centered on the point where the vertical station meets the ground. Substrate size will be estimated by visual observation; direct measurements may be taken at the discretion of the field crew.

Observations of cover characteristics will be noted for each habitat unit on the transect. Observations will include dominant cover type (Table 11.1-4), percent habitat unit with cover, and percent wetted width with cover (if applicable). Cover characteristics do not require measurement; the appropriate code will be entered for each observation of cover.

Estimating Connectivity with Mainstem. The nature of the connection between the off-channel habitats and UT will be estimated in the office using aerial photographs as described above under Study Site Selection and Establishment. Connectivity will be confirmed during the field studies. If necessary, this will be done by both foot survey and helicopter survey.

Measuring Water-quality Field Parameters. For OCH units that are wetted, water temperature (±1°C, dissolved oxygen (±0.5 milligrams per liter), and conductivity (±1 micromhos) will be measured at each OCHS site. The point of measurement will be at the deepest point along the transect. Measurements will be taken at 2 inches below the water surface and at the bottom. YSI meters will be used to collect the measurements following the protocol described in the 2007 field sampling plan for surface water quality (NDM, in press5).

Extrapolation from Selected Sites. To extrapolate data for sampled areas of off-channel habitat to the entire reach, GIS mapping will be used to quantify the total area of wetted habitats, allowing the field data to be expanded to provide an estimate of the total off-channel habitat present. Using georeferenced aerial photographs, all wetted areas will be delineated and identified as off-channel or main-channel areas. The upstream and downstream connection will be inferred from the photographs and will be classified as described under Study Site Selection and Establishment, above. The area and the connection type for the OCH units, as derived from field data, will be compared to GIS data to confirm the GIS results and to allow extrapolation of field data to the entire reach. This work will be restricted to Reach 2 of Upper Talarik Creek.

Fish-presence Surveys

Fish-presence surveys for the OCH study in 2007 will be conducted with methods similar to those employed during previous events in the SFK. Snorkeling will remain the primary method in 2007 unless conditions (e.g., shallow water—less than width of snorkel mask, poor visibility) limit its effectiveness. Snorkel observations will be used to enumerate fish by species and size class, indicate cover availability where fish are identified, and estimate relative visibility. Details of the snorkeling methods to be used are described under the field methods for the main-channel flow-habitat study, above. If low water or other conditions prevent the effective use of snorkeling, electrofishing or minnow trapping will be used.

Replicate surveys will be conducted at each OCH site following the initial survey in an effort to increase accuracy, as recommended by the literature (Slaney and Martin, 1987). If turbidity after the initial survey reduces visibility, the replicate survey will be delayed until the water has cleared. If visibility is not sufficient within 20 minutes, the replicate survey will be cancelled.

In the SFK drainage OCH sample sites will be resampled using electrofishing. The electrofishing will cover the same areal extent that was snorkeled. Electrofishing results will be compared to snorkeling results to estimate the relative accuracy of snorkeling and electrofishing. All newly established OCH sites in the UT drainage will be only electrofished.

Captured or observed fish will be enumerated by species and size class. The length of each OCH unit and the width at three locations within the unit will be recorded. Sample date, time, and method; water temperatures (in degrees Celsius); and incidental observations of fish or other wildlife also will be recorded on data sheets. Velocity and substrate composition will not be recorded during fish-presence surveys at OCH sites.

11.1.10.5 Field Sampling Schedule

Off-channel Habitat Surveys

Transects will be established in Reach 2 of UT in June. OCH surveys will be conducted at that time to obtain high-flow measurements that will provide good contrast to the low-flow data that will be collected in August.

Fish-presence Surveys

To document fish presence at OCH sites in the SFK, one field event is planned for 2007 during mid-to-late summer, when fish will likely be holding in their summer feeding/rearing areas and when emigration and immigration should be minimal.

Two field events are planned to document fish presence at OCH sites in UT. The first trip will occur in early summer, after the spring flood event and soon after the sites are established by the off-channel habitat team. The second trip will be conducted in mid-to-late summer, either at the same time as or soon after the survey in SFK.

11.1.10.6 Data Management

Data collected during 2007 will be recorded on data sheets and entered into an electronic database (Excel or Access) shortly after field personnel return to the office. The database will include the use of look-up tables to maintain consistency during data entry and thereby to provide an initial level of QA/QC. Electronic data will be checked against the corresponding hardcopy data. If discrepancies or incorrectly entered data are found, these will be noted and the electronic spreadsheet will be updated to reflect the rectified information. After each line of data has been either confirmed for accuracy or rectified, a “yes” will entered in the QC column set up in the electronic file. This protocol will be performed for 100 percent of the data collected in 2007.

Data collected using the differential GPS will be downloaded and reduced in an Excel spreadsheet. Data quality will be monitored by checking a random number of known elevations—TBMs, headpins, and tailpins at flow-habitat cross-sections—against the elevations measured with the differential GPS. These data quality reviews will be recorded in an electronic file.

Quality assurance/quality control procedures will be conducted as described in the *Off-Channel Habitat Study, Field Sampling Protocol* (ERL and HDR, 2005).

11.1.10.7 Data Analysis

Data analysis will be conducted using Excel spreadsheets and AutoCAD. Data on water quality and fish presence will be reduced and compared between cross-sections and between field trips. Channel geometry and water-surface elevations will be analyzed using Excel; transect geometry and water-surface elevation for select transects may be mapped using AutoCAD.

11.2 Macroinvertebrate and Periphyton Studies—Mine Study Area

11.2.1 Introduction

HDR Alaska, Inc., will conduct the 2007 baseline study for macroinvertebrates and periphyton in the mine study area. Andra Love is the project manager for all 2007 aquatic invertebrates studies.

The objective of the macroinvertebrates and periphyton program is to continue to characterize baseline macroinvertebrate and periphyton populations in the mine study area. The 2007 sampling program is being conducted by HDR Alaska, Inc., and will consist of three tasks, as follows:

- Macroinvertebrates will be collected at ten stations in the mine study area. Five of these stations have been sampled in previous years and the other five are additions based on the recent mine development concepts. Macroinvertebrates are being sampled because they are good indicators of changes in habitat and water quality (Barbour et al., 1999; Merritt and Cummins 1996).
- Periphyton will be sampled at the same ten stations. Periphyton is being sampled because it is sensitive to changes in the aquatic environment and can be used as a monitoring tool for in situ primary productivity (ADF&G, 1998).
- If they can be located, freshwater mussel tissues will be collected from up to three lakes in the mine study area. Mussels are being collected because they are good bioaccumulators of metals

and persistent organics (ADF&G, 2006). This rationale is consistent with the Mussel Watch Program, endorsed by the U.S. Environmental Protection Agency (EPA) and the Mussel Watch Project operated by the National Oceanic and Atmospheric Administration as part of the National Status and Trends Program. Analysis of mussel tissue will provide baseline characterization of select lakes in the mine study area. At locations where mussels are collected, surface water samples and sediment samples also will be collected for analysis for select analytes.

A summary of tasks for the macroinvertebrate and periphyton study in 2004 through 2007 is provided in Table 11.2-1. Detailed protocols for this sampling program are provided in the 2007 field sampling plan (FSP) for macroinvertebrates and periphyton (NDM, In press3). This document is a complete study plan for the 2007 macroinvertebrate and periphyton studies and supersedes all previously written study plans for this program.

11.2.2 Study Area

The mine study area includes the general project vicinity and downstream reaches of the streams in the mine area. Sampling stations will be located on the North Fork Koktuli River, South Fork Koktuli River, and Upper Talarik Creek (Figure 11.2-1). Mussel tissue collection stations will be established at up to three ponds that contain freshwater mussels if populations of these organisms can be located near the mine area.

11.2.3 Methods

As a result of conversations among Northern Dynasty Mines, Inc. (NDM), its consultants, EPA, and the Alaska Department of Natural Resources (ADNR), two sampling methods were used in 2005 for macroinvertebrate collection: the Alaska Stream Condition Index (ASCI) method and Surber sampling. The intent was to examine the results and determine the most appropriate method for sampling in future years specific to the Pebble Project. No decision having been reached, both methods again will be employed in 2007.

With the ASCI method, a sampling protocol based on multiple habitats, 20 subsamples of macroinvertebrates are collected proportionally from the various aquatic habitats at a given station. These subsamples are combined into one composite sample. Detailed sampling protocols are included in *The Alaska Stream Condition Index (ASCI): A Modification of the USEPA Rapid Bioassessment Protocols* (Major and Barbour, 1997) and in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

The Surber sampling method has been used successfully by state and federal agencies in Alaska for sampling macroinvertebrates. This method purportedly provides more quantitative population information than the ASCI method (ADF&G, 1998), but it does not collect macroinvertebrates from non-riffle habitat types. The Surber method calls for collection of five replicate samples from a specific habitat type (riffles) and location that can be resampled in successive years.

Only one sampling method for will be used for periphyton collection in 2007. The protocol was created by the EPA with modifications suggested by the Alaska Department of Fish and Game (ADF&G). This method calls for collection of 10 replicate samples from a riffle area. The ADF&G modification calls for analysis of chlorophyll *a* as a measure of periphyton presence or abundance, rather than the EPA's identification of diatoms. Periphyton samples will be collected at the same sites and at the same times as macroinvertebrate samples.

In addition to macroinvertebrate and periphyton samples, the 2007 field sampling effort will include sampling for freshwater mussels (*Anodonta beringiana*) from lakes in the mine study area. Mussels will be collected from as many as three lakes. Many conditions must be present for mussels to exist in these lakes, and reconnaissance will be done to determine which lakes may contain freshwater mussels. Mussels are filter feeders that cycle water and sediments through their systems. At locations where mussels are found, surface water samples and sediment samples also will be collected for comparison between the three media. Procedures for collection of surface water and sediment samples are described in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

11.2.3.1 Sample Stations and Sample Frequency

Data analysis from the sampling in previous years indicates that June will likely be the best month for sampling because the greatest numbers of macroinvertebrates have been found during this month in the past. June will likely also be when the warmer season has progressed enough to permit growth of periphyton. Proceeding on these assumptions, the 2007 sampling will take place in early June. In the event of a cold, rainy spring, the timing of the field work will be re-scheduled as appropriate.

Samples will be collected at 10 stations in the mine study area (Figure 11.2-1; Tables 11.2-2 and 11.2-3). These sites were selected because of their location with respect to the mine area (for example, upstream and downstream of possible locations of facilities) and because they are collocated with sampling sites for fish, water quality, and hydrology.

11.2.3.2 Field Sampling

ASCI Macroinvertebrate Collection

In ASCI sampling, 20 subsamples are collected from a 100-meter stream reach. Scientists will assess the abundance of five key macroinvertebrate habitats: riffles, undercut banks, aquatic vegetation, snags/downed woody debris, and sand/soft sediment. The 20 subsamples will be collected in proportion to the amount of each habitat type in the 100-meter stream reach. A D-frame dip net will be used to sample all habitat types. Field data will be recorded on field data forms (Appendix 11.2A).

Riffles, aquatic vegetation, and sand/soft sediment habitats all require kick sampling. The sampler will place the net facing upstream, and approximately 1 square foot of substrate or vegetation cover will be disturbed directly upstream by kicking or rubbing the material and allowing the loosened material and macroinvertebrates to flow into the net.

Undercut banks require the sampler to jab (three to five times) the dip net into the undercut bank below the surface of the water. The sampler will then pull the dip net through the suspended material to collect loosened material that did not get captured by the net initially.

Snags/downed woody debris habitats require sampling of an approximately 1-square-foot area. The sampler will place the dip net downstream, and the sample area will be disturbed or rubbed by hand to loosen material and allow it to flow into the net.

Details of the sampling procedure are described in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

ASCI Habitat Characterization

In addition to sampling the macroinvertebrate population, the project team will complete a visual assessment of aquatic and riparian habitat and collect ambient water-quality data. Field measurements of pH, dissolved oxygen, conductivity, turbidity, and water temperature also will be collected at each station.

The visual assessment of aquatic and riparian habitat is an integral part of the bioassessment process and considers the following habitat parameters:

- Epifaunal substrate and available cover.
- Embeddedness.
- Velocity and depth combinations.
- Sediment deposition.
- Channel flow status.
- Channel alteration.
- Channel sinuosity.
- Bank stability.
- Bank vegetative protection.
- Riparian-zone vegetation width.

Each of the 10 habitat parameters will be evaluated to determine habitat quality. A score of 1 through 20 will be assigned for each parameter based on a variety of habitat conditions identified on the field data sheet (Appendix 11.2A). Depending on the score chosen, for each parameter the habitat will fall into one of four habitat-quality categories: poor, marginal, suboptimal, or optimal. The process of categorizing the habitat based on recorded scores is aimed at minimizing sampler bias when assigning categories to habitat quality.

Macroinvertebrate Surber Method

The use of a Surber sampler is a semi-quantitative method to determine the density and composition of macroinvertebrate populations on stream-bottom (substrate) habitats. The sampler is constructed of a rectangular frame with a fine-mesh net. Attached to the bottom of the frame is a metal substrate frame that delineates the area of substrate to be sampled. A field team member will orient the net upstream, and the material within the frame will be disturbed and the cobbles will be scrubbed clean of debris and organisms. The debris and organisms will then flow into the net and be trapped. Details of the sampling procedure are described in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

The field team will collect five Surber samples from a selected riffle/cobble area at each sampling site. Habitat characterization completed in previous years indicates that this habitat type is available for sampling at all established sampling reaches that are included in the 2007 macroinvertebrate and periphyton studies. Riffle/cobble habitats sampled with Surber samplers in the 2005 study will be resampled in 2007. The locations of the riffle/cobble areas in sites newly examined in 2007 will be documented using a global positioning system (GPS) and will be flagged to ensure that any subsequent sampling will occur in the same riffle. Each Surber sample will be placed in a separate container and preserved with alcohol. Field data will be recorded on field data forms (Appendix 11.2A).

Periphyton Sampling

At each sampling site, the field team will collect 10 periphyton samples from the same riffle/cobble reach from which the Surber samples are collected. The periphyton sampling area will be flagged, and GPS coordinates will be recorded so that any future samples can be collected in the same place for continuity and comparison.

At each sampling site, periphyton will be collected from 10 cobbles in the riffle/cobble habitat. Sample collection will follow the modified EPA rapid bioassessment protocol (Barbour et al., 1999) as used by the ADF&G (1998). A 5-by-5-centimeter square (25 square centimeters) on each cobble will be sampled for periphyton as described in detail in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3). Ten discrete periphyton samples (one sample per cobble) will be collected from each sampling station. All 10 samples will be placed in the same zipper-seal bag with silica gel desiccant to absorb any excess moisture. The bag will be sealed and labeled, then stored in a lightproof cooler on ice. Field data will be recorded on field data forms (Appendix 11.2A).

Freshwater Mussel Sampling

The macroinvertebrate sampling team will search for mussel beds in select lakes in the mine study area in conjunction with the June macroinvertebrate and periphyton sampling. Assuming that mussels are found, the study team will collect mussels in as many as three lakes.

Once a mussel bed is located, the study team will record the location with GPS coordinates and mark the site with flagging. A field team member will use a mussel rake to collect approximately 10 mussels. The collected mussels will be consolidated in one zipper-seal bag for each site. The bag will be sealed and labeled and placed in coolers on gel ice. Details of the sampling procedure are provided in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

In addition, the field team will collect water quality and sediment samples from each mussel sampling site in accordance with procedures described in the 2007 FSP for macroinvertebrates and periphyton (NDM, In press3).

Field data will be recorded on field data forms (Appendix 11.2A).

11.2.3.3 Sample Processing and Identification

Macroinvertebrates

ASCI and Surber macroinvertebrate samples collected in 2007 will be processed and identified using the same methods followed in 2005. Before identification, organisms must be sorted from sample debris. ASCI samples will be subsampled with a Caton subsampling tray to collect approximately 300 organisms.

Macroinvertebrates collected with the Surber sampler will be completely sorted from the debris. Sorted samples will be preserved in labeled vials with alcohol for later identification. Biologists from HDR Alaska, Inc. (HDR), will identify all samples to genus or the lowest practicable taxon. Identified macroinvertebrates will be preserved in alcohol in labeled vials.

Examples of laboratory bench sheets are provided in Appendix 11.2A.

Periphyton

HDR will be responsible for filling out and maintaining electronic chain-of-custody forms and for transporting the samples from Iliamna to the laboratory. Periphyton samples will be frozen and shipped to Bill Morris of the Alaska Department of Natural Resources, Office of Habitat Management and Permitting, for laboratory analysis of chlorophyll *a* concentrations.

Freshwater Mussels

Shaw will be responsible for filling out and maintaining electronic chain-of-custody forms and for transporting the mussel, water quality, and sediment samples from Iliamna to the appropriate laboratories. The mussel samples will be shipped to primary laboratory, Columbia Analytical Services (CAS); CAS will split one mussel sample to create duplicate (or quality control [QC]) and triplicate (or quality assurance [QA]) samples. CAS will send the triplicate sample to the QA laboratory, Severn Trent Laboratories (STL).

Primary and duplicate water-quality samples (except for mercury analysis) and sediment samples will be shipped to SGS Environmental Services, Inc. (SGS). Primary samples for mercury analysis will be shipped to Test America Laboratories, and triplicate samples will be shipped to CAS.

Mussel tissue, water quality, and sediment samples will be analyzed for a suite of trace metals and other analytes as described in the 2007 quality assurance project plan (QAPP; NDM, In press4). Sample handling and transportation to the analytical laboratories also will follow procedures outlined in the QAPP.

11.2.3.4 Quality Management

NDM has appointed an Analytical QA/QC Manager who is responsible for quality management of all laboratory programs. This oversight will ensure consistency among the various programs within the baseline study and that data-quality objectives are met for all programs, including the macroinvertebrate and periphyton program.

The sample collection and handling protocols for environmental baseline studies for Pebble Project are outlined in the *Draft Environmental Baseline Studies, 2007 Quality Assurance Project Plan* (NDM, In press4) and the *Draft Environmental Baseline Studies, 2007 Field Sampling Plan, Macroinvertebrates and Periphyton, Mine Study Area* (NDM, In press3). Sampling equipment will be maintained following procedures described in the FSP. All instruments for measuring field parameters will be serviced before the field season and will be calibrated as described in the FSP.

Tracking forms (Appendix 11.2A) have been developed for maintaining proper macroinvertebrate identification protocol. All hard-copy identification and tracking forms will be backed up electronically. All sorted and unsorted macroinvertebrate samples will be stored, and a reference collection of identified samples will be submitted to the Environment and Natural Resources Institute (ENRI) laboratory at the University of Alaska Anchorage for taxonomic quality control.

11.2.3.5 Data Analysis and Reporting

Macroinvertebrates

Data on macroinvertebrates will be analyzed to develop a list of taxa, determine population density, and establish metrics suitable for use as indicators of habitat change in the study area. A quantitative population density of the riffle/cobble substrate will be calculated—based on the sampling area within the substrate frame—from the data collected using the Surber sampler. Population densities for ASCI samples are calculated based on the number of grids selected during subsampling. The exact surface area of stream substrate sampled using ASCI is not known; therefore, this density number can only be estimated.

Following are examples and definitions of metrics that will be developed:

- **Taxa richness** is calculated as the total number of taxa identified in specific categories. For example, all macroinvertebrates in each Surber sample for each site will be identified to genus or the lowest practicable taxon. From this list, the sums of all taxa for the following will be calculated:
  - Number of *Ephemeroptera* (mayflies) taxa
  - Number of *Plecoptera* (stoneflies) taxa
  - Number of *Trichoptera* (caddisflies) taxa
  - Number of *Chironomidae* (midges) taxa
  - Additionally, the total taxa richness for the entire sample will be calculated.
- **Percent EPT** (*Ephemeroptera*, *Plecoptera*, and *Trichoptera*) is the proportion of the population that is made up of organisms in the orders *Ephemeroptera*, *Plecoptera*, and *Trichoptera* at each station. It is calculated by dividing the number of EPT organisms in the sample by the total number of organisms in the sample.
- Similarly, **percent *Chironomidae*** is the proportion of the population represented by that family. It is calculated for each station by dividing the sum of all *Chironomidae* in the subsample by the total number of organisms in the subsample.
- **Percent dominant taxon** is the proportion of the population represented by the most populous taxon. It is calculated for each station by determining which taxon represents the largest number of organisms in the subsample and dividing that number by the total number of organisms in the subsample.
- A **Community Tolerance Index** will be developed for each station by weighting the tolerance value of each family identified for the subsample. The CTI is a method for relating macroinvertebrate community assemblages to water quality based on the known tolerance values for the taxa present at the station. The tolerance values for families of aquatic macroinvertebrates

have been established previously and appear in scientific literature (Wisseman, 1996; Hilsenhoff, 1988).

Nonparametric tests such as the Wilcoxon-Rank sum test will be performed on these metrics to test for temporal and spatial trends and to determine differences between the macroinvertebrate sampling methodologies.

Data collected with the two aquatic invertebrate methodologies will be compared on the basis of relative density and the metrics described above. Results of these analyses will be compared with current literature that examines results of riffle versus reach-wide sampling techniques (e.g., Rehn et al., 2007) and will be discussed with EPA and ADNR in order to make a final decision on the most appropriate sampling design going forward.

Periphyton

The concentration of chlorophyll *a* is generally 1.5 percent of the dry weight of organic matter from which the biomass of periphyton in the sampled 25-square-centimeter area can be calculated. Periphyton data will be tested for normality. If the data are normally distributed, then parametric tests—including student’s t-test, analysis of variance (ANOVA), and linear regressions—will be performed. If the data are not normally distributed, nonparametric equivalents will be used.

Freshwater Mussels, Surface Water, and Sediment

Mussel tissue, surface water, and sediment samples from up to three lakes will be analyzed for the suite of analytes documented in the QAPP (NDM, In press4). Nonparametric methods performed with Aquachem and Excel will be used to compare among the results from the three sites and also to compare the results to those for the freshwater mussels tested previously for the Iliamna Lake study. Data on mussel tissue, surface water, and sediment will be examined concurrently to determine whether there are any indicators of bioaccumulation in the mussel tissues, although any conclusions drawn from these analyses must be considered preliminary due to sample size.

Data Management

A preliminary QA/QC review will be performed on all field data as soon after field visits as practical. All data will be transmitted to the Pebble Project database managers for incorporation into the master Pebble Project database following preliminary QA/QC.

11.3 Iliamna Lake Study

11.3.1 Introduction

HDR Alaska, Inc., will conduct the 2007 baseline study for Iliamna Lake. Andra Love is the project manager for the 2007 Iliamna Lake study.

The objective of the 2007 Iliamna Lake study is to further establish baseline conditions for water quality and zooplankton in the lake. This study, which is being conducted by HDR Alaska, Inc., will supplement the ongoing investigations of freshwater systems in the mine study area and transportation corridor by gathering information on conditions in the lake in 2007. This document is the complete study plan for 2007 and supersedes all previously written study plans for the Iliamna Lake study. A summary of tasks for the Iliamna Lake study in 2005 through 2007 is provided in Table 11.3-1.

11.3.2 Study Area

The Iliamna Lake study focuses on the northeast portion of the lake. The study area extends from the mouth of Upper Talarik Creek on the west and to Pile Bay on the east (Figure 11.3-1). These boundaries were established based on currently proposed project activities and transportation-corridor alternatives, including road and lake transportation options.

11.3.3 Methods

11.3.3.1 Sample Stations and Sample Frequency

The Iliamna Lake study for 2007 will consist of sampling five stations in Iliamna Lake. Sample stations are located at Pile Bay, Knutson Bay, at the mouth of the Upper Talarik Creek, at a site near the Iliamna boat dock (Northeast Bay), and at a site near Roadhouse Bay (Figure 11.3-1, Table 11.3-2). These locations were established in 2005 based on their proximity to the proposed mine, the possible road alignments, possible barge landing sites, and currently populated villages. Sample stations were set up in nearshore areas (water depth of 20 meters or less) to characterize the conditions at the stream/lake and shoreline/lake interfaces within the watershed of the mine study area. Three surface water-quality samples and one zooplankton sample will be collected monthly from May through October at these sample stations.

11.3.3.2 Background Research

Research will continue for water quality and zooplankton resources pertaining to the study area and surrounding vicinity. Information sources will include scientific literature, gray literature, resource agency files, and interviews with agency personnel. The project team will continue to update the annotated bibliography.

11.3.3.3 Field Sampling

The field team will use a locally hired boat to access sample stations. Exact sample locations will be identified with a hand-held GPS. Site-specific information will be recorded on the field data sheet (Appendix 11.3A). Information recorded will include date and time, site conditions (weather, air temperature, etc.), station identification (GPS and identification code), sampler identification, sample depths, number of samples collected and number of sample containers at the site, and the presence of other notable conditions or fish/wildlife.

Field Parameters

Team members will measure and record field parameters, including temperature, dissolved oxygen, conductivity, pH, oxidation reduction potential, and turbidity during each sampling event. They also will record transparency as measured with a Secchi disk during each of the six sampling events. Details of how measurements will be taken are described in the FSP for Iliamna Lake (NDM, In press2).

Temperature, dissolved oxygen, pH, conductivity, and oxidation reduction potential will be measured using a YSI 556 multi-probe system. The field team will measure turbidity with a Hach 2100P turbidity meter and will check or calibrate meters daily as described in the field sampling plan (NDM, In press2).

Collection and Analysis of Water Quality Samples

Team members will collect water samples at three depths at each site in the following order:

1. At 1 meter below the surface.
2. At the thermocline or at the midpoint of the sample depth (when no thermocline exists).
3. At 1 meter above the substrate.

Upon arrival at each site, the YSI temperature probe will be used to record water temperatures at 1-meter-depth increments beginning at the surface and ending at 20 meters of depth (or at the substrate). Team members will use this temperature profile to determine the presence, if any, and depth of the thermocline. If no thermocline is found, the second sample will be collected at half the total depth at the site. This sampling strategy should detect the effects of lake stratification (if present) on the results of the analyses.

Team members will use an 8-L Model 1010 Niskin water sampler (grab sampling device) to collect the water quality samples as described in the FSP (NDM, In press2). They will place samples in clean polypropylene bottles prepackaged with appropriate preservatives provided by the laboratories. The volume of water to be collected for each analysis is outlined in the QAPP (NDM, In press4). All sample collection and processing equipment will be made of non-metallic material, such as Teflon or glass, to prevent sample contamination and minimize analyte losses through adsorption.

Samples will be analyzed for major ions, dissolved solids, dissolved organic carbon, nutrients, trace elements, and total and dissolved metals (Table 11.3-3). Samples to be analyzed for organics (semivolatile organic compounds, volatile organic compounds, and pesticides/polychlorinated biphenyls [PCBs]) will be collected during only the June and September sampling events. Details about methods, method detection limits, and QA/QC protocols are presented in the QAPP (NDM, In press4). Sample handling and transportation to the analytical laboratories will follow procedures outlined in the QAPP and the FSP (NDM, In press2). Shaw will be responsible for completing and maintaining electronic chain-of-custody documentation and for packaging and shipping samples to the appropriate laboratories.

Zooplankton Collection and Analysis

Collection of zooplankton will aid in characterization of productivity along the northeast shore of the lake. Vertical sample tows will be pulled from the substrate to the surface as described in the FSP (NDM, In press2). The preserved zooplankton samples will be transported with the field team to HDR's laboratory for identification and analysis. Zooplankton samples will be processed and identified to class or order in accordance with American Public Health Association's *Standard Methods for the Examination of Water and Wastewater* (APHA, 1998). Results will be compared to gather insight about changes in the population that may occur temporally and spatially throughout the open-water period at the sites.

11.3.3.4 Quality Management

NDM has appointed an Analytical QA/QC Manager who is responsible for quality management for all laboratory programs. This oversight will ensure consistency among the various programs within the baseline study and that data-quality objectives are met for the program.

The sample collection and handling protocols for environmental baseline studies in Iliamna Lake are outlined in the 2007 QAPP (NDM, In press4) and in the 2007 FSP for the Iliamna Lake study (NDM, In press2).

11.3.3.5 Data Reporting and Analysis

Ambient water-quality and zooplankton results will be characterized using appropriate parametric and nonparametric procedures. Aquachem, SPSS, Excel, and other programs will be used to examine spatial and temporal trends and interactions for surface water and zooplankton.

11.4 Fish and Aquatic Invertebrates—Transportation Corridor

No studies of fish resources or aquatic invertebrates in the transportation corridor are planned for 2007.

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TABLES

TABLE 11.1-1
Pebble Project Environmental Studies
Fish Studies Summary 2004-2007
Consultant: HDR Alaska

Field Studies Discipline	2004 Study Tasks	2005 Study Tasks	2006 Study Tasks	2007 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
	Fish Characterization Population analysis FPL, Removal Sampling, Habitat Surveys	Arctic Grayling Telemetry	Arctic Grayling Telemetry	
	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
	Flow Habitat Study	Flow Habitat and Snorkel Study (Main Channel)	Flow Habitat and Snorkel Study (Main Channel)	Flow Habitat and Snorkel Study (Main Channel)
		Off-channel Habitat Study	Off-channel Habitat Study	Off-channel Habitat Study
		Habitat Mapping and Fish Density Sampling		
				Rainbow Trout Telemetry Study
				Upper Talarik Juvenile Fish Abundance Study
				Juvenile Anadromous Fish Distribution Study
	Transportation Corridor			
	Road Corridor Survey	Y Creek Investigation	No field work planned	No field work planned
		Salmon Spawning Surveys		
		Barge Landing Area Survey		
		Transmission Line Corridor Survey		

Table 11.1-2
Pebble Project
Period-of-Record Index
Fish Resources, Mine Study Area

Sample Location	Year[1]	Period-of-Record By Discipline																							
		Hydrology[2]												Water Quality											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004					I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
KR100A	2004				I		I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005			I			I	I	I	I	I					Q			Q	Q	Q	Q	Q		
	2006			I			I	I			I		I			Q			Q	Q			Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100A (USGS)	2004						I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006			I	C	C	C	C	C	C	C				Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100A1	2004																								
	2005																								
	2006																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100B	2004								I	I	I						Q	Q			Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I		I	I	I	I		I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100C	2004				I	I		I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK119A	2004				I		I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I	C	C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK119B	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I																					
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100A	2004				I		I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B (USGS)	2004				I		I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B1	2004																								
	2005									I	I	C	C									Q	Q		
	2006	C	C	C	C	C	C	C	C	C	C	C	I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B2	2004																								
	2005					I	I	I	I	I	I							Q	Q	Q	Q	Q	Q		
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

Sample Location	Year[1]	Period-of-Record By Discipline																																			
		Fish Tissue[3]												Macroinvertebrates												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004								W										D		D										F	F		F			
	2005								W																						F	F					
	2006																																				
	2007																																				
KR100A	2004																															F		F			
	2005																																				
	2006																																				
	2007																																				
NK100A (USGS)	2004								W										D		D										F	F		F			
	2005								W										S												F	F					
	2006																														F						
	2007								W										S												F						
NK100A1	2004																																				
	2005																																				
	2006																																				
	2007																																				
NK100B	2004																		D												F						
	2005																														F	F		F			
	2006																														F						
	2007																														F						
NK100C	2004								W										D		D										F	F		F			
	2005								W										S												F	F		F			
	2006																														F						
	2007																		S												F						
NK119A	2004								W										D		D										F	F		F			
	2005								W																						F	F					
	2006																																				
	2007																		S												F						
NK119B	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK100A	2004								W										D		D										F						
	2005								W																						F	F					
	2006																														F						
	2007																		S												F						
SK100B (USGS)	2004								W										D		D										F	F		F			
	2005								W										S												F	F					
	2006																														F						
	2007								W										S												F						
SK100B1	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK100B2	2004																																				
	2005																																				
	2006																																				
	2007																																				

Sample Location	Year[1]	Period-of-Record By Discipline																																																											
		Hydrology[2]												Water Quality												Fish Tissue[3]												Macroinvertebrates												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SK100C	2004						I	I	C	C	C						Q	Q	Q	Q			Q										W										D												F	F		F			
	2005	I		I		C	C	C	C	C	C			Q				Q	Q	Q		Q	Q										W																						F	F					
	2006		I	I		I	C	C	C	C	C		I					Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
SK100D	2004						I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																			F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																						
	2006		I	I			I	I	I	I	I		I						Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S																		
SK100F	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q									W											D		D										F	F		F			
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
SK100G	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F	F	F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F	F					
	2006	I	I	I		C	C	C	C	C	C			Q	Q	Q		Q	Q	Q	Q	Q	Q																																					
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
SK119A	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q		Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK124A	2004																																																												
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q																																					
	2006	I	I	I			C	C	C	C	C		I	Q	Q	Q			Q	Q	Q		Q		Q																																				
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK131A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																	F		F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																					
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK133A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005			I		I	I	I	I	I	I							Q	Q	Q	Q	Q	Q																																					
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK134A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																					
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK136A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																					
	2006	I	I	I		I	I	I	I	I	I			Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
SK136B	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																					
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100A	2004					I			I	I	I						Q	Q			Q	Q	Q																																				F			
	2005	I		I		I	I	I			I			Q		Q		Q	Q	Q			Q																																					
	2006			I			I	I		I						Q			Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100B (USGS)	2004					I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F	F	F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W										S												F	F		F			
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q								W										S												F						

Sample Location	Year[1]	Period-of-Record By Discipline																																																										
		Hydrology[2]												Water Quality												Fish Tissue[3]												Macroinvertebrates												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
UT100C	2004				I	I											Q	Q			Q												W										D		D										F						
	2005			I																													W																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S																		
UT100C1	2004																																																												
	2005																																																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100C2	2004																																																												
	2005																																																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100D	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W										S												F	F		F			
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S												F						
UT100E	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006	I	I	I	C	C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
UT119A	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006	I	I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S												F						
UT119B	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																F					
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT135A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																						
	2006		I			I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT138A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q										W										D		D											F		F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q										W										S																		
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT141A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																F		F			
	2005			I		I	I	I	I	I	I					Q		Q	Q	Q	Q	Q	Q																																F					
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
UT146A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																F		F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																						
	2006		I			I	I	I	I	I	I		I		Q			Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
Black Lake	2004																																																												
	2005																																T																								F				
	2006																				Q												T												P																
	2007																				Q												T																												
Big Wiggly	2004																																T												M																
	2005																																T										M													F					
	2006																				Q																								P																
	2007																				Q												T																												

Period-of-Record By Discipline — Hydrology[2]

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005												
	2006												
	2007												
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005												
	2006												
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004					X				X			
	2005			X				X	X		X		
	2006			X			X		X		X		
	2007			X		X		X		X	X		

Water Quality

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005												
	2006							Q					
	2007								Q				
Chiquita Lake	2004												
	2005												
	2006								Q				
	2007								Q				
Lake No. 2	2004												
	2005												
	2006								Q				
	2007								Q				
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006								Q				
	2007								Q				
Small Pools	2004												
	2005												
	2006								Q				
	2007								Q				
Seeps	2004					X				X			
	2005			X				X	X		X		
	2006			X			X		X		X		
	2007			X		X		X		X	X		

Fish Tissue[3]

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004								T				
	2005								T				
	2006												
	2007								T				
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005								T				
	2006								T				
	2007								T				
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004												
	2005												
	2006												
	2007												

Macroinvertebrates

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004								M				
	2005						M						
	2006								P				
	2007												
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005												
	2006								P				
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004												
	2005												
	2006												
	2007												

Sediment

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005							F					
	2006							F					
	2007												
Chiquita Lake	2004												
	2005									F			
	2006												
	2007												
Lake No. 2	2004												
	2005								F				
	2006												
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005									F			
	2006												
	2007												
Small Pools	2004												
	2005												
	2006									F			
	2007									F			
Seeps	2004												
	2005							7			5		
	2006												
	2007												

KEY:

- **C** Continuous stage/discharge hydrometric data collected in streams (gaged stations with dataloggers).
- **D** Macroinvertebrate sites sampled with drift nets AND ASCI methods; periphyton collected with RBP, and diatoms were assessed.
- **F** Sediment samples collected. Seep sediment samples show number of seeps sampled through 2007. Sediment symbol not shown on associated map.
- **I** Instantaneous stream discharge measurements taken each month coincident with water quality sampling (ungaged stations without dataloggers).
- **M** Macroinvertebrate samples from lakes collected with a modified ASCI approach and dredge. Periphyton collected with RBP, and diatoms were assessed.
- **P** Plankton tows.
- **Q** Surface water quality samples collected for field and laboratory analyses.
- **S** Macroinvertebrate sites sampled with Surber Sampler AND ASCI methods; periphyton collected with ADNR methods, and chlorophyll *a* was assessed.
- **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. In 2007, adult grayling and whitefish (muscle tissues) will be sampled. If species is not present in adequate numbers, an alternative location will be selected.
- **X** Seep flow measurements and water quality samples collected.

NOTES:

1. Work for 2007 is shown as planned, but has not yet been completed.
2. At stations where continuous hydrometric data are collected, continuous hydrographs will be estimated throughout winter months using standard hydrometric methods. Stream gages are reinstalled each spring as early as breakup conditions allow.
3. One stream sample 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 (filet). In lakes, grayling, whitefish and northern pike will be collected; muscle tissue samples will be collected from all three species, as well as liver (archive) samples from northern pike.

TABLE 11.1-3
Modified Wentworth Scale for Substrate Size Classification, Instream Flow Study

Size	Code	Description
<2 mm	FI	Fines
2-16 mm	SG	Small Gravel
16-64 mm	LG	Large Gravel
64-128 mm	SC	Small Cobble
128-256 mm	LC	Large Cobble
>256 mm	BO	Boulders
Bedrock	BR	Bedrock

mm = millimeters

TABLE 11.1-4
Cover Codes, Instream Flow Study

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

TABLE 11.2-1
Pebble Project Environmental Studies
Study Summary for Macroinvertebrates and Periphtyon, 2004-2007
Consultant: HDR Alaska

Field Studies	2004 Study Tasks	2005 Study Tasks	2006 Study Tasks	2007 Study Tasks
Macroinvertebrates and Periphyton	**Mine Studies Area**			
	Sample Macroinvebrates and Periphyton at Study Sites	Sample Macroinvebrates and Periphyton at Study Sites	Sample for Zooplankton at Four Lakes and three NFK Sites	Sample Macroinvertebrates and Periphyton at ten Sites
	Sample Processing/Identification	Sample Processing/Identification	Sample Processing/Identification	Sample Processing/Identification
	Transportation Corridor			
	Sample Macroinvebrates and Periphyton at Study Sites	Sample Macroinvebrates and Periphyton at Study Sites	None	None
	Sample Processing/Identification	Sample Processing/Identification		

Table 11.2-2
Pebble Project
Period-of-Record Index
Macroinvertebrates and Periphyton, Mine Study Area

Sample Location	Year[1]	Period-of-Record By Discipline											
		Hydrology[2]											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004					I	I	I	C	C	C		
	2005	I		I	C	C	C	C	C	C	C		
	2006		I	I		C	C	C	C	C	C		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
KR100A	2004				I		I	I	I	I	I		
	2005			I			I	I	I	I	I		
	2006			I			I	I			I		I
	2007	I	I	I	I	I	I	I	I	I	I	I	I
NK100A (USGS)	2004						I	I	C	C	C		
	2005	I		I	C	C	C	C	C	C	C		
	2006			I	C	C	C	C	C	C	C		
	2007	I	I	I	C	C	C	C	C	C	C	I	I
NK100A1	2004												
	2005												
	2006												
	2007		I	I	C	C	C	C	C	C	C	I	I
NK100B	2004								I	I	I		
	2005	I		I		I	I	I	I	I	I		
	2006		I	I		I	I	I	I		I		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
NK100C	2004				I	I		I	C	C	C		
	2005	I		I		C	C	C	C	C	C		
	2006		I	I		C	C	C	C	C	C		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
NK119A	2004				I		I	I	C	C	C		
	2005	I		I		C	C	C	C	C	C		
	2006	I	I	I	C	C	C	C	C	C	C		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
NK119B	2004				I	I	I	I	I	I	I		
	2005	I		I		I	I	I	I	I	I		
	2006		I	I									
	2007	I	I	I	C	C	C	C	C	C	C	I	I
SK100A	2004				I		I	I	C	C	C		
	2005	I		I	C	C	C	C	C	C	C		
	2006		I	I	C	C	C	C	C	C	C		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
SK100B (USGS)	2004				I		I	I	C	C	C		
	2005	I		I	C	C	C	C	C	C	C		
	2006		I	I	C	C	C	C	C	C	C		I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
SK100B1	2004												
	2005									I	I	C	C
	2006	C	C	C	C	C	C	C	C	C	C	C	I
	2007	I	I	I	C	C	C	C	C	C	C	I	I
SK100B2	2004												
	2005					I	I	I	I	I	I		
	2006		I	I		I	I	I	I	I	I		I
	2007	I	I	I	I	I	I	I	I	I	I	I	I

Sample Location	Year[1]	Water Quality											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
KR100A	2004				Q	Q	Q	Q	Q	Q	Q		
	2005			Q			Q	Q	Q	Q	Q		
	2006			Q			Q	Q			Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100A (USGS)	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100A1	2004												
	2005												
	2006												
	2007		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100B	2004				Q	Q			Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK100C	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK119A	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
NK119B	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006												
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100A	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B (USGS)	2004				Q	Q	Q	Q	Q	Q	Q		
	2005	Q		Q		Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B1	2004												
	2005									Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100B2	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

Sample Location	Year[1]	Fish Tissue[3]												Macroinvertebrates											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004								W										D		D				
	2005								W																
	2006																								
	2007																								
KR100A	2004																								
	2005																								
	2006																								
	2007																								
NK100A (USGS)	2004								W										D		D				
	2005								W										S						
	2006																								
	2007								W										S						
NK100A1	2004																								
	2005																								
	2006																								
	2007																								
NK100B	2004																		D						
	2005																								
	2006																								
	2007																								
NK100C	2004								W										D		D				
	2005								W										S						
	2006																								
	2007																		S						
NK119A	2004								W										D		D				
	2005								W																
	2006																								
	2007																		S						
NK119B	2004																								
	2005																								
	2006																								
	2007																								
SK100A	2004								W										D		D				
	2005								W																
	2006																								
	2007																		S						
SK100B (USGS)	2004								W										D		D				
	2005								W										S						
	2006																								
	2007								W										S						
SK100B1	2004																								
	2005																								
	2006																								
	2007																								
SK100B2	2004																								
	2005																								
	2006																								
	2007																								

Sample Location	Year[1]	Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
KC100A	2004						F	F		F			
	2005						F	F					
	2006												
	2007												
KR100A	2004							F		F			
	2005												
	2006												
	2007												
NK100A (USGS)	2004						F	F		F			
	2005						F	F					
	2006						F						
	2007						F						
NK100A1	2004												
	2005												
	2006												
	2007												
NK100B	2004						F						
	2005						F	F		F			
	2006						F						
	2007						F						
NK100C	2004						F	F		F			
	2005						F	F		F			
	2006						F						
	2007						F						
NK119A	2004						F	F		F			
	2005						F	F					
	2006												
	2007						F						
NK119B	2004												
	2005												
	2006												
	2007												
SK100A	2004						F						
	2005						F	F					
	2006						F						
	2007						F						
SK100B (USGS)	2004						F	F		F			
	2005						F	F					
	2006						F						
	2007						F						
SK100B1	2004												
	2005												
	2006												
	2007												
SK100B2	2004												
	2005												
	2006												
	2007												

Sample Location	Year[1]	Hydrology[2]												Water Quality											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SK100C	2004						I	I	C	C	C						Q	Q	Q	Q			Q		
	2005	I		I		C	C	C	C	C	C			Q				Q	Q	Q		Q	Q		
	2006		I	I		I	C	C	C	C	C		I					Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100D	2004						I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I			I	I	I	I	I		I						Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100F	2004					I	I	I	C	C	C							Q	Q	Q	Q	Q	Q		
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I		C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK100G	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I		C	C	C	C	C	C			Q	Q	Q		Q	Q	Q	Q	Q	Q		
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK119A	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q		Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK124A	2004																								
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I			C	C	C	C	C		I	Q	Q	Q			Q	Q	Q		Q		Q
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK131A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK133A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005			I		I	I	I	I	I	I							Q	Q	Q	Q	Q	Q		
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK134A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK136A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I		I	I	I	I	I	I			Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
SK136B	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q		
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UT100A	2004					I			I	I	I						Q	Q			Q	Q	Q		
	2005	I		I		I	I	I			I			Q		Q		Q	Q	Q			Q		
	2006			I			I	I		I						Q			Q	Q	Q	Q	Q		Q
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
UT100B (USGS)	2004					I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q		
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q		
	2006		I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q

Sample Location	Year[1]	Fish Tissue[3]												Macroinvertebrates												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
SK100C	2004								W										D												F	F		F			
	2005								W																						F	F					
	2006																														F						
	2007																														F						
SK100D	2004																																	F			
	2005																																				
	2006																																				
	2007																		S																		
SK100F	2004								W										D		D										F	F		F			
	2005								W																						F						
	2006																																				
	2007																														F						
SK100G	2004								W										D		D										F	F	F	F			
	2005								W																						F	F					
	2006																																				
	2007																														F						
SK119A	2004								W										D		D										F	F		F			
	2005								W																						F						
	2006																														F						
	2007																																				
SK124A	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK131A	2004																															F		F			
	2005																																				
	2006																																				
	2007																																				
SK133A	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK134A	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK136A	2004																																				
	2005																																				
	2006																																				
	2007																																				
SK136B	2004																																				
	2005																																				
	2006																																				
	2007																																				
UT100A	2004																																	F			
	2005																																				
	2006																																				
	2007																																				
UT100B (USGS)	2004								W										D		D										F	F	F	F			
	2005								W										S												F	F		F			
	2006																														F						
	2007								W										S												F						

Sample Location	Year[1]	Period-of-Record By Discipline																																																										
		Hydrology[2]												Water Quality												Fish Tissue[3]												Macroinvertebrates												Sediment											
	Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
UT100C	2004				I	I											Q	Q			Q												W										D		D										F						
	2005			I																													W																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S																		
UT100C1	2004																																																											
	2005																																																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100C2	2004																																																											
	2005																																																												
	2006				I																																																								
	2007		I	I	C	C	C	C	C	C	C	I	I		Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT100D	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I		C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W										S												F	F		F			
	2006		I	I		C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S												F						
UT100E	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006	I	I	I	C	C	C	C	C	C	C		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
UT119A	2004				I	I	I	I	C	C	C						Q	Q	Q	Q	Q	Q	Q										W										D		D										F	F		F			
	2005	I		I	C	C	C	C	C	C	C			Q		Q		Q	Q	Q	Q	Q	Q										W																						F						
	2006	I	I	I	C	C	C	C	C	C	C		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	C	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																		S												F						
UT119B	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																	F					
	2006	I	I	I		I	I	I	I	I	I		I	Q	Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT135A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																						
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																						
	2006		I			I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	C	C	C	C	C	C	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT138A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q										W										D		D											F		F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q										W										S																		
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
UT141A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																	F		F			
	2005			I		I	I	I	I	I	I					Q		Q	Q	Q	Q	Q	Q																																	F					
	2006		I	I		I	I	I	I	I	I		I		Q	Q		Q	Q	Q	Q	Q	Q		Q																														F						
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																														F						
UT146A	2004				I	I	I	I	I	I	I						Q	Q	Q	Q	Q	Q	Q																																	F		F			
	2005	I		I		I	I	I	I	I	I			Q		Q		Q	Q	Q	Q	Q	Q																																						
	2006		I			I	I	I	I	I	I		I		Q			Q	Q	Q	Q	Q	Q		Q																																				
	2007	I	I	I	I	I	I	I	I	I	I	I	I	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q																																				
Black Lake	2004																																																												
	2005																																T																								F				
	2006																				Q												T												P																
	2007																				Q												T																												
Big Wiggly	2004																																T												M																
	2005																																T										M													F					
	2006																				Q																								P																
	2007																				Q												T																												

Period-of-Record By Discipline

Hydrology[2]

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005												
	2006												
	2007												
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005												
	2006												
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004					X				X			
	2005			X				X	X		X		
	2006			X			X		X		X		
	2007			X		X		X		X	X		

Water Quality

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005												
	2006							Q					
	2007								Q				
Chiquita Lake	2004												
	2005												
	2006								Q				
	2007								Q				
Lake No. 2	2004												
	2005												
	2006								Q				
	2007								Q				
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006								Q				
	2007								Q				
Small Pools	2004												
	2005												
	2006								Q				
	2007								Q				
Seeps	2004					X				X			
	2005			X				X	X		X		
	2006			X			X		X		X		
	2007			X		X		X		X	X		

Fish Tissue[3]

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004								T				
	2005								T				
	2006												
	2007								T				
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005								T				
	2006								T				
	2007								T				
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004												
	2005												
	2006												
	2007												

Macroinvertebrates

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004								M				
	2005						M						
	2006								P				
	2007												
Chiquita Lake	2004												
	2005												
	2006												
	2007												
Lake No. 2	2004												
	2005												
	2006								P				
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005												
	2006												
	2007												
Small Pools	2004												
	2005												
	2006												
	2007												
Seeps	2004												
	2005												
	2006												
	2007												

Sediment

Sample Location	Year[1] / Month	J	F	M	A	M	J	J	A	S	O	N	D
Frying Pan Lake	2004												
	2005							F					
	2006							F					
	2007												
Chiquita Lake	2004												
	2005									F			
	2006												
	2007												
Lake No. 2	2004												
	2005								F				
	2006												
	2007												
Mud Lake (Near Lily Lake)	2004												
	2005									F			
	2006												
	2007												
Small Pools	2004												
	2005												
	2006									F			
	2007									F			
Seeps	2004												
	2005							7			5		
	2006												
	2007												

KEY:

C Continuous stage/discharge hydrometric data collected in streams (gaged stations with dataloggers).
D Macroinvertebrate sites sampled with drift nets AND ASCI methods; periphyton collected with RBP, and diatoms were assessed.
F Sediment samples collected. Seep sediment samples show number of seeps sampled through 2007. Sediment symbol not shown on associated map.
I Instantaneous stream discharge measurements taken each month coincident with water quality sampling (ungaged stations without dataloggers).
M Macroinvertebrate samples from lakes collected with a modified ASCI approach and dredge. Periphyton collected with RBP, and diatoms were assessed.
P Plankton tows.
Q Surface water quality samples collected for field and laboratory analyses.
S Macroinvertebrate sites sampled with Surber Sampler AND ASCI methods; periphyton collected with ADNR methods, and chlorophyll *a* was assessed.
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. In 2007, adult grayling and whitefish (muscle tissues) will be sampled. If species is not present in adequate numbers, an alternative location will be selected.
X Seep flow measurements and water quality samples collected.

NOTES:

1 Work for 2007 is shown as planned, but has not yet been completed.
2 At stations where continuous hydrometric data are collected, continuous hydrographs will be estimated throughout winter months using standard hydrometric methods. Stream gages are reinstalled each spring as early as breakup conditions allow.
3 One stream sample 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 (filet). In lakes, grayling, whitefish and northern pike will be collected; muscle tissue samples will be collected from all three species, as well as liver (archive) samples from northern pike.

TABLE 11.2-3
Sampling Stations and Sample Summaries for Macroinvertebrate and Periphyton Sampling, Mine Study Area

Location	Station Name	Sampling Method/Type	No. of Primary Samples	No. of QC Samples	Total No. of Samples
North Fork Koktuli River	NK100A	ASCI, Surber, periphyton	16	**6 total**: Duplicate and triplicate mussel[b] Duplicate and triplicate water quality Duplicate and triplicate sediment	**175 total**: 50 Surber 10 ASCI 100 periphyton 3 primary mussel 3 primary water quality 3 primary sediment 1 duplicate and 1 triplicate for each of mussel, water quality, and sediment
	NK100C	ASCI, Surber, periphyton	16		
	NK119A	ASCI, Surber, periphyton	16		
South Fork Koktuli River	SK100A	ASCI, Surber, periphyton	16		
	SK100B	ASCI, Surber, periphyton	16		
	SK100D	ASCI, Surber, periphyton	16		
Upper Talarik Creek	UT100B	ASCI, Surber, periphyton	16		
	UT100C	ASCI, Surber, periphyton	16		
	UT100D	ASCI, Surber, periphyton	16		
	UT119A	ASCI, Surber, periphyton	16		
Lakes	3 Mine Area Lakes	Mussels, water quality, sediment	3 each		

Notes:

a. Mussel collection will occur if mussels are present in up to three lakes.

b. Mussel duplicate and triplicate samples will be split by the laboratory as needed.

TABLE 11.3-1
Pebble Project Environmental Studies
Iliamna Lake Study Summary, 2005-2007
Consultant: HDR Alaska

Field studies	2005 Study Tasks	2006 Study Tasks	2007 Study Tasks
Iliamna Lake	Sample at 5 Water Quality Stations for Water, Sediments and Zooplankton, May-Oct.	Sample at 4 Sites for Mussels, Water and Sediments in August	Sample at 5 Stations for Surface Water and Zooplankton, May-Oct.
	Sample at 4 Sites for Mussels		
	Process and Identify Zooplankton Samples		Process and Identify Zooplankton Samples

Table 11.3-2
Pebble Project
Period-of-Record Index
Iliamna Lake Study

Sample Location	Year[1]	Period-of-Record By Discipline Iliamna Lake Study											
	Month	J	F	M	A	M	J	J	A	S	O	N	D
Pile Bay	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Knutson Bay	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Northeast Bay	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Roadhouse Bay	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q	Q	Q		
Upper Talarik (Outlet)	2004												
	2005					Q	Q	Q	Q	Q	Q		
	2006												
	2007					Q	Q	Q	Q		Q		
Flat Island	2004												
	2005						A			A			
	2006						A			A			
	2007												
Finn Bay	2004												
	2005						A			A			
	2006						A			A			
	2007												
Whistlewing Bay	2004												
	2005						A			A			
	2006						A			A			
	2007												
Bucket Lake	2004												
	2005						A			A			
	2006						A			A			
	2007												

KEY:

Q Surface water quality, zooplankton samples

A Freshwater mussel, sediment, surface water quality

NOTES:

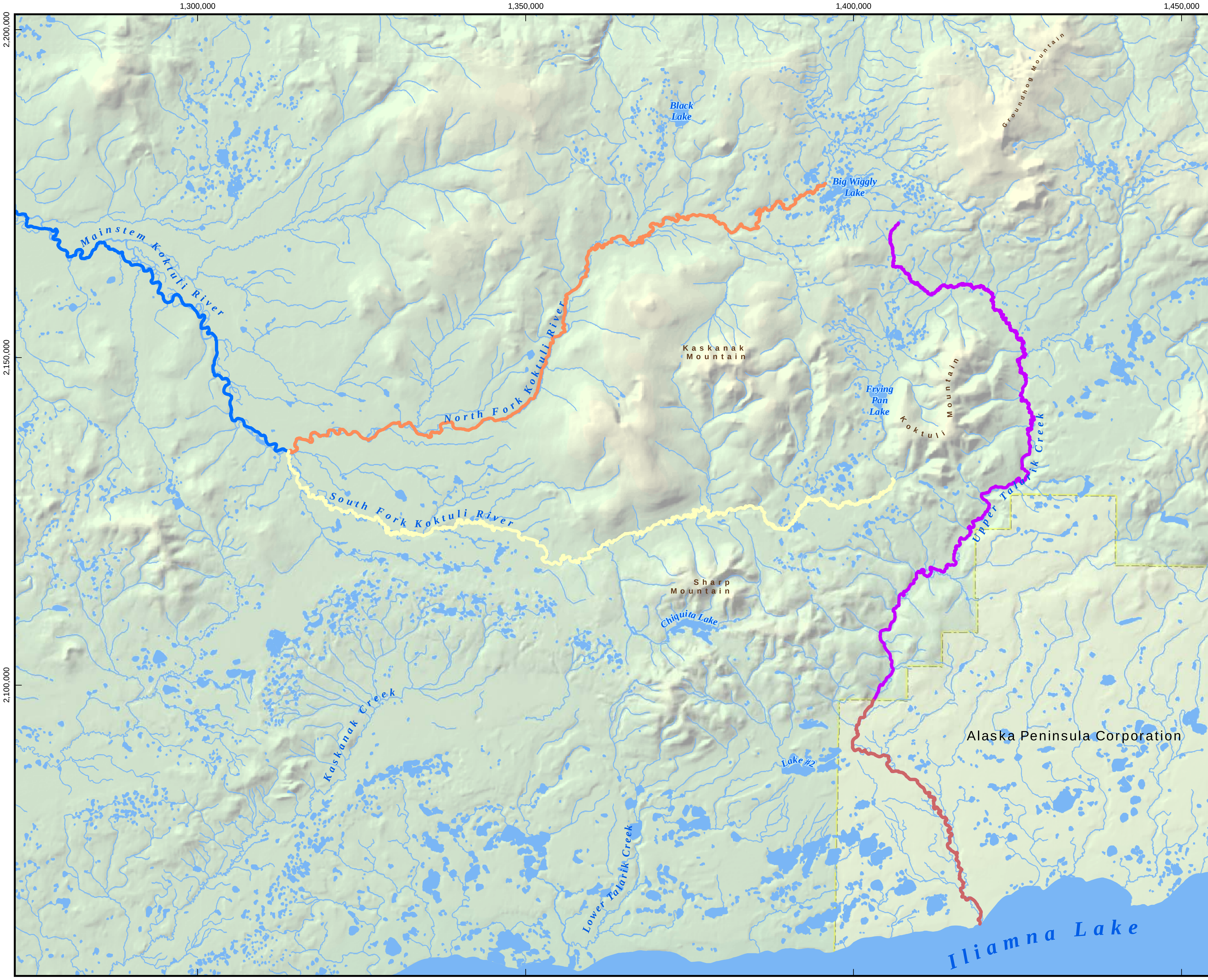
1. Work shown for 2007 is as planned but not yet completed.

TABLE 11.3-3
Surface Water Analytes for Iliamna Lake Sampling Program

Analyte	**Analyte**
Aluminum, total and dissolved	Tin, total and dissolved
Antimony, total and dissolved	Vanadium, total and dissolved
Arsenic, total and dissolved	Zinc, total and dissolved
Barium, total and dissolved	Semivolatile organic compounds*
Beryllium, total and dissolved	Volatile organic compounds*
Bismuth	Pesticides*
Boron	Polychlorinated biphenyls*
Cadmium, total and dissolved	pH
Calcium, total and dissolved	Conductivity
Chromium, total and dissolved	Alkalinity
Cobalt, total and dissolved	Acidity
Copper, total and dissolved	Ammonia
Iron, total and dissolved	Chloride
Lead, total and dissolved	Cyanide-total
Magnesium, total and dissolved	Cyanide, weak acid dissociable (WAD)
Manganese, total and dissolved	Fluoride
Mercury, total and dissolved	Nitrate + nitrite
Molybdenum, total and dissolved	Phosphorus, total
Nickel, total and dissolved	Sulfate
Potassium, total and dissolved	Silicon
Selenium, total and dissolved	Total dissolved solids
Silver, total and dissolved	Total suspended solids
Sodium, total and dissolved	Thiocyanate
Thallium, total and dissolved	Dissolved organic carbon

* To be collected during the June and September sampling trips only.

FIGURES



Pebble Project
NORTHERN DYNASTY MINES INC.

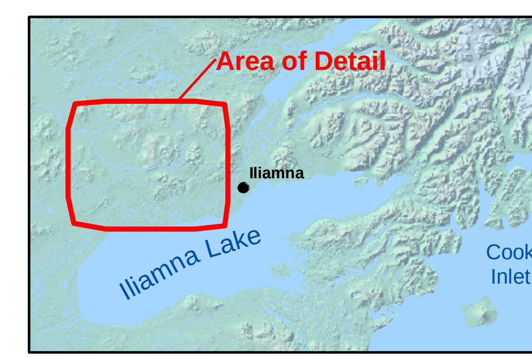
Figure 11.1-1
2007 Study Plan
Fish Resources
Mine Study Area Streams

Draft

Legend

Study Area Streams

- North Fork Koktuli
- South Fork Koktuli
- Upper Talarik Creek
- Upper Talarik on APC-owned land
- Mainstem Koktuli River
- Stream
- Waterbody
- Alaska Peninsula Corporation-owned land



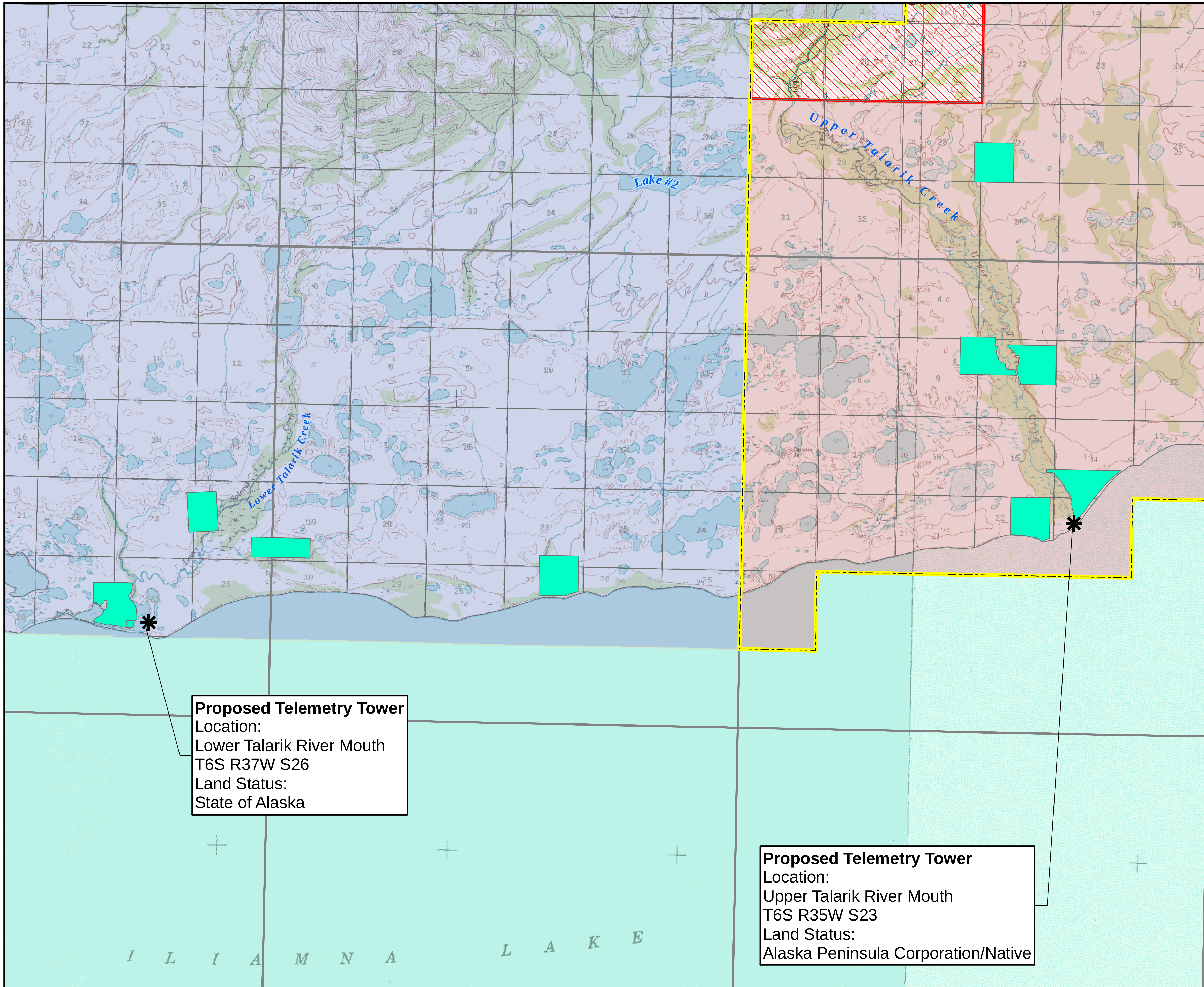
Miles: 0, 1.25, 2.5, 3.75, 5
Kilometers: 0, 1.25, 2.5, 3.75, 5
N

Scale 1:176,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyPlan_Figure11-1-1_2007_july20.mxd	Date: July 27, 2007
Version:1	Author: HDR - JC, AH

Z:\200847 Northern Dynasty Minerals\All Disciplines\GIS\RD\Source\HDR\Fisheries\MapDocs\StudyPlan\StudyPlan_Figure11-1-1_2007_july20.mxd - 7/27/2007 @ 2:24:54 PM

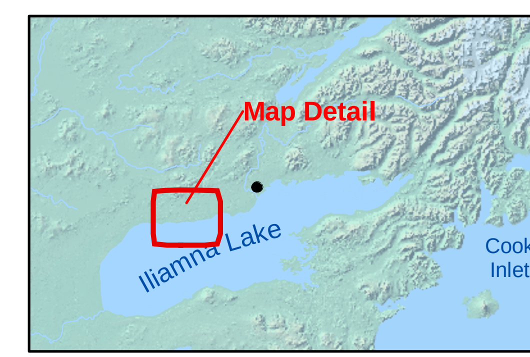


Pebble Project
NORTHERN DYNASTY MINES INC.

Figure 11.1-2
2007 Study Plan
Fish Resources Upper Talarik Creek
Rainbow Trout Telemetry
Fixed Tower Locations
Mine Study Area

Draft

Legend
- Proposed Telemetry Tower Location
- Land Status
  - Bureau of Land Management
  - Native Patent
  - Native Selected
  - State Patent
  - Native Allotments / Private Land
  - Alaska Peninsula Corporation

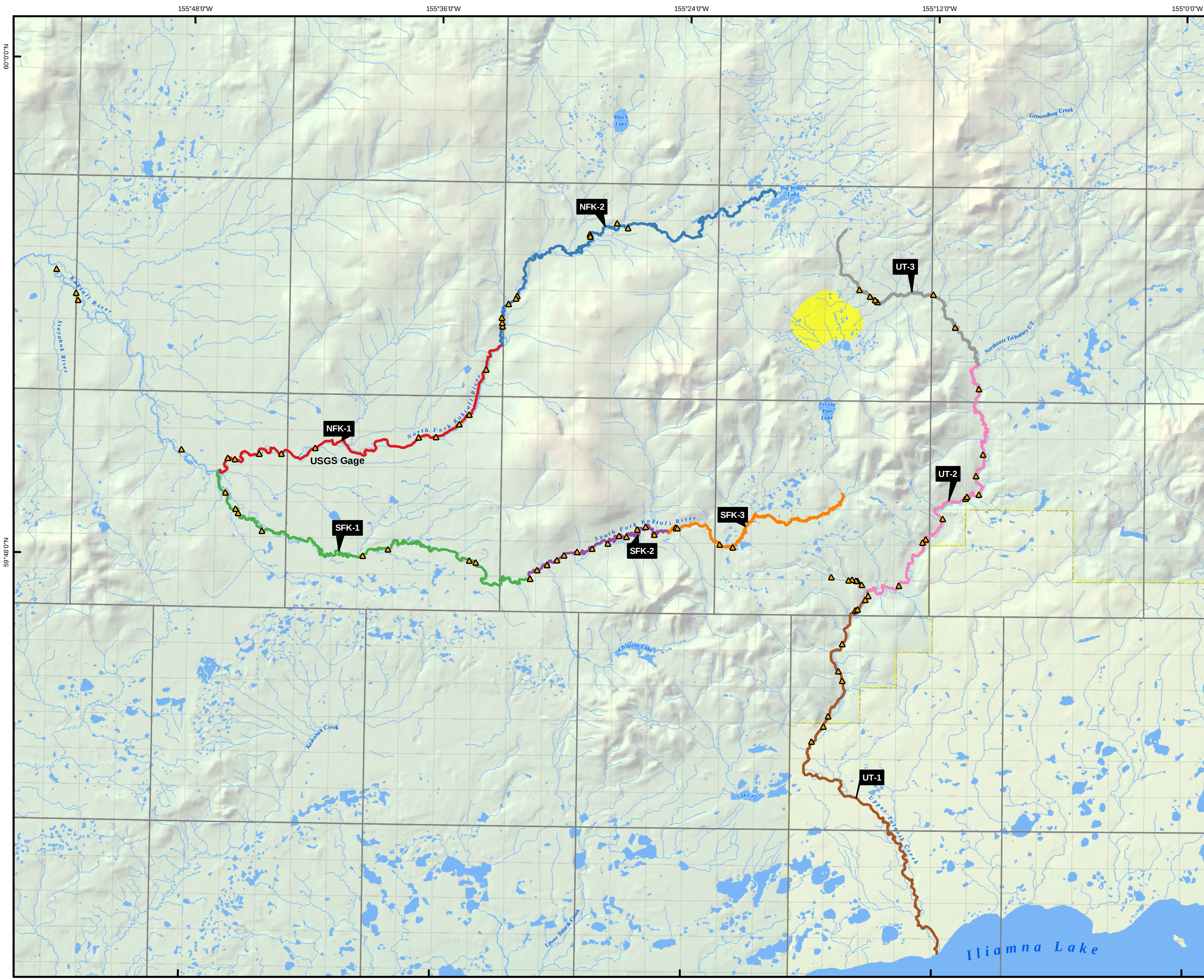


Miles: 0, 1.25, 2.5, 3.75
Kilometers: 0, 1.25, 2.5, 3.75, 5
N

Scale 1:80,000
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyPlan_11.1-2	Date: 07-20-2007
Version: 1	Author: HDR - JOC, AH

Z:\200847 Northern Dynasty Minerals\All Disciplines\GIS\RD\Source\HDR\Fisheries\MapDocs\StudyPlan\StudyPlan_Figure11-1-2_2007Telemetry_Fixed_Tower_Loc_july20.mxd - 7/20/2007 @ 2:59:14 PM



Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 11.1-3
2007 Study Plan
Fish Resources Flow-habitat Sample Sites and Reach Designations
Mine Study Area

Draft

Legend

Flow-habitat Site

Stream

Waterbody

General Deposit Area

Village Corporation Boundary

Flow-habitat Reach

NFK-1

NFK-2

SFK-1

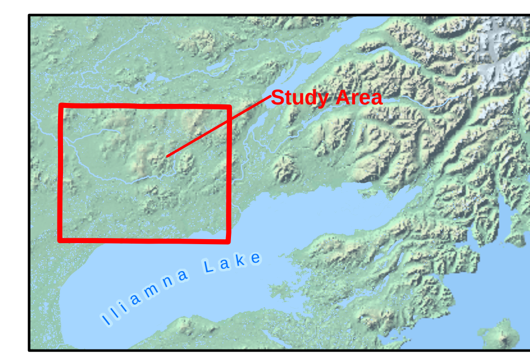
SFK-2

SFK-3

UT-1

UT-2

UT-3



Miles: 0, 1.25, 2.5, 3.75, 5

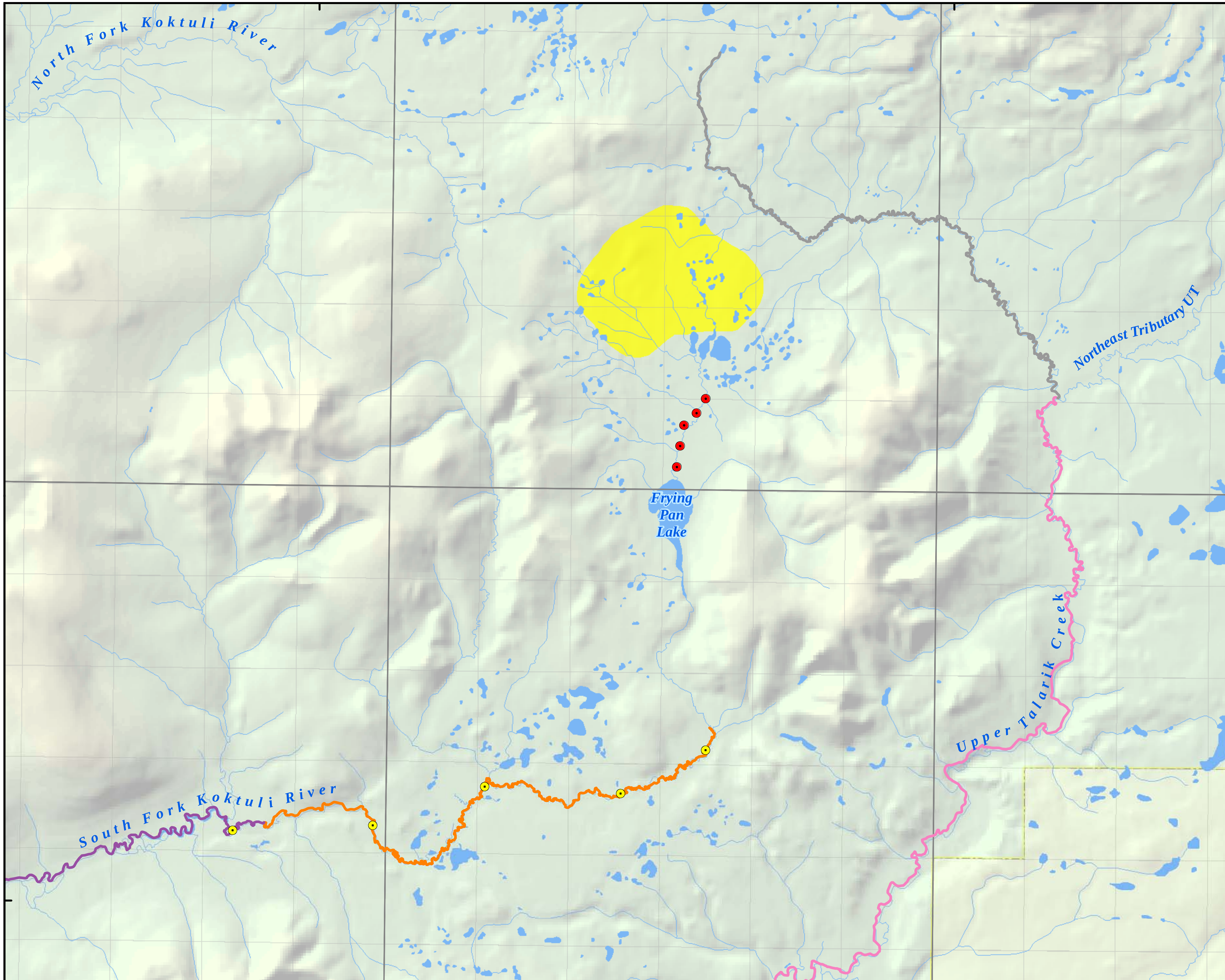
Kilometers: 0, 1.25, 2.5, 3.75, 5

N

Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyPlan_Fig11.1-3.mxd	Date: July 27, 2007
Version: 1	Author: HDR - MC, JC, AH



Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 11.1-4
2007 Study Plan
Fish Resources Anadromous Fish
Distribution Study Sites
Mine Study Area

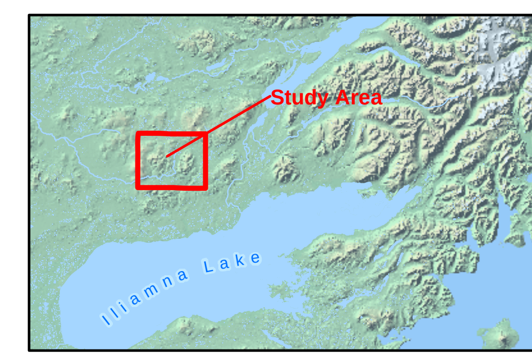
Draft

Legend

- Intermittent Reach Study Sites
- Snorkel Sites
- Stream
- Waterbody
- General Deposit Area
- Village Corporation Boundary

Flow-habitat Reach

- SFK-2
- SFK-3
- UT-2
- UT-3



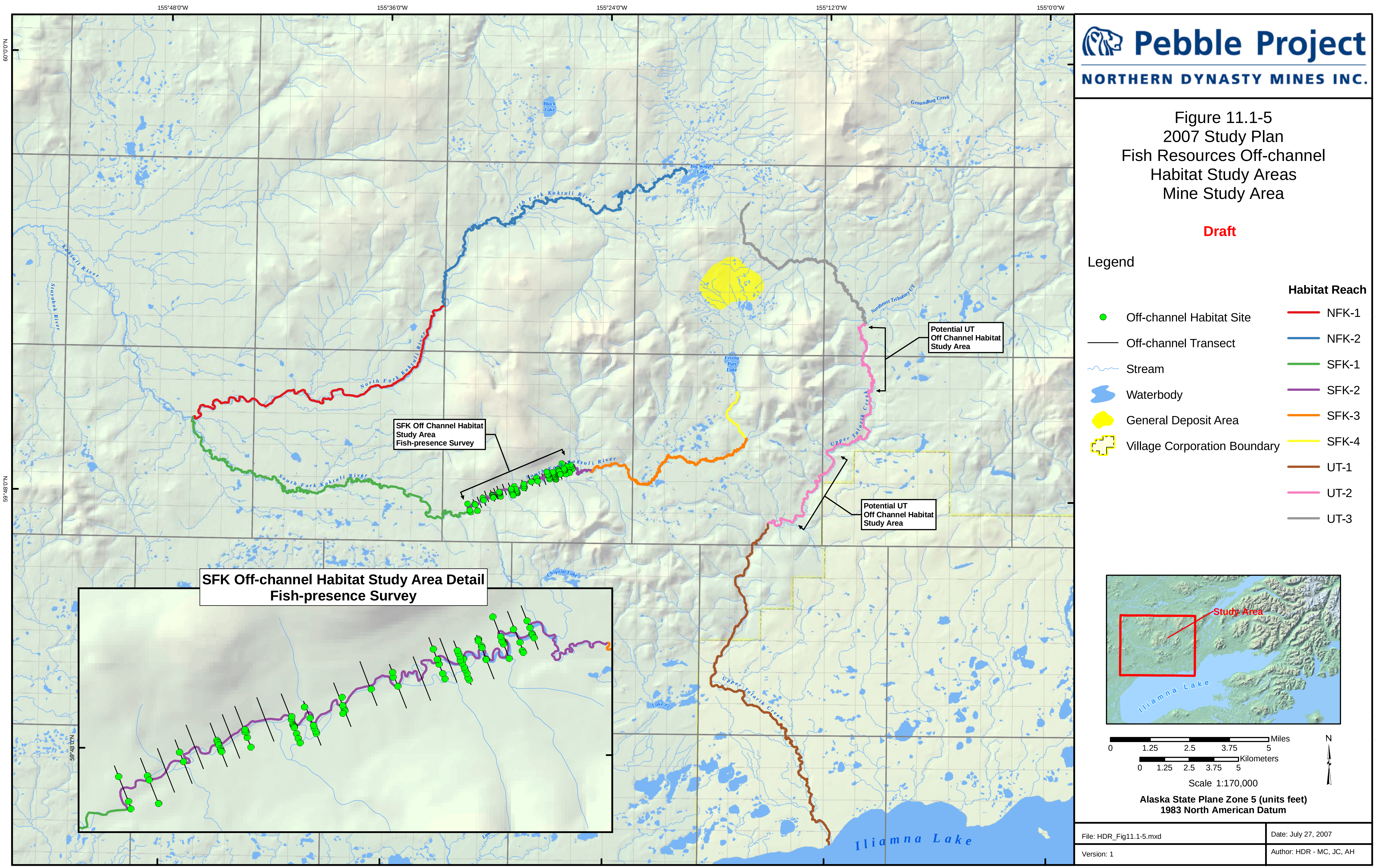
Miles: 0 0.5 1 1.5 2
Kilometers: 0 0.5 1 1.5 2
N

Scale 1:68,264

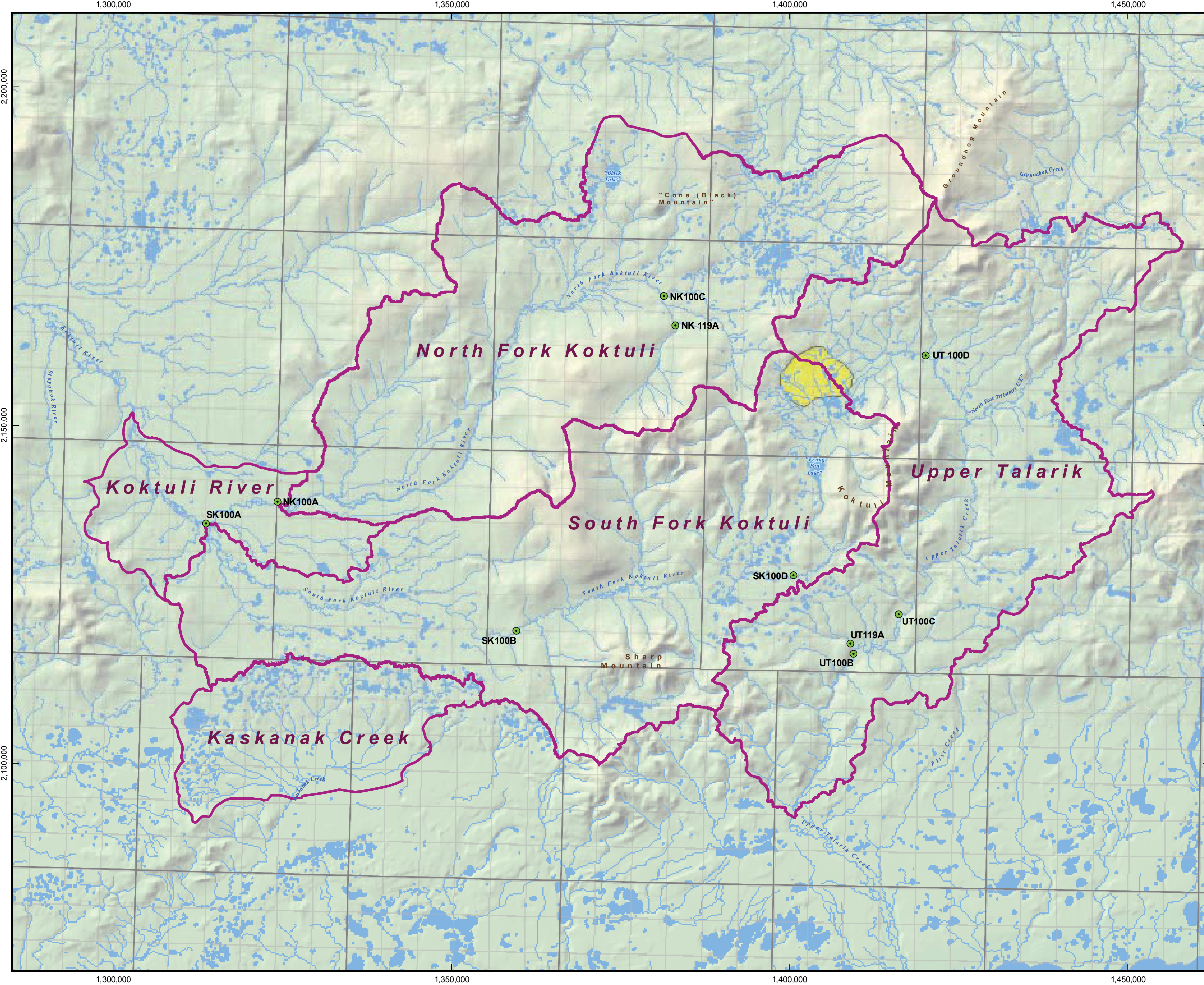
Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyPlan_Fig11.1.4.mxd	Date: July 27, 2007
Version: 1	Author: HDR - MC, JC, AH

Z:\200847 Northern Dynasty Minerals\All Disciplines\GIS\RD\Source\HDR\Fisheries\MapDocs\StudyPlan\StudyPlan_Figure11-1-4_2007Anadromous_Fish_Dist_Study_Area_july20.mxd - 7/27/2007 @ 2:20:57 PM



Pebble Project
NORTHERN DYNASTY MINES INC.
Figure 11.1-5
2007 Study Plan
Fish Resources Off-channel
Habitat Study Areas
Mine Study Area
Draft
Legend
Off-channel Habitat Site
Off-channel Transect
Stream
Waterbody
General Deposit Area
Village Corporation Boundary
Habitat Reach
NFK-1
NFK-2
SFK-1
SFK-2
SFK-3
SFK-4
UT-1
UT-2
UT-3
Study Area
Iliamna Lake
Miles
0 1.25 2.5 3.75 5
Kilometers
0 1.25 2.5 3.75 5
N
Scale 1:170,000
Alaska State Plane Zone 5 (units feet)
1983 North American Datum
File: HDR_Fig11.1-5.mxd
Date: July 27, 2007
Version: 1
Author: HDR - MC, JC, AH
SFK Off-channel Habitat Study Area Detail
Fish-presence Survey
SFK Off Channel Habitat
Study Area
Fish-presence Survey
Potential UT
Off Channel Habitat
Study Area
Potential UT
Off Channel Habitat
Study Area
North Fork Koktuli River
South Fork Koktuli River
Koktuli River
Stuyahok River
Upper Talarik Creek
Northeast Tributary UT
Groundhog Creek
Big Wiggly Lake
Black Lake
Frying Pan Lake
Chiquita Lake
Iliamna Lake
155°48'0"W
155°36'0"W
155°24'0"W
155°12'0"W
155°0'0"W
60°0'0"N
59°48'0"N
Z:\200847 Northern Dynasty Minerals\All Disciplines\GIS\RD\Source\HDR\Fisheries\MapDocs\StudyPlan\StudyPlan_Figure11-1-5_OffChannelHabitat_july20.mxd - 7/27/2007 @ 2:17:32 PM



Pebble Project

NORTHERN DYNASTY MINES INC.

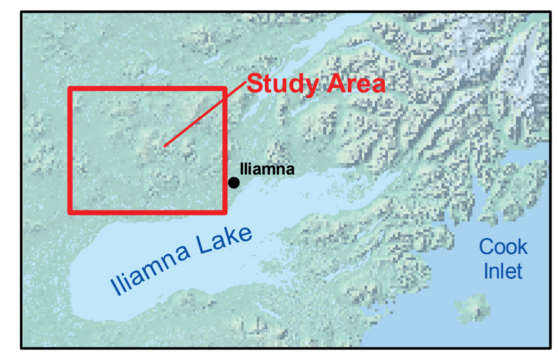
Figure 11.2-1

2007 Study Plan Macroinvertebrate and Periphyton Sampling Stations

DRAFT

Legend

- Macroinvertebrate and Periphyton Sampling Station
- Stream
- Waterbody
- General Pit Outline
- Watershed Boundary



Miles: 0 1.25 2.5 3.75 5

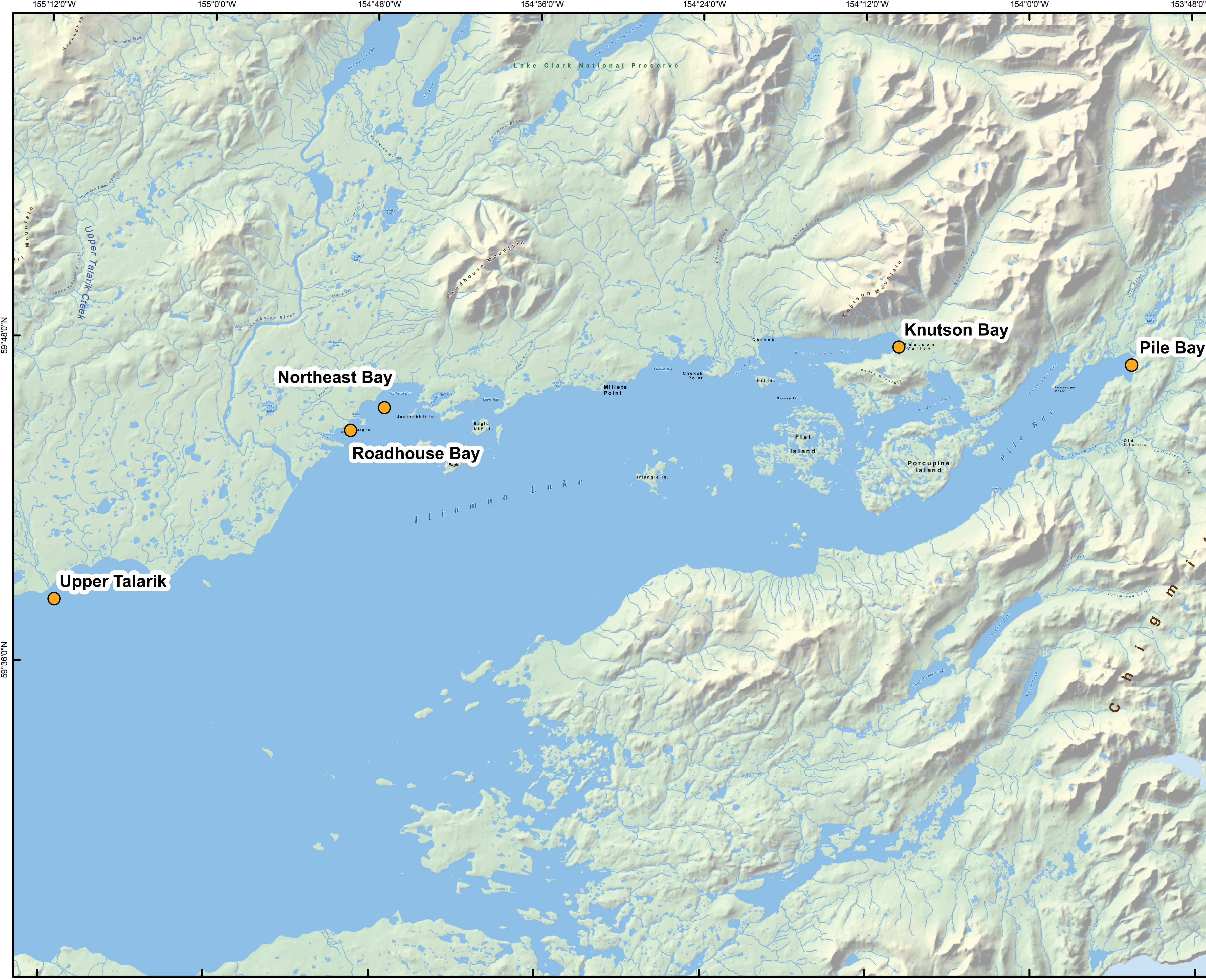
Kilometers: 0 1.25 2.5 3.75 5

N

Scale 1:170,000

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: StudyArea.mxd	Date: January 15, 2007
Version: 2	Author: HDR - JC, SS, AL



Pebble Project

NORTHERN DYNASTY MINES INC.

Figure 11.3-1

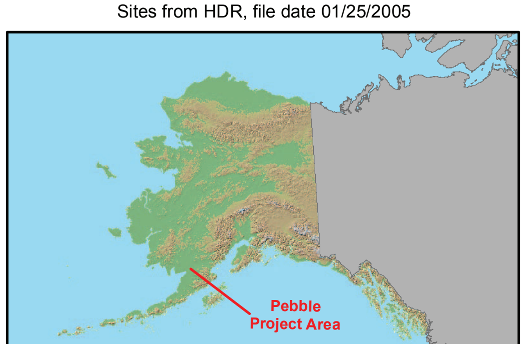
2007 Study Plan
Iliamna Lake Sampling Stations

DRAFT

Legend

- Nearshore Sampling Stations (waterquality, zooplankton)

Sites from HDR, file date 01/25/2005



0 1 2 4 6 8 Miles

0 1.5 3 6 9 12 Kilometers

N

Scale 1:268,590

Alaska State Plane Zone 5 (units feet)
1983 North American Datum

File: Fig3Iliamna LakeFieldSamplingPlan.mxd	Date: March 3, 2005
Version: 1	Author: HDR-DS

Z:\200847 Northern Dynasty Minerals\13988 Macroinvertebrate Road\GIS\MXD\Fig1Iliamnastdyplan.mxd

APPENDICES

APPENDIX 11.2A

Macroinvertebrates and Periphyton Field Data Forms

FIELD DATA SHEET: Benthos/Water Quality

Station ID **Lat** **Long**

Stream/River Name **Watershed**

Date **Start Time** **End Time** **Investigators**

Describe Site Location

Comments

Weather Conditions

Previous 7-day precipitation *(Circle one)*: Fl. Flood Heavy Mod Light None

Air Temperature _____ (°F) Other:_________________

Riparian Vegetation (18 m buffer) *(Circle the dominant type and height)*

Spruce/Hemlock/Coniferous Veg. Height: <1.5 m

Birch/Alder Grasses 1.5 – 3 m

Willow Cottonwood >3 m

Canopy Cover

<20% open 20-40% open 40-60% open 60-80% open >80% open

Water Quality Measurements **Instrument used**

Temperature ____ °C Hydrolab MiniSonde/surveyor 4 _______

pH ______ Other ___________________________

TDS_____________mg/L

Specific Conductance ______µS @25°C

Turbidity ______ NTUs D.O. ______mg/L ______% Saturation

Local Watershed Characteristics *(Circle)*

Land Use: Forest Field Agricultural Residential Logging Mining

Commercial/Industrial Recreational Other________________________

Watershed Erosion: None Slight Moderate Heavy

Watershed NPS Pollution: No evidence Some sources Obvious sources

Map Characteristics *(To be completed in office from candidate list info)*:

Map___________ T/R/S___________ HUC ________Ecoregion________

Elevation_______ft Drainage Area_________ Gradient _________

Anadromous Fish: Spawning___ Rearing_____

% Wetland______ % Lake _____ % Forested_____

Site Location Map *(Draw map & indicate gross characteristics)*

Photos: Roll#________ Picture#__________ Description:

Sample Allocation Formula Circle one: Riffle/Run Glide/Pool

SZ–R/R	=	_____ m at bank *x* 1 or 2 banks *x* 100 m	=	_______(1)
SZ–G/P	=	2(_____m at bank *x* 2 banks *x* 100 m)	=	_______(2)
BZ	=	_____m avg wetted w *x* 100m	=	_______(3)
Total Area	=	SZ + BZ _______+ _______	=	_______(4)
% SZ	=	(1) or (2) / (4) *x* 100	=	_______% SZ
% Bottom	=	100–% SZ *(Including snags & aquatic vegetation)*	=	______% *BZ*

% Total & No. jabs/kicks from each habitat type Total Jars _____

Cobble ____% _____ Stream Banks _____% _____

Snags ____% _____ Aquatic Veg. _____% _____

Sand/Soft Sed ____% _____ Other _____% _____

Water samples collected ____ yes ____ no

Number of jars: _____ Filtered _____ Unfiltered

Avg. Estimated Stream Depth

Riffle _______ Run ______ Pool ______

Alternate Site ID Code Agency_________________

Site ID _________________

Notes:

HABITAT ASSESSMENT FIELD DATA SHEET

Station ID____________Stream Name_________________ Date____________ Investigators__________ Total Score________

Stream Type *(Circle one)*: **Riffle/Run (coarse substrate) or Glide/Pool (fine substrate)**

Habitat Parameter (#1–5 evaluate in sample reach)	Category			
	Optimal	**Suboptimal**	**Marginal**	**Poor**
1. Epifaunal Substrate/ Available Instream Cover	>70% of substrate favorable for epifaunal colonization, mix of snags, submerged logs, undercut banks, cobble, or other stable habitat and not new fall.	40–70% mix of stable habitat; well suited for full colonization potential; adequate habitat; new fall, but not ready for colonization.	20–40% mix of stable habitat; habitat availability less than desirable; substrate frequently disturbed or removed.	<20% stable habitat; lack of habitat is obvious; substrate unstable or lacking.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
2. Embeddedness (Riffle/Run)	Gravel, cobble, and boulder particles are 0–25% surrounded by fine sediment. Substantial niche space.	Gravel, cobble, and boulder particles are 25–50% surrounded by fine sediment.	Gravel, cobble, and boulder particles are 50–75% surrounded by fine sediment.	Gravel, cobble, and boulder particles are >75% surrounded by fine sediment.
Pool Substrate Characterization (For Glide/Pool)	Mixture of substrate materials, gravel and firm sand may be prevalent; root mats and submerged vegetation common.	Mixture of soft sand, mud, or clay; mud may be dominant; some root mats and submerged vegetation present	All mud, clay, or sand bottom; little or no root mat; no submerged vegetation.	Hard-pan clay or bedrock; no root mat or vegetation.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
3. Velocity-Depth Combinations (Riffle/Run)	All 4 velocity-depth combinations present (slow-deep, slow-shallow, fast-deep, fast-shallow).	Only 3 of the 4 combinations present (if fast-shallow is missing, score lower than if missing other combinations).	Only 2 of the 4 habitat combinations present (if fast-shallow or slow-shallow are missing, score low).	Dominated by 1 velocity-depth combination (usually slow-deep).
Pool Variability (Glide/Pool)	Even mix of large-shallow, large-deep, small-shallow, small-deep pools present.	Majority of pools large-deep; very few shallow.	Shallow pools much more prevalent than deep pools.	Majority of pools small-shallow or pools absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
4. Sediment Deposition (Riffle/Run)	Little or no enlargement of islands or point bars and <5% of the bottom affected by sediment deposition.	Some new increase in bar formation, mostly from gravel, sand, or fine sediment; 5–30% of the bottom affected; slight deposition in pools.	Moderate deposition of new gravel, sand on old and new bars; 30–50% of the bottom affected; deposits at obstructions, bends, & constrictions; moderate deposition of pools prevalent.	Heavy deposits of fine material, increased bar development; >50% of the bottom changing frequently; pools almost absent due to major sediment deposition.
(Glide/Pool)	<20% of the bottom affected by sediment deposition; slight accumulation of CPOM & FPOM; little or no enlargement of point bars.	20–50% affected; moderate accumulation; substantial sediment movement only during major storm event; some new increase in bar formation.	50–80% affected; major deposition; pools shallow, heavily silted; embankments may be present on both banks; sediment movement during storm events.	>80% affected, channelized; mud silt or sand in braided or non-braided channels; pools almost absent.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
5. Channel Flow Status	Water reaches base of both lower banks and minimal amount of channel substrate is exposed.	Water fills >75% of available channel or <25% of channel substrate is exposed.	Water fills 25–75% of the available channel, and/or riffle substrates are mostly exposed.	Very little water in channel and mostly present as standing pools.
SCORE	20 19 18 17 1	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1

Riffle/Run prevalent**:** Moderate to high gradient streams with primarily coarse substrate (i.e., gravel or larger).
Glide/Pool prevalent**:** Lower gradient streams with primarily fine substrate or infrequent aggregations of more coarse sediment.

Habitat Parameter (6–10 evaluate broader than sample reach)	Category: Optimal	Suboptimal	Marginal	Poor
6. Channel Alteration	Channelization or dredging absent or minimal; stream with normal pattern.	Some channelization present, usually in areas of bridge abutments; evidence of past channelization, i.e., dredging, (greater than past 20 yrs.).	Channelization may be extensive; embankments or shoring structures present on both banks; 40 to 80% of stream reach channelized and disrupted.	Banks shored with gabion or cement; over 80% of stream reach channelized and disrupted. Instream habitat greatly altered or removed entirely.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
7. Frequency of Riffles or Bends (Riffle/Run)	Occurrence of riffles (or bends) relatively frequent; distance between riffles divided by stream width = 5 to 7; with continuous riffles, placement of natural obstruction important.	Occurrence of riffles (or bends) infrequent; distance between riffles divided by width of stream is between 7 and 15.	Occasional riffle or bend; bottom contours provide some habitat; distance between riffles (or bends) divided by width of stream is between 15 and 25.	Generally all flat water or shallow riffles (or bends); poor habitat; distance between riffles divided by width of stream is >25.
Channel Sinuosity (Glide Pool)	Bends in stream increase stream length 3–4 times longer than if it were in a straight line.	Bends in stream increase stream length 2–3 times longer than if it were a straight line.	Bends in stream increase stream length 1–2 times longer than if it were a straight line.	Channel straight; waterway has been channelized for long distance.
SCORE	20 19 18 17 16	15 14 13 12 11	10 9 8 7 6	5 4 3 2 1
8. Bank Stability (Score each bank) ***Note: Determine left or right side by facing downstream.***	Banks stable; evidence of erosion or bank failure absent or minimal; little potential for future problems. <5% of bank affected.	Moderately stable; infrequent, small areas of erosion mostly healed over. 5–30% of bank in reach has areas of erosion.	Moderately unstable; 30–60% of bank in reach has areas of erosion; high erosion potential during floods.	Unstable; many eroded areas; "raw" areas frequent along straight sections and bends; obvious bank sloughing; 60–100% of bank has erosional scars.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0
9. Bank Vegetative Protection (Score each bank)	>90% of streambank and immediate riparian zone surfaces covered by native vegetation, including trees, shrubs, or nonwoody macrophytes; vegetative disruption through grazing or mowing minimal or not evident; almost all plants allowed to grow naturally.	70–90% of stream-bank surfaces covered by native vegetation, but one class of plants not well represented; disruption evident but not affecting full plant growth potential to any great extent; more than one-half of potential plant stubble height remaining.	50–70% of streambank surfaces covered by vegetation; disruption obvious; patches of bare soil or closely cropped vegetation common; less than one-half of potential plant stubble height remaining.	<50% of streambank surfaces covered by vegetation; disruption of streambank vegetation very high; vegetation has been removed to 5 centimeters or less in average stubble height.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0
10. Riparian Vegetative Zone Width (Score each bank riparian zone)	Riparian zone width >18 m; human activities (i.e., parking lots, roadbeds, clear-cuts, lawns, or crops) have not impacted zone.	Riparian zone width 12–18 m; human activities have impacted zone only minimally.	Riparian zone width 6–12 m; human activities have impacted zone a great deal.	Riparian zone width <6 m; little or no riparian vegetation due to human activities.
SCORE	**Left bank** 10 9	8 7 6	5 4 3	2 1 0
SCORE	**Right bank** 10 9	8 7 6	5 4 3	2 1 0

TOTAL HABITAT ASSESSMENT SCORE ______

LABORATORY BENCH SHEET – Identification

Station ID _______________Collected by _______________Date _________ Stream____________________

Sorted by____________ Date Sorted___________ Subsample *(underline)*: 300 (+/-20%) 5' Pick QC 5' Pick Other

Taxonomist Init. _________ Date ID _____________

Organisms	No.	Found in 5' pick	TCR*
Ephemeroptera			
Ameletidae - *Ameletus*			
Baetidae - unid			
- *Acentrella*			
- *Baetis*			
Ephemerellidae - unid			
- *Drunella*			
- *Ephemerella*			
Heptageniidae - unid			
- *Cinygmula*			
- *Epeorus*			
- *Rithrogena*			
Leptophlebiidae - *Paraleptophlebia*			
Plecoptera			
Capniidae - unid			
- *Capnia*			
Capniidae/Leuctridae - unid			
Leuctridae - unid			
- *Despaxia*			
Chloroperlidae - unid			
- *Neaviperla*			
- *Plumiperla*			
- *Suwallia*			
- *Sweltsa*			
Nemouridae - *Nemoura*			
- *Zapada*			
Perlodidae - unid			
- *Isoperla*			
- *Diura*			
Pteronarcyidae - *Pteronarcella*			
Taeniopterygidae - *Taenionema*			
Turbellaria			
Gastropoda			
Lymnaeidae - Lymnaea			
Physidae - *Physa*			
Planorbidae - unid			
Valvatiidae - *Valvata*			
Bivalvia - Sphaeriidae			
Arachnoidea - Hydracarina			
Crustacea			
Amphipoda - unid			
Gammaridae - unid			
Ostracoda - unid			
Oligochaeta			
Nematoda			

Organisms	No.	Found in 5' pick	TCR*
Trichoptera			
Apataniidae - *Apatania*			
Brachycentridae - *Brachycentrus*			
Glossosmatidae - *Glossosoma*			
Hydroptilidae - *Ochrotrichia*			
- *Oxyethira*			
Hydrosychidae - *Hydropsyche*			
- *Arctopsyche*			
Lepidostomatidae - *Lepidostoma*			
Leptoceridae - *Ceraclea*			
Limnephilidae -unid			
- *Ecclisomyia*			
- *Eocosmoecus*			
- *Grensia*			
- *Hesperophylax*			
- *Limnephilus*			
- *Onocosmoecus*			
- *Psychoglypha*			
Polycentropodidae - *Polycentropus*			
Rhyacophilidae - *Rhyacophila*			
Uenoidae - *Neophylax*			
Diptera			
Ceratopogoniidae - unid			
- *Bezzia*			
- *Ceratopogon*			
- *Probezzia*			
Chironomidae - unid			
Empididae - unid			
- *Chelifera*			
- *Clinocera*			
- *Oreogeton*			
Psychodidae - *Pericoma*			
Sciomyzidae - unid			
Simuliidae - *Simullium*			
Tipulidae - unid			
- *Dicranota*			
- *Hesperoconopa*			
- *Hexatoma*			
- *Tipula*			
Coleoptera			
Other			
Other			

*Taxonomic certainty rating (TCR): 5 = most certain, 1 = least certain. If rating is 3–1, give reason (e.g., missing gills).

Total No. Organisms _______ **Total No. Taxa** _______

LABORATORY BENCH SHEET – Chironomidae Identification

Station ID _______________Collected by _______________Date _________ Stream_____________________

Sorted by___________ Date Sorted_________ Subsample *(underline)*: (20%) 5' Pick Other

Taxonomist Init. _________ Date ID _____________ Total No. of Slides __________

Tribe-Genus	No.	Found in 5' pick	TCR*
Chironomidae – unid			
Chironomini – unid			
- *Chironomus*			
- *Cryptochironomus*			
- *Dicrotendipes*			
- *Einfeldia*			
- *Glypotendipes*			
- *Kiefferulus*			
- *Omisus*			
- *Parachironomus*			
- *Paracladopelma*			
- *Paralauterborniella*			
- *Paratendipes*			
- *Phaenopsectra*			
- *Polypedilum*			
- *Stenochironomus*			
- *Stictochironomus*			
Diamesinae – unid			
- *Diamesa*			
- *Diamesinae*			
- *Lappodiamesa*			
- *Odontomesa*			
- *Pagastia*			
- *Potthastia*			
- *Prodiamesa*			
- *Sympotthastia*			
Tanypodinae – unid			
- *Brundiniella*			
- *Coelotanypus*			
- *Conchapelopia*			
- *Helopelopia*			
- *Krenopelopia*			
- *Larsia*			
- *Macropelopia*			
- *Natarsia*			
- *Nilotanypus*			
- *Oliveridia*			
- *Paramerina*			
- *Rheopelopia*			
- *Tanypodinae*			
- *Telmatopelopia*			
- *Thienemannimyia*			
- *Xenopelopia*			
- *Zavrelimyia*			
Podonominae - *Boreochlus*			

Tribe-Genus	No.	Found in 5' pick	TCR*
Orthocladiinae – unid			
- *Brillia*			
- *Cardiocladius*			
- *Chaetocladius*			
- *Corynoneura*			
- *Cricotopus*			
- *Diplocladius*			
- *Doithrix*			
- *Eudactylcladius*			
- *Eukiefferiella*			
- *Euorthocladius*			
- *Heterotrissocladius*			
- *Hydrobaenus*			
- *Krenosmittia*			
- *Limnophyes*			
- *Metriocnemus*			
- *Nanocladius*			
- *Oliveridia*			
- *Orthocladius*			
- *Paracricotopus*			
- *Parakiefferiella*			
- *Parametriocnemus*			
- *Paraphaenocladius*			
- *Paratrichocladius*			
- *Parorthocladius*			
- *Psilometriocnemus*			
- *Rheocricotopus*			
- *Rheosmittia*			
- *Smittia*			
- *Stilocladius*			
- *Symposiocladius*			
- *Synorthocladius*			
- *Thienemanniella*			
- *Tvetenia*			
- *Zalutschia*			
Tanytarsini – unid			
- *Cladotanytarsus*			
- *Constempellina*			
- *Micropsectra*			
- *Paratanytarsus*			
- *Radotanytarsus*			
- *Rheotanytarsus*			
- *Stempellina*			
- *Stempellinella*			
- *Tanytarsini*			
- *Tanytarsus*			
- *Zavrelia*			

*Taxonomic certainty rating (TCR): 5 = most certain, 1 = least certain.
If rating is 3–1, give reason (e.g., young specimen).

Total No. Chironomidae _______ **Total No. Taxa** _______

SAMPLE LOGIN SHEET

Sample ID	Stream Name	Collect Date	Samplers ID	Sample Processing						QC	
				# Jars	SS Y/N	5' Pick Y/N	Sorting Date/Init	ID Date/Init	Chiro Date/Init	Processing Date/Init	ID Date/Init

APPENDIX 11.3A

ILIAMNA LAKE STUDY
FIELD DATA FORMS

Pebble Project - Iliamna Lake Study - 2007- Field Data Collection Form

Station ID:	**Date:** / /07	**Start Time :** **End Time:**	**GPS - Lat:**
Team:		**Site Observer:**	**Long:**
Photos:	**Camera:**	**Weather: Air:** º (C) **Wind:** **Precip:**	

WATER QUALITY: Y N **Duplicate:** Y N **Triplicate:** Y N **MS/MSD:** Y N **Collection Method:** (Niskin)

Turbidity-Sample 1 (NTU):	**Depth-Sample 1 (m):**	**Turbidity Meter: HACH 2100 #**	**Turbidity Sampler:**
Turbidity-Sample 2 (NTU):	**Depth-Sample 2 (m):**	**Dissolved Metals Filter Lot #:**	**Filtered by:**
Turbidity-Sample 3 (NTU):	**Depth-Sample 3 (m):**	Hg Trip Blank: _________07TAPOWS60______ (prim)	__________07CASKWS60______ (trip)

Comments:

SECCHI DISK TRANSPARENCY: Y N

Disappear Depth: **Time:**

Reappear Depth: **Average Depth:**

Notes:

ZOOPLANKTON COLLECTION: Y N

Duplicate: Y N **# of sample bottles:**

Notes:

SEDIMENT COLLECTION: Y N

Duplicate: Y N **Triplicate:** Y N **MS/MSD:** Y N

Sediment Sample ID: **Collection Time:**

Collection Depth: **Collection Method:** (Ekman Dredge)

MUSSEL COLLECTION: Y N

Duplicate: Y N **Triplicate:** Y N **Collection Time:**

Mussel Sample ID: **Collection Depth (m):**

No. of organisms collected/sample: **Collection Method:** (Clam rake)

Mussel/Sediment Station Coordinates - Lat: **Long:**

Mussel/Sediment Notes:

Depth Profile Notes/Site Sketch:

Collection Summary: Depth Profile: Y N Water: Y N WQ Field Parameters: Y N Secchi Trans: Y N Zooplankton: Y N Sediment: Y N Mussels: Y N

Pebble Project - Iliamna Lake Study - 2007- Field Data Collection Form

Station ID:	Date: / /07	Team:
Meter Make and Model: YSI 556# _____________		Altimeter Reading: mm Hg

Depth	Temperature	Relative Conductivity	Specific Conductivity	DO	DO (% sat)	pH	ORP	Notes
1 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
2 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
3 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
4 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
5 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
6 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
7 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
8 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
9 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
10 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
11 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
12 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
13 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
14 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
15 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
16 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
17 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
18 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
19 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	
20 m	°C	uS/cm	mS/cm	mg/L	%	pH	mV	